Tropentag 2014

International Research on Food Security, Natural Resource Management and Rural Development

Bridging the gap between increasing knowledge and decreasing resources

Book of abstracts

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Preface

The annual *Tropentag* is the largest European interdisciplinary conference on Research on Tropical and Subtropical Agriculture, Food Security, Natural Resource Management and Rural Development. Continuous organisational support for the event is provided by the Council for Tropical and Subtropical Agricultural Research (ATSAF e.V.), the German Institute for Tropical and Subtropical Agriculture (DITSL) in Witzenhausen, and the GIZ Advisory Service on Agricultural Research for Development (BEAF). During its 15-year long history in the current constellation, the *Tropentag* was hosted by the universities of Bonn, Göttingen, Hamburg, Hohenheim, Kassel-Witzenhausen, Berlin, Zurich, and this year it is for the first time held in Prague, at the Czech University of Life Sciences. The 2014 *Tropentag* is held under the patronage of the Minister of Foreign Affairs of the Czech Republic, Mr. Lubomír Zaorálek.

The *Tropentag* has become the most important international conference on development-oriented research in the fields of food security, natural resource management and rural development in Europe and provides a unique platform for scientific and personal exchange for students, junior and senior scientists, development experts and funding organisations together with their international partner institutions. More than 800 participants from around 65 countries underline the importance of inter- and trans-disciplinary scientific exchange to address the challenges ahead of us.

The *Tropentag* 2014 takes place on the campus of the Czech University of Life Sciences Prague from September 17 - 19. It is organised by the Faculty of Tropical AgriSciences, comprising of four departments and more than 30 academic members – a unique institution in Czech Republic with over fifty years of tradition in tropical agriculture, rural development and sustainable management of natural resources in the tropics.

The theme of the 2014 conference is “Bridging the gap between increasing knowledge and decreasing resources”. Natural resources provide the basis for human survival and development but the increasing demands on these resources, and decrease in availability, emphasise the need for a coordinated approach to sustainable management. A large variety of scientific journals focusing on natural resources management and sustainable development research proves that our knowledge are increasing, but today’s world is still a place of uneven development, unsustainable use of natural resources, worsening impact of climate change, and continued poverty and malnutri-

tion. There is still a question of how scientific knowledge can be transformed into better management of natural resources and poverty alleviation especially in developing countries.

This year's *Tropentag* invites participants to present research on community-based management of resources to reduce poverty, enhance food security, and ensure biodiversity and watershed management. Contributions of the conference should help in answering questions such as to how the current natural resources in developing countries could be managed and conserved in a way that would ensure their accessibility for future generations; how the increasing food demand could be met in a sustainable way, or, which technological innovations would enhance their sustainability; and what type of institutions and regulations are needed to prevent the over-utilisation and exploitation of land-based biological resources.

These aspects will be addressed in the conference by several internationally renowned keynote speakers as well as through 20 oral presentation sessions presenting around 110 talks, 22 guided poster sessions with around 370 posters and number of thematic side events. A special session to commemorate the 40th anniversary of International Livestock Research Institute (ILRI) is also planned. This will highlight products of ILRI's livestock research contributing to the global development agenda, from generating research products (*performing*) to targeting research investments and policy-making (*informing*) to reshaping whole livestock production systems (*transforming*).

Our special thanks go to the colleagues from Berlin, Bonn, Bogota, Braunschweig, Copenhagen, Göttingen, Nairobi, Prague, Stuttgart and Vienna, who acted as reviewers for the submitted abstracts and thus contributed substantially to maintaining the scientific standard of the conference. We express our gratitude to Eric Tielkes, DITSL Witzenhausen, without whose support the conference would not have been possible. Our thanks include the Czech University of Life Sciences Prague for providing substantial financial and logistical support, and *Tropentag*'s regular donors whose financial contributions have made this conference possible and affordable especially for young scientists.

We welcome you to the city of Prague and wish you an enjoyable and rewarding stay.

The organising committee of Tropentag 2014

Bohdan Lojka	Jan Banout	Martina Opočenská
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Prague, September 2014

Message

The Czech University of Life Sciences Prague (CULS) is connected with life – society – environment. These three branches of knowledge have been the focus of CULS since decades. Our university offers study programs in agriculture, forestry and environmental sciences, nature protection, sustainable resources, food processing, special breeding, economics, informatics, management, and technology. In all these study programs the university's goal is to implement the principles of sustainable development of the human habitat, as well as protection of natural resources. Teaching goes hand in hand with research activities including Research for Development related to the most important issues in developing countries. Our Faculty of Tropical AgriSciences has a long tradition in research and education focusing on tropical agriculture and development.

The *Tropentag* is a highly renowned interdisciplinary conference on research in Tropical and Subtropical Agriculture and Natural Resource Management with a long tradition. Nowadays it has become one of the most important international conferences on development-oriented research in the fields of food security, natural resource management and rural development. That is why the *Tropentag* 2014 is an important and very meaningful event, which is highly appreciated by our university.

For the very first time in the history of *Tropentag*, the conference is held outside a German speaking country. On behalf of The Czech University of Life Sciences Prague, I would like to welcome all Tropentag participants at our university campus and I believe in the good success of Tropentag 2014. Our organising committee has worked hard to fulfil your expectations. I wish to all of you a very fruitful stay in our beautiful city of Prague.

Prof. Ing. Jiří Balík, CSc.
Rector of CULS

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Plenary speeches

Czech Republic's Contribution to Global Development Beyond 2015

ZUZANA HLAVIČKOVÁ

Ministry of Foreign Affairs, Development Cooperation and Humanitarian Aid Department, Czech Republic

As we are approaching 2015, when the current Millennium Development Goals (MDG´s) should be accomplished, there is a unique opportunity for the international community to set new development priorities best responding to current challenges. The new framework of international development for the post-2015 period should be based on the results achieved at the fulfilment of MDG´s and should put a sustainable development, sustainable growth and eradication of poverty at its core. The Czech Republic is committed to support this process, leading to evidence based, universal, concrete and realistic post-2015 development goals.

The Czech Republic wants to actively contribute to global efforts to identify a new paradigm for international development cooperation going beyond aid, as well as enhanced aid effectiveness. In this respect, it participates actively in formulation of the new "post-2015" development framework. Development cooperation is an integral part of the Czech Republic's foreign policy. The main strategic objective of the Czech development policy is to eradicate poverty and promote security and prosperity through effective partnership, enabling poor and undeveloped countries to realise their development goals.

The Czech Republic, in accordance with its international commitments, contributes to poverty and sustainable development promotion by specific programs and projects in five programme partner countries (Afghanistan, Bosnia and Herzegovina, Ethiopia, Moldova and Mongolia) and five project countries (Cambodia, Georgia, Kosovo, Palestine Autonomous Territories and Serbia). Dozens of scholarships to study at Czech universities are regularly offered to students in about 40 developing countries. Humanitarian aid to people in need affected by natural disasters or conflicts is provided in a number of countries. In the area of development cooperation the Czech Republic seeks to assert its comparative advantage, including the transition experience of rebuilding a democratic political system and the transition from centrally planned to market economy. We can, therefore, pass on our knowledge of political transition, reformation of the judiciary and public administration, privatisation, changes in the tax system and building market environment.

Further substantial progress in reducing global poverty can not be reached without the involvement of the private sector as the equivalent engine for further development. The Ministry of Foreign Affairs in cooperation with the Czech Development Agency aims to strengthen the motivation of Czech investors at this new role. Spe-

Contact Address: Zuzana Hlavičková, Ministry of Foreign Affairs, Development Cooperation and Humanitarian Aid Department, Prague, Czech Republic, e-mail:

cial attention is paid, therefore, to the promotion of innovative and value-integrated approach leading to long-term sustainable economic and social changes, including creation of new and better paid jobs on both sides.
As an evidence of the successful Czech efforts to increase effectiveness of its development cooperation system, the Czech Republic had been invited to become member of the Development Assistance Committee of the OECD (OECD-DAC). The accession process was completed in May 2013. Membership in the DAC represents for the Czech Republic a new impulse for further enhancement of effectiveness and lasting impact of its development interventions and for intensifying partnerships with the respective developing countries, international organisations and private sector.

Orientating and Keeping Scientific Research for Development on Track

RICHARD HALL

International Foundation for Science, Sweden

The International Foundation for Science (IFS) supports scientists in developing countries with research grants and through training workshops to enhance capacity in e.g. scientific communication, proposal writing, putting results into use, scientists and the value chain, and more.

IFS support is given for applied research on the sustainable utilisation of biological and water resources. But the question arises how does one ensure that such applied research leads to a likely practical outcome or implementation (an objective of 'Approach Three' of the IFS Strategy)? A sample of IFS grants suggested that grantees who were aware of the needs of potential end-users by e.g. consulting with stakeholders at the conceptualisation stage of their research projects, were the most successful later in reporting meaningful implementation of their results.

Clearly, in order to make the best possible use of donor resources for applied research, stakeholder consultation is essential. This may range from a simple process of researchers consulting with targeted beneficiaries of expected research outcomes, through to innovation platforms wherein stakeholders representing different groups of actors are assembled to discuss e.g. how to upgrade a value chain. Such platforms have recently been employed by IFS, and other partners, in sub-Saharan Africa within an EU-ACP project to upgrade value chains of under-utilised crops. These workshops were not only of value to producers and processors of under-utilised crops but also to the researchers who attended inasmuch as many highly relevant researchable questions were identified. However, innovation platforms come with a cost but, within a well targeted long-term research programme, the relative outlay would usually be low.

For the goal of fostering innovative research and putting results into use, preferably low-cost means of stakeholder consultation are needed at the project's conceptualisation stage and indeed on a continuing basis during the project. One such mechanism in an increasingly digital age would be to expand the use of virtual workspaces as wider communications platforms. This presentation considers the possible options for doing this and introduces also the idea of providing real-time comparisons of research plans with on-going project achievements.

Keywords: Innovative research, stakeholders

Contact Address: Richard Hall, International Foundation for Science, Karlavägen 108 , SE-115 26 Stockholm, Sweden, e-mail: richard.hall@ifs.se

Food and Nutrition Security and Differing Capacities

JUDITH FRANCIS

CTA, Science & Technology Policy, The Netherlands

Food and nutrition security (FNS) is a complex, multi-dimensional, multi-sectoral issue, with links to health, economic development, environmental sustainability, and trade. The food and economic crisis of 2007/2008, a world population that is expected to reach 9 billion or more by 2050, climate change, diminishing natural resources — land, biodiversity and water have put FNS and improving nutrition outcomes on the global policy agenda requiring international science and technology cooperation and social and technological innovation among other interventions. Yet, FNS is the responsibility of nation states, requiring policy responses and actions by governments, the research and academic community and the private sector. FNS is also on the radar of major economic blocs and global private sector corporations. Herein lies the tensions in the quest for producing and accessing 'new' knowledge for addressing the global FNS challenge with its related national dimensions while operating within a complex global system involving multiple actors with differing interests and resources. What are the implications for research partnerships; North-South, South-South, public-private? Who determines the research priorities and how? What criteria will be used for dispensing funding — scientific merit vs social relevance or both? Whose interest will be served — public or private? Who will own the knowledge generated — knowledge as a public good and what will be the role of traditional knowledge? Using cases from across Africa, Caribbean and the Pacific (ACP) and lessons from ACP-EU research cooperation and international trends; this presentation will explore these related issues and posit that progress can only be made in addressing global challenges which have national dimensions through investments in science, technology and innovation, if we acknolwedge the limitations in capacities and resources and are willing to address them at national and global levels.

Keywords: Economic development, food security

Contact Address: Judith Francis, CTA, Science & Technology Policy, Wageningen, The Netherlands, e-mail: francis@cta.int

Can an Integrated Livestock Wildlife Production System Bridge the Gap Between Increasing Knowledge and Decreasing Resources?

LOUWRENS C. HOFFMAN
Stellenbosch University, Dept. of Animal Sciences, South Africa

By now it is accepted within the scientific community, by regulators and to a lesser extent, by commercial producers that the agricultural sector needs to dramatically change their way of doing things to meet the challenge of feeding an exponentially fast growing population. Although a large sector of the role players are propagating more intensive/factory farming-like systems as the answer to the challenge, the reality is that large sections of the surface area of the earth does not have the natural resources to allow this type of production system. In fact, most of these areas are only suitable for extensive animal production systems.

This paper explores the suitability of indigenous wildlife species towards meeting the challenge of increasing protein production, either in isolation or combined with traditional livestock production. It further explores our knowledge, or lack thereof, as pertaining to such production systems. This paper explores the farming of cervids in intensive systems as well as the production of various ungulates in the more extensive pastoral systems utilised in Africa.

Two of the major obstacles to the development of meat production from wildlife are access to land (land tenure) and ownership of the wildlife occurring on the land. As example, in Africa it is only the countries (Namibia, South Africa) where the land owner has ownership of the fauna occurring there that we have seen an increase in wildlife numbers resulting in the sustainable usage thereof.

Another understudied area that warrants further research and garnering of knowledge is the use of mini-livestock species in the production of food. Here focus is placed in the production of species such as nutria, cavy and other rodents. Within war-torn central Africa this is frequently the only meat protein source available.

Keywords: Land tenure, livestock, Namibia, South Africa, wildlife protection

Contact Address: Louwrens C. Hoffman, Stellenbosch University, Dept. of Animal Sciences, Matieland, South Africa, e-mail: lch@sun.ac.za

From Lab to Field: The Role of Development Cooperation in Bridging the Gap Between Increasing Knowledge and Decreasing Resources

CHRISTEL WELLER-MOLONGUA

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Rural Development and Agriculture, Germany

The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) has long-standing experiences in bringing knowledge and practice together for the improvement of agricultural production systems in developing and transition countries. For more than 15 years, GIZ supports international agricultural research of the CGIAR global research partnership as well as The World Vegetable Center (AVRDC) and the International Centre of Insect Physiology and Ecology (icipe). Innovations produced by international agricultural research include, amongst others, improved varieties, management techniques, and diagnostic tools. They are not only integrated in farming systems by national research and extension systems, but also promoted and scaled up through international development cooperation. In Vietnam, for instance, GIZ and the International Rice Research Institute (IRRI) have been closely working together to develop and promote salt-tolerant rice varieties and alternative management practices which so far reached thousands of farmers and increased their income substantially. Moreover, GIZ is running a programme on Innovation Transforming Agriculture-Adaptation to Climate Change (ITAACC), which aims at matching supply for innovations based on international agricultural research and demand from farmers for agricultural innovations in Africa. Besides this, GIZ also develops innovations together with partners in bilateral or regional projects as well as in sectorial projects and integrates them in farmer's productions systems in close cooperation with farmers and partner organisations. For example, in several countries in sub-Sahara Africa, GIZ promoted the development and refinement of water-spreading weirs that offer improved water management technics to entire river basins and increased yields by 25 to 90 percent. GIZ is also strongly committed to strengthen the role of gender in agricultural development and maximise its potentials: yield increases up to 30 percent are possible, should women receive the same support, inputs and trainings as men do. In order to sustain the momentum of bringing knowledge and innovations into use in agriculture on a large scale, the German Federal Ministry for Economic Cooperation and Development launched major new initiatives. In cooperation with GIZ, it will establish agricultural innovation centres in Africa, which will link research, value chain management and training, and setup a global programme for soil fertility management.

Keywords: Development cooperation, international cooperation

Contact Address: Christel Weller-Molongua, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Rural Development and Agriculture, Dag-Hammarskjöld-Weg 1 - 5, 65760 Eschborn, Germany, e-mail: schmidt_heh@web.de

Sustainable Research Options for Food, Nutrition and Economic Security: Health, Wealth and Environmental Benefits of Livestock

JAMES SMITH

International Livestock Research Institute (ILRI), Directorate, Kenya

Feeding the world, eradicating absolute poverty and keeping both people and the planet healthy dominate the global development agenda as the challenges presented by a population of almost 10 billion people by mid-century loom ever closer. While the large roles of agriculture and agricultural science in addressing such global challenges are increasingly recognised, the specific roles of animal agriculture and related sciences are commonly under-appreciated or neglected entirely. This despite all the evidence showing that the biggest opportunities regarding not just adequate food production but also mitigating hunger, ensuring balanced nutrition, ending poverty, balancing equity, averting public health threats and sustaining our environmental resources all relate intimately to the livestock sector. This presentation will make the case that the growth and transformation of smallholder livestock systems in developing countries is one of the biggest opportunities for creating a more nourished, healthy, environmentally sound/balanced and equitable world. The presentation will set out the global livestock research issues impinging on major development challenges facing the world. It will further explore the new opportunities for translating livestock research knowledge into practical development solutions to ensure that science-based solutions result in outcomes and impacts at significant scale.

Keywords: Smallholder livestock systems

Contact Address: James Smith, International Livestock Research Institute (ILRI), Directorate, P O Box 30709 00100, Nairobi, Kenya, e-mail: j.smith@cgiar.org

Can Well Managed Consumptive and Non-consumptive Use of Wildlife Help in Protecting Endangered Species While Contributing to Local Economic Development?

MIROSLAV ZÁMECNÍK
Boston Venture Central Europe, Czech Republic

1. Case of Markhor (Capra falconeri) in Pakistan and Tajikistan (key words: sharing of permit hunts' proceeds to locals where hunting takes place; increase in income; population stats)
2. Case of Indian One Horned Rhinos (Rhinoceros unicornis) in Chitwan N.P. in Nepal as an example of non-consumptive use of key species benefiting local communities (key words: sharing of gross park entrance revenues- 50 % to communities; increase in alternative income through tourism and participation; limited but legal use of resources inside protected areas; cooperation between govt. agencies and local communities)
3. Case of Namibia's Community Wildlife Management (key words: ownership of wildlife/communal management in a low corruption environment, increase in income via multiple uses, alternatives to cattle/sheep/goat ranching in arid areas)
4. Kenya-the case of Ishaqbini communal reserve (key words: non-consumptive use of single species-hirola)
5. "Communal rhinos in South Africa" (key words: transfer of rhinos to local community reserves as a response to poaching crisis, stakeholder issues- how to spread the benefits so that they could possibly overweight poachers' incentives)
6. "Pride , money and protection"- the case of Delacour's Langur (Trachypithecus delacouri) in Van Long Reserve, Viet Nam (key words: non-consumptive use and tourism development, pride in unique species, proceeds sharing, community involvement, factor of pride)
7. General discussion: Can we ever achieve success in endangered species protection without sharing the benefits with those who do actually share the same environment and obtain livelihood from it? No way. So- the community involvement is the key: they have to own it and share it: not only the costs but significant part of the benefits, too. Then, probably, we can hope that we will be able to mitigate to some extent, what will happen anyway.

Keywords: Wild life management

Contact Address: Miroslav Zámecník, Boston Venture Central Europe, Prague, Czech Republic, e-mail: miroslav.zamecnik@bostonventure-ce.com

Plants and soils

Crop management

'Traditional' Agriculture Versus Biotechnology: Challenges for Research and (development) Practice

PATRICK VAN DAMME

University of Ghent, Dept. of Plant Production - Lab. for Tropical Agronomy, Belgium

The human population continues to increase against a background of dwindling natural resources and changing climates. The biotechnology lobby tries to convince the world the only solution is to develop tailor-made GMOs that w/should guarantee high output and quality with less input use. Nutrition science has brought biofortification and brings health solutions in a pill. It is the contention of this presentation that traditional approaches that build on experience gained through years of practice, sound scientific reasoning and principles, and integrate natural resource use eventually offer more sustainable production solutions that are user- and consumer-friendly. Agro-ecology and agro-sylvo-pastoral systems are cited and highlighted as examples of good practices that would need to be further developed and implemented to continue to guarantee food security, esp. in the developing world.

Keywords: Biotechnology, food security, traditional agriculture

Contact Address: Patrick van Damme, University of Ghent, Dept. of Plant Production - Lab. for Tropical Agronomy, Coupure links 653, 9000 Ghent, Belgium, e-mail: patrick.vandamme@ugent.be

Doubled-Up Legumes in Malawi: An Innovation for Sustainable Rain-Fed Cereal Production in Developing Countries

SIEGLINDE SNAPP[1], REGIS CHIKOWO[1], WEZI MHANGO[2], VICKI MORRONE[3], MATEETE BEKUNDA[4], IRMGARD HOESCHLE-ZELEDON[5]

[1]*Michigan State University, Plant Soil and Microbial Sciences, United States of America*

[2]*Lilongwe University of Agriculture and Natural Resources, Crop Science, Malawi*

[3]*Michigan State University, Commuity Sustainability, United States of America*

[4]*International Insitute of Tropical Agriculture, Tanzania*

[5]*GFU (Global Facilitation Unit for Underutilized Species), Italy*

The basis for calorie production and income generation on many smallholder farms is monoculture cereals. Legume crops occupy only about 10 to 15 % of the land on rain-fed smallholder farms in Malawi, which is typical of mixed-maize systems across Africa. Overall, the widespread cultivation of cereal crops is understandable in that farmers prioritise production of large amounts of calories, and crops with minimal labour inputs; however, this has led to cropping systems that are dependent on nutrient inputs. Fertiliser subsidies in Malawi and neighbouring countries have to some extent addressed this need, but this is an expensive strategy. Over 10 % of Malawi gross domestic product has supported this – hampering alternative investments. A sustainable intensification strategy in African agriculture is urgently needed, and we will present evidence on a promising innovation: 'doubled-up legumes'. This system promotes growing improved types of N_2-fixing shrubby food legume pigeonpea (*Cajanus cajan*) which is being evaluated in new regions of Malawi, in combination with an understory crop of soybean, groundnut or cowpea. Doubled up legumes addresses the urgent need for protein and high caloric food in combination with soil organic matter replenishment through leaf litter and root biomass. The performance of this system on-farm is being tested at field-scale in central Malawi through participatory action research supported by a USAID project 'Africa RISING'. This research involves collaboration of IITA, Michigan State University, Lilongwe University of Agriculture and Natural Resources, Malawi Department of Agricultural Extension and about 1000 small-holder farmers. Farmers and researchers are co-experimenting with doubled-up legumes and related innovations, intensifying planting of improved varieties and integrated nutrient management. On-farm results show evidence for substantial gains in both grain legume productivity (0.6 to 2.4 t ha^{-1}) and fertiliser-use efficiency (30 to 100 % increase in maize response over monoculture maize). We will report on agronomic and farmer assessments of performance over two years from this large-scale sustainable intensification project.

Keywords: Multipurpose legumes, nutrient efficiency, smallholder cropping

Contact Address: Sieglinde Snapp, Michigan State University, Plant Soil and Microbial Sciences, 1066 Bogue St., 48824 East Lansing, United States of America, e-mail: snapp@msu.edu

Root Yield Response of 12 Cassava Varieties to Leaf Harvest in DR Congo

STEFAN HAUSER[1], TONY BAKELANA[2], DENIS BUNGU[3], MBUTA KUHUMA MWANGU[2]

[1]*International Institute of Tropical Agriculture (IITA), The Dem. Rep. of the Congo*

[2]*INERA DR Congo, National Cassava Program, The Dem. Rep. of the Congo*

[3]*University of Kinshasa, Crop Science, The Dem. Rep. of the Congo*

Cassava leaves are a major source of protein for a large portion of poor people in DR Congo. No recent information exists on the root yield response of newly released cassava mosaic disease (CMD) resistant varieties, nor exist leaf production data. Eleven CMD resistant and one susceptible variety were planted in 6 locations, leaves were harvested 3 times (4, 8 and 11 months after planting (MAP)) before final root harvest (12 MAP). Edible leaf dry matter (DM) yields were affected by location and variety with a significant location × variety interaction. Root DM yields were significantly affected by location, variety and leaf harvest with significant location × variety interaction. Across varieties and locations, leaf harvest caused 15 % root DM yield reduction. All locations except Mvuazi2 and Mampu1 produced significantly different root yields (in Mg ha^{-1} DM) in the order Kisangani: 9.25 (province Oriental, coarse sand soil), Kiyaka: 6.78 (Province Bandundu, coarse sand soil), Mvuazi1: 4.42 (Province Bas Congo, heavy clay soil), Mvuazi2: 3.40 (Province Bas Congo, degraded clay soil), Mampu1: 3.30 (Province Kinshasa, coarse poor sand soil) and Mampu2: 2.54 (Province Kinshasa, coarse poor sand soil) out-yielded all others. Across locations and leaf harvest variety TME419 produced highest root DM yields (7.55 Mg ha^{-1}). The susceptible variety produced the lowest edible leaf (209 kg ha^{-1}) and root (2.53 Mg ha^{-1}) DM yields in all locations. Root yield reductions due to leaf harvest ranged from 0–10 % in varieties producing the lowest root yields and were insignificant. Higher yielding varieties suffered root yield reductions of 13–26 %, equivalent to 1–1.6 Mg ha^{-1} DM. Root yield reductions across varieties were significant in all locations except Kiyaka. Significant reductions in all other locations ranged from 12–31 % being equivalent to 0.8–1.2 Mg ha^{-1} DM. There was no significant correlation between edible leaf yield and root yield. Results indicate that maximising root and leaf yields requires location specific selection of varieties. Variety TME419 produced the highest average yield and highest yields in 3 of 6 locations. The best three leaf producing varieties were not among the best root producers indicating an incompatibility of the two production objectives.

Keywords: Cassava, DR Congo, leaf yield, root yield

Contact Address: Stefan Hauser, International Institute of Tropical Agriculture (IITA), Avenue Haut Congo, Quartier Revolution, Commune de Gombe, Kinshasa, The Dem. Rep. of the Congo, e-mail: s.hauser@cgiar.org

Overcoming Seed Germination Problems of Traditional Vegetables after Cold Storage

ANDREAS WILHELM EBERT, TIEN-HOR WU

AVRDC - The World Vegetable Center, Genetic Resources and Seed Unit, Taiwan

The experiments described here address the constraints of hard-seededness of fresh and stored seed of okra (*Abelmoschus esculentus* (L.) Moench) and water spinach (*Ipomoea aquatica* Forssk.). Freshly harvested fruits of two water spinach and two okra accessions were dried for two weeks in a screenhouse prior to manual seed extraction and cleaning. Cleaned seed was dried to 6 % seed moisture content in a dehumidified drying room for 8 days at 18°C and 15 % RH. The two accessions of both crops showed a marked difference in initial germination rate prior to storage. The water spinach accession from Thailand (VI050476) had a very low initial germination rate of 4 % compared to 77 % for the accession from Taiwan (VI054533). Okra seeds of an accession from Thailand (VI046536) had an initial germination rate of 26 % compared with 90 % for the accession from Zambia (VI050598). Seed priming was conducted after 6 months of storage at 5°C and -15°C. The germination rate of water spinach seed from Thailand (VI050476) remained very low at 4 % and 1 % after 6 months of storage at 5°C and -15°C, respectively (T1; control). Partial removal of the seed coat followed by 24 h soaking in water (T3) elevated the germination rate substantially to 82 % and 85 % after 6 months of storage at 5°C and -15°C, respectively. The germination rate of seed from Taiwan (VI054533) increased from 77 % prior to storage to 92 % and 93 % after 6 months of storage at 5°C and -15°C, respectively. Seed priming of the latter did not have any additional beneficial effect on the germination rate. Storage temperature of okra seed had a major impact on the germination rate. While the germination rate of seed stored for a 6-month period at 5°C was low for the accessions from Thailand (18 %) and Zambia (20 %), the germination rate reached 99 % and 96 %, respectively, when seed was stored at -15°C. Seed priming was highly beneficial for seed stored at 5°C (T3), but was not required when seed was stored under sub-zero temperatures.

Keywords: Cold storage, germination rate, hard-seededness, okra, seed priming, water spinach

Contact Address: Andreas Wilhelm Ebert, AVRDC - The World Vegetable Center, Genetic Resources and Seed Unit, P.O. Box 42, Shanhua, 74199 Tainan, Taiwan, e-mail: andreas.ebert@worldveg.org

Cocoa Yield in Bolivian On-Farm Trials 2010–2013: Monitoring Outstanding Farmers and Comparing Clones and Sites

CHRISTIAN ANDRES[1], EUCEBIO PEREZ[2], FREDDY ALCON[3], ROMERO CHOQUE[4], GERMÁN TRUJILLO[3], JOACHIM MILZ[3], MONIKA SCHNEIDER[1]

[1]*Research Institute of Organic Agriculture (FiBL), Dept. of International Cooperation, Switzerland*

[2]*PIAF - El Ceibo Foundation, Bolivia*

[3]*ECOTOP, Consulting on Successional Agroforestry, Bolivia*

[4]*Catholic University Carmen Pampa, Bolivia*

Cocoa (*Theobroma cacao* L.) trees have a lifespan of up to 100 years in their natural environment, the lower strata of tropical alluvial forests. Sustainability of global cocoa production is at stake due to the deterioration of soil fertility, high losses due to pests and diseases (P&D) and old tree stock. Producing cocoa in shaded, low-input agroforestry systems offers a potential solution for achieving long-term productivity and sustainability. However, shade-tolerant cocoa clones are needed which are productive and resistant to P&D, as well as meeting the quality standards requested by the industry. In Bolivia, the cocoa mirid (*Monalonion dissimulatum*) and the novel disease frosty pod rot ("Monilia" *Moniliophthora roreri*) are among the most devastating P&D. The Research Institute of Organic Agriculture (FiBL) and its local partners have been conducting cocoa production systems research in the Alto Beni region of Bolivia since 2008. A participatory rural appraisal revealed that indeed, how to reduce incidences of the cocoa mirid and frosty pod rot was the top priority of cocoa farmers. Furthermore, a need for evaluating the productivity of different cocoa clones and for the documentation of best practices was expressed. In order to address these points, several research activities were carried out:

1. 16 cocoa clones have been evaluated for productivity and susceptibility to P&D for four consecutive years (2010—13) in on-farm trials at multiple locations.
2. The yield development and prevalence of P&D in the fields of four outstanding farmers was assessed for two years (2012–13)

Data analysis revealed that some locally selected clones (elite tree selection program) were not only among the most productive, but also showed earliest maturation and some degree of resistance to Monilia (i.e. with lower incidences of the disease). Thus these clones hold the potential to escape attacks by P&D which occur later on in the season and may serve as a basis for further germplasm development towards clones with resistance to Monilia. However, before disseminating information to farmers and farmers' organisations, sound scientific data from at least five years is required.

Keywords: Cocoa, diseases, pests, production system, yield development

Contact Address: Christian Andres, Research Institute of Organic Agriculture (FiBL), Dept. of International Cooperation, Ackerstrasse 113, CH-5070 Frick, Switzerland, e-mail: christian.andres@fibl.org

Productivity of Maize and Baby Corn in Organic and Conventional Farming System

NOAH ADAMTEY[1], JUAN GUILLERMO COBO[1], MARTHA MUSYOKA[2], EDWARD KARANJA[2], KOMI K. M. FIABOE[2], ANNE MURIUKI[3], MONICAH MUCHERU-MUNA[4], ESTELLE BERSET[1], ANDREAS FLIESSBACH[1], DIONYS FORSTER[1]

[1]*Research Institute of Organic Agriculture (FiBL), Switzerland*

[2]*International Centre for Insect Physiology and Ecology (ICIPE), Kenya*

[3]*Kenya Agricultural Research Institute, National Horticultural Research Center, Kenya*

[4]*Kenyatta University, Environmental Sciences, Kenya*

Productivity (output per unit of land or labor) growth in Africa is far behind that in other regions of the world and is well below the growth required to meet food security and poverty reduction goals set forth in national and regional plans. To increase food security, reduce hunger and poverty, soil fertility improvement is urgently needed in sub-Saharan Africa. Farming systems have been developed using conventional (fertilisers, improved seeds, pesticides) and organic (system optimisation, organic fertilisers, nutrient recycling) approaches. Conventional farming systems aim at high productivity but also at high financial and environmental costs. Organic farming systems aim at improving the stability and resilience of the whole agro-ecosystem, maximising nutrient and energy use efficiency and using natural renewable inputs, but have generally been perceived not to be able to support and sustain high productivity and production levels. To create a scientific basis for discussions the Research Institute of Organic Agriculture (FiBL) established long-term farming systems comparison trials in Kenya, India and Bolivia. In two agro-ecological zones in Kenya (Chuka and Thika), FiBL and its partners are comparing two farming systems (organic and conventional) at low and high level of management intensity (low fertilisation without irrigation/high fertilisation with irrigation) since 2007. The three-year crop rotation is consisting of maize-beans-vegetable-Irish potato. The productivity of maize and baby corn in the organic and conventional farming systems will be presented. The maize yields in 2007 and 2010 for the conventional high input system (Conv-High) were similar to those of the organic high input systems (Org-High) at both Chuka and Thika, except in the first year (2007), when Conv-High yields were 4 times higher ($P < 0.05$) than the ones from Org-High in Thika. In the low input systems, Conv-Low and Org-Low showed similar yields in 2007 and 2010 at Chuka, whilst at Thika, maize yields for Conv-Low was 3.5 times ($P = 0.010$) higher than the yields of Org. Low in 2007 and 2010. Baby corn yields over 4 years were similar for both Conv. High and Org. High at both sites.

Keywords: Conventional farming, crop rotation, farming systems, organic farming, productivity

Contact Address: Noah Adamtey, Research Institute of Organic Agriculture (FiBL), Dept. of International Cooperation, Ackerstrasse 21, 5070 Frick, Switzerland, e-mail: noah.adamtey@fibl.org

Oyster Mushroom (*Pleurotus ostreotus*) Yield in Different Substrates Prepared by Cowpea Pod Shell Waste

AYSUN PEKSEN, GULSUN DADAYLI, ZEHRA SATILMIS, SAVAS CATAL

Ondokuz Mayis University, Horticulture Department, Turkey

Recently, mushroom cultivation gains more attention as a possibility to use agricultural wastes, and to help alleviate poverty and food insecurity in Turkey. Rising demand for oyster mushroom (*Pleurotus ostreatus*) leads to an increasing interest among small-scale farmers in rural areas and also consumers. This is due to its flavor, aroma and high nutritional value and easy grow process with low inputs, minimum requirements for growing conditions and also equipments. Also, some agricultural and industrial wastes can be used for oyster mushroom production.

This experiment was conducted to determine the possible use of cowpea dry pod shells remaining as a waste after threshing in the oyster mushroom cultivation. In the experiment, ten different substrates prepared from poplar sawdust (S), cowpea pod shell (CP) and rice bran (RB) mixtures were tested. Substrate mixtures were 100S, 90S+10RB, 75S+25CP, 50S+50CP, 25S+75CP, 65S+25CP+10RB, 40S+50CP+10RB, 15S+75CP+10RB and 90CP+10RB, 100CP. HK35 strain of oyster mushroom was used in the study. Moisture, pH, ash, nitrogen (N), carbon (C) content and C:N ratio of the substrates were determined after sterilisation.

Mycelia did not grow on the substrate prepared by S alone. The highest mushroom yields were obtained from 90CP+10RB, 100CP, 15S+75CP+10RB, 25S+75CP and 65S+25CP+10RB (264.80, 257.60, 219.20, 217.6 and 206.00 g per kg substrate, respectively). It was concluded that cowpea dry pod shells can be used in the cultivation of oyster mushrooms. The use of agricultural wastes such as cowpea pod shells will ameliorate the product: efficiency for small scale farmers.

Keywords: Cowpea pod shell, oyster mushroom, *Pleurotus ostreatus*, substrate

Contact Address: Aysun Peksen, Ondokuz Mayis University, Horticulture Department, Atakum, 55139 Samsun, Turkey, e-mail: aysunp@omu.edu.tr

Chenopodium quinoa as a New Non-Traditional Crop in Egypt

SAYED EISA[1], AHMED ABDEL-ATI[2], MOHAMED EBRAHIM[1], MOHAMED EID[3], EMAD EL-DIN ABD EL-SAMAD[4], SAYED HUSSIN[1], NASR EL-BORDENY[5], SAFWAT ALI[6], ABD-EL-RAHMAN EL-NAGGAR[1]

[1]*Ain Shams University (ASU), Dept. of Agricultural Botany, Egypt*

[2]*Desert Research Center, Plant Production Dept., Ecology & Dry Land Agriculture Division, Egypt*

[3]*Ain Shams University, Dept. of Soil Science, Egypt*

[4]*National Research Center, Vegetable Crop Research Dept., Agricultural & Biological Research Division, Egypt*

[5]*Ain Shams University (ASU), Dept. of Animal Production, Egypt*

[6]*Ain Shams University (ASU), Dept. of Agricultural Biochemistry, Egypt*

Dry land salinity increasingly affect large tracts of agriculture land in Egypt. Efforts are hence needed to find alternate solutions to allow farmers to make productive use of saline land. One option is the use of high potentiality halophytes for crop production. *Chenopodium quinoa* Willd is one of the promising halophyte cash crops for cultivation on saline soils. The aim of this study was to compare the potential seed yield and quality of quinoa grown under high saline soil conditions (ECe=27 ds.m^{-1}) with neutral-soil conditions (ECe=1.9 ds.m^{-1}). Seed yield and weight of 1000 seeds significantly decreased under saline-soil to record 40 % and 20 % reduction compared with neutral-soil conditions, respectively. Beside quantity, the composition of reserves also changed under saline conditions. The concentration of the total carbohydrates decreased significantly whereas, concentration of protein, Fe, Na and ash increased significantly in seeds. No significant differences were found for oil, fiber, P and K contents under saline conditions. However, the higher accumulation of ash in seeds under saline condition was not obtained solely by an increase of Na concentration; it was achieved also by increasing K and Fe concentrations. The Energy Dispersive X-ray microanalysis clearly indicated that the passage of Na to seed interior was hindered by seed pericarp leading to low accumulation of Na in seed interior reserving tissue. Quinoa as a new cultivated halophyte cash crop has a potential as grain crop under saline conditions due to its high nutritional quality of seeds.

Keywords: *Chenopodium quinoa*, halophyte cash crop, nutritional value, saline soil, yield

Contact Address: Sayed Eisa, Ain Shams University (ASU), Dept. of Agricultural Botany, 68 Hadyke Shubra, 12244 Cairo, Egypt, e-mail: sayed_eisa@hotmail.com

Studying Quinoa *Chenopodium quinoa* Willd Adaptability from Tropical to Temperate Conditions

LEITER GRANDA[1], ELENA DUSKOVA[2], GUILLERMO CORREDOR[3], DEISY ROSERO[4], AMPARO ROSERO[4], RADIM CERKAL[1]

[1]*Mendel University in Brno, Dept. of Crop Science, Breeding and Plant Medicine, Czech Republic*

[2]*Crop Research Institute, Genetic Resources of Vegetables and Special Plants, Czech Republic*

[3]*Agriculture University Foundation of Colombia-UniAgraria, Dept. of Animal Production, Colombia*

[4]*Indigenous Organization for Research ORII-Tierra y Vida, Crop Production Program, Colombia*

The low diversity in cultivated crop species has been considered a potential treat to food security. The homogeneity of the used crops in the human diet affects human health by increasing high-energy and low-nutrients diets ignoring an adequate nutritional diversity and also producing genetic erosion in crops. Quinoa (*Chenopodium quinoa* Willd) is an important andean crop that can increase the food and nutritional security due to its healthly composition and gluten absence. This alternative crop has an exceptional adaptability that could mitigate the effects of the climate change in several countries around the world. The aim of this study was to evaluate the adaptability and production of nine quinoa varieties under tropical and temperate conditions. Multi-environment trial involving were diverse sets of 9 varieties tested in 4 places under tropical (Colombia) and temperate (Czech Republic) environmental conditions using a randomised complete block design with four replicates. Yield parameters and phenological phases were evaluated. In the first phenological stage, the varieties Pasankalla, Blanca de Hualhuas, Blanca Sajama, Tunkahua, Amarilla de Marangani showed the best adaptation to both tropical and temperate conditions, while Blanca Dulce, Dark Commercial and Rosada de Huancayo had low germination rate and weak seedlings under conditions of Czech Republic. The selected varieties showed a great range of pericarp colours, flavour and grain size. Our first observations, confirm that some quinoa varieties have good adaptability to temperate conditions and the final effect on yield components will be determined.

Keywords: Adaptability, *Chenopodium quinoa*, food security, quinoa, variety

Contact Address: Leiter Granda, Mendel University in Brno, Dept. of Crop Science, Breeding and Plant Medicine, Zemedelská 1/1665, 613 00 Brno, Czech Republic, e-mail: leiter.granda@gmail.com

Improving Seed Potato Quality in Southwestern Uganda for Strengthening Food and Cash Security

UTA PRIEGNITZ[1], WILLEMIEN LOMMEN[1], RENÉ VAN DER VLUGT[2], STEPHEN ONAKUSE[3], PAUL STRUIK[1]

[1]*Wageningen University and Research Centre, Centre for Crop System Analysis (CSA), The Netherlands*

[2]*Wageningen University and Research Centre, Plant Research International, The Netherlands*

[3]*University College Cork, Food Business and Development, Ireland*

Uganda is highly vulnerable to poverty, and further investment in agriculture is crucial for sustainable, long-term food security, and rural development. Potato (*Solanum tuberosum*) is an important crop for poverty reduction in the rural environment of southwestern Uganda because it is both a source of food and a source of income. The national mean potato yield is about 7 t ha^{-1}, which is low compared to a potential yield of 25 t ha^{-1}. The major yield constraining factor is the overall poor seed potato quality. The majority of smallholder farmers use seed from the informal sector, in which seed-borne virus diseases accumulate over time. Lack of disease-free seed tubers and of commercially traded high quality seed tubers are main impediments for small-scale farmers. This research aims at improving agricultural productivity in southwestern Uganda by evaluating and understanding improved seed potato production technologies and their opportunities at local scale. The project will focus on testing and adoption of the method positive seed selection to maintain and improve seed quality. Positive selection, pegging healthy looking plants during flowering to potentially serve as seed for the next season, is a tool to create alternative seed multiplication and develop knowledge on how to sustainably improve the quality of seed potatoes and therefore food and cash security for small-scale farmers in southwestern Uganda. Positive selection can lead to yield increases after one season and is easily adoptable by seed producers, but is not tested across multiple seasons; moreover, the mechanisms behind it and virus incidence are not fully understood. On-farm field trials over several generations will provide a proof of concept and further insight in why positive selection causes regeneration of the seed potato stock. A sociological study among small-scale farmers will provide more insight into farmers' livelihoods and opportunities and bottlenecks of different seed technologies, and will investigate adoption of seed technologies and perspectives of the availability of high-quality potato seed tubers in southwestern Uganda. An economic analysis will assess and evaluate costs and benefits of the different technologies to develop recommendations with respect to affordability and feasibility for smallholder farmers.

Keywords: Positive selection, potato, seed potato systems, Uganda, viruses

Contact Address: Uta Priegnitz, Wageningen University and Research Centre, Centre for Crop System Analysis (CSA), Droevendaalsesteeg 1, 6708 PB Wageningen, The Netherlands, e-mail: uta.priegnitz@wur.nl

Dramatic Loss of Potato Yields – The Failure of Crop and Storage Management in Ugandan Smallholder Farms

ELIZABETH METTO[1], BERNHARD FREYER[2], KIBET NGETICH[3], ARTHUR WASUKIRA [4], SUSAN KAMURU[1], CATHERINE MUNYUA[1]

[1]*Egerton University, Applied Community Development, Kenya*
[2]*University of Natural Resources and Life Sciences (BOKU), Division of Organic Farming, Austria*
[3]*Egerton University, Sociology and Anthropology, Kenya*
[4]*National Agricultural Research Organization, Uganda*

On the slopes of Mt. Elgon in eastern Uganda, potato is one of the leading crops grown by small scale farmers for food and income. However, their yields are low (7 tons ha^{-1}) compared to that of Kalengere and Buginyanya research stations (25 tons ha^{-1}). A qualitative study was carried out to assess the influence of the farmer's crop and storage management on potato production in the region. Cluster and purposive sampling techniques were used to select 40 farmers and five key informants who included four National Agricultural Advisory (NAADS) service providers and one official of Appropriate Technology Uganda (AT) (an NGO whose mission is to empower rural households in Uganda). In addition, four focus group discussions made up of between eight and twelve small scale farmers were held. The most important finding was that the low potato production among small scale potato farmers was a result of the use of low quality, recycled seed potato made up of small tubers that remained after the selection of ware potatoes, short rotations with a high share of potatoes resulting in accumulation of disease pathogens in the soil, limited use of both organic and inorganic fertiliser, and the effects of pests and diseases, the most important being late blight and bacterial wilt which destroy much of the potato before and after harvest. Additionally, low soil pH are seen as an important cause of the low yields. Interventions by government and non-governmental organisations and other stakeholders to minimise or eradicate these factors will bring into realisation the inherent potentials of potato farming among the farmers within the region.

Keywords: Crop management, low yield, potato, smallholder, storage management

Contact Address: Elizabeth Metto, Egerton University, Applied Community Development, University of Eastern Africa Baraton P. O. Box 2500-30100 Eldoret, Nairobi, Kenya, e-mail: jepkorireliza@gmail.com

Performance of Sugarbeet Sown in Sudan under Comparatively High Temperatures (May-July)

SALAHELDIN ABDELGADIR MUKHTAR ELTAHIR[1], AHMED OBEID[1], HAYDER ABDELGADER[2]

[1]*Sugarcane Research Center-Guneid, Sudan*

[2]*Agricultural Research Corporation, Crop Protection Research Center, Sudan*

This study was carried out in seasons 2012 and 2013 in the Sugarcane Research Center-Guneid, Sudanese Sugar Company, Sudan following attempts of mixing sugarbeet with sugarcane in cane mills. The overall idea was to synchronise the maturity of beet crop (5 to 6 months of age) with the beginning of cane crushing season (factory start-up at November) where sugarcane quality was usually low. However ambient temperature in these months was relatively high (max temp.: 40–45 and min temp.: 20–25°c). In the first season sugarbeet cultivar (Posada) was sown on three sowing dates: May 21, June 6 and 21 and in the second season it was sown on May 15, 30, June 15, 30 and July 15. Harvest was programmed at three crop ages: 5, 5.5 an 6 months. In the first season some deaths of seedlings occurred and in the second season there was complete failure of germination for May 15 and 30 sowing dates. Otherwise, no significant differences between treatments were shown; however, tuber yield was relatively low in the two seasons recording 23 to 40 t ha^{-1} compared to the sown sugarbeet in winter months (October-December) that usually yielding 60 to 80 t ha^{-1} tuber. Beet plants were still green and growing at harvest where high leaf weight (fodder) was recorded. Sugarbeet quality was relatively high. Brix, pol and estimated recoverable sugar (ERS) % recorded 17.95, 15.74 and 13.24 in average respectively. The study emphasises the need for more research in the subject including selection of proper sugarbeet cultivars. Crop management operations such as pre watering before sowing and water stoppage (dry-off) at harvest should be thoroughly investigated.

Keywords: Brix, cultivars, ERS, pol, pulp, sowing dates, sugarbeet cultivars, tuber yield

Contact Address: Salaheldin Abdelgadir Mukhtar Eltahir, Sugarcane Research Center-Guneid, Agronomy and Soil Science, Alguneid, Sudan, e-mail: salahamukhtar@hotmail.com

Evaluate the Potential Yields of *Sesuvium portulacastrum* (L.) Cultivated in Coastal Salt Marshes of Egypt

SAYED EISA[1], SAFWAT ALI[2], SAYED HUSSIN[1], NASR EL-BORDENY[3]

[1]*Ain Shams University (ASU), Dept. of Agricultural Botany, Egypt*

[2]*Ain Shams University (ASU), Dept. of Agricultural Biochemistry, Egypt*

[3]*Ain Shams University (ASU), Dept. of Animal Production, Egypt*

Of all natural resources freshwater is worldwide the major concern for prospective development. Fresh water resources both for domestic and agriculture use are constantly depleting and crop yield suffer from a steady increase in water salinity, particularly in arid and semi-arid regions. A burgeoning population in most developing countries is a further threat not only to sustained food supply but also affect other resources like fodder and fuel wood. Efforts are hence needed to find an alternate source of water and utilisation of saline lands for economic benefits. Thousands of kilometers of coastal deserts in developing countries may serve as a new agriculture land, with the use of sea water for irrigation of salt tolerant plants. These plants can grow using land and water unsuitable for other conventional crops and provide food, fodder, fuel, medicines, landscaping. Saving the precious freshwater resources especially in the coastal areas where tourist development is planned, it is possible to select suitable halophytes for ornamentation purpose in landscaping. Seapurslae, *Sesuvium portulacastrum* (L.) is one of the fast growing, perennial, herbaceous, psammophytic halophyte, with great potentials. The plant is utilised as a vegetable, forage, landscaping and potentially use for environment protection like soil covering, sand dune fixation, bioreclamation of saline soil, phytoremediation and carbon sequestration. Furthermore, this species has medicinal value and produces secondary metabolites useful as substitutes for synthetic raw materials in food, perfumery, cosmetic and pharmaceutical industries. *S. portulacastrum* is characterised for its adaptability to hard environmental conditions of the coastal sand dune habitats that limit the survival of most vegetation. A field experiment was carried out to evaluate the potential yields of *S. portulacastrum* cultivated on coastal salt marshes region in northern Sinai. Salt-remediation, vegetable yield, protein, amino acids and nutrient contents were estimated. The results showed that *Sesuvium* can tolerate and grow under extremely high salinity concentrations of up to 68.0 ds m^{-1}. The highest forage yield recorded was 12.0 t ha^{-1} with 8 % protein content. However, the Na content in *Sesuvium* shoots is 10 times higher than found for K and P.

Keywords: Coastal salt marshes, halophytes, potential yields, *Sesuvium portulacastrum*

Contact Address: Sayed Eisa, Ain Shams University (ASU), Dept. of Agricultural Botany, 68 Hadyke Shubra, 12244 Cairo, Egypt, e-mail: sayed_eisa@hotmail.com

Impact of Cultivation and Gathering on Medicinal Aromatic Plants: A Case Study in Makwanpur District, Nepal

KRISTEN KELLY

University of Copenhagen, Dept. of Food and Resource Economics, Denmark

Medicinal aromatic plants (MAPs) are an integral part of many households found in developing countries. Traditional knowledge of MAPs is often deeply rooted within the communities found close to the source of these plants. While a majority of MAPs are still being harvested from the wild, over-exploitation and unsustainable practices are depleting these resources at an alarming rate, particularly in Nepal. Bringing these threatened species into cultivation on a small-scale has become more apparent throughout the literature as a potential remedy to this persistent issue. Also, it could be an additional source of income generation. However, there seems to be a gap in the literature in the decisions leading up to the choice to cultivate by the farmer. The aim of this study was to highlight the variables that influenced or hindered the farmer to cultivate MAP species.

This study examined the differences, in terms of productivity, knowledge, and socio-economic factors between cultivating and collecting MAPs from the wild in Makwanpur District, Nepal. The influence of MAP cultivation on conservation and productivity was also analysed. An ethnobotanical approach was implemented applying both qualitative and quantitative methods using empirical data collected from the field as part of a master thesis project. One hundred households along with a number of focus groups and informal interviews were conducted in community forest user groups over a period of three months.

It was found that the challenges with adapting MAP cultivation include: lack of MAP cultivation knowledge, lack of quality planting material, technology and training, as well as a lack of a beneficial market. Collection was seen by the farmers as a conservation hazard both to the species itself and to the surrounding forest. Farmers that successfully cultivated MAPs had more knowledge, access to land, proper resources and a market benefiting the MAP species cultivated. The main motivation overall, however, was income generation.

Identifying the factors that promote successful cultivation of MAPs is imperative if cultivation is to be more prevalent in the future. Further research should be carried out to get a better representative picture.

Keywords: Community forestry, conservation, domestication, medicinal plants, Nepal, wild collection

Contact Address: Kristen Kelly, University of Copenhagen, Dept. of Food and Resource Economics, 95 Duevej, 2000 Frederiksberg, Denmark, e-mail: kellykristen00@gmail.com

Analysis of Weed Flora in Traditional Vineyards of Malayer

MAJID ROSTAMI[1], ABDOL REZA AHMADI[2]

[1]*Malayer University, Raisin & Grape Research Institute, Iran*

[2]*Lorestan University, Dept. of Plant Protection, Iran*

In Malayer city (West Iran) grape (*Vitis venifera L.*) is the most important horticultural crop and the area under grape cultivation is more than 10000 ha. There are many factors that affect yield and quality of grape, one of these is weed management. Vineyard weed management is critical for controlling competing weed with young vines, particularly within the first years after planting. Weed growth and propagation depends on many factors such as climate, soil physico-chemical properties, training system of vines and irrigation system. Weed identification is important to identify the proper weed control options. In order to identify weed flora and study weed species diversity in vineyards of Malayer a survey was conducted. Collected data were clustered by hierarchical complete linkage method. Based on the results weeds belonged to 22 families and 51 species. The majority of weed species were dicotyledonous (43 species). Poacea family was the dominant family with a relative frequency of 17.4 %, and was closely followed by Fabaceae family with a relative frequency of 15.2 %. Among all 51 species, field bindweed (*Convolvulus arvensis*) showed the highest frequency in weed flora, followed by wild lettuce (*Lactuca virosa*) and red-root amaranth (*Amaranthus retroflexus*). Field bindweed showed also the highest plant density (19 plants m^{-2}) while the mean density of 28 species was less than one plant per square meter. In general, annual C3 weeds were dominant. The identification of numerous weed species means that different weed control methods must be selected. The higher number of dicotyledonous weeds means that special attention for the use of chemical herbicides is necessary as many recommended herbicides for broadleaf weeds can result in serious damages to the vineyards.

Keywords: Grape, relative frequency, species diversity, weed management

Contact Address: Majid Rostami, Malayer University, Raisin & Grape Research Institute, Postal Code: 65719- 95863, Malayer, Iran, e-mail: majidrostami7@yahoo.com

On Farm Energy Analysis of Sweet Orange Production in Nigeria

SIMEON OLATAYO JEKAYINFA[1], AFOLAYAN STEPHEN OLAOYE[2]
[1]*Ladoke Akintola University of Technology, Dept. of Agricultural Engineering, Nigeria*
[2]*National Horticultural Research Institute (NIHORT), Agricultural Engineering, Nigeria*

Efficient use of energy is one of the principal requirements of sustainable agriculture. Energy use in agriculture has been increasing in response to increasing population, limited supply of arable land, and a desire for higher standards of living. Continuous increasing demands of food products have resulted in intensive use of chemical fertilisers, pesticides, agricultural machinery, and other natural resources. Efficient use of energy in agriculture will minimise environmental problems, prevent destruction of natural resources, and promote sustainable agriculture as an economical production system. The study was undertaken to investigate the energy inputs and outputs of a group of citrus research farms in Nigeria. Data used in this study was collected *in situ* on yearly basis; therefore the analysed and discussed energy values were averages of data collected over the years. The research results indicated that total energy inputs were 46.64 GJ ha^{-1}. About 35 % was generated by human labour, 38 % from diesel oil and machinery, while other inputs contributed 29 % of the total energy input. About 87 % of the total energy inputs used in sweet orange production was from direct sources (seeds, fertilisers, manure, chemicals, machinery) and 13 % was from indirect sources (human labour, diesel). Mean orange yield was about 41 t ha^{-1}. The net energy and energy productivity value was estimated to be 31.3 GJ ha^{-1} and 0.88 kg MJ^{-1}, respectively. The ratio of energy outputs to energy inputs was found to be 1.67. This indicated an intensive use of inputs in sweet orange production not accompanied by increase in the final product. Cost analysis revealed that total cost of production of sweet orange production was $ 5590 ha^{-1}. Benefit-cost ratio was calculated as 2.2. A methodological shift from the use of energy from non-renewable sources to renewable ones could bring about an improvement in the energy use pattern of the research citrus farms in Nigeria.

Keywords: Energy sources, energy use indices, Nigeria, sweet orange

Contact Address: Simeon Olatayo Jekayinfa, Ladoke Akintola University of Technology, Dept. of Agricultural Engineering, P.M.B. 4000, - Ogbomoso, Nigeria, e-mail: jekaysol@yahoo.com

Implementation of Cocoa Crops as a Measure for Replacement of Illicit Crops in Western Boyacá, Colombia

Sonia Natalia Vásquez Díaz[1], Elber Giovanni Paez[2]

[1] *Wageningen University and Research Center (WUR), Agris Mundus Student, The Netherlands*

[2] *Land of Freedom Foundation, Boyaca, Colombia*

The negative impact of coca (*Erythroxylum coca*) growing is not only in the social side. As illegal crop, producers have to deforest areas within native forests to grow it and they apply a variety of chemical products for plant protection and leaf processing without an environmental management plan. That is why this illicit activity has promoted not only social problems but also land degradation in rural zones of Colombia. In the western part of Boyacá (Colombia), production and processing of coca leaf were important economic activities for the farmers during the years 2000–2005. However, in 2006 a group of peasants decided to eradicate coca fields and replace them with cocoa crops (*Theobroma cacao*). The first governmental programme which supported them was the National Policy for the Eradication of Illicit Crops. This study analyses the current productive system of these cocoa crops with its specific practices, looking for the benefits for soils and landscape and the perspectives for improving it, with the opinion and experiences of people from the board of the Cocoa Farmers' Associations and agronomists from the region and from governmental institutions. Also this paper aims to analyse how a specific national policy influences the change to modify the local land use and management. So far, social and land degradation processes are being stopped and there are possibilities to continue developing sustainable land management in the western region of Boyacá. The farmers' organisation is one of the most important achievements in this process; it is a bottom-up initiative strengthened by a top-down national policy.

Keywords: Agroforestry, coca, cocoa, farmer organisation, replacement illicit crops, sustainable land management

Contact Address: Sonia Natalia Vásquez Díaz, Wageningen University and Research Center (WUR), Agris Mundus Student, Wageningen, The Netherlands, e-mail: natavasd15@yahoo.com

Research and Development for a Modern Horticulture in the Groundnut Basin of Senegal

ROSELLA GIUNTA, GAETANO LAGHETTI, PAOLO DIRENZO, PATRIZIO VIGNAROLI, FEDERICO VALORI , VIERI TARCHIANI, DOMENICO PIGNONE
Italian National Council of Research (CNR), Italy

Over the past ten years, the horticultural production in Senegal has strongly increased, due to the productivity consolidation of some suitable areas (such as the coastal band of Niayes and the Senegal River Valley), and in relation to a progressive population growth concentrated in urban areas. Therefore the demand for domestic and subregional markets has raised together with an international commercial interest for off-season products. In fact, considering the main vegetable crops (e.g. onion, tomato, cabbage) the overall production has increased from 286,000 tons in 2001 to 640,000 tons during 2011, with an average annual growth rate of 7 %.
In addition, the productive potential of traditional rain-fed crops such as groundnut, millet and sorghum has been dramatically affected by the global climate change, with wet seasons characterised by an increasingly uneven distribution of rainfall and a significantly higher intensity of rain events. In this changing environment, horticulture represents a real vector of economic growth, by the possibility to cultivate with the help of irrigation throughout the year, even in marginal areas.
The "Programme d'Appui au Programme National d'Investissement dans l'Agriculture au Sénégal (PAPSEN)", funded by the Italian Ministry of Foreign Affairs supports the diffusion of drip irrigated horticulture in the three Regions of Thies, Diourbel and Fatick. Within the programme, a research and development component aims to identify best performing species and varieties and improve crop management practices. The planned research activities foresee the implementation of a full-field experimental trial at the Centre National de Recherche Agronomiques (CNRA) of Bambey, in collaboration with the Institut Sénégalais de Recherches Agricoles (ISRA). Experimental activities are focused on evaluating the performances of ten vegetable crops (onion, pepper and hot pepper, cabbage, melon, tomato, eggplant, lentil, carosello and barattiere) in three different seasons for the adaptation of crop production calendars to meet best market opportunities. At the same time, the effects of biochar on soil fertility and water holding capacity will be evaluated and an appropriate and simplified water balance model will be developed in order to optimise the use of water resources through a more efficient management of the irrigation practices.

Keywords: Biochar, cultivars, drip irrigation, horticulture, research & development, Senegal, soil fertility

Contact Address: Rosella Giunta, Italian National Council of Research (CNR), Institute of Biosciences and Bioresources (IBBR), V. G. Amendola 165/a, 70126 Bari, Italy, e-mail: rosella.giunta@ibbr.cnr.it

Promoting Nutrition Sensitive and Climate Smart Agriculture through Increased Use of Traditional Underutilised Species in the Pacific

DANNY HUNTER[1], MARY TAYLOR[2], ADELINO LORENS[3]

[1]*Bioversity International, Nutrition and Marketing of Diversity Programme, Italy*

[2]*University of the Sunshine Coast, School of Science, Australia*

[3]*Island Food Community of Pohnpei, Micronesia, Fed States*

Traditionally the Pacific Islands have depended on the diversity of their local food crops for food and nutritional security. However, increasing urbanisation, poor investment in agriculture and the availability of cheap food imports have contributed to the decline of traditional crop production. The focus on markets has encouraged a general erosion of diversity in the food production systems through farmers concentrating on those crops and varieties attractive to the markets. The Pacific region has always faced challenges, due in part to the size of the islands and their geographical isolation. However, with the increasing reliance on imported food products affecting the health of the people across all age ranges, and climate change questioning the resilience of Pacific agriculture, the challenges for food security are greater than they have ever been. Promoting the use of traditional underutilised species has to incorporate development of a value chain approach and market strategies to ensure delivery of health benefits to consumers and economic benefits to local horticultural producers and other value chain actors? Identifying the reasons behind food choices is an essential component of successful value chain development, and addressing those issues that prevent more consumption of traditional, underutilised species. Highlighting the link between dietary diversity and resilient food production systems must be strengthened to ensure that practitioners in both nutrition-sensitive and climate smart agriculture coordinate their interventions. This paper will discuss these issues in the context of the Pacific region, and will focus on a number of species which have been identified by the Pacific Plant Genetic Resources Network (PAPGREN) as target species for promotion and development. The currently underutilized priority crops include breadfruit (*Artocarpus altilis*), bananas of the Fe'i group and/or Pacific plantain, Polynesian chestnut (*Inocarpus fagifer*), *Pometia pinnata*, giant swamp taro (*Cyrtosperma merkusii*), bele (*Abelmoschus manihot*), the lesser aroids *Alocasia* and *Xanthosoma* and, particularly for the atoll islands, *Pandanus* spp..

Keywords: Climate smart agriculture, nutrition-sensitive agriculture, Pacific Islands, underutilised species

Contact Address: Danny Hunter, Bioversity International, Nutrition and Marketing of Diversity Programme, Via Dei Tre Denari 472/a, 00057 Maccarese, Italy, e-mail: d.hunter@cgiar.org

Crop management and abiotic stresses

Genetic Basis of Iron Toxicity Tolerance in Rice (*Oryza sativa* L.)

ELSA MATTHUS[1], LIN-BO WU[1], ANDO RAZAFINDRAZAKA[1], MICHAEL FUH[1], MICHAEL ASANTE[1], YOSHIAKI UEDA[1], STEFANIE HÖLLER[1], ANDRES G C SAJISE[2], GLENN GREGORIO[2], MATHIAS BECKER[1], MICHAEL FREI[1]

[1] *University of Bonn, Inst. Crop Sci. and Res. Conserv. (INRES) - Plant Nutrition, Germany*

[2] *International Rice Research Insitute (IRRI), Plant Breeding, Genetics and Biotechnology, Philippines*

Iron (Fe^{2+}) toxicity limits rice (*Oryza sativa* L.) growth in paddy fields worldwide, reducing yields up to complete crop failure. Fe^{2+} leads to the formation of reactive oxygen species (ROS) within the plant, followed by bronzing of the leaves. Tolerance varies depending on the genotype, the stress type (pulse vs. chronic stress) and further environmental parameters. Tolerance mechanisms, such as root exclusion, iron compartmentalisation within organs or true tissue tolerance, have been proposed but remain unexplored. We followed several approaches to dissect the genetic basis, including (i) a QTL analysis of a Pokkali/IR29 recombinant inbred population and a Nipponbare/Kasalath/Nipponbare backcross inbred population, yielding seven and three QTLs, respectively. QTLs were found to be co-localised with QTLs previously reported for both pulse and chronic stress treatment. To exploit the genetic diversity of rice, we (ii) conducted a genome wide association study (GWAS), identifying iron tolerance loci in a panel of 329 varieties, representing all sub-groups of *O. sativa* from 79 countries. The lines were grown in hydroponic solution for four weeks, then exposed to a pulse stress of 1000 ppm Fe^{2+} for five days. All plants were phenotyped by quantifying leaf damage, growth and shoot iron content. All phenotypic traits yielded genomic loci significantly associated with tolerance to excess iron. *Temperate japonica* and *aromatic* sub-populations proved more tolerant than *tropical japonica*, *indica* and *aus* ($p < 0.001$). (iii) Putative candidate genes such as the metal tolerance protein (OsMTP1) are currently being sequenced and verified in mutant experiments. (iv) A subset of the diversity panel was validated on a known iron-toxic field site in the Philippines, in co-operation with the International Rice Research Institute (IRRI). (v) To bridge different stress types (chronic vs. pulse) and growth conditions (controlled vs. field), contrasting genotypes are currently being grown up to maturity in soil under controlled greenhouse conditions and exposed to both long- and short-term excess iron. This project adds to the genetic understanding of iron uptake, transport and tolerance mechanisms, which is the basis for enhancing yield and producing fortified crops on iron toxic soils.

Keywords: Genetics, genome-wide association study, iron toxicity, rice

Contact Address: Michael Frei, University of Bonn, Inst. Crop Sci. and Res. Conserv. (INRES) - Plant Nutrition, Karlrobert-Kreiten Strasse 13, 53115 Bonn, Germany, e-mail: mfrei@uni-bonn.de

Salinity Effects on Soil Microbial Properties and Nutrient Fluxes in a Rice Paddy Soil During Short Term Aerobic Incubation

FLORIAN WICHERN[1], TOUFIQ IQBAL[2], CONOR WATSON[1], YASHNEEIL SINGH[3], CHRISTOPH KNOBLAUCH[1], RAINER GEORG JOERGENSEN[4]

[1]*Rhine-Waal University of Applied Sciences, Faculty of Life Sciences, Germany*
[2]*University of Rajshahi, Dept. of Agronomy and Agricultural Extension, Bangladesh*
[3]*Indian Institute of Technology (IIT), Agricultural and Food Engineering Dept., India*
[4]*University of Kassel, Dept. of Soil Biology and Plant Nutrition, Germany*

As a consequence of climate change, a rising sea-water level results in increased salt-water intrusion and soil salinity problems in Bangladesh. The affected agricultural soils are characterised by temporarily high concentrations of soluble salts, low organic matter and reduced plant growth. However, addition of organic matter (such as rice straw) is expected to ease the effect of salinity on soil microorganisms therefore positively influencing nutrient cycling. Therefore, a short term laboratory incubation experiment was conducted to evaluate the benefit of rice straw addition to saline Bangladeshi soils from paddy rice fields on the microbial community and associated nutrient and matter dynamics. Soil samples were collected from two locations in Batiaghata (B) and Dumuria (D) in the coastal area of Bangladesh. Both soils were then incubated with rice straw (0, 25 and 50 % of the straw yield) and three levels of salinity (0, 15 and 50 mg NaCl g^{-1} soil) for 28 days at 25°C. Soil respiration was measured during incubation. At the end of the experiment microbial properties (microbial biomass C, ergosterol), extractable carbon and inorganic nitrogen was determined. In both soils, increasing soil salinity decreased soil respiration, microbial biomass C and ergosterol content, which were generally on a very low level. On the other hand, addition of rice straw increased microbial properties and resulted in nitrogen immobilisation. Thus, by improving the soil organic matter content, rice straw addition can ease the negative effects of soil salinity on soil microbial communities allowing them to maintain some of their ecological functions, such as immobilisation and mineralisation processes. To improve soil fertility, addition of organic matter is crucial. Returning parts of the rice straw to the soil might contribute to this goal. However, rice straw is a valuable source used e.g. as feed or burning material, making the return to the field a less economic viable option.

Keywords: Ergosterol content, microbial biomass C, mineralisation, nitrification, soil respiration

Contact Address: Florian Wichern, Rhine-Waal University of Applied Sciences, Faculty of Life Sciences, Marie-Curie Str. 1, 47533 Kleve, Germany, e-mail: florian.wichern@hsrw.eu

Whole-Plant Gas Exchange Characteristics of a Super Dwarf Rice Genotype

MARC SCHMIERER, FOLKARD ASCH

University of Hohenheim, Inst. of Plant Production and Agroecology in the Tropics and Subtropics, Germany

Gas exchange measurements are not only an effective tool to capture a plant's biological status *in vivo*, but in addition, they can be used to gain essential insights into numerous physiological mechanisms. Most frequently, these measures are carried out on single leaves clamped into a measuring cuvette in whole or in part, while the basic environmental factors are kept under control. However, a crucial feature of plant stands is a microclimatic gradient through consecutive horizontal canopy layers. The slope and degree of this gradient depend on the composition of the bulk atmosphere and its coupling to the canopy as well as on several characteristics of the canopy itself. Hence, the CO_2 and water fluxes measured on single leaf basis do not necessarily represent the full spectrum of canopy-atmosphere interactions, and possible feedback mechanisms of the CO_2 and water fluxes driven by the canopy itself are in fact neglected. With the aim of measuring gas exchange of rice on plant level in response to varying environmental conditions, we developed a measuring cuvette of sufficient size, which can be connected to control units of commercially available gas exchange systems. The system consists out of an air tight transparent acrylic glass tube with connections for incoming and outgoing air. All measurements are carried out with plants of a super dwarf rice variety that is of extremely small size and shows an excessive tillering behaviour, leading to a dense canopy structure with a distinct microclimate. Data about whole-plant responses to changes in the aerial environment will be presented together with the operation principles and the basic technical design of the system. Implications of the partly aerial and energetic decoupling of the plant from the environment for data interpretation will be highlighted. Furthermore, the presented data will be discussed in an agro-ecological context.

Keywords: Decoupling coefficient, gas exchange, rice

Contact Address: Marc Schmierer, University of Hohenheim, Inst. of Plant Production and Agroecology in the Tropics and Subtropics, Stuttgart, Germany, e-mail: marc.schmierer@gmail.com

Evaluating Crop Production Potential in a Floodplain Wetland in Tanzania: The Challenge of Soil-Moisture Monitoring

BEATE BÖHME[1], MATHIAS BECKER[2], BERND DIEKKRÜGER[3]

[1]*TU Bergakademie Freiberg, Inst. of Drilling Technology and Fluid Mining, Germany*

[2]*University of Bonn, Inst. Crop Sci. and Res. Conserv. (INRES) - Plant Nutrition, Germany*

[3]*University of Bonn, Dept. of Geography, Germany*

Floodplain wetlands in East Africa are a valuable resource for the cultivation of staple crops, such as rice and vegetables, or for dry season grazing. Information on spatial and temporal water availability for agricultural production is indispensible for land use planning. However, characterisation of complex hydrological processes poses a challenge, especially in data scarce regions.

We quantified soil water availability in the floodplains of the Mkomazi River, situated in the sub-humid lowlands west of the Usambara Mountains, Tanzania. Frequency Domain Reflectometry (FDR) based soil moisture contents, groundwater levels, and climate, were monitored over 2 years at different landscape positions and land use types within the wetland.

Based on the analysis of water sources (river flooding, spring water, ponding of rain water) and land uses, we were able to differentiate five major land use classes within the floodplain: (1) rain fed rice; (2) grazing land; (3) natural vegetation; (4) vegetables and irrigated rice; and (5) upland crops. During the wet season, periods of 4–5 months of soil flooding allow cultivating lowland rice while during the dry season groundwater levels drops below 2 m. The one-dimensional HYDRUS software package was used to simulate seasonal water movement in the soil based on observed soil hydraulic properties and climate. After calibrating the model, simulated soil moisture could be used for filling spatio-temporal gaps in the observed time series of soil moisture. Thus, the water availability for crop production could be evaluated despite the data limitations.

The findings of our research are useful for future work on the agricultural use of floodplain wetlands in the region. Moreover, using HYDRUS for quantifying climate scenarios, they provide the basis for formulating land use recommendations under increasingly variable weather conditions.

Keywords: Calibration, FDR, HYDRUS, model

Contact Address: Beate Böhme, TU Bergakademie Freiberg, Inst. of Drilling Technology and Fluid Mining, Agricolastrasse 22, 09599 Freiberg, Germany, e-mail: beate.boehme@tbt.tu-freiberg.de

Comparative Physiological and Molecular Response of Kenyan Barley (*Hordeum vulgare* L.) Cultivars in Response to Abiotic Stress

JAYNE BINOTT[1], JULIUS OWUOCHE[2], DOROTHEA BARTELS[1]

[1] *University of Bonn, Institute of Plants Molecular Physiology and Biotechnology (IMBIO), Germany*

[2] *Egerton University, Crops, Horticulture and Soil Science, Kenya*

Abiotic stresses such as drought, salinity high temperatures, mineral deficiency and toxicity limits the growth and productivity of cereals globally accounting for 70% of yield losses. In Kenya barley is used as a source of malt for brewing, animal feed and is gradually gaining importance as a food security crop in the wake of pronounced climate change in sub-Saharan Africa. Exploitation of varietal diversity to identify cultivars with wider agroecological adaptability for enhanced selection for abiotic stress tolerance is essential. In this study, various physiological and molecular screening assays were performed in in order to characterise Kenyan barley lines. Quantitative and qualitative changes in physiological parameters including ionic leakage damage, lipid peroxidation, chlorophyll content, metabolite accumulation of proline, sucrose and glycine betaine (GB) and expression profiles of major genes involved in abiotic response in barley such as dehydrin (*LEA II*), *Hordeum spontaneum* dehydration response gene (*Hsdr4*) and genes encoding transcription factors such as *HvDREB1* were evaluated. Twelve days old seedlings grown under controlled conditions were subjected to varying levels of salt and or combined with dehydration stress treatments. A phenotype assessment cluster was generated based on leaf colour, survival rate, tillering abilities emergence of the new apical leaf, and the ability to maintain "stay green trait". Based on combined phenotype, physiolological and biochemical assays, a cluster of representative putative tolerant and susceptible cultivars were generated. Response to abiotic stress was found to be genotype dependent and varied with the severity of stress especially salt. *HvBBD1* was strongly constitutively expressed in roots than in leaves while *HvBBD2* was strongly induced in leaves in response to stress suggesting the potential role of increased GB in osmotic adjustment. Low ion leakage, lipid peroxidation and increased GB, proline, chlorophyll was associated with abiotic stress tolerance. Dehydrin *Dhn1* and *Dhn9* genes were exclusively associated with dehydration response. *Dhn3*, *Dhn4* and *Dhn7* were induced by both dehydration and increased salt treatments. *Dhn8* were constitutively expressed. The results presented here are the first report on the status of abiotic stress tolerance in Kenyan cultivars and forms a basis for further improvement using both conventional and biotechnological approaches.

Keywords: Abiotic stress tolerance, barley, aldehydes, betain aldehyde dehydrogenase, compatible solutes, dehydrins, glycine betaine, *Hordeum vulgare*, transcription factors

Contact Address: Dorothea Bartels, University of Bonn, Institute of Plants Molecular Physiology and Biotechnology (IMBIO), Kirschallee 1, 53115 Bonn, Germany, e-mail: dbartels@uni-bonn.de

Physiological Characteristics of two Rose (*Rosa hybrida* L.) Cultivars Grown under Different Levels of Shading

MANSOURE HATAMIAN[1], HASSAN SALEHI[2]

[1]*University of Tehran, Dept. of Horticultural Sciences, Iran*
[2]*Shiraz University, Dept. of Horticultural Sciences, Iran*

Light is one of the most important environmental factors affecting plant growth and development. However, high light intensities particularly during summer can lead to problems in cut flower production under open field as well as greenhouse condition. Despite the fact that roses prefer sunny places for optimum growth, under greenhouse conditions shading is applied in order to improve the quality of the cut flowers. The applied shading is based on experience and differs among rose producers. Therefore, it is necessary to find the light intensities under which different rose cultivars produce optimum yield with acceptable quality. The present study was conducted in 2011, in a commercial greenhouse in Pakdasht, Iran. Two rose cultivars, "Red One" and "Gulmira" representing red and white colours, were used in this study. The treatments were different light intensities including control without shade application (1200 μmol $m^{-2}s^{-1}$), and three treatments 640, 520 and 240 μmol $m^{-2}s^{-1}$. Result showed that protein concentration was significantly different among shade treatments ($p \leq 0.05$), as the highest protein concentration of leaves was observed under light intensity of 640 μmol $m^{-2}s^{-1}$. The activity of peroxidase enzyme was affected by different shading treatments as well as by interaction of shading and cultivar ($p \leq 0.05$). The activity of catalase enzyme showed significant difference between two cultivars and there was no significant difference among shading treatments. The highest concentration of anthocyanin of petals was observed in "Red One" cultivar in the 520 μmol $m^{-2}s^{-1}$ treatment. The highest amount of leaf carbohydrate was observed in 520 μmol $m^{-2}s^{-1}$ treatment. This indicates that shading up to a light intensity of 520 μmol $m^{-2}s^{-1}$is beneficial for quality improvement of the rose cultivars studied.

Keywords: Catalase, light intensity, peroxidase, physiological traits, rose, shading

Contact Address: Mansoure Hatamian, University of Tehran, Dept. of Horticultural Sciences, Tehran, Iran, e-mail: hatamian.m@ut.ac.ir

Lablab purpureus (L.) Sweet: A Promising Multipurpose Legume for Enhanced Drought Resistance in Smallholder Farming-Systems of Eastern Kenya

KRISTINA GROTELÜSCHEN[1], ANNE SENNHENN[1], ANTHONY WHITBREAD[2], BRIGITTE L. MAASS[3], DONALD NJARUI[4]

[1]*Georg-August-Universität Göttingen, Dept. for Crop Sciences: Tropical Agronomy, Germany*

[2]*International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India*

[3]*International Center for Tropical Agriculture (CIAT), Tropical Forages Program, Kenya*

[4]*Kenya Agricultural Research Institute, Animal Production, Kenya*

In Kenya arable land is scarce, accounting only for 20 % of the total land area with the majority found in semi-arid regions. For these drier regions where farming activities are mostly operated by smallholder farmers, unreliable and highly variable rainfall, lack of irrigation facilities and poor soils lead to low crop yields. Facing also the impacts of climate change, the introduction of drought tolerant germplasm may help farmers manage risk. Because *Lablab purpureus* (L.) is considered to be drought tolerant and is a highly valued traditional crop for food and fodder in Africa; it offers great potential for smallholder farming-systems in semi-arid eastern Kenya. The aim of this study therefore was to evaluate the production potential of different lablab accessions in semi-arid eastern Kenya as well as their acceptability for human consumption. Six promising short-season lablab accessions (Q6880B, CPI60795, CPI52508, CPI52513, CPI52535, and CPI81364) were grown on-station in a water-deficit and on-farm in a rainfed-only experimental setting. Data on time to flowering and maturity, dry matter (DM) production and leaf area index (LAI) were taken. Additionally an organoleptic tasting was conducted to identify suitable accessions for human consumption.

Time to flowering ranged from 63 to 70 days after planting (DAP) with Q6880B, CPI60795 and CPI81364 being the earliest. Final DM yields ranged from 1200 kg ha^{-1} to 7200 kg ha^{-1} under rain-fed conditions on-station and from 500 kg ha^{-1} to 5000 kg ha^{-1} on-farm. Under irrigation, DM yields reached 14000 kg ha^{-1}. Most promising and high yielding lablab accessions included Q6880B and CPI81364 with grain yields from 1200 kg ha^{-1} to 1600 kg ha^{-1}. The accession CPI52535 seemed to be more suitable for fodder or dual-purpose use with the highest biomass production. In the organoleptic tasting CPI81364 proved to have high cooking and eating qualities.

In summary this study indicates the great potential of Q6880B and CPI81364 for semi-arid farming systems due to high grain yields and short growing periods. However, the susceptibility of lablab to pests and diseases is a significant issue that requires management packages to be developed so that farmers may successfully cultivate this important food legume.

Keywords: Drought resistance, dry-land farming systems, eastern Kenya, *lablab purpureus* (L.) sweet

Contact Address: Kristina Grotelüschen, Georg-August-Universität Göttingen, Dept. for Crop Sciences: Tropical Agronomy, Kreuzbergring 56 05, 37075 Göttingen, Germany, e-mail: k.grotelueschen@stud.uni-goettingen.de

Does Combining Canopy Reflectance and Canopy Temperature Allow Identifying Drought Resistance Strategies in Potato?

JULIA AUBER[1], M. AWAIS KHAN[2], EVELYN FARFAN[2], MERIDETH BONIERBALE[2], FOLKARD ASCH[1]

[1] *University of Hohenheim, Inst. of Plant Production and Agroecology in the Tropics and Subtropics, Germany*

[2] *International Potato Center (IPC), Germplasm Improvement, Peru*

Changes in seasonal precipitation patterns lead to variations in water availability for different development stages of agricultural crops. Potato has been classified as sensitive to even minor drought spells partly due to its shallow root system. Increasing demand for potatoes and increase of the global production area, increases the need for resistant potato varieties to seasonal water deficits. Tolerance of potato to drought may comprise a number of traits representing different strategies, such as deeper rooting for better access to water or leaf level adaptation to avoid early drought induced senescence. Evaluation of yield or yield reductions alone does not allow identifying the underlying resistance strategies. Thermographic evaluation of canopy temperature allows estimating stomatal control over transpirational water losses and changes in crop surface reflectance indicate leaf senescence levels. Whereas thermography alone allows estimation of leaf surface temperature, only the combination with crop surface reflectance provides information on rooting depth. To evaluate the suitability of this combination as a screening tool for drought resistance in potato, 56 potato clones from CIP's advanced breeding population were grown between October 2013 and February 2014 in a costal arid region of southern Peru. Plants were subjected to two irrigation treatments: fully watered (340mm per 4 month season) and terminal drought (withholding irrigation 68 days after planting). At 10-day intervals after withholding irrigation crop surface reflectance (FieldSpec, ASD) was measured and surface infrared temperature was taken with a thermo camera (B335, FLIR). Rooting depth and yield were determined at harvest.
Drought induced genotypic responses in reflectance and leaf temperature in relation to yield reduction and rooting depth will be presented. Potential genotypic strategies for drought resistance will be evaluated and the potential of the combined measurements as an early screening tool will be discussed.

Keywords: Genotypic responses, hyperspectral reflectance, root system, *Solanum tuberosum*, vegetation index

Contact Address: Folkard Asch, University of Hohenheim, Inst. of Plant Production and Agroecology in the Tropics and Subtropics, Garbenstr. 13, 70599 Stuttgart, Germany, e-mail: fa@uni-hohenheim.de

Considering the Effects of Temperature and Photoperiod on the Growth and Development of Lablab (*Lablab purpureus* L.) in the Search for Short-Season Accessions for Smallholder Farming Systems

ANNE SENNHENN[1], JUDE J.O. ODHIAMBO[2], BRIGITTE L. MAASS[3], ANTHONY WHITBREAD[1]

[1]*Georg-August-Universität Göttingen, Dept. for Crop Sciences: Crop Production Systems in the Tropics, Germany*

[2]*University of Venda, Dept. of Soil Science, South Africa*

[3]*International Center for Tropical Agriculture (CIAT), Tropical Forages Program, Kenya*

Legumes have gained increased importance in smallholder farming systems of sub-Saharan Africa due to their contribution to household nutrition and health and their ability to prevent the depletion of already poor soils. Unpredictable and highly variable rainfall make short-season grain types a promising option for risk reduced farming in semi-arid areas. The ability to predict phenological development and in particular time to flowering is crucial information needed estimating the production success of new accessions in new environments. Therefore the photoperiod-sensitivity of ten promising short-season *Lablab purpureus* L. accessions (CPI 525313, CPI 52533, CPI 52535, CPI 52535, CPI 52552, CPI 52554, CPI 60795, CPI 81364, CQ 3620, Q 6880B) were evaluated for their response to varying temperature and daylength regimes in field trials in Limpopo province, South Africa and under controlled conditions in growth chamber experiments in Göttingen, Germany. Photoperiod sensitivity was quantified using the triple-plane rate mode of flowering response. Further, time to flowering was expressed in thermal time units. Piecewise regression analysis was used to estimate the critical photoperiod (Pc) above which time to flowering was delayed significantly. Relatively high variation of time to flowering among and within accessions in days after planting (DAP) was observed, ranging from 60 to 120 depending on sowing date or daylength/temperature regime. A clear positive effect of temperature on growth and development of the tested accessions could be proven, and time to flowering expressed as thermal time were consistent for the tested accessions, ranging from 600 to 800 °Cd for day length $<$13 h. At daylength conditions of $\geq$13 h (temperature 28 °C) development towards flowering was delayed significantly for the accessions CPI 52513, CPI 52535, CPI 52554 and CPI 60795 with vegetative growth continuing for $>$100 DAP. Consequently the tested lablab accessions can be rated as having a weak photoperiod response and can be classified as short-day plants (SDP). From 30°N to 30°S daylength does not exceed 13 h and the tested lablab accessions can therefore be recommended as short-season grain legumes for cultivation in small-holder farming systems in the tropics and subtropics including semi-arid areas of sub-Saharan Africa.

Keywords: Flowering time, *Lablab purpureus* L., phenology, photoperiod-sensitivity, photothermal response

Contact Address: Anne Sennhenn, Georg-August-Universität Göttingen, Dept. for Crop Sciences: Crop Production Systems in the Tropics, Göttingen, Germany, e-mail: asennhe@gwdg.de

Effects of Drought Stress on Crop Development, Growth and Chlorophyll Fluorescence in Five Potato Clones

LEAH KUPPINGER[1], JULIA AUBER[1], EVELYN FARFAN[2], M. AWAIS KHAN[2], MERIDETH BONIERBALE[2], FOLKARD ASCH[1]

[1] *University of Hohenheim, Inst. of Plant Production and Agroecology in the Tropics and Subtropics, Germany*

[2] *International Potato Center (IPC), Germplasm Improvement, Peru*

World food production increasingly faces problems due to increasing temperatures, extreme weather events, and climate change-related seasonal water scarcity. Potato is the fourth most important food crop in the world and susceptible to drought stress, due to its shallow root system. As potato production is often affected by water scarcity, identification of drought resistance traits will help the breeding/selection process to sustain potato production. The aim of this study was to investigate the effects of drought on plant growth and on carbon partitioning/tuber production in 5 potato clones from the advanced breeding population developed at the International Potato Center. A field experiment was conducted from August to November 2013 in the costal arid region in southern Peru. Five contrasting potato genotypes (392797.22, 301040.63, 392025.7, 397073.16, 397078.12) were subjected to 4 different irrigation treatments (i.e. fully watered, until 54 days after planting (DAP), 67 DAP, and 80 DAP respectively) in a "split-split plot" design. Destructive samplings and non-destructive measurements were conducted at ten day intervals in each treatment. At each date, chlorophyll fluorescence and SPAD measurements were taken and above and below ground biomass (leaves, stems, roots, and tubers) was sampled for all treatments. Since irrigation was withheld at different development stages, plants' transpirational capacity and thus stress severity experienced by the plant varied with the treatments. Late drought (withholding irrigation at 67 or 80 DAP, respectively) resulted in a more severe drought stress compared to early drought due to higher air temperature later in the season and increased leaf area. Nonetheless, across all genotypes total biomass reduction was rather related to drought duration then to stress intensity. Unexpectedly, this was accompanied by a decrease in quantum yield of PS II under drought stress which in turn was related to changes in SPAD values. Average and maximal root lengths, the importance of biomass partitioning for tuber growth as well as the link between stress severity and phenological stage with regard to the effects on biomass development and photosynthesis will be presented and discussed for genotype specific responses.

Keywords: Biomass partitioning, phenological stage, stress severity index

Contact Address: Leah Kuppinger, University of Hohenheim, Inst. of Plant Production and Agroecology in the Tropics and Subtropics, Garbenstraße 13, 70599 Stuttgart, Germany, e-mail: leah.kuppinger@uni-hohenheim.de

Traits Related to Drought Resistance in Tamarind (*Tamarindus indica* L.)

SIAMAK GHAFFARIPOUR, NINA VAN DEN BILCKE, KAREN WUYTS, ROELAND SAMSON

University of Antwerp, Dept. of Bioscience Engineering, Belgium

Tamarind is a multipurpose tree that belongs to the Fabaceae. Seedling responses of Tamarind to drought were investigated using populations from eight regions of Asia, Africa and America used in agroforestry systems and planted in home gardens. The two drought stress treatments (i.e. low- and medium-watered soil) affected seedling biomass. Water stress reduced the expression of most traits such as leaf area, total plant biomass, leaf mass, root mass, stem diameter, root diameter, leaf mass fraction, root mass fraction, specific leaf area and photosynthesis with the exception of stem and root density which were increased by drought stress. Genotypic variation was observed among provenances for biomass and ecophysiological traits, but was limited for photosynthetic rate. We assume that drought resistance is a genotypic performance that can be based on plant traits such as biomass or other indices. Plant biomass under drought correlated positively (r= 0.481**) with genotypic performance under non-stress (Yp). Drought intensity indices (DII) were 0.26 and 0.30 at the medium-watered and low-watered level, respectively. Plant biomass reduction (Yp-Yd) did not relate to genotypic performance under stress (Yd) for both levels of stress. Geometric mean plant biomass (GM) was weakly correlated to drought susceptibility index (S) (r=0.365*) at the moderate level of drought but it was not significant (r=-0.045) at the low-watered stress. Traits did not tend to correlate with S at both levels of drought stress. On average, provenances with low S value are not desirable as these provenances are often unresponsive to stress-free conditions. Whereas, GM generally correlated with most other traits such as biomass and biomass allocation at moderate and low-watered level of drought stress. The differential correlations between traits and the indices for plant biomass and drought susceptibility would suggest that the most effective approach in breeding for drought resistance in tamarind could be based on selecting for high geometric plant biomass performance (GM) in tamarind.

Keywords: Drought index, drought resistance, tamarind

Contact Address: Siamak Ghaffaripour, University of Antwerp, Dept. of Bioscience Engineering, Groenenborgerlaan 171, 2020 Antwerp, Belgium, e-mail: siamak.ghaffaripour@uantwerpen.be

Polyamine Action in Sweetpotato Plants in Response to Environmental Stresses

MERVAT AHMED EL-FAR[1,2], HANS-WERNER KOYRO[2], THOMAS BERBERICH[3]

[1]*Agricultural Genetic Engineering Research Institute (AGERI), Agricultural Research Centre (ARC), Egypt*

[2]*Justus-Liebig University Giessen, Institute for Plant Ecology, Germany*

[3]*Biodiversity and Climate Research Center, Laboratory Centre (BIK-F), Germany*

Adjustment to certain environmental stresses is one of the most required abilities of crop plants in times of global climatic changes especially in arid and semi-arid regions. *Ipomoea batatas* (sweetpotato) shows a high viability as it is a species with a high adaptability and a wide range of genotypes. It is therefore cultivated in more than 100 countries with tropical, subtropical and moderate climate. It is expected that the importance of sweetpotato, world wide ranked number seven among the most important food crops, will increase in times of drought, flooding and rising temperatures. It already serves as a candidate for reducing the increasing food insecurity and poverty alleviation in developing countries, buffering malnutrition and has the potential to play an important role in the industrial sector. However studies are rare about the mechanisms behind the stress resistance of sweetpotato.

Certain metabolites play important roles in the resistance of plants to a broad range of stresses. Polyamines, small organic polycations found in all eukaryotic cells, have been identified as such metabolites. The major plant polyamines, putrescine (Put), spermidine (Spd), and spermine (Spm) frequently accumulate in response to abiotic and biotic stresses. Our aim is to identify the correlation between abiotic stresses and polyamine production in sweetpotato. Abees, sweetpotato Egyptian orange-flesh genotype was used in this study. Four weeks old plants were exposed to heat, cold, drought and salinity stresses separately. Polyamines, putrescine (Put), spermidine (Spd), and spermine (Spm) were analysed using the high-performance liquid chromatography (HPLC).

The results obtained showed a correlation among the identified polyamines putrescine, spermidine, spermine and the different abiotic stresses in our study. Moreover, unique polyamine products were found as a specific response to each stress type. These polyamine products undergo identification process by mass spectroscopy. Our results indicate that the expression of polyamines can serve as specific stress indicators.

Keywords: Environmental stresses, polyamines, sweetpotato

Contact Address: Mervat Ahmed El-Far, Agricultural Genetic Engineering Research Institute (AGERI), Agricultural Research Centre (ARC), 9 Gamaa st., 12619 Giza, Egypt, e-mail: elfarmervat@hotmail.com

Analysis of Energy and Economic Efficiency of Irrigated Canola Production in Brazilian Central-West Region

EDER PEREIRA GOMES[1], CAROLINA BILIBIO[1], OLIVER HENSEL[2], ARTHUR CARNIATO SANCHES[1], CESAR JOSÉ DA SILVA [1], DHIONES DIAS[1]

[1]*Federal University of Grande Dourados, Dept. of Agricultural Engineering, Brazil*

[2]*University of Kassel, Agricultural Engineering, Germany*

Energy efficiency, defined as the ratio of energy produced to energy consumed, is a major tool to assess sustainability of agricultural activities. However, other areas such as economy and water use should be included. Thus, we developed a study to assess energy and economic efficiency of irrigated off season crop canola (*Brassica napus* L.) in the Central West region of Brazil. First, a study was conducted on the campus of the Federal University of Grande Dourados over two years, 2012 and 2013, to evaluate the effect of different irrigation frequencies on grain yield of canola. We used a split plot, randomised block design with four replications. Treatments in the plot consisted of three (3) irrigation frequencies: no irrigation - SI, weekly irrigation - IS, irrigation three times a week - I3S. Different irrigation frequencies significantly affected grain yield (kg ha^{-1}) on average of both seasons. The highest yields were obtained with irrigation performed three times a week, corresponding to 2,983 kg ha^{-1}. Economic analysis showed that non irrigated crop had a loss of BRL 558.22 ha^{-1} (BRL 1=USD 0,48), while irrigation applied three times a week generated the highest total operating profit (LOT), which totalled R$ 736.15 ha^{-1}. Energy analysis showed that the energy used (EU) for crop production without irrigation (SI) was 8,695 MJ ha^{-1}, followed by 14,097 MJ ha^{-1} (IS) and 14,561 MJ ha^{-1} (I3S), while the energy extracted (EE), corresponding to energy from grain, followed the order: 17,038 MJ ha^{-1} (SI); 55,236 MJ ha^{-1} (IS) and 71,589 MJ ha^{-1} (I3S). Therefore, the maximum energy efficiency was achieved with irrigation performed three times a week, reaching a coefficient of 4.92 (I3S), followed by 3.92 (IS) and 1.96 (SI). Moreover, the specific energy obtained was 4.88 (I3S), 6.13 (IS) and 12.25 (SI) MJ kg^{-1} of grains. It is concluded that absence of irrigation made it economically unfeasible to produce off season canola in the Central-West region of Brazil, while irrigation promoted energy and economic viability. In addition, the most frequent irrigation, three times a week, produced the best results.

Keywords: Energy balance, irrigation management, off season production, production cost

Contact Address: Carolina Bilibio, Federal University of Grande Dourados, Dept. of Agricultural Engineering, Rodovia Dourados a Itahum km 12, 79804-970 Dourados, Brazil, e-mail: carolina.bilibio@yahoo.com.br

Potential Yield of Canola under Different Irrigation Frequencies and Nitrogen Levels in Brazilian Center-West Region

ARTHUR CARNIATO SANCHES[1], EDER PEREIRA GOMES[1], CAROLINA BILIBIO[1], OLIVER HENSEL[2], CESAR J. SILVA[3], DENISE NASCIMENTO FABRIS[1], LUCAS FILGUEIRA[1]

[1]*Federal University of Grande Dourados, Dept. of Agricultural Engineering, Brazil*

[2]*University of Kassel, Agricultural Engineering, Germany*

[3]*Brazilian Enterprise for Agricultural Research , Embrapa Agropecuária Oeste, Brazil*

Canola (*Brassica napus* L.) is an oilseed crop cultivated in several regions of the world. Canola can be used for industrial purposes but in Brazil canola is used for food production and livestock feeding. In the Brazilian Cerrado region canola is grown in the off season and during this period rainfall is not sufficient to ensure the potential of maximum crop yield, so there is a need for irrigation. It is known that canola has a high demand for nitrogen, thus the application of this nutrient is essential for obtaining a good crop yield. Considering these aspects, a study was conducted at the Federal University of Grande Dourados over the years, 2012 and 2013, to evaluate the effects of different irrigation frequencies and nitrogen on morphological and productive components of canola. We used a randomised block split-plot design with four repetitions. Treatments in the plot consisted of three irrigation frequencies (no irrigation -SI, weekly irrigation -IS and irrigation three times a week -I3S). Subplots received different doses of nitrogen: 0, 30, 60, 90 and 120 kg ha^{-1} in 2012; and 0, 60, 120, 180 and 240 kg ha^{-1} in 2013. In both years the different irrigation frequencies significantly affected plant height (cm), dry weight (g plant^{-1}), grain yield (kg ha^{-1}), thousand grain weight (g), oil content (%) and oil yield (kg ha^{-1}). The different nitrogen levels significantly affected dry weight, thousand grain weight and oil content in 2012, as well as plant height, number of pods, dry weight (g plant^{-1}), grain yield (kg ha^{-1}) and oil yield (kg ha^{-1}) in 2013. It is concluded that additional irrigation should be used in the Center-west region to ensure a maximum yield potential of canola, as the highest grain yield in this study, 2,999 kg ha^{-1}, was obtained through irrigation performed three times a week. Canola yields demonstrate a positive result with increasing levels of nitrogen, which shows the importance of using this nutrient for achieving high levels of grain yield and oil. Considering two years of evaluation, the highest grain yield was obtained with 60 kg ha^{-1} of nitrogen.

Keywords: Depth of irrigation, morphological components, nitrogen, yield

Contact Address: Carolina Bilibio, Federal University of Grande Dourados, Dept. of Agricultural Engineering, Rodovia Dourados a Itahum km 12, 79804-970 Dourados, Brazil, e-mail: carolina.bilibio@yahoo.com.br

Chlorophyll Fluorescence as a Tool for Evaluation of Drought Stress Tolerance in Iranian Pistachio Cultivars

ALI ESMAEILPOUR[1,2], MARIE-CHRISTINE VAN LABEKE[2], ROELAND SAMSON[3], PATRICK VAN DAMME[2]

[1] *Iran Pistachio Research Institute, Iran*

[2] *University of Ghent, Dept. of Plant Production, Belgium*

[3] *University of Antwerp, Dept. of Bioscience Engineering, Belgium*

Pistachio (*Pistacia vera* L., Anacardiaceae) is one of the major horticulture crops in Iran with high plantation surface areas, production and export rates. However, water deficiency has been becoming a main limiting factor for growth and development, and especially for maintaining yield quality and volume of this crop. In this study, the responses of chlorophyll fluorescence, carbohydrate content and a number of growth parameters of three Iranian pistachio cultivars (*P. vera* cv. Akbari, Kaleghochi and Ohadi) to different osmotic drought stress levels (-0.1, -0.75 and -1.5 MPa) and subsequent recovery were investigated in a greenhouse experiment held in Ghent, Belgium. With increasing drought stress intensity, desired parameters were monitored during both drought stress build—up and subsequent recovery. Maximum quantum efficiency of PSII photochemistry (Fv/Fm), effective quantum yield (ΦPSII) and photochemical quenching (qP) decreased in drought-stressed plants in both drought and recovery stages. Non-photochemical quenching (NPQ) was not significant influenced after two weeks of drought stress. When comparing the different cultivars of pistachio, our results show that decreasing the solution's osmotic potential lowered Fv/Fm and NPQ in Akbari while no effect was observed for the other cultivars. There were no significant differences between ΦPSII and qP during drought stress build-up among the three cultivars. For the drought treatments, we evidenced a significant accumulation of fructose, sucrose and starch in all cultivars during drought stress stage, whereas there was no significant accumulation of glucose compared to control. Total fresh and dry plant weights and leaf dry weight decreased significantly at all drought stress levels compared to control. The ratio of root/shoot and leaf dry weight increased in drought-stressed treatments. Stem elongation had a significantly higher value in control compared to drought stress treatments. Seedling main stem diameter did not vary significantly between drought stress treatments and control. As overall conclusion, most of chlorophyll florescence parameters decreased in drought stress condition. Therefore, these parameters could be used as a tool to recognise the resistant or susceptible pistachio cultivars.

Keywords: Carbohydrate content, growth parameters, water deficiency

Contact Address: Ali Esmaeilpour, Iran Pistachio Research Institute
current address: University of Ghent, Dept. of Plant Production, Ghent, Belgium, e-mail: ali.esmaeilpour@ugent.be

Differences in Morphology, Physiology and Biomass Between African Baobabs from Malian Provenances under Salt Stress

SHADI JAFARI, ROELAND SAMSON
University of Antwerp, Dept. of Bioscience Engineering, Belgium

Throughout the world, hundred million hectares or five percent of the arable land is adversely affected by high salt concentration, which reduces crop growth and yield. Almost fifty percent of the irrigated land is affected by high salinity, often resulting in secondary Stalinisation due to inappropriate use of saline irrigation water. The African baobab (*Adansonia digitata* L.) is a gigantic, deciduous, stem-succulent iconic tree belonging to the family Malvaceae and subfamily Bombacoideae. The general objective of this research was to study the effect of salinity on growth and physiological behaviours of baobab seedlings related to classification them in terms of salt tolerance. Baobab seedlings from three contrasting Malian provenances seedlings (western, southern and eastern) have been collected related to different precipitation gradient and IWC-IWC-O of top soil from those provenances were selected to using and tested for their salinity tolerance. The effect of salinity on growth indicators of seedlings of three provenances was compared after revealing to increasing salt stress. The old seedlings were adapted 0–20-40 mM NaCl with final nutrient solution for ten weeks. Seedlings of baobab growth were slightly influenced by 20 mM NaCl but were noticeably reduced on 40 mM NaCl treatment. Salt stressed seedlings had a reduced characteristic appearance rate such as: length, diameter, number of leaves and, leaf area. Increased NaCl salinity decreased the chlorophyll fluorescence and relative chlorophyll content in 40 mM treatment compared with the control. Response of morphology baobab seedlings of eastern Mali was significantly higher resistant to salt stress compared to the northern and southern Mali provenance. Seedlings of the northern provenance in Mali seem to be least resistant to salt stress. However, resistance of salinity on physiological characteristics from this provenance is higher compared to other seedling of two provenances. In additional, the seedlings of the provenances for physiological behaviour showed compensation for an increased response in length, leaf area etc as means of recovery for morphology. Results indicate that salinity significantly influences growth and physiology behaviour of baobab seedlings. Therefore, the baobab seedlings appear to be very salt-sensitive species.

Keywords: Baobab, biomass allocation, growth, Mali, morphology, physiology, salinity

Contact Address: Shadi Jafari, University of Antwerp, Dept. of Bioscience Engineering, Romeinse Put 95 Bus 42, 2650 Edegem, Belgium, e-mail: shadi.jafari@student.ua.ac.be

Plant nutrition and soil improvement

Soil Fertility after Six Years of Organic and Conventional Management in two Long-Term Field Experiments in Kenya

ANDREAS FLIESSBACH[1], ELSE BÜNEMANN[2], PAUL MAEDER[1], MIRA PORTMANN[1], HANNAH SCHMALZ[1], JUAN GUILLERMO COBO[1], ANNE MURIUKI[3], MARTHA MUSYOKA[4], NOAH ADAMTEY[1]

[1]*Research Institute of Organic Agriculture (FiBL), Dept. of Soil Sciences, Switzerland*

[2]*ETH Zurich, Dept. of Environmental Systems Science, Group of Plant Nutrition, Switzerland*

[3]*Kenya Agricultural Research Institute, National Horticultural Research Center, Kenya*

[4]*International Centre of Insect Physiology and Ecology (ICIPE), Kenya*

Soil fertility is at stake in many regions of sub-Saharan Africa. 500 Mio hectares are affected by some kind of degradation, equivalent to 22 % of the potentially productive land of the African continent. Restoring soil fertility and increasing stability of soil is an urgent call to farmers and officials. Building soil organic matter by using organic and mineral fertilisers is an important part of it. The use of available organic resources is not limited to organic farmers, but they may serve as an example on how strictly organic fertilisation is altering soil characteristics. In the SysCom project organic and conventional farming systems are compared in India, Bolivia and in two field trials in Kenya.

The Kenyan trials have been started in 2007 in Thika and Chuka. A three year rotation with maize, beans, vegetables and potatoes is running in each of the replicated organic and conventional farming systems. Each system is performed at low (subsistence level) and high input (export oriented) level. Soil samples from the top 20 cm were analysed at the start (2007) and at the end of each crop rotation period (2010, 2013). All samples were analysed for Corg, Ntotal, pH, Ptotal, Presin. In soil samples from 2010 and 2013 soil microbial biomass, soil respiration, dehydrogenase activity and alkaline phosphatase activity were additionally determined.

The field site in Chuka showed clearly higher level of soil fertility than the one in Thika. Total soil contents of C, N and P showed little change over time and treatments, whereas soil microbial biomass and microbial activities showed differences between farming systems and intensities. In Chuka soil microbial biomass in high input organic systems developed to higher levels than in all other treatments, whereas in Thika the differences between treatments were not significant. High input systems in Thika showed higher dehydrogenase activity than low input systems, but overall Thika soils appeared to be less responsive to the treatments than the ones in Chuka.

Keywords: Farming systems, Kenya, soil fertility, soil microbial biomass, soil organic matter

Contact Address: Andreas Fliessbach, Research Institute of Organic Agriculture (FiBL), Dept. of Soil Sciences, Ackerstrasse 113, CH-5070 Frick, Switzerland, e-mail: andreas.fliessbach@fibl.org

Soil Physical Properties under a Long-Term System Trial Comparing Organic and Conventional Management in India

STEFFEN A. SCHWEIZER[1,5], NISAR A. BHAT[2,5], BHUPENDRA S. SISODIA[3], SABINE ZIKELI[1], GEORG CADISCH[4], GURBIR S. BHULLAR[5]

[1] *University of Hohenheim, Co-ordination for Organic Farming and Consumer Protection, Germany*

[2] *Government Holkar Science College (DAVV Indore), Dept. of Botany, India*

[3] *bioRe Association, India*

[4] *University of Hohenheim, Inst. of Plant Production and Agroecology in the Tropics and Subtropics, Germany*

[5] *Research Institute of Organic Agriculture (FiBL), Dept. of International Cooperation, Switzerland*

Agricultural systems with deteriorating carbon stocks lead to unstable soil structure in India. Especially in 'black cotton soils' the stability of aggregates and pores is critical for soil fertility due to a high slaking risk. Therefore, a higher input of biomass resulting in higher soil organic carbon (SOC) is advocated e.g. by biodynamic and organic farming. Higher SOC in turn influences soil physical parameters. This study analysed whether organic farming leads to (i) lower bulk density, (ii) higher surface area of cracks, (iii) higher infiltration, and (iv) lower erosion during rain compared to conventional farming. Various structural properties of the soil were determined in field plots of a long-term trial, which were 7 years under four farming systems: biodynamic, organic, conventional, and conventional farming with Bt cotton. The long-term experiment follows a two-year crop rotation comprising cotton-soybean-wheat. While the conventional systems receive mainly mineral fertilisers, the biodynamic and organic systems are fertilised with fresh and composted organic manures. To analyse soil structure bulk density was determined by core method, crack volume by image analysis, infiltration with double ring infiltrometers, and surface runoff by simulated rain. Preliminary results showed that the bulk density under wheat was similar in all systems after irrigation but was 5 % higher in the conventional than in the organic systems 28 days after irrigation. Image analysis of cracks is in progress. The linear regression slope of water infiltration rate (logarithmized time) increased 8 times from irrigation to 39 days later. Then, in unsaturated state the conventional systems showed a 25 % higher infiltration slope under wheat. However, in the furrows of the cotton crop the organic systems showed a 73 % higher infiltration slope. The surface runoff of a simulated rain event (100 mm h^{-1}) ranged from 3.5 to 8.5 mm with a soil content of 113 to 219 g m^{-2}, but showed no significant differences between treatments. This study suggests a higher impact of organic farming on bulk density and infiltration when soil is in unsaturated and shrunk state. Further results, the possibilities of assessing physical soil parameters in the field, and their contribution towards sustaining soil fertility will be discussed.

Keywords: Bulk density, longterm experiment, organic farming, soil structure, Vertisol

Contact Address: Steffen A. Schweizer, University of Hohenheim, Co-ordination for Organic Farming and Consumer Protection, Fruwirthstraße 14-16, 70599 Stuttgart, Germany, e-mail: schweizer.steffen@gmx.de

Availability and Management of Silicon Nutrition to Rice Plants in Contrasting Southeast Asian Regions

REINHOLD JAHN[1], THIMO KLOTZBÜCHER[1], ANIKA MARXEN[2], LEUTHER FREDERIC[2], DORIS VETTERLEIN[2]

[1] *University of Halle (S.), Institute of Agricultural and Nutritional Sciences, Germany*
[2] *Helmholtz Centre for Environmental Research - UFZ, Soil Physics, Germany*

Silicon (Si) is a beneficial element for rice plants. The plant accumulates up to 10 % Si, which precipitates in plant tissue forming amorphous Si bodies, so-called 'phytoliths'. A sufficient Si supply can enhance the strength and rigidity of rice plants, improve their resistance against pathogens, the efficiency of fertilisers, and prevent the uptake of toxic metals.
Our aim is to develop recommendations on an adequate management of Si in contrasting regions.
Plant-available Si concentrations in the fields were significantly higher in the Philippines than in Vietnam; differences between both countries are much larger than differences within the regions. We refer this finding to differences in geo- and pedologic conditions between both countries. In Vietnam, soil material derived from older land surfaces and are in comparison to the Philippines stronger weathered and thus desilicated. In the Philippines, soils were more recently formed and are in parts influenced by active volcanism and therefore high amounts of plant-available Si are released during mineral weathering. Also Si concentrations of rice plants were higher in the Philippines than in Vietnam. Si concentration in straw positively correlates with concentration of plant-available Si up to a level of 9–10 % Si in plants and 0.3 g kg^{-1} acetate-extractable Si in soils. Higher concentrations of plant-available Si do not lead to an increase of Si uptake. Moreover, variation in plant-available Si status within regions might be due to management of rice straw (i.e., some farmers burn the straw, some export part of the straw or ash from fields). The straw comprises about 70 % of total plant Si uptake. Results of laboratory and field experiments on silicon cycling, effects of phytoliths addition (with rice straw or ash from rice straw) and of easily dissolvable silica-gel addition to topsoils on Si in soil solution, plant-Si-uptake, and plant growth will be presented.

Keywords: Paddy, Philippines, phytoliths, silicon, Vietnam

Contact Address: Reinhold Jahn, University of Halle (S.), Institute of Agricultural and Nutritional Sciences, Von-Seckendorff-Platz 3, D-06120 Halle (Saale), Germany, e-mail: reinhold.jahn@landw.uni-halle.de

Soil Attribute Changes and Effect on Plant Production in the Littoral Wetland of Lake Naivasha

CHRISTIAN DOLD, MATHIAS BECKER

University of Bonn, Inst. Crop Sci. and Res. Conserv. (INRES), Germany

Lake Naivasha is a freshwater lake in the East African Rift Valley, which was affected by a continuously declining water level from 1980 to 2011. The newly exposed littoral land area has been gradually put under agricultural use by pastoralists and small-scale farmers, forming chronosequences of land use with distance to the lake shore (space-for-time approach). Transects representing land use durations of 0 – 30 years were established on pasture and cropland comprising soils of both alluvial and lacustrine origin. We assessed changes in soil moisture, carbon and nutrient content in a field study (November 2010 to December 2011) and additionally assessed the responses of kikuyu grass and maize in potted topsoil in a greenhouse experiment. With distance from the lake shore and increasing duration of land use there was a significant decline ($p < 0.05$) in soil organic carbon (SOC), permanganate oxidised and non-oxidised carbon as well as N contents under both pasture and cropland uses, following a model of exponential decay. Additionally, carbon in particulate organic matter (POM C) in all fractions decreased, revealing that both labile sand-bound and stable silt- and clay-bound carbon were affected. The decay rates did not differ between soil and land use types. Observed changes in plant-available Olsen P were not related to the duration of land use. Only the resin adsorbed P fraction decreased significantly with land use duration on lacustrine pasture and was associated with changes in SOC and soil moisture. On chronosequence positions $\geq$ 20 years the topsoil dried up temporarily. In croplands, this water deficit could be partially compensated by supplementary irrigation. The dry matter accumulation of both kikuyu grass (proxy for pasture vegetation) and maize (proxy for crops) in potted soil declined with duration of land use and was significantly related to soil nitrogen. The continuous agricultural use of the littoral wetland zone of Lake Naivasha is likely to entail declining production potentials for both pastures and food crops. The chronosequence model provides a suitable tool to study edaphic and hydrological change processes and their impact on plant production.

Keywords: Carbon, chronosequence, nitrogen, phosphorus, soil moisture content

Contact Address: Christian Dold, University of Bonn, Inst. Crop Sci. and Res. Conserv. (INRES), Karlrobert-Kreiten-Strasse 13, 53115 Bonn, Germany, e-mail: s7chdold@uni-bonn.de

Substrate Specification of Different Hydrogeomorphic Peatland Types in KwaZulu-Natal (ZA) with Focus on Cultivation and Restoration

GABRIEL MARVIN[1], FRANZISKA FAUL[2], NIKO ROSSKOPF[1], JUTTA ZEITZ[1]
[1]*Humboldt-Universität zu Berlin, Inst. of Agriculture and Horticulture, Germany*
[2]*Universität Potsdam, Institute of Earth- and Environmental Science, Germany*

More than two third of the South African peatland resources are found on the Maputaland Coastal Plain in the province KwaZulu-Natal. Overall, there are about 22.500 ha of peatlands, varying from the size of less than 1 ha up to 8.800 ha. With their ecosystem functions they render precious services to local communities, especially the provision of freshwater, fertile ground and natural building material. However, peatlands in this region are menaced by a broad range of threats, mostly due to human activities, like inappropriate cultivation practices and the spread of eucalyptus plantations. As a consequence, the soils of the peatlands face degradation and the loss of their ecological functions.
As part of the AllWet-RES project (Alliance for Wetlands – Research and Restoration), the Humboldt-University Berlin covers the soil related research-objectives to find out more about the response of degraded peatland soils to possible rewetting measures and to develop recommendations on more sustainable cultivation practices. According to their hydrogeomorphic setting, peatlands develop different characteristics. So far we selected three hydrogeomorphic peatland types (HGMT), namely "interdune depression", "unchanneled valley-bottom" and "channeled valley-bottom". Further, a distinction between nature-near and degraded sites was made as well. All together six sites were investigated. Each site was examined along 1–3 transects. In total 128 soil-profiles were cored. In doing so, a first characterisation of the substrates, their degree of decomposition, their stratigraphy and the soil structure were made. Further, typical soil profiles for each site were sampled to determine physical and chemical properties, such as bulk density, saturated hydraulic conductivity, water retention characteristics, hydrophobicity and C, N contents, in the laboratory. Especially the knowledge of the physical soil properties, which yield information on the water movement in the soil, is crucial for the development of recommendations on more sustainable land use and appropriate restoration measures. By the end of the project in 2015 the results should provide the pedological basis for the designing of restoration principles and wise use concepts for peatlands in Maputaland.
We would like to present and discuss intermediate results of our research.

Keywords: Peatlands, soil properties, South Africa

Contact Address: Gabriel Marvin, Humboldt-Universität zu Berlin, Inst. of Agriculture and Horticulture, Blücherstraße 13, D-10961 Berlin, Germany, e-mail: marvin.gabriel@agrar.hu-berlin.de

Influence of Water Harvesting and Soil Fertility Management on the Performance of Wheat in Kenya

PATRICK AWUOR OORO[1], RHODA BIRECH[2], JOYCE MALING'A[3], JÖRN GERMER[4], BERNHARD FREYER[5], KIBET NGETICH[6], RAEL TAIY[7]

[1]*Kenya Agricultural Research Institute (KARI), Kari-Njoro, Kenya*
[2]*Egerton University, Crops, Horticulture and Soil Chemistry, Kenya*
[3]*Kenya Agricultural Research Institute Njoro-Kenya, Biotechnology, Kenya*
[4]*University of Hohenheim, Inst. of Plant Prod. and Agroec. in the Trop. and Subtr., Germany*
[5]*University of Natural Resources and Life Sciences (BOKU), Division of Organic Farming, Austria*
[6]*Egerton University, Sociology and Anthropology, Kenya*
[7]*Ministry of Agriculture, Agricultural Sector Development Support Programme, Uasin Gishu County, Kenya*

Cropping systems in Njoro sub-county of Kenya are based on cereal-root crop alternating between the long (LRS) and short rain seasons (SRS) using di-ammonium phosphate and calcium ammonium nitrate. Cereals (maize) are usually sown at the beginning of the LRS as either monocrop or sole crop while wheat is planted as a monocrop. Potato crop is usually planted during the SRS as a sole crop when rain fall is becoming increasingly unpredictable and with prolonged drought periods while the nutrient and organic matter-impoverished soils have very low water holding capacity. In view of the foregoing, a study was conducted at the Kenya Agricultural Research Institute (KARI) to develop climate smart - soil nurturing technologies for small scale farmers. Four factors were studied and included (1) water harvesting (WH=no ridge and tie ridge), (2) crop rotation (CR) lablab-potato-wheat-potato-lablab-potato; wheat-lablab-potato-lablab-wheat-potato; wheat-potato-lablab-potato-lablab-potato), (3) intercrop (IC= with or without intercrop) and (4) soil fertility management (SFM) = which included four treatments such as untreated control, farm yard manure (FYM) at 5 t ha^{-1}, green manure (*Leuceana triachandra*) at 2.5 t ha^{-1} in the main season. The treatments were replicated three times in a split-plot design. This paper informs on data generated on WH and SFM from the 2013 season (July-November) during which the mean rainfall was 568.5 mm with mean minimum and maximum temperatures of 9.2 and 21.8°C, respectively. The data was subjected to an analysis of variance (ANOVA) using SAS statistical package. Results show that all the yield components of wheat and *Lablab purpureus* (cv DL1002) were not influenced significantly ($p > 0.05$) by WH and SFM strategies. Soil moisture accumulation was higher in the tie-ridged than non tie-ridged plots, however, it improved more with the incorporation of green manure (*Leuceana triachandra*). Grain yield of wheat was positively influenced by inorganic fertiliser (calcium ammonium nitrate) at 25 kg N ha^{-1} as opposed to the other organic sources. In the event of reduced or unreliable rainfall, use of water harvesting structures and organic sources of nutrients may be established to help conserve moisture to increase crop productivity.

Contact Address: Patrick Awuor Ooro, Kenya Agricultural Research Institute (KARI), Kari-Njoro, Nakuru-Njoro, 20107 Nakuru, Kenya, e-mail: paooro@yahoo.com

Keywords: Climate change, Dolichos, smallholder, wheat

Enhancement of Nitrogen Use Efficiency to Increase Yield and Maize Grain Quality in No-Till Systems

ALANA DAS CHAGAS FERREIRA AGUIAR[1], EMANOEL GOMES DE MOURA[2], ELIALDO SOUZA[3], ANÁGILA CARDOSO-SILVA[4]

[1]*Maranhão Federal University, Agrarian and Environment Science Center, Brazil*
[2]*Maranhão State University, M.Sc. Course in Agroecology, Brazil*
[3]*Paulista State University, Agriculture, Brazil*
[4]*Maranhão Federal University, Animal Science, Brazil*

In sandy loam soils of the humid tropics, adverse environmental effects such as low nitrogen use efficiency may impose severe constraints on the exploitation of quality protein maize (QPM) with higher lysine and tryptophan contents. The aim of this study was to test if the combined use of residues in no-tillage alley cropping systems would substantially enhance N use efficiency, grain protein content and grain yield in a sandy loam tropical soil prone to cohesion. We tested the QPM variety BR 473 under four tree leguminous species, *Leucaena leucocephala* (L), *Gliricidia sepium* (G), *Clitoria fairchildiana* (C) and *Acacia mangium* (A). The leguminous species were arranged in mixed rows, with or without urea (U). The experiment was arranged in a randomised complete block design with 10 treatments and four replicates: L+C+U, L+A+U, G+C+U, G+A+U, L+C, L+A, G+C, G+A, B+U, bare soil with urea; and control, bare soil without mineral fertiliser. These residue combinations also increased the protein yield. The increase in grain yield was more important than the influence of N nutrition on grain composition for achieving higher protein production. The great differences among residue treatments indicated that the higher N uptake and also the higher yield of the gliricidia + clitoria + urea treatment could not be accounted for only by the physical and chemical improvements of the root zone. Other factors, such as antagonistic interactions between species, may also be involved and will require further attention in future research. Therefore, to increase the protein yield in cohesive soils of humid tropical regions, the alley cropping system is effective when tree species that do not interact antagonistically with the crops but rather provide nutrients and improve the root environment are used.

Keywords: Alley cropping, leguminous, nitrogen nutrition, quality protein maize

Contact Address: Alana Das Chagas Ferreira Aguiar, Maranhão Federal University, Agrarian and Environment Science Center, BR 222 km 04 S/n, 65500000 Chapadinha, Brazil, e-mail: alanaaguiar@elo.com.br

How 23 Years of Different Soil Managements Affect a Tropical Acrysol? Lessons from a No-Tillage Experiment

CLÉRIO HICKMANN[1], MARCOS ALBERTO LANA[2], FRANK EULENSTEIN[2], ANGELIKA WURBS[2]

[1]*Universidade Federal de Lavras, Brazil*

[2]*Leibniz-Centre for Agricultural Landscape Research (ZALF), Germany*

No-tillage (NT) plays an important role in soil conservation, and is usually accredited to improve many soil parameters. The objective of this work is to verify the effect of 23 years of different soil management systems on chemical and physical soil parameters of an Acrysol in Coimbra, Brazil. The experiment uses four different soil management systems, namely no tillage (NT), one operation with disk plow (DP), one operation with disk harrow followed by disk plow (DH+DP) and two operations with disk harrow (DH). Soil samples were collected at different depths (0–5, 5–10, 10–20 and 20–40 cm, respectively) for the following analyses: pH, levels of available P, K^+, Ca^{2+}, Mg^{2+}, exchangeable Al^{3+}, total organic carbon (TOC), texture, bulk density (BD), among others. The results were submitted to an analysis of variance and the means were compared by Tukey HSD test ($p<0,05$). The results indicate that soil management influenced several soil parameters, while others remained unaffected. Differences are mostly observed at the surface. As predictable, the TOC is significantly higher in the NT, but only at the superficial level. Regarding pH, and taking into account the soil in the region, NT was able to increase the pH level only superficially. This is explained by the deposition of lime applied when planting. The use of lime also influenced Ca, Mg and Al levels. For those parameters, NT presented at the more superficial depth better values (more suitable for agricultural production), while at other depths a turn-over is observed, especially in Al^{3+}. Regarding physical parameters, and as for the chemical parameters, differences between NT and other soil managements were more pronounced at superficial depths. As expected, BD in NT is significantly higher at the surface and it keeps the tendency to maintain the value at other depths. In opposition, other soil management systems present a lower BD at the surface, but rapidly increasing the values according the depth. With exception of BD at the most superficial depth, NT presented similar or better values for physical parameters. Overall, the results indicate that in long term NT is more suitable for agronomic purposes.

Keywords: Agricultural soils, no-tillage, organic matter, soil changes, tropical soils

Contact Address: Marcos Alberto Lana, Leibniz-Centre for Agricultural Landscape Research (ZALF e.V.), Land Use Systems, Eberswalder Str. 84, 15374 Müncheberg, Germany, e-mail: lana@zalf.de

Farmers' Soil Management Decision-Making and the Effects on Soil Fertility in Nyeri South District, Kenya

PIN PRAVALPRUKSKUL[1], TANJA LÜBBERS[1], PERNILLE NIELSEN SPANGSBERG[2], ANNE DAMGAARD MØLLER[1]

[1] *University of Copenhagen, Agricultural Development, Denmark*

[2] *Roskilde University, Dept. of Environmental, Social and Spatial Change, Denmark*

Soil degradation is known to be a major challenge for agricultural productivity in the Central Highlands of Kenya, an intensive and high-potential food production area. This study investigates factors that influence smallholder farmers' decision-making regarding soil management practices in Thuti Village, Nyeri South District, as well as the effects of their decisions on soil fertility. Questionnaire surveys, semi-structured interviews and participatory rural appraisal (PRA) tools were used to explore factors influencing soil management choices, while soil samples from six different maize plots were analysed to assess the existing state of soil fertility. Results showed that manure and fertiliser application were the most common soil fertility management practices, terracing and grass strips the most common soil conservation practices, and that intercropping was widespread. Factors found to influence the choice of practices include financial constraints in buying inputs and hiring labour, land fragmentation, and factors limiting awareness of and access to extension services such as old age. Women were found to have considerable decision-making power in the households surveyed, but some had less access to financial and extension resources; the role of gender calls for further investigation. Soil analysis results revealed that despite the restrictions farmers face in soil management, the current status of soils is fairly fertile and suitable for agricultural production. This is likely due to the widespread use of manure, which is a relatively affordable nutrient input for farmers. Findings suggest that continued land fragmentation and loss of labour due to increasing age of farmers and the movement of youth away from agriculture may limit investment in soil conservation, with future implications for greater soil erosion in an already erosion-prone area. Policy and extension recommendations for soil and agricultural management should address these trends and restrictions, such as by suggesting multi-purpose practices that require little additional inputs.

Keywords: Central Highlands, decision-making, Kenya, smallholder farmers, soil conservation, soil fertility, soil management

Contact Address: Pin Pravalprukskul, University of Copenhagen, Sustainable Development in Agriculture, Cigales 337, 2 Place Viala, 34060 Montpellier Cedex 2, France, e-mail: ppravalp@wellesley.edu

Developing Climate-Smart Crop-Livestock Systems for Smallholders in the Tropics through Regulation of Nitrification in Soil

IDUPULAPATI RAO[1], JACOBO ARANGO[1], MANABU ISHITANI[1], MARGARET WORTHINGTON[1], JOHN MILES[1], MICHAEL PETERS[1], JOE TOHME[1], MARIO CUCHILLO HILARIO[1], ARACELY CASTRO[1], GLENN HYMAN[1], JEIMAR TAPASCO[1], JORGE DUITAMA[1], DANILO MORETA[1], JONATHAN NUÑEZ[1], MICHAEL SELVARAJ[1], REIN VAN DER HOEK[2], HANNES KARWAT[3], ALVARO RINCÓN[4], REYNALDO MENDOZA[5], MAURICIO SOTELO[1], DANIEL VERGARA[1], PAOLA PARDO[1], GONZALO BORRERO[1], GUNTUR SUBBARAO[6], GEORG CADISCH[3]

[1]*International Center For Tropical Agriculture (CIAT), Colombia*

[2]*International Center for Tropical Agriculture (CIAT), Central America, Nicaragua*

[3]*University of Hohenheim, Inst. of Plant Production and Agroecology in the Tropics and Subtropics, Germany*

[4]*Corporación Colombiana de Investigación Agropecuaria (Corpoica), Colombia*

[5]*National Agricultural University, Nicaragua*

[6]*Japan International Research Center for Agricultural Sciences (JIRCAS), Japan*

It is widely recognised that crops use less than 50 % of applied nitrogen (N) fertiliser, and the estimated economic value of this "wasted N" globally is US$90 billion annually. Worse still, this "wasted N" has major effects on the environment. CIAT researchers and their collaborators in Japan reported a major breakthrough in managing N, benefiting both agriculture and the environment. Termed "Biological Nitrification Inhibition" (BNI), this is a mechanism by which certain plants naturally inhibit the conversion of N in the soil from a stable form of ammonium to a mobile form of nitrate and a potent greenhouse gas, N_2O. *Brachiaria humidicola* (Bh) is well adapted to the low-nitrogen soils of South American savannahs and has shown high BNI-capacity among the tropical grasses tested. The major nitrification inhibitor released from Bh is brachialactone, a cyclic diterpene. Reduction of N loss from the soil under a Bh pasture has a directly beneficial environmental effect. We hypothesise that conservation of soil N will have additional positive impact on a subsequent crop (e.g., maize). Presently, recovery of fertiliser N and the impact on crop yield is not known. The goal of our interinstitutional and multidisciplinary project, targeting small-scale farmers, is to develop the BNI innovative approach using Bh forage grass hybrids to realise sustainable economic and environmental benefits from integrated crop-livestock production systems.

The project started in March 2012 and we intend to report the major achievements from the following outputs of the project.

Contact Address: Idupulapati Rao, International Center for Tropical Agriculture (CIAT), Tropical Forages, A A 6713 Cali Colombia, NA Cali, Colombia, e-mail: i.rao@cgiar.org

1. Rural livelihood benefits enhanced by involving small-scale farmers as decision makers and co-researchers in the integration of new Bh hybrids in smallholder crop-livestock systems.
2. Bh hybrids with different levels of BNI identified.
3. Quantitative trait loci (QTL) associated with the BNI trait identified and molecular markers developed for Bh hybrid selection.
4. Indicators of BNI activity developed for use under field conditions based on the role of BNI in improving the efficiency of utilisation of fertiliser N while reducing N_2O emissions from agricultural production systems.
5. Application domains of BNI technology in crop-livestock systems identified, potential economic benefits assessed and local capacity to evaluate BNI strengthened.

Keywords: *Brachiaria*, molecular markers, nitrogen use efficiency, nitrous oxide emissions, participatory evaluation

Foliar Application of Soluble Forms of Calcium Alleviates Boron Toxicity in Pistachio Seedlings

KEIVAN MOHIT RABARI[1], MAHMOUD REZA ROOZBAN[1], MOHAMMAD KAZEM SOURI[2]

[1] *University of Tehran, College of Aburaihan, Dept. of Horticulture, Iran*

[2] *Tarbiat Modares University, Dept. of Horticultural Science, Iran*

A great portion of pistachio growing regions in Iran is affected with boron toxicity. Increasing calcium to boron (Ca/B) ratio in plant tissues may alleviate the boron toxicity. Calcium by stabilising cellular membranes and control of ion channels activities prevents influx of excess boron to the cells. In the present study, foliar application of calcium amino-chelate and chloride in two concentrations were evaluated in alleviating boron toxicity in two pistachio species including 'Badami' (*Pistacia vera* L. 'Badami') and 'Atlantica' (*P. atlantica* subsp. 'atlantica'). The concentrations of $CaCl_2$ applied were 1.1 and 2.2. g l^{-1} and the corresponding concentrations of Ca-amino-chelate were 0.5 and 1 %. Boron was also added to the irrigation water as boric acid in concentrations of 20 and 40 mg l^{-1}. Based on the obtained results, foliar application of Ca amino-chelate at 1 % concentration and $CaCl_2$ in 2.2 g l^{-1} showed the highest alleviation effect on the boron toxicity in the leaf tissues. The Ca amino-chelate were found to be more effective in reducing boron toxicity than $CaCl_2$. Foliar sprays of soluble forms of calcium resulted in plants with higher height, more leaf number and area, and longer roots. However, there were no significant differences found between the treatments for proline content, relative water content and osmotic potential of the leaves. In aggregate, foliar application of soluble forms of calcium, reduced boron contents in the leaves, stems and roots of pistachio seedlings. Comparing two species indicated that the 'Atlantica' is less sensitive to boron toxicity than 'Badami'.

Keywords: Boron excess, Ca amino-chelate, calcium chloride, *Pistacia atlantica*, *Pistacia vera*

Contact Address: Mahmoud Reza Roozban, University of Tehran, College of Aburaihan, Dept. of Horticulture, Pakdasht, Iran, e-mail: mroozban@ut.ac.ir

Poverty-Driven Dependence on Agricultural Waste Streams: A Challenge for Soil Fertility Management to Smallholder Farmers

ABEBE NIGATU[1], SANDER BRUUN[1], THOM KUYPER[2], LIJBERT BRUSSAARD [2], ANDREAS DE NEERGAARD[1]

[1]*Copenhagen University, Plant and Environmental Science, Denmark*

[2]*Wageningen University, Soil Quality, The Netherlands*

Many smallholder farmers in developing countries do not apply sufficient amounts of manure and compost on farmlands. Previous studies identified lack of education, shortage of manure and labour as the main causes. In addition, use for competitive purposes influence farmers' decision to utilise wastes as soil amendment. Thus, the objectives of the study were (i) to quantify partial nutrient balances across different urban farming systems (ii) to investigate competitive purposes of agricultural wastes and farmers' preference for waste utilisation (iii) to identify determinants that influence farmers´ decision to use agricultural wastes as fertilisers (iv) to determine willingness of farmers to participate in composting of non-agricultural waste (i.e urban waste). The data were collected from 220 urban farmers in Addis Ababa, Ethiopia. Four categories of urban farmers namely, (i) subsistence farmers growing cereals (ii) vegetable producers (iii) ornamental plant growers (iv) farmers practicing mixed farming were identified using principal component and cluster analysis. Since inorganic and organic fertilisers were applied below the recommended rates, partial nutrient balances were negative for nitrogen (N) and potassium (K) and slightly positive for phosphorus (P) in all farming systems. Use of agricultural wastes for fuel, animal feed and source of income were the main causes for insufficient application of organic fertilisers. Seventy-one percent of farmers preferred to use agricultural wastes as fuel and animal feeds rather than soil amendment. Farmers' experiences with soil fertility issues, farm distance from home, sex, access to extension services and farming strategy were the socioeconomic factors that influenced farmers' decision to use agricultural wastes as fertiliser. Interestingly, about 60 % of farmers were willing to apply urban waste compost on their farmlands. Nevertheless, willingness of farmers to contribute money/labour for production of urban waste compost varied significantly ($p < 0.01$) across different farmer categories. Education, access to extension service, land tenure and farmers' perception towards compost influenced farmers´ willingness to participate in urban waste composting programs. Therefore, urban waste compost should be considered as alternative soil amendment and we recommend that it is supported through economic incentives or legislation.

Keywords: Competitive use, compost, manure, organic resources, smallholder urban farmers, urban waste

Contact Address: Abebe Nigatu, Copenhagen University, Plant and Environmental Science, Bülowsvej 17, 1870 Copenhagen, Denmark, e-mail: nigatu@plen.ku.dk

The Potential for Organic Production of Savory (*Satureja hortensis*) in Iran

MOIEN NAIEJI, MOHAMMAD KAZEM SOURI
Tarbiat Modares University, Dept. of Horticulture Sciences, Iran

Savory knows a high demand on local markets of Iran, as fresh vegetable or as a valuable medicinal plant. The genotypes used are mainly local genotypes. Improvement of savory quality such as fresh life and less browning is of interest, particularly for fresh consumption. It seems that similar to any other agronomic crops, its yield and quality is improved by application of chemical or organic fertilisers. The current study was done under greenhouse conditions to evaluate the effect of organic and biological fertilisers on some morphologic and physiologic traits in savory during 2013. Treatments were control (without fertiliser application), NPK fertiliser, vermicompost at 20 and 40 % of pot volume, manure at 20 and 40 % of pot volume, and phosphate biofertiliser (Barvar 2). The results showed that plant height, leaf area, number of leaves, fresh weight, stem diameter, P and N concentration in shoots were significantly influenced by treatments, but shoot dry weight and K concentration was not affected. The highest plant height, leaf number, leaf area, fresh and dry weight and N concentration was found for the vermicompost 20 % treatment. Further, the highest stem diameter was found with the application of manure 20 %, the highest chlorophyll index and P concentration with biophosphate, and the highest K concentration with vermicompost 40 %. The results revealed that savory seed germination and early establishment is very sensitive to application of chemical and organic fertilisers, resulting in damping off and die back of most of seedlings. This indicate that savory is a good candidate for organic production in Iran using biofertilisers.

Keywords: Biophosphate, fresh and dry weight, manure, NPK, savory, vermicompost

Contact Address: Mohammad Kazem Souri, Tarbiat Modares University, Dept. of Horticultural Science, Tehran, Iran, e-mail: mk.souri@modares.ac.ir

Strains of *Trichoderma* sp. and their Capacity to Mobilise Phosphorus

MAURICIO CRUZ[1], MARTHA GÓMEZ[1], CARLOS MORENO[1], BETTINA EICHLER-LOEBERMANN[2]

[1]*Corpoica Colombia, Center of Biotechnology and Bioindustry, Colombia*

[2]*University of Rostock, Fac. of Agricultural and Environmental Sciences, Germany*

Soil microorganisms may enhance the plant availability of phosphorus (P). This ability is related to the production of organic acids and the activity of phosphatases. Whereas organic acids affect the pH and the solubility of mineral P compounds, phosphatases control the organic P mineralisation. We evaluated 21 strains of *Trichoderma* sp. regarding their potential to increase the P availability. At first, Petri dishes with NRBIP medium were inoculated with the fungi to estimate the solubilisation of $Ca_3(PO_4)_2$ by measuring halo zones after 8 days incubation. Four promising strains belonging to *Trichoderma koningiopsis* sp. (Th003 and Th013) and *Trichoderma asperellum* (Th019 and Th204) were selected for further investigations. To quantify the phosphate solubilisation capacity 50 mL of NRBIP liquid medium were inoculated with the fungi and the concentration of ortho-P (mg mL^{-1}) were measured after 5 days of incubation. Activities of acid and alkaline phosphatases (in units (EU) of p-nitrophenol mol min^{-1} L^{-1}) were determined by using Pikovskaya's culture. Finally, the effect of these four strains of *Trichoderma* sp on the plant growth of maize (*Zea mays*) and tomato (*Solanum lycopersicum*) were evaluated under greenhouse conditions. Highest ortho-P concentrations of more than 100 mg mL^{-1} were measured for Th013 and Th204, whereas the ortho-P concentrations for Th003 and Th019 were lower than 20 mg mL^{-1}. The strain Th013 also showed a higher activity of acid phosphatase than the other strains tested, with an EU value of 4.26, followed by the strain Th204 with a value of 1.01 EU. However, the strain Th013 was not superior regarding its effect on plant growth. Neither for maize nor for tomato increased values for shoot or root weight and length, number of leaves or stem diameter were found when Th013 was applied. Probably, the plant available P concentration in soil was not the limiting factor and clearer results can be expected on soils with lower P contents.

Keywords: Phosphatases, phosphorus, *Trichoderma*

Contact Address: Bettina Eichler-Loebermann, University of Rostock, Fac. of Agricultural and Environmental Sciences, J. von Liebig Weg 6, 18059 Rostock, Germany, e-mail: bettina.eichler@uni-rostock.de

The Dynamics of Residue Decomposition under Aerobic and Anaerobic Systems

ELSA RAKHMI DEWI, SARA HUESO, ANTHONY WHITBREAD
Georg-August-Universität Göttingen, Dept. for Crop Sciences: Tropical Agronomy, Germany

In lowland rice cropping systems, soil water content may vary widely between aerobic and anaerobic conditions due to a shortage of rainfall or through management aimed at reducing water use. The effects of water content on soil chemistry and in particular carbon and nitrogen dynamics are profound but literature describing these effects on the dynamics of residue decomposition is scarce. Decomposition of residues mostly releases ammonium into the flooded soil. However, as soils become saturated with water, decomposition of residue is reduced due to limited aeration for microbial activity and concomitance enhances anaerobic metabolites such as volatile fatty acids, CH_4 and sulphide.

To determine the effects of aerobic and anaerobic conditions on dynamics of residue decomposition, a closed incubation system with treatments containing soil, soil + residues under aerobic or anaerobic conditions was conducted in the laboratory. Using 3 L incubation pots, 400 g of soil and 5 g of maize leaves were pre-incubated for 7 days and then measured for 19 days at a constant temperature of 25C. To create aerobic soil conditions, soil water content was maintained at 50 % of water holding capacity, while to create anaerobic conditions, the pots were flooded with water to 2 cm above the soil surface. On days 1, 2, 3, 5, 8, 10, 12 and 19, incubation pots were opened and flushed with air and then closed for 1 h prior to the collection of gas samples from the headspace. The headspace was sampled at 0, 2, 4 and 6 hours and analysed by gas chromatography.

Treatments containing soil+residues had higher gas accumulation compared to control treatments (soil only). Accumulation of CO_2, CO_2+CH_4 and N_2O was higher under aerobic than anaerobic condition with the addition of residues but were similar in the control treatments. Of the total carbon added in soil and residues, 15 % and 13.5 % of carbon released from maize residues under aerobic and anaerobic conditions respectively over 19 days incubation. Further study is underway to further investigate the effects of aerobic and anaerobic condition on the dynamics of residue decomposition of diverse crop residues over longer periods.

Keywords: Closed incubation system, aerobic, anaerobic, gas chromatography, residue decomposition

Contact Address: Elsa Rakhmi Dewi, Georg-August-Universität Göttingen, Dept. for Crop Sciences: Tropical Agronomy, Grisebachstr. 6, 37077 Göttingen, Germany, e-mail: edewi@uni-goettingen.de

Converting Sand into Gold: The Case of Sand Bar Cropping in Bangladesh

SATTAR MANDAL[1], MATTHIAS KLEINKE[2]

[1]*Bangladesh Agricultural University, Mymensingh, Agricultural Economics, Bangladesh*
[2]*Rhine-Waal University of Applied Sciences, Fac. of Life Sciences, Germany*

In a land scarce country like Bangladesh, the increasing population pressure causes rapid decline of arable land, which renders average farm size to about half a hectare. Per capita availability of cultivable land is further reduced due to severe land erosion and thick sand deposits caused by annual floods in the big river systems. One such vulnerable and unstable sand bars, popularly called chars, spreads along the two sides of the mighty Brahmaputra and Teesta river system, which leave out about 180,000 hectares of land largely barren during the dry season. The inhabitants in the vicinity of the sand bars are extremely vulnerable to frequent displacement of settlement from one location to another. These 'lands' are mostly newly accreted common property resources, while some are privately owned but can hardly be used for crop production due to sand deposits. The new technology of digging 2–3 feet deep compost pits served with temporary low- cost pump irrigation allows pumpkin seeds to grow from down the pit and then creep up over the sand to produce suitable pumpkins (sweet gourd). The cultivation of pumpkins in some locations of the vast tracts of sand bars, is significantly contributing to household food security, income and employment of family members, especially women. The utilisation of these sand bars demonstrates the development of new production systems under land scarcity pressure.
This paper illustrates the unfavourable landscape, socioeconomic background of the extremely poor pumpkin producers, inputs and technology support for pumpkin production, low-cost technology for creating irrigation water source in sand bar, storage of pumpkins, and development of pumpkins supply chains. The paper does also suggest also potential areas of further collaborative research into sand bar cropping with vegetables and fruits, value addition and agribusiness development.

Keywords: Converting sand into gold, low-cost technology, sand bar cropping, women labour

Contact Address: Sattar Mandal, Bangladesh Agricultural University, Mymensingh, Agricultural Economics, B-6, Arambag Housing, Main Road, Mirpur-7, 1216 Dhaka, Bangladesh, e-mail: asmandal11@gmail.com

Application of Poultry Manure with Zeolite Reduces the Use of Commercial Fertilisers and Improves the Soil Fertility in Organic Sugar Cane Production

LILIBET PÉREZ-GARLOBO[1], ONELIO FUNDORA[1], YORDÁN RAMALLO[1], ILIÁ LUGO[1], BETTINA EICHLER-LOEBERMANN[2]

[1] *University of Santa Clara, Fac. of Agriculture, Cuba*

[2] *University of Rostock, Fac. of Agricultural and Environmental Sciences, Germany*

The enterprise "Carlos Baliño", which is the only producer of organic sugar cane in Cuba, carries out various projects focussing on technologies for the sustainable management of sugar cane plantations. To fulfil the international standards expensive imported products are applied, such as the bio stimulant of organic origin Enerplant®, produced in Mexico, and K_2SO_4 because of the common poverty of potassium (K) in Cuban soils and the high K demand of sugar cane. However, deposits of poultry manure absorbed in zeolite (Man-Zeo) exist as residues near the "Carlos Baliño" enterprise and could be applied in order to reduce the application rate of imported products. To evaluate the effect of Man-Zeo as single application and combined with K and Enerplant® an experiment under production conditions in macro plots was carried out on a Rhodic Eutrustox soil (organic matter 2.6%; pH 6.3; K content 60.0 mg kg^{-1}soil, H_2SO_4 extraction). The following treatments (single and in combination) were applied: control (without any application), K supply (100 kg ha^{-1}), K supply (50 kg ha^{-1}), Man-Zeo (5 t ha^{-1}, N 1.52%; P 2.01%; K 0.97 %), Enerplant® 1 dose, Enerplant® 2 doses. Plant and soil characteristics were investigated after the harvest of the sugar cane. The application of 5 t ha^{-1} Man-Zeo reduced the necessity of K application from 100 to only 50 kg ha^{-1} and the use of Enerplant® from two to one application. Enerplant® showed poor results when applied without further nutrients. The treatments including Man-Zeo increased the stability of soil aggregates, the bioavailable contents of P and K in soil and the diversity of soil macro fauna, mainly regarding the sub-class of *Oligochaeta*. The results showed the high potential of residues to improve soil fertility and plant growth.

Keywords: Fertiliser, organic, sugar cane

Contact Address: Bettina Eichler-Loebermann, University of Rostock, Fac. of Agricultural and Environmental Sciences, J. von Liebig Weg 6, 18059 Rostock, Germany, e-mail: bettina.eichler@uni-rostock.de

The Role of Trees in Homegardens on Soil Nutrient Improvement in Maytemeko Watershed, Northwestern Highlands of Ethiopia

MESERET KASSIE DESTA[1], HERBERT HAGER[1], MONIKA SIEGHARDT[1], BELAYNEH AYELE ANTENEH[2], DEMEL TEKETAY[3]

[1] *University of Natural Resources and Life Sciences (BOKU), Institute of Forest Ecology, Austria*

[2] *Bahir Dar University, Dept. of Natural Resources Management, Ethiopia*

[3] *Botswana College of Agriculture, Dept. of Crop Science and Production, Botswana*

Soil nutrient depletion is a major threat of Ethiopian highland soils that causes a decline in productivity, resulting in food insecurity problem in the country. Homegardens are among the most important agroforestry practices since they contain more diverse tree species compared to the open farm plots in Maytemeko watershed. Despite this reality, the influence of different tree species under farmers' traditional farm management level has not been documented in the area. The objective of this study was, therefore, to assess the status of soil nutrients in homegardens under and outside the canopies of different tree species, namely *Croton macrostachyus* Del., *Cordia africana* Lam., *Acacia abyssinica* Hochst. Ex. Benth., *Sesbania sesban* (L.) Merr. and *Eucalyptus camaldulensis* Dehnh. To compare the status of soil total nitrogen (N), organic carbon (OC), cation exchange capacity (CEC) available phosphorus (P) and exchangeable potassium (K^+), a total of 160 composite soil samples were collected from two soil depth classes (0-15 cm and 15-30 cm) at a distance equivalent to two thirds of the canopy radius from the trunk and in areas, which were relatively outside the influence of the tree canopies and root lateral growth. Mean value of all parameters were significantly different ($P < 0.05$) from soil samples collected under and outside the canopies of different tree species. Soil samples collected under the canopy of trees of *C. africana* showed relatively higher OC (32.4 mg g^{-1}) and N contents (3.0 mg g^{-1}) compared with those collected under trees of other species and outside tree canopies. The magnitude of contents of OC and N under soils of trees had the following order: A. *abyssiniaca* > *C. macrostachyus* > *S. sesban* > *E. camaldulensis*. Soil samples collected outside the canopies of trees exhibited the lowest contents of OC (18.9 mg g^{-1}) and N (2.0 mg g^{-1}). Significant variation in the contents of N and OC was also observed in between soil samples collected from the two depth classes under and outside the canopies of different tree species. Soil samples under trees of *C. africana* also showed the highest P (0.054 mg g^{-1}) and CEC (16.6 cmolc kg^{-1}). The lowest values of P (0.033 mg g^{-1}) and CEC (11.7 cmolc kg^{-1}) were found from soil samples collected outside the canopies of trees while the highest value of K^+ was found from soil samples collected under *A. abyssinica*. Generally, soils under tree canopies of homegardens exhibited better nutrient status compared with those outside the canopies of trees.

Keywords: Agroforestry, cation exchange capacity, nitrogen, potassium, phosphorous, tree species

Contact Address: Meseret Kassie Desta, University of Natural Resources and Life Sciences (BOKU), Forest and Soil Sciences, Peter Jordan Street 82, 1190, Wien Vienna, Austria, e-mail: meseretkassie@gmail.com

Nutrient Capture Efficiency, Use Efficiency and Productivity in Sole Cropping and Intercropping of Rapeseed, Bean and Corn

SAMANEH NAJIB NIA[1], ALIREZA KOOCHEKI[2], MEHDI NASSIRI MAHALLATI[2], HASSAN PORSA[3]

[1]*Ministry of Education, Dept. of Education District 1, Iran*
[2]*Ferdowsi University of Mashhad, Dept. of Agronomy, Iran*
[3]*Ferdowsi University of Mashhad, Research Center for Plant Sciences, Iran*

In order to evaluate nutrient capture efficiency, use efficiency and productivity in sole cropping and intercropping systems of rapeseed (*Brassica napus* L.), bean (*Phaseolus vulgaris* L.) and corn (*Zea mays* L.), an experiment was conducted in the growing seasons of 2007–2008 and 2008–2009 at the Research Field of Faculty of Agriculture, Ferdowsi University of Mashhad, Iran.

The experiment was conducted as a randomised complete block design with three replications and six treatments including monoculture of rapeseed (sown 23 September) (I), monoculture of bean (sown in 30 April) (II) and monoculture of corn (sown in 30 April) (III) as sole cropping and also simultaneous intercropping of bean and corn (sown in 30 April) (IV), two-stage relay intercropping of rapeseed (sown in 23 September) and bean and corn (sown in 30 April) (V) and finally three-stage relay intercropping of rapeseed (sown in 23 September), bean (sown in 9 April) and corn (sown in 30 April) (VI). In this investigation, the indices of capture efficiency, use efficiency and productivity (based on total dry matter and seed yield) for nitrogen, phosphorus and potassium, and the land equivalent ratio were calculated. Sole cropping and simultaneous intercropping of bean and corn (III and IV) showed positive effects ($P \leq 0.01$) for all three indices as compared to the relay intercropping systems (V and VI). Nitrogen productivity for bean and corn was highest for the simultaneous intercropping system, 4.3 kg kg^{-1} and 20.4 kg kg^{-1}, respectively, and significantly different ($P \leq 0.01$) to the relay intercropping systems. Phosphorus productivity for rapeseed, bean and corn was highest in the sole cropping systems, 31.6 kg kg^{-1}, 22.5 kg kg^{-1} and 77.1 kg kg^{-1}, respectively, as compared to the relay intercropping systems ($P \leq 0.01$). Overall, the results indicated that among intercropping combinations, simultaneous intercropping showed superiority compared to relay intercropping combinations ($P \leq 0.01$) in terms of nitrogen productivity and phosphorus productivity in corn and nitrogen productivity in bean. It is recommended to use simultaneous intercropping farming systems rather than sole cropping in this region to take advantage of its benefits.

Keywords: Capture efficiency, capture productivity, nitrogen, phosphorus, potassium, use efficiency

Contact Address: Samaneh Najib Nia, Ministry of Education, Dept. of Education District 1, Office of Education of Mashhad, 9188893554 Mashhad, Iran, e-mail: samanehnajibnia@yahoo.com

Conservation Agriculture: An Alternative for Soil Erosion Control in Steep-Slope Regions Cultivated by Small-Scale Farmers

RICARDO ROMERO PEREZ GROVAS, MIET MAERTENS
Katholieke Universiteit Leuven, Dept. of Earth and Environmental Sciences, Belgium

Agricultural activities in steep-slope regions of the world have been increasing in recent years. When cyclical crops are produced in these regions, high soil erosion rates become a constant threat. There is an extended body of literature that proposes reforestation or plantations with perennial crops as potential solutions. However, such approaches fail to meet the needs of the small-scale farmers in these regions who rely on cyclical crops to produce the lion's share of their food.

Another commonly used measure to tackle erosion is the construction of physical barriers – a solution that demands substantial investment, for both for its implementation and maintenance. One alternative solution is conservation agriculture (CA), which is a cropping system based on three principles: 1) minimal soil disturbance; 2) crop rotations and/or intercropping, and 3) permanent soil cover through crop residue management.

Using longitudinal statistical analysis and controlling for climatic factors, this research – based on survey data (154 observations) collected in 1994 and 2008 within two *ejidos* of Motozintla in the state of Chiapas, Mexico – found that under CA, maize (*Zea mays*) and bean (*Phaseolus vulgaris*) yields had remained at minimum consistent, and in some cases had increased over time. The maize yields reached 3.3 ton ha^{-1}, whilst bean reached 262 kg ha^{-1}. The maize yields were also consistently higher than the long-term state's average from 1987 to 2012 of 2.3 ton ha^{-1}. Moreover, 99% of the farmers also perceived that CA had improved soil fertility; 93% noted that CA had increased soil moisture content, and 99% observed that CA had effectively controlled erosion.

The traditional system in these two *ejidos* presented a number of positive characteristics for facilitating CA implementation: no mechanisation was being utilized, intercropping was already a common practice, and the main competitor for crop residue use (ruminants) could eventually be substituted for other livestock such as pigs. This research provides evidence to demonstrate that long-term adoption of CA in a steep-slope region cultivated by small-scale farmers can help to control soil erosion whilst allowing the farmers to produce their staple crops.

Keywords: Chiapas, conservation agriculture, Mexico, soil erosion, steep-slopes

Contact Address: Ricardo Romero Perez Grovas, Katholieke Universiteit Leuven, Dept. of Earth and Environmental Sciences, Celestijnenlaan 200E, 3001 Heverlee-Leuven, Belgium, e-mail: rromeropg@gmail.com

Impact of "Biological Nitrification Inhibition" on N Recovery Efficiency, N Leaching and N_2O Emissions Using the Example of *Brachiaria humidicola*

KONRAD EGENOLF[1], HANNES KARWAT[1], FRANK RASCHE[1], GEORG CADISCH[1], DANILO MORETA[2], JACOBO ARANGO[2], IDUPULAPATI RAO[2]

[1]*University of Hohenheim, Institute of Plant Production and Agroecology in the Tropics and Subtropics, Germany*

[2]*International Center For Tropical Agriculture (CIAT), Colombia*

Biological Nitrification Inhibition (BNI) has been reported for several plant species. Amongst these the tropical forage grass *Brachiaria humidicola* has gained major attention due to its high BNI-activity. An increased N-recovery efficiency (reduced N-leaching) and reduced N_2O-emissions are proposed for *B. humidicola* based pastures. Breeding programs targeting on BNI-activity currently lack indicators suitable for large scale field evaluation. A promising approach could be the link between the plant ^{15}N-signature and its N-nutrition (ammonium versus nitrate). As both pools usually possess different isotopic signatures, the nutritional contribution of each N-pool should be reflected in the plant, thus indicating the magnitude of nitrification inhibition (BNI-activity). Objectives of the present study are the evaluation of selected *B. humidicola*-hybrids regarding their BNI-activity; the assessment of BNI's impact on N recovery efficiency, N-leaching and N_2O-emissions; and a correlation analysis on the relation between the plant's BNI-activity and its ^{15}N-signature.

The study was designed as a two phased greenhouse trial. In a first phase the plant *15*N-signatures were analysed and assessed in relation to the ^{15}N background signal of soil and fertiliser. In a second phase the fertilisation regime was switched to ^{15}N-labeled ammonium sulfate. This enabled tracing of N-fluxes, estimation of the hybrid's BNI-activity (via the nitrification rates) and determination of overall N recovery efficiency. N-leaching and N_2O-emissions were assessed in relation to the estimated BNI-activity.

Plants were cultivated in PVC-tubes (12cm * 100cm) on a ferralitic substrate. Nitrification rates and nitrate dislocation were derived on the basis of soil nitrate levels determined by regular sampling of soil solution through suction tubes installed at different depths within the soil column. Anion exchange resin bags were installed at the bottom of the column to quantify cumulative N-leaching. N_2O-emissions were quantified after irrigation inducing reducing conditions.

Keywords: *Brachiaria*, denitrification, N use efficiency, N_2O emissions, nitrification, nitrification inhibition

Contact Address: Konrad Egenolf, University of Hohenheim, Institute of Plant Production and Agroecology in the Tropics and Subtropics, Neuhauser Straße 23, 70599 Plieningen, Germany, e-mail: konrad.egenolf@uni-hohenheim.de

Effect of Early Mycorrhisation and Root Length on Low Phosphorus Tolerance of West African Millet

FRANCESCA BEGGI, ANDREAS BUERKERT

University of Kassel, Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, Germany

Phosphorus deficiency at early seedling stages is critical for final yield of pearl millet. Longer roots and colonisation with arbuscular mychorrizal (AM) fungi are well known to enhance P uptake and crop performance. Assessing the genotypic variation of early mycorrhisation and its effect on plant growth is important to clarify mechanisms of tolerance to low soil P. In this study, eight pearl millet varieties contrasting in tolerance to low P were grown in pots under low P (no P supply) and high P (0.4 g P pot^{-1}) conditions and harvested at two, four, six and eight weeks after sowing (WAS). Root length was calculated at 2 WAS through scanning of dissected roots and evaluation with WinRhizo software. AM infection (%) and P uptake (shoot P concentration multiplied per shoot dry matter) were measured at each harvest.

Under low P, tolerant genotypes had higher total root length infected with AM fungi across harvests (83.700 cm), higher percentage of AM colonisation (11.6 %) and increased P uptake (69.4 mg P $plant^{-1}$) compared to sensitive lines (17.700 cm, 7.1 % and 46.4 mg P $plant^{-1}$, respectively). At 2 WAS tolerant genotypes were infected more than sensitive ones (4.1 % and 2.1 %) and the tolerant genotypes differed in the timing of peak of infection. AM colonisation was positively related to final dry matter production in pots, which also corresponded to field performance. Early mycorrhisation enhances P uptake in pearl millet grown under P-deficiency, with the genotypic variation for this parameter allowing selection for better performance under field conditions.

Keywords: Acid soils, arbuscular mycorrhizal fungi, P deficiency, P use efficiency

Contact Address: Andreas Buerkert, University of Kassel, Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, Steinstraße 19, 37213 Witzenhausen, Germany, e-mail: tropcrops@uni-kassel.de

Interactive Effects of Polyacrylamide and Dicyandiamide on Soil Organic Matter and Nutrient Dynamics

FLORIAN WICHERN[1], YASHNEEIL SINGH[2], TOUFIQ IQBAL[3], CONOR WATSON[1], CHRISTOPH KNOBLAUCH[1], PETER FRIEDRICH SIMON[1]

[1]*Rhine-Waal University of Applied Sciences, Faculty of Life Sciences, Germany*

[2]*Indian Institute of Technology (IIT), Agricultural and Food Engineering Dept., India*

[3]*University of Rajshahi, Dept. of Agronomy and Agricultural Extension, Bangladesh*

Soil conditioners are increasingly used in agriculture. For example anionic polyacrylamide (PAM) is used to improve the water holding capacity of the soil and to decrease soil erosion especially under arid and semi-arid conditions. Dicyandiamide (DCD) is used to optimise nitrogen (N) use efficiency in intensively managed systems by reducing the biological activity of nitrifiers. As a consequence, the question arises, if addition of PAM increases mineralisation and if nitrification can be effectively managed using DCD in combination with PAM. This study therefore investigates the short term effects of PAM and DCD on carbon (C) and N mineralisation and on soil microbial properties after addition of maize straw and ammonium-sulphate fertiliser (AS) in an incubation experiment. A sandy soil was incubated for 28 days at 22 °C and 50 % water holding capacity. PAM was added to the soil at a rate of 100 % and 200 % of the recommended application rate. In addition, also maize straw, ammonium sulphate and DCD were added. Throughout the experiment, soil respiration was monitored. Microbial biomass C and N mineralisation was determined at the end of the experiment. Addition of maize straw increased soil respiration and the soil microbial biomass, whereas NH_4^+ addition decreased both these measures. On the other hand, DCD addition resulted in a decreased basal respiration but did not decrease the microbial biomass. As a consequence, DCD application reduced the metabolic quotient (qCO_2) an indicator of substrate use efficiency. Moreover, DCD addition reduced nitrification as expected. The decrease in soil respiration and nitrification indicated a reduction of the nitrifier activity in the soil. However, the added PAM increased mineralisation and nitrification, especially when applied without additional fertiliser and increased the nitrate content in the absence of maize straw, which indicated that PAM may increase nitrification. Moreover, PAM increased the metabolic quotient, indicating either microbial use of PAM or an increased relative activity due to stress or less efficient substrate use in the presence of PAM. The present study showed, that DCD can be an effective tool to reduce nitrification under conditions, where mineralisation is increased by addition of PAM.

Keywords: Microbial biomass, mineralisation, nitrification, nitrogen management, soil conditioner

Contact Address: Florian Wichern, Rhine-Waal University of Applied Sciences, Faculty of Life Sciences, Marie-Curie Str. 1, 47533 Kleve, Germany, e-mail: florian.wichern@hsrw.eu

Evaluation of Climate Adaptation Options for Cotton Cultivation in the Sudan Savannah of West Africa

ISAAC DANSO, THOMAS GAISER, HEIDI WEBBER, FRANK EWERT
University of Bonn, Inst. Crop Sci. and Res. Conserv. (INRES), Germany

In the Sudan Savannah region of West Africa, cotton is one of the most important cash crops. Some of the major constraints for its production are low soil fertility and intra and inter-annual rainfall variability. We evaluated the effect of tillage practices (contour and reduced tillage), nitrogen fertiliser regimes (no nitrogen 0-kg N ha^{-1}, moderate nitrogen -45 kg N ha^{-1} and high nitrogen -90 kg N ha^{-1}) and residue management (improved and standard) on the yield of a non-transgenic cotton variety FK 37, for two landscape positions (upslope and downslope) in the Sudan Savannah zone of Burkina-Faso (Dano) and Republic of Bénin (Dassari). The on-farm research managed experiment was carried out as split-plot design with four replications at each of the two sites. Across the two sites, both potassium and phosphorus fertilisers were applied to be non-limiting at 40 kg K_2O ha^{-1} and 60 kg P_2O_5 ha^{-1}. Contour tillage, improved residue and moderate nitrogen all improved yields at Dassari but only contour tillage and improved residue were significant ($p < 0.1$). At Dano, contour tillage, improved residue and moderate nitrogen also improved yield but none was found to be significant ($p < 0.1$). Across the two sites, interaction effects of tillage and slope position had significant ($p < 0.1$) effects on yield and aboveground biomass at harvest. Cotton yield from contour tillage planted at foot slope position gave the highest yield of 1.10 t ha^{-1} across sites and this was approximately 39 % higher than the lowest yield (0.79 t ha^{-1}) recorded by combined effects of reduced tillage and foot slope position. Even though the two sites belong to the same agro-ecological zone, treatment effects were site specific and this may be attributed to climate variability and different soil types. According to the results of this study, cotton should be cultivated with recommended fertiliser with improved residue management regardless of the landscape position.

Keywords: Climate change adaptation, landscape position, reduced tillage, residue management, Sudan savannah

Contact Address: Frank Ewert, University of Bonn, Inst. Crop Sci. and Res. Conserv. (INRES), Bonn, Germany, e-mail: fewert@uni-bonn.de

Nutritive Improvement Possibilities in Pasture Production Using Ammonia-Loaded Zeolite

IVA ZIVANOVIC[1], ALEKSANDAR SIMIĆ[1], VESNA RAKIĆ[1], VLADISLAV RAC[1], TORE KROGSTAD[2], ŽELJKO DŽELETOVIĆ[3]

[1]*University of Belgrade, Fac. of Agriculture, Serbia*

[2]*Norwegian University of Life Sciences, Fac. of Enviromental Science and Technology, Norway*

[3]*University of Belgrade, Inst. for the Application of Nuclear Energy, Serbia*

The farmyard manure (FYM) is an organic fertiliser produced on dairy farms, but it deplets due to large losses of ammonia during fermentation. Its application on pastures is a low-cost and sustainable source of nutritive matters, as it is part of the livestock - manure - plant cycle.

Natural zeolite - clinoptilolite is used in agriculture as soil conditioner and as nitrogen retaining medium for nitrogen fertilising improvements. In this study, clinoptilolite loaded with ammonia was used as a fertiliser and its influence on the growth of grass and legume species, was investigated.

Since two species are important for Serbian pastures and dairy production - Italian ryegrass (*Lolium multiflorum* Lam.) and red clover (*Trifolium pratense* L.), pot experiments were carried out to investigate the impact of ammonia loaded zeolite on their growth under controlled conditions. The experiment was conducted on two types of soil (Planosol and Dystric Cambisol) and it included four fertilising treatments: a) soil (control); b) soil+zeolite; c) soil+ammonia-loaded zeolite; d) nitrogen application by mineral fertiliser; all in 4 replications. The results suggest that different fertilising treatments could affect crop yield and its protein content. The yield of Italian ryegrass was higher on both experimental soils and the nitrogen application had a greater impact on this species. Unfavourable chemical properties of Dystric Cambisol had a negative impact on yield, so the effects of the treatments were reduced. The main goal of this study was to shed light on how zeolite added to FYM during the fermentation process affect crop yield. The results could serve as an indicator for the use of zeolite under field conditions on pastures.

Keywords: Farmyard manure, Italian ryegrass, red clover, zeolite

Contact Address: Iva Zivanovic, University of Belgrade, Fac. of Agriculture, Belgrade, Serbia, e-mail: lukic.b.iva@gmail.com

Agrobiodiversity and plant genetic resources

Regeneration and Agrobacterium-Mediated Transformation of Cowpea

ALEMAYEHU TERESSA NEGAWO, FATHI HASSAN, HANS-JÖRG JACOBSEN
Leibniz Universität Hannover, Plant Genetics, Plant Biotechnology, Germany

Cowpea (*Vigna unguiculata* L. Walp.), a widely grown multipurpose legume, is attacked by many insect pests during its life cycle and under storage. Insect resistance breeding has been limited by the lack of resistance traits in the cowpea gene pool. Alternatively, transgenic approaches can be used to close this gap via introducing genes from other pools. The recalcitrance nature of the cowpea to *in vitro* regeneration and transformation and varietal dependence of the existing protocols make, however, the transgenic approach quite challenging. Thus, in this study, we have optimised different regeneration and transformation conditions such as (a) the media for inoculation, co-cultivation and regeneration, (b) type of explants and (c) bacterial concentration. Transformation vectors containing GUS and GFP genes were used for transient transformation studies.

Cowpea was regenerated from cotyledonary node (CN) explants on MSB5 medium containing varying level of BA alone or in combination with Kinetin or NAA. The optimal medium for multiple shoot production from CN explants was MSB5 medium supplemented with 3 μM BA and 0.5 μM Kinetin. CN explants obtained from BA supplemented pre-conditioning medium showed better shoot production than medium supplemented with TDZ. Rooting of *in vitro* shoots was obtained on media with or without IBA. The *in vitro* rooted plantlets were successfully acclimatized and transferred to greenhouse. Based on transient transformation, decapitated embryo explants from dry seeds showed better transformation efficiency as compared to CN explants from 3–4 days old germinated seedling (33–56 % and 2–6 %, respectively) in relation to the media used for inoculation and co-cultivation. Adjustment of the overnight bacterial concentration to higher optical density value (up to 2.0) in the inoculation medium seemed to improve transient transformation both in terms of efficiency and the strength of the GUS gene expression. The optimised protocol could facilitate the stable transformation of cowpea for economical traits of interest such as insect resistance.

Keywords: Resistance breeding, transformation

Contact Address: Alemayehu Teressa Negawo, Leibniz Universität Hannover, Plant Genetics, Plant Biotechnology, Hannover, Germany, e-mail: alemayehu_teressa@yahoo.com

Characterisation of Wild *Musa* Accessions Recently Introduced to the International Gene Bank

JANA CÍZKOVÁ[1], EVA HŘIBOVÁ[1], PAVLA CHRISTELOVÁ[1], INES VAN DEN HOUWE[2,3], RONY SWENNEN[3,2], NICOLAS ROUX[4], JAROSLAV DOLEŽEL[1]

[1]*Institute of Experimental Botany, Centre of the Region Haná for Biotechnological and Agricultural Research, Czech Republic*

[2]*Katholieke Universiteit Leuven, Laboratory of Tropical Crop Improvement, Belgium*

[3]*Bioversity International, Belgium*

[4]*Bioversity International, France*

Bananas and plantains (*Musa* spp.) are one of the most important world trade commodities and are a staple food for millions of people in countries of the humid tropics. The production of bananas is, however, threatened by the rapid spread of various diseases and adverse environmental conditions. The *Musa* genetic diversity, which is of paramount importance for breeding of resistant cultivars, needs to be preserved and better characterised. The world's largest banana and plantain collection is managed by the Bioversity International Transit Centre (ITC) in Belgium and contains more than 1500 accessions maintained *in vitro*. The collection is being continuously expanded by new accessions representing various edible cultivars, improved materials and wild species from different parts of the world. Recently new germplasm was collected in Indonesia and successively introduced into the international *Musa* gene bank. The aim of this work was to characterise the genotype of these accessions in order to shed light on their genome structure and to confirm their taxonomic classification. A total of 21 wild *Musa* accessions were analysed and their nuclear genome size and the genomic distribution of ribosomal RNA genes were determined, showing a high degree of variability in both characters. Genotyping with a set of 19 microsatellite markers identified *Musa* species that are closely related to the studied accessions and provided data to aid in their classification. Sequence analysis of their internal transcribed spacers ITS1 and ITS2 suggested that some of the accessions are of interspecific hybrid origin and/or represent backcross progenies of interspecific hybrids.

Keywords: FISH, genome size, genotyping, musa, rDNA

Contact Address: Jana Cízková, Institute of Experimental Botany, Centre of the Region Haná for Biotechnological and Agricultural Research, Olomouc, Czech Republic, e-mail: cizkova@ueb.cas.cz

On-Farm Fruit Tree Species Richness and Diversity and its Influencing Factors in Western Kenya

LOYCE JEPKORIR[1], JOSEPH WAKIBIA[2], STEPHA MCMULLIN[1], ROELAND KINDT[1], KATJA KEHLENBECK[1]

[1] *World Agroforestry Centre (ICRAF), Tree Diversity, Domestication and Delivery, Kenya*

[2] *Jomo Kenyatta University of Agriculture and Technology, Dept. of Botany, Kenya*

Numerous wild and exotic fruit tree species are growing in Kenya, but overall fruit production and consumption are rather low, particularly regarding indigenous fruit trees (IFTs). Within a bigger project that aims at increasing production and consumption of fruits in Kenya, the objective of this study was to assess on-farm species richness and diversity of fruit trees and identify the bio-physical and socio-economic factors influencing fruit tree diversity in Kakamega and Siaya counties, western Kenya. In five agro-ecological zones, 100 households were randomly selected from 370 baseline households of the bigger project. Tree inventories were used to record all on-farm fruit trees and farmers were interviewed on basic socio-economic data and fruit farming information. A total of 26 fruit tree species were recorded, including 18 exotic and 8 indigenous species. In terms of abundance, exotic species clearly dominated with 89 % of the 5447 counted fruit tree individuals. On average, 55 fruit tree individuals (range 1–726) belonging to 4.5 fruit tree species (range 1–11) were cultivated per farm. The three most frequent species were the exotics *Mangifera indica* (occurred on 82 % of the surveyed farms), *Psidium guajava* (63 %) and *Persea americana* (60 %). The most abundant species were the exotics *Lantana camara* (35 % of all tree individuals), *P. guajava* (29 %) and *M. indica* (7 %). Indigenous species were rare as 73 % of the surveyed farms did not contain a single indigenous fruit tree (IFT). The most abundant and frequent IFTs were *Rhus* spp. and *Carissa edulis*, occurring on 16 and 12 % of the farms, respectively. While altitude and farm size had no influence on total fruit tree species numbers, number of indigenous species was negatively correlated with altitude (p=0.001) and positively with farm size (p=0.008). Multivariate regression analysis for identifying bio-physical and socio-economic factors influencing fruit tree species richness and diversity are currently being performed and results will be presented at the conference. Findings from this study will contribute to a better understanding of fruit farming in the research area and can be used to improve the ongoing programme on promoting fruit production and consumption in Kenya.

Keywords: Abundance, biophysical factors, diversity, indigenous fruit trees, socio-economic factors

Contact Address: Loyce Jepkorir, World Agroforestry Centre (ICRAF), Tree Diversity, Domestication and Delivery, P.O. Box 30677, 00100 Nairobi, Kenya, e-mail: Ljepkorir@cgiar.org

Genetic Diversity of Aguaje (*Mauritia flexuosa* L.f.) in Peruvian Amazon

HANA DOLEZALOVA[1], BOHDAN LOJKA[1], JOEL ESTEBAN ODICIO GUEVARA[1], DAVID HONYS[2]

[1]*Czech University of Life Sciences Prague, Faculty of Tropical AgriSciences, Czech Republic*

[2]*The Academy of Sciences of the Czech Republic, Inst. of Experimental Botany, v.v.i - Laboratory of Pollen Biology, Czech Republic*

Aguaje (*Mauritia flexuosa* L.f.) is a dioecious edible fruit-bearing palm with enormous importance across Amazon River Basin. Despite its doubtless local importance as natural key species and as an economical asset this species is little known outside of its range distribution. Moreover, due to its relative abundance in natural populations, aguaje was generally perceived as inexhaustible natural source. Thus, till nowadays, the majority of local fruit production is still derived from female palms logged in wild stands. This long-term practice leads to negative selection, since usually the most fruitful females with the best attributes are chopped down. Such long-lasting disturbance is significantly affecting natural stands and contributes to genetic erosion of this palm species. We investigated aguaje's genetic variation in Peruvian Amazon with the main objective to describe its genetic diversity in the area of its origin. So far nine microsatellite primers (SSR) were tested in preliminary assay comprising of 57 individuals collected from natural stands of Pacaya Samiría Natural Reserve and from cultivated stands in Tingo María district. Eight out of nine microsatellites tested were polymorphic and observed heterozygosity in Pacaya Samíria and Tingo María was 0.427 and 0.285, respectively. Size of amplified region ranged from 90 to 260 with an average number of alleles per locus of 2.44 in Pacaya Samíria and 2.67 in Tingo María with a mean polymorphic information content (PIC) of 0.378 and 0.335, respectively. The results indicated the higher degree of polymorphism within natural population of Pacaya Samíria which is strongly supporting a hypothesis of a higher genetic variation within the natural genetic pool. Moreover, our results are consistent with the theory of higher genetic variance in the centres of origin, since an earlier similar study from Brazil recorded also a lower degree of heterozygosity. Our research verified high reproducibility of those microsatellite primers for further studies of this species. Furthermore, our research also identified study sites in Peruvian Amazon as promising zone for germplasm derivation for further domestication and breeding programmes.

Keywords: Genetic conservation, genetic variation, microsatellite

Contact Address: Hana Dolezalova, Czech University of Life Sciences Prague, Dept. of Crop Sciences and Agroforestry in the Tropics and Subtropics, Kamýcká 129, 165 21 Prague 6, Czech Republic, e-mail: dolezalovah@ftz.czu.cz

Effective Techniques for Resynthesized Rapeseed Production of Contrasting Components via Ovule Culture and Flow Cytometry

ALOIS ANTONÍN HILGERT-DELGADO[1,2], KLÍMA MIROSLAV[2], IVA VIEHMANNOVÁ[1], ELOY FERNÁNDEZ CUSIMAMANI[1]

[1]*Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Dept. of Crop Sciences and Agroforestry, Czech Republic*

[2]*Crop Research Institute, Dept. of Genetics and Plant Breeding, Czech Republic*

Resynthesis of *Brassica napus* is an important tool for broadening the genetic diversity in oilseed rape and crop cultivar improvement since sources of genetic variation from natural populations cannot be used. In addition to other untraditional approaches to introgress traits from allied species, the use of current crop cultivars different from the first parental components give rise to resynthesized oilseed rapes with new desired characteristics. Crossability and embryogenic potential were evaluated by means of ovule culture in different one-sided crosses between accessions of turnip (*Brassica rapa* L. ssp. *rapa*), winter and spring turnip rape (*Brassica rapa* ssp. *oleifera f. biennis* and *f. praecox*) – female components and assessions of cabbage and winter curly kale (*Brassica oleracea* L. em. DC. var. *capitata* L. and *Brassica oleracea* convar. *acephalla* var. *sabellica*) – male components. Successful regeneration of embryos was achieved in 42 combinations; It was possible to identify the most productive crosses. The pollination efficiency (i.e. the setting of siliquae) and the number of embryos per siliqua was studied. Results of this method in the majority of crosses were better than in similar, already published experiments and provided a simplified and less laborious method. Due to highly significant differences in relative DNA content between all hybrid combinations and their respective parental components it was possible to reliably assess the hybrid nature of all regenerants via flow cytometry. As the occurrence of the self-pollinated and/or somatic-tissue regenerated female parent was not detected, the hybridity of all regenerants was reliably verified. Morphological assessment of regenerated plants showed typical characteristics originating from both parental components, and further corroborated the results of flow cytometric analysis. It can be concluded, that the method used is sufficient enough to be applicable in breeding programmes, aimed at diversity expansion of winter oilseed rape gene pool.

Keywords: *Brassica napus*, *Brassica oleracea*, *Brassica rapa*, flowcytometric analysis , interspecific hybridisation, oilseed rape resynthesis, ovule culture

Contact Address: Alois Antonín Hilgert-Delgado, Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Dept. of Crop Sciences and Agroforestry, Kamýcká 129, Praha 6 - Suchdol, 16521 Prague, Czech Republic, e-mail: hilgert@vurv.cz

An Interdisciplinary Monitoring Network of Diversity Hotspots for Long-Term *in-situ* Conservation of Potato Landraces

SEVERIN POLREICH[1], STEF DE HAAN[1], HENRY JUAREZ[1], ALEJANDRA ARCE INDACOCHEA[1], FRANKLIN PLASENCIA[1], RAUL CCANTO[2], MARIA MAYER DE SCURRAH[2], DOMINGO BEGAZO OLIVIERA[3]

[1]*International Potato Center (CIP), Peru*

[2]*Grupo Yanapai, Peru*

[3]*CADEP-JMA, Peru*

Custodian farmers have been cultivating a highly diverse and nutritive potato landrace portfolio over centuries in a sustainable and balanced manner. The largest part of cultivated potato diversity is not available in genebanks and custodians form a critical part for the future conservation of PGRs. To date no strategies and methods have been promoted for long-term monitoring approaches that are suitable to assess the dynamics and evolutionary processes within crop genepools, which are important ecosystem services. In 2012 the International Potato Center (CIP) and partners have founded the initiative Chirapaq Ñan (Quechua = rainbow route), a network of diversity hotspots to monitor the world's largest potato genepool from Colombia to Chile. The initiative focuses on (i) improving the understanding of the dynamics of ongoing evolution and its role as an adaptive process to changing environments, to strengthen the future provision of ecosystem services derived from ongoing evolution, (ii) implement a communication strategy linking stakeholders at community, private and national level across hotspots to foster in-situ management of PGR through custodian farmers, (iii) strengthening the engagement of the local youth in maintaining agrobiodiversity as heritage that consolidates the cultural identity of local communities for the future. The Initiative has thus far begun the monitoring effort in three selected hotspots in Peru and Bolivia and will expand by 2015 to four countries. As part of its baseline documentation the temporal-spatial management of potato fields and its relationship to risk mitigation, geographical setting and intraspecific diversity is investigated. Landrace diversity is characterised molecularly and morphologically following developed standard procedures for monitoring at gene, variety, species and landscape level. Potential interactions between extreme weather events -such as frost, hail, periods of heavy rainfall and drought- yield and diversity are explored at field level. Through yield sampling and potato diversity sampling methods which followed participatory field mapping, yield impacts for 312 native potato fields located between 3200 and 4200 meters above sea level were quantified by cultivar and weather stressor types. Results from the initial baseline documentation evidence high levels of contemporary diversity and a complex matrix of interactions at the biophysical and socio-ecological level.

Keywords: Agrobiodiversity, Andes, characterisation, conservation, *in-situ*, landraces, monitoring, ongoing evolution, potato

Contact Address: Severin Polreich, International Potato Center/CIM, Global Program of Genetic Resources, Avenida La Molina,, Lima, Peru, e-mail: s.polreich@cgiar.org

Hybrid Maize for Food and Feed Security in Mixed Farming Systems of Western Nepal: An *ex-ante* Assessment

GOKUL PAUDEL[1], NILS TEUFEL[2], CHRISTIAN BÖBER[3], ANDREW MCDONALD[1], DHIRAJ KUMAR SINGH[4]

[1]*International Maize and Wheat Improvement Centre (CIMMYT), Nepal*
[2]*International Livestock Research Institute (ILRI), Kenya*
[3]*International Maize and Wheat Improvement Center (CIMMYT), India*
[4]*International Livestock Research Institute (ILRI), India*

Mixed crop-livestock farming systems are predominant in South Asia and play a vital role in meeting the food security challenges. Maize is especially important in marginal areas, where poverty is greatest. Hybrid maize technology can increase crop productivity leading to multiple benefits, especially in regions where it is used as food, feed and fodder. The study area surveyed in western Nepal is characterised by small farm sizes and a high livestock density. The present study uses a minimum data Trade-off Analysis for Multidimensional Impact Assessment (TOA-MD) approach to assess ex-ante the economic viability of hybrid maize in three districts of western Nepal. A household survey collected farming system data from 40 households growing hybrid maize and 40 matched households growing local maize varieties. The local maize household sample was obtained through propensity score matching within each district using variables from a household census. Results indicated that many farmers would benefit economically from switching from the currently prevailing local maize to hybrid maize production. Adopting farmers increased their maize yields by almost two fold despite having same land and livestock ratio among adopters and non adopters. However, the costs of production increased while switching from current practices to hybrid maize production. Based on the assumption of profit maximising farmers, the predicted adoption rate based on distribution the resulting income increases varies between 48 % and 56 % amongst the three districts. At the predicted adoption rate, farmers would improve their net farm return significantly. The overall poverty rate would decline and per capita income would increase significantly in two of the districts. The model predicts a significant improvement in concentrate feeding to livestock in one of the districts associated with hybrid maize adoption while the effects are smaller in other two districts. The results suggested that dissemination of hybrid maize technology could support the livelihoods of many smallholder farmers by providing more food and feed in mixed crop-livestock farming systems in western Nepal.

Keywords: *Ex-ante* assessment, food and feed security, hybrid maize, mixed farming systems, Nepal

Contact Address: Gokul Paudel, International Maize and Wheat Improvement Centre (CIMMYT), Kathmandu , Nepal, e-mail: g.paudel@cgiar.org

Combining Abilities and Heterosis for Yield and Quality Traits in Forage Sorghum [*Sorghum bicolor* (L.) Moench]

AWADALLA ABDALLA ABDELMULA[1], MOHAMMED ISMAIL AHMED[2], MAAROUF IBRAHIM MOHAMMED[3], SEIFELDIN GASIM[1]

[1]*University of Khartoum, Dept. of Agronomy, Sudan*

[2]*University of Bakht el Ruda, Dept. of Crop Science., Sudan*

[3]*Agricultural Research Corporation (ARC), Shambat Research Station, Sudan*

This study was conducted to estimate the magnitude of combining abilities (general and specific) and heterosis for forage yield and quality characters of forage sorghum [*Sorghum bicolor* (L.) Moench]. Five exotic cytoplasmic male sterile lines of forage sorghum were crossed with eleven fertile local inbred lines, as testers, to produce 55 F1-hybrids. Both parental lines and their F1-hybrids were field-evaluated for yield and quality traits at four environments in the Sudan. These environments were: Shambat summer 2007, Shambat winter 2007, Ed-Duiem summer 2008 and Ed-Duiem winter 2008. Line × tester analysis was performed to estimate general (GCA) and specific (SCA) combining abilities, among parental lines as well as F1-hybrids. Also, the magnitudes of mid-parents (MPH%), better-parent (BPH%) and standard (STH%) heterosis were estimated. The results revealed that the predominance of additive gene effect (GCA) was high for forage fresh and dry yields, whereas there was predominance of non-additive gene effect (SCA) for most of the quality traits. For forage fresh and dry yields, the testers exhibited higher contribution to the GCA variance than the lines. The best general combiners for forage yields were Aklamoi and Kambal among testers, and Atlas and *E. sumac* among lines. Lines *E. sumac* and Blue Ribbon and testers Wad Ahmed and S.42ANK were the best general combiners for forage quality traits. The highest SCA effect for Forage yield was given by the hybrid *E. sumac* × Aklamoi. High estimates of heterosis were determined for forage fresh and dry yields. Therefore, it could be concluded that the most suitable parental lines for improving forage yield could be Aklamoi and Kambal among testers and *E. sumac* and Atlas among lines. However, Wad Ahmed and S.42ANK from testers and *E.Sumac* and Blue Ribbon from lines could be the most appropriate ones for improving the forage quality.

Keywords: Combining abilities, forage sorghum, heterosis, quality, traits, yield

Contact Address: Awadalla Abdalla Abdelmula, University of Khartoum, Dept. of Agronomy, Shambat, 13314 Khartoum North, Sudan, e-mail: aabdelm63@yahoo.com

Aroids: Orphans in the Global Food System

KARIN VANEKER

Independent researcher, The Netherlands

The aroid plant family currently comprises of more than 120 genera and about 3,750 species of which many are used as food, medicine, animal fodder, ornamental plants, and cut flowers. Several genera, such as *Anthurium*, *Calla* and *Spathiphyllum*, are among the world's most popular ornamentals, but the five most important cultivated aroid genera are species of: Elephant ear (L. *Alocasia*); elephant foot yam (L. *Amorphophallus*); Swamp taro (L. *Cyrtosperma*); Taro (L. *Colocasia*) and Tannia (L. *Xanthosoma*). Taro is the world's oldest cultivated food plant, and together with tannia the most widely distributed and consumed aroid. All plant parts of aroids are eaten. The roots and tubers are rich in carbohydrates and the leaves and stalks are an important source of protein, vitamins and folic acid.

The Food and Agriculture Organisation of the United Nations (FAO) roughly estimates that around half a billion people in the (sub)tropics and developing world are involved in aroid cultivation, consumption, and trade. Apart from a staple in the diets of numerous ethnicities in and from Asia, Polynesia, Africa and Latin America, aroids are important economic crops with high cultural and ceremonial value. Because the cultivation and consumption of aroids is foremost restricted to populations in and from sub-tropical regions and the developing world, aroids are little known outside of non-western food systems. Still, and as a result of globalisation, urbanisation, transnational trade, and the (global) South to North migration, aroids are increasingly assuming importance and meanwhile widely available in densely populated urban areas throughout the world. Meanwhile concerns about population growth, land use, agricultural biodiversity, small-scale farmers, sustainability, and food security encompass every area of the world. Despite aroids already being widely available in the gardens and diets of the world's most vulnerable people, schemes to address these issues hardly incorporate the nutrient richness of aroids. The paper will present an overview of traditional uses of aroids in cuisines and cultures and will stress the importance of incorporating current uses in strategies to alleviate hunger and poverty.

Keywords: Aroids, food security, global food system, root and tuber crops, significance, vegetables

Contact Address: Karin Vaneker, Independent researcher, Zuideinde 71, 1511 GB Oostzaan, The Netherlands, e-mail: karinvaneker@braitman.com

Morphological, Genetic and Chemical Fruit Characterisation of Baobab (*Adansonia digitata* L.) Accessions from Kenya

MOLLY MURAGE[1], KATJA KEHLENBECK[1], JOHN WANANGWE[1], KEN NJOGU[1], CHARLES WARUHIU[1], REMMY KASILI[2], BARBARA STADLMAYR[1]

[1] *World Agroforestry Centre (ICRAF), Tree Diversity, Domestication and Delivery, Kenya*

[2] *Jomo Kenyatta University of Agriculture and Technology, Institute of Biotechnology Research, Kenya*

Baobab (*Adansonia digitata* L.) is an important multipurpose fruit tree occurring throughout semi-arid and sub-humid sub-Saharan Africa. Its most important product, the fruit pulp, is an excellent source of vitamin C and several minerals. In Kenya, baobab is underutilised and markets for its products are poorly developed. This can be partly attributed to the lack of documentation of the species' morphological and genetic diversity and of its nutritional value in Kenya. The study's objective was to determine the morphological and molecular variation among baobab populations sampled across Eastern and Coastal Kenya and to assess the nutrient content of fruit pulp from the same trees.

Sixty-four baobab trees were sampled for the study. Morphological fruit characterisation was done using a baobab descriptor list developed according Descriptor for Mango (IPGRI, 2006) including qualitative and quantitative traits. Nutritional analysis was done using official AOAC methods. Molecular analysis was performed using leaf material and simple sequence repeat (SSR) primers.

Cluster analysis of the morphological variables using minimum variance method resulted in three different clusters. Cluster 1 grouped accessions with very big fruits from the Coastal region, cluster 2 accessions from the inland and cluster 3 accessions with small fruits from both inland and the coast. Fruit weight, pulp weight, fibre weight and number of seeds per fruit were the variables most responsible for cluster formation. The highest fruit and pulp weights were observed in cluster 1 (means 515 g and 103 g, respectively). Fruits in cluster 3 had the lowest fruit and fibre weights (means 106 g and 2 g, respectively), while pulp weight and number of seeds were lowest in cluster 2 (means 20 g and 69 g, respectively). Nutrient analysis showed that there were no significant differences in vitamin C, calcium and iron contents among the three clusters. Among all accessions, the range for vitamin C content was 45–155 mg/100 g edible portion, for calcium 213–538 mg and for iron 0.7–3.0 mg. Molecular analysis is still on-going and results will be presented at the conference. Findings of this study will assist in selecting superior mother trees for future baobab domestication and improving baobab production in Kenya.

Keywords: Cluster analysis, diversity, domestication, fruit, nutritional value

Contact Address: Katja Kehlenbeck, World Agroforestry Centre (ICRAF), Tree Diversity, Domestication and Delivery, United Nations Avenue, 00100 Nairobi, Kenya, e-mail: k.kehlenbeck@cgiar.org

Determination of Stable Traits for Morphological Characterisation of Bitter Gourd (*Momordica charantia* L.) Accessions

NIEN CHAU NGUYEN, MICHAEL BÖHME, INA PINKER
Humboldt-Universität zu Berlin, Horticultural Plant Systems, Germany

Diversity of plant morphology is a result of interaction between genetic factors and environment. To identify the differences between accessions of bitter gourd (*Momordica charantia* L.), morphological characterisation were tested for its suitability. Quantitative, qualitative and pseudo-qualitative traits were evaluated for distinctness and the more stable traits resulted in accurate discernment in different growing conditions. The experiments were carried out in RCBD (randomized complete block design) for seven indigenous bitter gourds accessions collected in Vietnam in two different environmental conditions: greenhouse in Berlin, Germany and field in Binh Thuan, Vietnam. There were 28 characteristics evaluated for stability under both conditions. Measurements and visual assessment values were analysed using NTSYS-PC version 2.10. UPGMA (the unweighted pair group method with arithmetic mean) was applied to compare the diversity of accessions, and "double-centered" matrix allowed figuring out the stable characteristics. Among 28 assessed morphological characteristics, seven characteristics were firmly fixed (including number of leaf lobe; ridge of fruit; size of fruit warts; present of fruit spines; color of fruit skin at ripe stage; indentation of seed edge; and striation of seed coat) and four characteristics were less varying (including fruit weight; weight of 100 seeds; number of note up to note with first male flower, and time of first male flower flowering). The clustering patterns of seven accessions based on the above 11 traits were consonant in two growing conditions. These traits were appropriate for classifying the diversity of bitter gourd.

Keywords: Growing condition, *Momordica charantia*, morphological characterisation, stable traits

Contact Address: Nien Chau Nguyen, Humboldt-Universität zu Berlin, Horticultural Plant Systems, Lentzeallee 75, 14195 Berlin, Germany, e-mail: nguyench@cms.hu-berlin.de

Fruits and Leaves of Bitter Gourd Varieties Differ in Antidiabetic Effects on Cell Culture Level

SANDRA HABICHT[1], MICHAEL KRAWINKEL[1], RAY-YU YANG[2]
[1]*Justus-Liebig University Giessen, Inst. of Nutritional Science, Germany*
[2]*AVRDC - The World Vegetable Center, Taiwan*

Type II diabetes mellitus has been known to be a problem for elder people especially in the western world. This has changed in the past years with now 80 % of diabetic patients living in low-income and middle-income countries. To find an alternative treatment that is more affordable and available for the poor to control their blood glucose levels, the use of bitter gourd (*Momordica charantia*) fruits and leaves is discussed.

As bitter gourd fruits differ in size, shape and bitterness, varietal selection might be relevant for diabetes management. To test this assumption, nine germplasm accessions and seven commercial hybrids of *Momordica charantia* were planted on 'AVRDC – The World Vegetable Center's fields in Taiwan. Leaf and fruit extracts were tested for their effect on glucose uptake in TNF-α induced insulin resistant FL83B cells.

Bitter gourd leaves and fruits improved insulin dependent glucose uptake of the cells. Intervarietal differences in glucose uptake were found for fruits and leaves of commercial hybrids and germplasm accessions. The three most effective varieties, namely Best 165 F1, High Moon, and TOT 2533, were less to medium bitter with green or cream colour.

Bitter gourd varieties exert different effects on insulin dependent glucose uptake and thus in quality of antidiabetic treatment. Varietal selection and breeding can improve quantity and quality of antidiabetic compounds in bitter gourd products. Selecting varieties with stronger antidiabetic effects could help to develop and refine dietary recommendations for diabetes management with bitter gourd fruits or leaves. The common belief that varieties with strong bitter taste and dark green colour are best for diabetes treatment could not be confirmed.

Keywords: Diabetes mellitus, intervarietal differences, *Momordica charantia*

Contact Address: Sandra Habicht, Justus-Liebig University Giessen, Inst. of Nutritional Science, Wilhelmstrasse 20, 35392 Giessen, Germany, e-mail: sandra.d.habicht@uni-giessen.de

Yield Efficiency of Citrus Scions and Rootstocks in Northeastern Brazil

CARLOS ROBERTO MARTINS, ADENIR TEODORO, HÉLIO WILSON LEMOS DE CARVALHO

EMBRAPA Coastal Tablelands, CPATC, Brazil

The Brazilian northeastern states of Bahia and Sergipe encompass the largest tropical citrus-producing region in the world. Orchards throughout this region are cultivated by smallholders under limiting conditions of cohesive soils and hydric stress. In this region, most farmers cultivate the sweet orange 'Pera' (*Citrus sinensis*) grafted on 'Rangpur Lime' (*Citrus limon*ia). Although this scion-rootstock combination presents positive characteristics it is evident the need for new combinations to increase varietal diversification in order to avoid problems with pests and diseases as well as to favour management practices leading to reduced production costs and natural resource use. Here, we evaluated yield efficiency of new scion and rootstock combinations under field conditions of northeastern Brazil. The experiment was installed in 2008 in a completely randomised block design with 8 scions grafted on 18 rootstocks. We periodically evaluated phenology, growth, drought tolerance, early-bearing yield, fruit quality and yield of scion-rootstock combinations over a period of 5 years. Among rootstocks the hybrid HTR-051 had a smaller crown volume compared to control, leading to high yields. The Citrandarin rootstocks Indio, Riverside and San Diego also presented high yield efficiency. These rootstocks together with LVK-010, Tropical Sunki Mandarin and Santa Cruz Rangpur Lime adapted well to hydric stress conditions of the region. Also, there was a variation in phenological patterns in different scion-rootstock combinations. We conclude that the sweet oranges Sincorá and Valencia Tuxpan, Tangerine Piemonte, Tahiti acid lime grafted on the rootstocks HTR-051, LVK-010, Indio, Riverside and San Diego citrandarins, Tropical Sunki Mandarin and Santa Cruz Rangpur Lime could be recommended to smallholder citrus farmers as these combinations allow a better yield efficiency under conditions of cohesive soils and hydric stress of northeastern Brazil.

Keywords: *Citrus* sp., earliness, natural resource, smallholders, water deficit

Contact Address: Carlos Roberto Martins, EMBRAPA Coastal Tablelands, CPATC, Av. Beira-Mar 3250. Bairro Jardins Po Box 44, 49025-040 Aracaju, Brazil, e-mail: carlos.r.martins@embrapa.br

Pandan Leaves (*Pandanus amaryllifolius* Roxb.) "Vanilla of the East" and its Application as Food Ingredient

ANDRIATI NINGRUM, MATTHIAS SCHREINER

University of Natural Resources and Life Sciences (BOKU), Institute of Food Science, Austria

Pandan leaves (*Pandanus amaryllifolius* Roxb) or called as "Vanilla of the East" have been traditionally used in Indonesia for food colourant, food flavour and also traditional herbs. The genus name *Pandanus* is derived from the Indonesian name of the tree, pandan. This leaves are easy to be cultivated and potential to be applied as food ingredient. Pandan leaves are also used in cooking ordinary non-aromatic rice to imitate the more expensive aromatic Basmati and Jasmine rice. The objectives of the research was to investigate the profile of natural colourant in pandan leaves e.g. carotenoids, the profile of aromatic compounds in pandan leaves, the potential application of green chemistry assessment for the formation of natural aroma from natural colourants, and also further aspect of antioxidant activities of pandan leaves in vegetable oil model. Natural colourant e.g. carotenoids were identified by C18 RP-HPLC. Several aromatic compounds from carotenoids degradation e.g. norisoprenoids, lipid oxidation e.g. aldehydes were identified by HS-SPME GC-MS. The formation of aroma compounds e.g. norisoprenoids from natural colourants e.g. carotenoids was investigated also. The crude enzymes from pandan leaves had activities to produce natural aroma from natural colourants. Natural β-ionone was found as the major product of crude enzymes activities from β-carotene and also β-apo-8-carotenal as carotenoid substrates. The application of crude extract from pandan leaves (PLE) to prevent oxidation was investigated in Red Palm Oil Model (RPO) and Soybean Oil Model (SO). The crude extract can help to protect the oxidation of the oil during the accelerated shelf life storage.

Keywords: Antioxidant, natural colourant, natural flavor, pandan leaves

Contact Address: Andriati Ningrum, University of Natural Resources and Life Sciences (BOKU), Institute of Food Science, Klabundgasse 4/1, 1190 Vienna, Austria, e-mail: andriati.ningrum@students.boku.ac.at

Evaluation of Agronomic Characters of 'egusi' Melon Genotypes from Various Agro-Ecological Zones of Nigeria

EMMANUEL IDEHEN

Federal University of Agriculture, Abeokuta, Dept. of Plant Breeding and Seed Technology, Nigeria

Evaluation of agronomic characters of 'egusi' melon genotypes from various agro-ecological zones of Nigeria was carried out in order to determine their variability and identification of characters responsible for the variation pattern. Eleven agronomic characters were measured from field evaluations of fifty 'egusi' melon genotypes. Analysis of variance revealed that there was significant agro-ecological effect for all the characters measured except for number of days to germination and fruit circumference. The highest yield was observed for the genotypes from the rainforest-5 agro-ecological zone (2092 kg ha^{-1}). The highest genotypic coefficient of variation was observed for seed yield (63.09) and the least for fruit circumference per plant (5.02). Phenotypic coefficient of variation ranged from 2.81 for fruit circumference per plant to 63.02 for seed yield. Broad sense heritability estimates ranged from 31.27 % for fruit circumference per plant to 99.78 % for seed yield. High heritability estimates were also observed for 100-seed weight (99.23 %), fruit weight per plant (99.01 %), seed weight per fruit (97.50 %) and vine length per plant (97.86 %). The four principal components had eigen values greater than one and these accounted for 35.26, 23.70, 19.37 and 12.12 % of the total variation individually and 90.46 % cumulatively. Characters such as number of days to flowering, number of days to first fruiting, fruit weight per plant and seed weight per fruit were the most discriminatory in determining the overall variation pattern in the genotypes. Both single linkage clustering and component biplots analysis showed the distinction of the genotypes from rainforest-5 agro-ecological zone from all others. The information from this study will help in future breeding programmes for the conservation and improvement of melon genotypes to help bridge the gap between researchers and end users.

Keywords: Agro-ecological zones, biplots, clustering analysis, melon, Nigeria

Contact Address: Emmanuel Idehen, Federal University of Agriculture, Abeokuta, Dept. of Plant Breeding and Seed Technology, Alabata Road P. M. B. 2240, Abeokuta, Nigeria, e-mail: emmaidehen@yahoo.com

Morphological Diversity and Root Dry Extract Content of Different Licorice (*Glycyrrhiza glabra* L.) Ecotypes from Five Provinces in Iran

MOHAMMAD KAZEM SOURI, MOHAMMAD AHMADI HOSEINI
Tarbiat Modares University, Dept. of Horticultural Science, Iran

Licorice (*Glycyrrhiza glabra*) is one of the most popular medicinal herbs in many Asian and European countries. The plant belongs to the *Glycyrrhiza* genus and Leguminosae family, which has a wide distribution all over the world. Licorice is used extensively for treating diseases of the stomach, liver, catarrh of the respiratory organs and skin disorders. Licorice roots and rhizomes are also extensively used in food, confectionery and pharmaceutical products. The roots represent a powerful natural sweetener, 50-170 times sweeter than sucrose. The glycyrrhizin content of *G. glabra* may vary among different regional populations, and may be influenced by environmental variables. In the present study, twelve populations in arid, semi-arid and Mediterranean climates of different parts of Iran, located in 5 provinces, were collected and analysed for morphological characters. In addition, the effects of different root size (root diameter of $\leq$1 and $\leq$2 cm) on dry matter and water soluble extracts in different origins were examined. All morphological characters showed significant differences among populations. The amount of licorice dry mater according to both root diameters was similar (42.07-49.93 %), but the water-soluble extract was significantly different. Correlation coefficients among morphological characters, dry matter and water-soluble extracts were not significant. Cluster analysis classified all populations into four groups. Regarding the characters dry matter and water soluble extracts, Doshman Ziari, Araghi Mahale, Koh Sorkh and Deh Sorkh were superior regions. So, these regions represent elite ecotypes which could be included in domestication process.

Keywords: Dry matter, environmental parameters, *Glycyrrhiza glabra*, morphological characters, water soluble extract

Contact Address: Mohammad Kazem Souri, Tarbiat Modares University, Dept. of Horticultural Science, Tehran, Iran, e-mail: mk.souri@modares.ac.ir

Transgressive Segregations in Interspecific Crosses Between *Cicer arietinum* L. and *C. echinospermum* P.H. Davis

CENGIZ TOKER[1], C.O. CEYLAN[1], C. IKTEN[2], B. UZUN[1]

[1]*Akdeniz University, Dept. of Field Crops, Turkey*

[2]*Akdeniz University, Dept. of Plant Protection, Turkey*

Unlike the domestic chickpea (*Cicer arietinum* L.), wild *Cicer* species are resistant to biotic and abiotic stresses. It was reported that 11 different accessions of *C. echinospermum* P.H. Davis were maintained in national and international genebank in the world. Some of the accessions of *C. echinospermum* are not only resistant to seed beetle, leaf miner, fusarium wilt and ascochyta blight, but also important genetic sources of cold tolerance. From *C. echicnospermum* to the domestic chickpea, the present study aimed to transfer desirable gene(s) for resistance to biotic and abiotic stresses and yield criteria as well. An accession of *C. echicnospermum* (AWC 302) was crossed with the domestic chickpea genotype CA 2969. In F1 and F2–3, yield and yield criteria such as flowering and maturity time, plant height, canopy width, number of main stem per plant, number of pods and seeds per plant, biological and seed yield per plant, harvest index and 100-seed weight were recorded. Considerable heterosis and transgressive segregation were detected for some agronomical characteristics in F1 and F2, respectively. Results suggested that *C. echicnospermum* is a member of second genepool as it can conventionally be crossed with the domestic chickpea and produced fertile plants in F2 and F3. Also, it was concluded that agronomical characteristics could be improved using *C. echicnospermum* as pollen donor. Some lines in F3 were selected for resistance to cowpea seed beetle (*Callosobruchus maculatus* Fabricius) in choice and no-choice tests. Recombinant inbred lines (RILs) will be used for gene mapping for resistance to cold during vegetative stage.

Keywords: Chickpea, *Cicer* sp.

Contact Address: Cengiz Toker, Akdeniz University, Fac. of Agriculture, Dept. of Field Crops, TR-07070 Antalya, Turkey, e-mail: toker@akdeniz.edu.tr

Would Combination of Drought QTLs and Rice Xa Genes Be Suitable to Control Bacterial Blight under Climate Change?

C. Sylvestre Gerbert Dossa[1], M. Casiana Vera Cruz[1], Amelia Henry[1], Rolando Torres[1], Arvind Kumar[1], Ricardo Oliva[1], Edgar Maiss[2], Kerstin Wydra[3]

[1]*International Rice Research Institute (IRRI), Philippines*

[2]*Leibniz Universität Hannover, Inst. of Plant Diseases and Plant Protection, Germany*

[3]*Erfurt University of Applied Sciences, Horticulture - Plant Production and Climate Change, Germany*

Environmental changes, such as water scarcity and high temperature negatively affect plant growth, production and response to biotic stress. Drought and high temperature in the future will considerably influence rice R gene's response to bacterial blight (BB) caused by *Xanthomonas oryza* pv. *oryzae* (Xoo). To understand the outcome of the interaction between rice, drought and bacterial blight, comparative analysis of single and double stress responses by field and greenhouse studies were conducted. Sixteen rice genotypes (drought QTLs, Xa-genes, Xa-gene + drought QTLs and drought/BB susceptible check) were screened under field drought and irrigated conditions with Xoo strains PXO61 and PXO86 (field) and PXO61, PXO86, PXO99 and PXO145 (greenhouse). Our results showed lines with drought QTLs being susceptible to BB under drought and irrigated conditions although disease severity was less in drought treatment compared to irrigated one. Near isogenic lines carrying Xa-genes revealed effective under drought except Xa4 which showed disease increase with PXO61 (avrXa4 strain). Combination of drought QTLs and Xa4 gene revealed more effective compared to drought QTLs genotypes. Our results also showed significant difference between disease severity at 14 and disease severity at 21 days post inoculation. Evaluation of the response of 5 out of the 16 genotypes to bacterial blight under different soil moisture (SM) conditions showed BB resistance NIL IRBB4 less effective under 50 % SM compared to 70 % SM. Under drought stress, leaf water potential and plant canopy temperature did not influence rice bacterial blight growth in plant and drought QTLs varieties with no Xa-gene revealed susceptible under both treatments. Our results suggests that rice single gene Xa4 effectiveness is affected by drought and improving rice tolerance to stress may require targeting a combination of biotic and abiotic stress resistance traits. Furthermore, IRBB67 (Xa4+Xa7) revealed the most resistant variety against the double stresses (Xoo + drought), demonstrating that combination of Xa4+Xa7 with drought QTLs in rice varieties will be suitable under the future climate situations.

Keywords: Bacterial blight, climate changes, drought QTLs, rice, Xa-genes

Contact Address: Kerstin Wydra, Erfurt University of Applied Sciences, Horticulture - Plant Production and Climate Change, Leipziger Str. 77, 99085 Erfurt, Germany, e-mail: kerstin.wydra@fh-erfurt.de

Two Rice Major Xa Genes: Xa4 and Xa7 Showed Complementary Effects to Combined Stresses of Bacterial Blight and High Temperature

C. Sylvestre Gerbert Dossa[1], Kerstin Wydra[2], Johnny Balidion[1], Ricardo Oliva[1], Edgar Maiss[3], M. Casiana Vera Cruz[1]

[1]*International Rice Research Institute (IRRI), Plant Breeding, Genetics and Biotechnology, Philippines*

[2]*Erfurt University of Applied Sciences, Horticulture - Plant Production and Climate Change, Germany*

[3]*Leibniz Universität Hannover, Inst. of Plant Diseases and Plant Protection, Germany*

Ambient temperature is predicted to increase, and global warming with amplitude of heat episodes affects different physiological processes in crops. Rice is one of the most important cereal crops used as model crops for genomics and genetics studies. Although elevated temperature influences resistance (R) genes, the effect of heat on rice Xa-gene mediated resistance to *Xanthomonas oryzae* pv. *oryzae* (Xoo) remains to be elucidated. In this study, in IR24 near-isogenic-lines, IRBB4 (IR24+Xa4), IRBB7 (IR24+Xa7), and IRBB67 (IR24 +Xa4+Xa7) complementary effects of Xa4 on Xa7 in pyramided line IRBB67 were shown, and less effectiveness of single Xa4 gene to bacterial blight when ambient temperature increased from 29/21°C (day/night temperatures) to 35/31°C. The bacterial spread was limited in IRBB7 at high temperature, but no differences were observed between IR24 (no effective R gene) and IRBB4. Time course transcriptome profiling of susceptible IR24 and resistant IRBB67 inoculated with PXO145 (avrXa4, avrXa7) under high (35/31°C) and low (29/21°) temperature at different time points (3, 24 and 120 h post-inoculation) showed 2-fold change expression pattern of 4608 genes. Interestingly, the temperature effect was observed on expression of genes from the nodulin-family in IR24. Our results suggest, that temperature affects plant defense responses to biotic stress under complex mechanisms. Genes involved in ethylene metabolism or regulation of known susceptibility genes might play a major role in the reduction of lesion length observed in IRBB67 under high temperature. Bacterial spread and growth quantification in the resistant IRBB67 and the susceptible IR24 are in progress and may also provide evidence on how the resistant line enhances its effectiveness to Xoo under high temperature.

Keywords: Bacterial blight, High temperature, rice, Xa4, Xa7

Contact Address: Kerstin Wydra, Erfurt University of Applied Sciences, Horticulture - Plant Production and Climate Change, Leipziger Str. 77, 99085 Erfurt, Germany, e-mail: kerstin.wydra@fh-erfurt.de

Assessment of Genetic Fidelity of Micropropagated Plants and *in vitro* Polyploidisation in *Monarda didyma* L.

MICHAELA HRDLIČKOVÁ[1], ELOY FERNÁNDEZ CUSIMAMANI[1], JANA ZIAROVSKÁ[2], JOSÉ LUIS ROS SANTAELLA[1], ALEŠ HOLÍK[3]

[1]*Czech University of Life Sciences Prague, Faculty of Tropical AgriSciences, Czech Republic*

[2]*Slovak Agricultural University, Fac. of Agrobiology and Food Resources, Slovakia (Slovak Republic)*

[3]*Czech University of Life Sciences Prague, Fac. of Agrobiology, Food and Natural Resources, Czech Republic*

Crimson beebalm (*Monarda didyma* L.) is a medicinal plant belonging to the family Lamiaceae, native to North America. Crimson beebalm has a high content of thymohydroquinone, dithymoquinone and thymoquinone. The main objective of this study was the development of an appropriate protocol for *in vitro* propagation of Crimson beebalm by using nodal segments and to obtain tetraploid plants (2n=64 chromosomes) from diploid plants (2n=32) by *in vitro* induced mitotic polyploidisation. For micropropagation the nodal segments were cultured on basal MS medium supplemented with different concentrations of 6-benzylaminopurine (BAP), kinetin (KIN), indolyl-acetic acid (IAA) and naphthalene acetic acid (NAA) and with cytokinins/auxins combination of BAP with IAA and KIN with NAA for shoot and root induction. For the polyploidisation nodal segments of *Monarda* were exposed to 40, 60 and 80 μM oryzalin for 24 and 48 h. Genetic fidelity in regenerated plants was assessed using RAPD (Randomly Amplified Polymorphic DNA) markers.The highest multiplication rate was obtained from MS medium containing 0.5 mg l^{-1} of KIN (1.90±0.31 shoots per plant) and 1.5 mg l^{-1} of KIN (5.60±2.16 new nodes on longer shoots). The best root induction was achieved on medium supplemented with 1.0 mg l^{-1} IAA (6.70 ±4.84 roots per plant). Cultivation time was 60 days. The percentage of survival of plantlets under *ex vitro* conditions was 30 %. Tetraploid plants (2n=64) were obtained in concentration of 40 and 60 μM of oryzalin with treatment duration of 24 h. Triploid plant (2n=48) was obtained in concentration of 60 μM of oryzalin with treatment duration of 48 h. In total, the polyploidisation efficiency was 1.92 %. RAPD analysis confirmed the genetic stability in micropropagated and polyploid plants.

Keywords: Genetic fidelity, *in vitro*, Lamiaceae, micropropagation, *Monarda didyma*, oryzalin, polyploidisation, root induction, shoot induction

Contact Address: Michaela Hrdličková, Czech University of Life Sciences Prague, Faculty of Tropical AgriSciences, Kamycka 129, 165 21 Prague 6, Czech Republic, e-mail: hrdlickova.michaela@seznam.cz

Inter Simple Sequence Repeat (ISSR) Markers as Reproducible Tools for Genetic Diversity Analysis of an Agroforestry Tree Species *Guazuma crinita* from Peruvian Amazon

LADY LAURA TUISIMA CORAL, PETRA HLÁSNÁ ČEPKOVÁ, BOHDAN LOJKA
Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Dept. of Crop Sciences and Agroforestry, Czech Republic

Agroforestry system is an efficient method for sustainable use and conservation of tropical trees. *Guazuma crinita* is an important fast-growing timber tree species for agroforestry systems in the Peruvian Amazon and little is known about its genetic variation. A molecular approach using inter-simple sequence repeat (ISSR) markers was applied to 45 genotypes of *G. crinita* from a collection of clones from a small and representative watershed in Peruvian Amazon. To obtain clear and reproducible bands, 30 ISSR primers and 2 parameters (annealing temperature, DNA concentrations) were screened. The optimal conditions for ISSR system for each 20 μl PCR reaction mixture was composed of 10 μl of 2$\times$ PPP Master Mix, 0.5 μl of respective ISSR primer, 2 μl of DNA (50 ng/μl), 0.2 μl of BSA and 7.3 μl PCR H_2O. Of the total 30 ISSR markers, seven primers produced well reproducible bands with optimal annealing temperature (Ta) varying from 47 to 52C. A total of 47 were amplified of which 44 were polymorphic (93.62 %). The range of DNA amplification varied from 260 to 1700 bp. The general genetic differentiation (*Gst*) was estimated to be 0.40 and the gen flow (*Nm*) 0.75 alleles per generation. The analysis of molecular variation (AMOVA) assigned 100 % of genetic variability to within provenances diversity. The UPGMA analysis did not distinguish provenances relationship suggesting a common gene pool. The genetic assessment suggests the collection of plant material for the establishment of genebank and in situ conservation strategies program for this tree species. ISSR markers were chosen because the technique is very simple, fast and it also requires small quantity of sample DNA.

Keywords: Genetic diversity, *Guazuma crinita*, inter-simple sequence repeat marker, sustainable conservation

Contact Address: Bohdan Lojka, Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Dept. of Crop Sciences and Agroforestry, Kamýcká 129, 169 21 Prague, Czech Republic, e-mail: lojka@ftz.czu.cz

Characterisation of Accessions Held at the International *Musa* Genebank

EVA HŘIBOVÁ[1], JANA CÍZKOVÁ[1], INES VAN DEN HOUWE[2,3], RONY SWENNEN[3,2], NICOLAS ROUX[4], JAROSLAV DOLEŽEL[1]

[1]*Institute of Experimental Botany, Centre of the Region Haná for Biotechnological and Agricultural Research, Czech Republic*

[2]*Katholieke Universiteit Leuven, Laboratory of Tropical Crop Improvement, Belgium*

[3]*Bioversity International, Belgium*

[4]*Bioversity International, France*

The International Transit Centre (ITC) managed by the Bioversity International is the largest *ex situ* collection of *Musa* germplasm. The genebank is hosted by Katholieke Universiteit Leuven in Belgium and maintains *in vitro* more than 1500 accessions, which include cultivated clones of banana, improved materials and wild *Musa* species. Efficient conservation of plant germplasm and use in breeding programs depends on proper identification and in-depth characterisation at the phenotypic and genotypic level.

We have been involved in the cytogenetic and molecular characterisation of the ITC accessions. This included estimation of nuclear genome size and/or ploidy level using flow cytometry, chromosome number, characterisation of the karyotype and genomic constitution by fluorescence in situ hybridisation as well as genotyping with molecular markers. Here we report on the application of a standard *Musa* genotyping platform which enables discrimination between individual *Musa* species, subspecies and subgroups. This platform is based on 19 microsatellite markers which are scored using fluorescently labelled primers and high-throughput capillary electrophoresis separation with high resolution. In order to characterise selected ITC accessions in more detail, we analysed their ITS sequences and studied phylogenetic relationships within the Musaceae family. To date, we have genotyped more than 280 diploid and more than 300 triploid accessions including edible bananas and their putative parents, as well as wild *Musa* accessions, which have been described for the first time. This work provided new and important information on the accessions held at ITC and identified mislabeled and putative duplicated accessions.

Keywords: Genetic diversity, *Musa*, *Musa* genebank, SSR genotyping platform

Contact Address: Eva Hřibová, Institute of Experimental Botany, Centre of the Region Haná for Biotechnological and Agricultural Research, Olomouc, Czech Republic, e-mail: hribova@ueb.cas.cz

Morphological and Molecular Characterisation of 11 Varieties of Native Chilli Peppers (*Capsicum* spp.) of the Peruvian Amazon

GOLDIS PERRY DAVILA[1], JANA ZIAROVSKÁ[2], ELOY FERNÁNDEZ CUSIMAMANI[1], JITKA PERRY[1]

[1]*Czech University of Life Sciences Prague, Faculty of Tropical AgriSciences, Czech Republic*

[2]*Slovak Agricultural University, Fac. of Agrobiology and Food Resources, Slovakia (Slovak Republic)*

Peruvian Amazonia is one of the most diverse ecosystems of the world. With its specific location and climatic conditions it forms a habitat for more than 50 % of world wide species and represents the origin for many plant species with a high economic, cultural and medicinal importance. Among these species are native chili peppers (*Capsicum* sp.). Till today the information on the diversity of Amazonian chili peppers is not complete although its importance is increasing. For present research, 11 native chili peppers were collected with the main purpose to measure their genetic distance. First the samples were described morphologically according to international standardised descriptors for *Capsicum*. Biological material, especially seeds, was first homogenized and then tested in the laboratory using PCR and modern IPBS (Inter Primer Binding Site) method to provide molecular based polymorphism description. Despite the fact that the samples were diverse, the results showed very interesting facts: 11 varieties belonged to only 3 species: *C. chinense*, *C. baccatum* and *C. frutescens*. The lowest dissimilarity rate was found in "charapita amarillo" and "charapita rojo" chili (0.38) and the highest rate was recorded in chili "pinchito de mono" (0.73). At least we compared the results to find a substitute to the widely used "charapita amarillo" variety, which has a high local economic and cultural importance. The chili "trompito amarillo" presented similar characteristics and promised good yield as well. This research formed a good data base for further investigation and studies. There is a great scientific challenge to determine and deeply investigate the majority of Amazonian chili peppers to get a complete data base.

Keywords: Amazonian chilli peppers, genetic distance, IPBS, morphologic descriptors, PCR

Contact Address: Goldis Perry Davila, Czech University of Life Sciences Prague, Faculty of Tropical AgriSciences, Kamycka 129, 165 21 Prague 6, Czech Republic, e-mail: goldis_perry@hotmail.com

Diversity of Mango (*Mangifera indica* L.) Cultivars from Motherblocks in Kenya: A Morphological Characterisation Approach

MONICA OMONDI, KATJA KEHLENBECK
World Agroforestry Centre (ICRAF), Tree Diversity, Domestication and Delivery, Kenya

Mango (*Mangifera indica* L.) is one of the most important fruit crops for commercial use and home consumption in the tropical and subtropical lowlands. In Kenya, mango production is mainly based on a few cultivars. Fruit tree mother blocks of the Kenya Agriculture Research Institute and prison farms in Central, Eastern and Coastal Kenya, the main mango producing areas, harbour a diversity of local and introduced mango cultivars. However, documentation of these cultivars, including morphological fruit characterisation, is largely missing, but this is a prerequisite for selecting most suitable mango cultivars for different climatic zones and use categories. The aim of this study was to document fruit morphological characteristics of the available mango cultivars to establish a mango cultivar database.

At six mother blocks in Central, Eastern and Coastal Kenya, twenty mature mango fruits each were harvested from 53 different cultivars, mostly improved cultivars from Florida and local Kenyan ones. Morphological fruit characterisation, including 44 qualitative and 20 traits, was done according to 'Descriptors for Mango' (IPGRI 2006). Differences in variable means and correlations were analysed.

Fruit shapes were mainly 'oblong' for the studied improved cultivars, but 'roundish' for the local Kenyan ones. Fruit ground colour was 'yellow, orange, purple or red' for 80 % of the improved varieties while 'green' for 95 % of the local varieties. A rootstock cultivar from Israel ("13–1") had the lowest mean fruit weight (96 g), pulp weight (42 g) and pulp proportion (44 %), but the highest stone proportion (30 %). Fruit length was lowest for the Kenyan landrace "Kimbole" (5.7 cm) and highest for the Florida cultivar "Anderson" (19 cm), which also had the highest fruit weight (680 g), pulp weight (531 g) and pulp proportion (77 %), but the lowest stone proportion (7 %). Proportion of juice from the pulp ranged from 35 % (landrace "Ndoto") to 87 % (landrace "Zanzibari"). Fruit length was significantly positively correlated with fruit weight (r=0.820**) and pulp weight (r=0.803**), but negatively with the proportion of the stone (r=-0.306*). The ongoing development of a mango cultivar database for Kenya will facilitate future variety identification and assist in selecting suitable cultivars.

Keywords: Descriptors, qualitative traits, quantitative traits, variety identification

Contact Address: Monica Omondi, World Agroforestry Centre (ICRAF), P.O.Box 30677, 00100 Nairobi, Kenya, e-mail: omondimonica@ymail.com

Morphological and Genetic Diversity of Local Mango Accessions from the Eastern Region of Kenya

ROBERT GITAHI[1,3], REMMY KASILI[1], MARTINA KYALLO[2], KATJA KEHLENBECK[3]

[1] *Jomo Kenyatta University of Agriculture and Technology (JKUAT), Inst. of Biotechnology Research (IBR), Kenya*

[2] *International Livestock Research Institute (ILRI), Kenya*

[3] *World Agroforestry Centre (ICRAF), Tree Diversity, Domestication and Delivery, Kenya*

Mango (*Mangifera indica* L.) is an important tropical fruit tree known to have highly nutritious fruits with a delicious taste. In Kenya, cultivation is mainly done by small scale farmers and is based on three categories of cultivars/landraces; local small fruited (often with fibers), local big fruited (mostly without fibers) and improved cultivars mostly introduced from Florida. The Kenyan local small fruited landraces are said to be well adapted and stress-tolerant, however, their diversity has not been documented and their numbers are decreasing. This study aimed at analysing morphological and genetic diversity of local Kenyan mangoes. Leaves of 36 mango accessions were sampled from three locations in the eastern region of Kenya. Simple sequence repeats (SSR) markers were used for genetic diversity assessment. Fruits from the same 36 accessions were collected for morphological characterisation using 29 qualitative and 20 quantitative descriptors according to IPGRI's "Descriptors for Mango". The level of polymorphism revealed by 19 SSR markers was 54 %, while genetic diversity among samples was 59 % and heterozygosity 64 %. AMOVA revealed that variation within the individuals was high at 89 %, while among the populations/locations and among individuals it was 2 % and 9 %, respectively. Cluster analysis of the genetic data resulted in three major clusters. Cluster 1 (n=10) grouped accessions mostly from Ukambani region (50%) and fruits with a 'roundish' shape. Cluster 2 (n=22), combined accessions from both Ukambani (41 %) and Embu regions (36%) having large-sized and 'oblong' fruits. In cluster 3 (n=4), accessions mostly from Ukambani were found and fruits had an orange-colored flush on their skin. Morphological characterization of the fruit samples revealed high variability among the accessions. Fruit length ranged from 5.6-12.4 cm, while fruit weight from 95-578 g. The most frequent fruit shape was 'roundish', and the most frequent ground color of the fruit skin was 'green'. Hierarchical cluster analysis with 8 discriminant morphological variables resulted in three clusters which were, however, not consistent with the genetic clusters. Findings from this characterization study may help to improve mango farming and productivity in Kenya and to develop "conservation through use" strategies for Kenyan local mangoes to retain their valuable genetic resources.

Keywords: Cluster analysis, conservation, fruit characterisation, SSR marker

Contact Address: Robert Gitahi, Jomo Kenyatta University of Agriculture and Technology (JKUAT), Inst. of Biotechnology Research (IBR), 62000, 00200 Nairobi, Kenya, e-mail: robertgitahi@gmail.com

The Environmental Variation of Traits for Interpreting Genotypic Characterisation in Broad-Adapted Populations of Tamarind

SIAMAK GHAFFARIPOUR, NINA VAN DEN BILCKE, ROELAND SAMSON

University of Antwerp, Dept. of Bioscience Engineering, Belgium

Environmental variation limits genetic gain to identify superior genotypes for quantitative traits such as plant biomass or biomass variables. Characterisation of the environmental variance is an important step in understanding heritability of traits. A modelling approach is proposed here to genotypically characterise broad-adapted populations of tamarind from different continents to provide breeders to analyse their target trials in a breeding program. Open-pollinated seeds were chosen from three broad-adapted populations to indicate environmental variance of traits such as total plant mass (TPM), leaf mass (LM), stem mass (SM), root mass (RM), hypocotyl (Hyp.), epicotyl (Ep.) and leaf chlorophyll a (Cha), chlorophyll b (Chb), total carotenoids (Caro) in non-inbred families. In each provenance, one population was sampled as a family and three seed classes were grouped within family. Seed groups and populations were established in a two level nested design I. Simulates of variance components (s2), phenotypic variance (δ2p), genotypic variance (δ2g) and environment variance (δ2e) are given for each trait. The ranking of ten trials for broad-sense heritability varied substantially between traits (h2=0.48%-81 %). Leaf chlorophyll a and total plant mass were more heritable (81.01 % and 80.71 % respectively). The average plant biomass increased considerably among populations, while the environmental variance was less than the genotype variance (δ2e=5.11 and δ2g=13.38) and environment variance was less for most of the other trials as well. Moreover the ranking of the environmental variance varied considerably between trials. The presence of genotypic variance component indicated that in the genotype performance of these populations, genetic variance is more important than the environment variance to predict the variation of trials. The incorporation aids interpretation of the relative effect of environment variables, and helps to identify opportunities to improve breeding and germplasm-testing strategies for these populations.

Keywords: Broad-sense heritability, environment variance, tamarind, variance component

Contact Address: Siamak Ghaffaripour, University of Antwerp, Dept. of Bioscience Engineering, Groenenborgerlaan 171, 2020 Antwerp, Belgium, e-mail: siamak.ghaffaripour@uantwerpen.be

A Preliminary Study on the Screening of Mungbean (*Vigna radiata* (L.) Wilczek) Genotypes for Adaptation Ability and Yield Potential

ERKUT PEKSEN[1], CENGIZ TOKER[2], TARIQ AZIZ[1], MUHAMMAD FAROOQ[3]
[1]*Ondokuz Mayis University, Field Crops Department, Turkey*
[2]*Akdeniz University, Fac. of Agriculture, Dept. of Field Crops, Turkey*
[3]*University of Agriculture, Dept. of Agronomy, Pakistan*

Food legumes are the main components of dryland cropping systems in Turkey. Chickpea, lentil and dry bean are three important commercial food legume crops in the country. Turkey was one of the largest pulse producer and consumer countries during the 1980's in the world. Nowadays, even though Turkey is a pulses producer country, it imports a large amount of pulses from rest of the world. Farmers use limited inputs in production of pulses due to their low purchasing power, high cost of certified seed and fertiliser, and also low market prices. There is an increasing demand for mungbean.

This study was conducted at Faculty of Agriculture, Ondokuz Mayis University, Samsun, Turkey. Field experiment was arranged in completely randomised block design with four replications using 20 mungbean genotypes in 2010. Plant height, first pod height, dry weight of root and straw, pod number per plant, pod length, number of seeds per pod, 100-seed weight and seed yield (kg ha^{-1}) were determined.

Mungbean genotypes were significantly different for 100-seed weight and seed yield. CN95, CD3, Basanti and VB92 gave the highest seed yield (1120.51, 955.00, 902.91 and 808.01 kg ha^{-1}, respectively). The highest 100-seed weight (6.26 g)was determined in CN95 and this was followed by KPS^{-1} and KPS^{-2} genotypes with 6.20 and 6.17 g. Study results revealed that mungbean can be grown in the Middle Black Sea Region of Turkey. Comprehensive and comparative researches should be conducted in the dryland conditions to be able to recommend mungbean cultivation for chickpea and lentil sowing areas.

Keywords: Mungbean, *Vigna radiata* genotypes, yield

Contact Address: Erkut Peksen, Ondokuz Mayis University, Field Crops Department, Atakum, 55139 Samsun, Turkey, e-mail: erkutp@omu.edu.tr

In vitro Propagation of *Puya berteroniana* and Assessment of Genetic Stability Using Molecular Markers

PETRA ŠTRÉBLOVÁ[1], IVA VIEHMANNOVÁ[1], PETRA HLÁSNÁ ČEPKOVÁ[1], JANA ANDRLOVA[1], JAN VITAMVAS[2]

[1]*Czech University of Life Sciences Prague, Fac. of Tropical Agrisciences, Dept. of Crop Sciences and Agroforestry, Czech Republic*

[2]*Czech University of Life Sciences Prague, Fac. of Forestry and Wood Science, Dept. of Forest Ecology, Czech Republic*

Puya berteroniana belonging to the family Bromeliaceae is a giant plant with very attractive turquoise flowers, that have a great potential to be used for ornamental purposes. The aim of this study was the development of an optimisation protocol for *in vitro* propagation and assessment of the genetic fidelity of this plant using inter simple sequence repeat (ISSR) molecular markers. An efficient protocol for *in vitro* propagation via direct morphogenesis was succesfully established. Plant growth regulators as benzylaminopurine (BAP) and zeatin alone or in combination with α-naphthaleneacetic acid (NAA) were examined for their effects on *in vitro* offsets induction. Media containing NAA or indole-3-acetic acid (IAA) were used to optimise *in vitro* rooting of plantlets. For *in vitro* propagation, the most effective treatment was 1/2 MS medium enriched by 0.1 mg l^{-1} BAP and for *in vitro* rooting medium containing 0.3 mg l^{-1} NAA was optimal. Genetic stability of the *in vitro* regenerated plants was determined by using ISSR molecular markers. Out of 170 *in vitro* plantlets, 10 randomly chosen plants from the most effective treatment supplemented by 0.1 mg l^{-1} BAP were used for DNA screening. 6 ISSR primers produced totally 19 clear and reproducible bands resulting in a total of 253 bands where the banding pattern per each primer was highly uniform and identical to the mother plant from which the tissue cultures had been established. The occurrence of somaclonal variation was not detected trough screening of *in vitro* regenerants and thus, process of *in vitro* production can be used for mass production of *P. berteroniana*.

Keywords: Direct morphogenesis, genetic stability, molecular markers, plant growth regulators, *Puya berteroniana*

Contact Address: Petra Štréblová, Czech University of Life Sciences Prague, Fac. of Tropical Agrisciences, Dept. of Crop Sciences and Agroforestry, Pod Bendovkou 1776, 26901 Rakovník, Czech Republic, e-mail: petrastreblova@gmail.com

Use of Lab-on-a-Chip Technology in Characterisation of Seed Storage Proteins and Protein Fractions in Inca Peanut (*Plukenetia volubilis*) Samples

PETRA HLÁSNÁ ČEPKOVÁ[1], VÁCLAV DVOŘÁČEK[2], IVA VIEHMANNOVÁ[1], MARTIN OCELÁK[1], DANTER CACHIQUE HUANSI[3], BOHDAN LOJKA[1]

[1]*Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Dept. of Crop Sciences and Agroforestry, Czech Republic*

[2]*Dept. of Gene Bank, Crop Research Institute, Czech Republic*

[3]*Instituto de Investigaciones de la Amazonía Peruana-IIAP, Peru*

Inca peanut (*Plukenetia volubilis* L.) is oil seed crop originated in Peruvian Amazon. The kernel possesses great nutritive composition beside high levels of essential fatty acids (ω3 and ω6) high level of storage proteins (~27 %). Protein spectra of single seed samples and bulked seed samples of *Plukenetia volubilis* were isolated from collected Inca peanut seeds in ten localities of Peru. There were characterised storage seed protein and three Osborne protein fractions - albumins+globulins, prolamins and glutelins. Protein bands were evaluated by the classical SDS-PAGE method. Protein bands of total seed protein were detected in the range of molecular weight 10-75 kDa. A large portion of Inca peanut protein formed albumins and globulins, abundant patterns were detected in position from 55-75 kDa and 15-35 kDa. *Plukenetia volubilis* samples were very low in prolamin fraction, on gel four subunits were found out with molecular weight from 20 to 25 kDa. In the obtained spectra were detected differences in intensity of protein bands, but the polymorphism in band position has generally been found low among for all tested samples. Visualized protein pattern were compared with obtained protein spectra by using the chip microfuidic electrophoresis. The recent lab-on-a-chip technology provided quick quantification of protein bands with computerized interpretation. The comprehensive protocol employing chip electrophoresis was established for purposes of description protein patterns of Inca peanut. Detailed pattern description of each group was provided here in the form of simplified patterns code for albumins+globulins and prolamins. Inca peanut seeds can be considered as a gluten-free due to low content of prolamin fraction.

Keywords: *Plukenetia volubilis*, proteins, SDS-PAGE, chip microfluidic electrophoresis

Contact Address: Bohdan Lojka, Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Dept. of Crop Sciences and Agroforestry, Kamýcká 129, 169 21 Prague, Czech Republic, e-mail: lojka@ftz.czu.cz

Crop biotic stresses (DPG session)

Whitefly Transmitted Begomoviruses in Asia and their Impact on Europe

MONIKA GÖTZ, STEPHAN WINTER

Leibniz Institute DSMZ-German Collection of Microorganisms and Cell Cultures, Plant Virus Department, Germany

Viruses circulatively transmitted by the whitefly *Bemisia tabaci*, the begomoviruses, infect a variety of important vegetable and agricultural crops worldwide and cause serious yield losses especially in tropical and subtropical regions. They present an increasing threat to crop production because of the emergence of more competitive begomovirus species and strains and the very intense international movement of plant materials which brings new viruses and / or new cryptic species of insect vectors transmitting viruses into new environments.

In warm climates around the world, *B. tabaci* insects are of concern because of virus spread but also because more invasive *B. tabaci* species introduced from other regions can be more efficient to transmit viruses or, display other features like resistance to insecticides or, a better adaptation to crops and environment. Likewise, the introduction of new viruses in a region can jeopardise existing measures of virus control and crop management.

The BMZ/GIZ project "Beating Begomoviruses: Better livelihoods for farmers in tropical Asia" concentrates on begomoviruses, *B. tabaci* and sustainable strategies to reduce impact of the diseases in tomato, hot peppers and mungbean. A diversity study was conducted, to identify the predominant species of viruses and their vector whiteflies in Vietnam, Thailand and India and to implement this in a screening of newly developed cultivars to identify virus resistance. In all countries, the diversity of begomovirus was considerably high. Interestingly while several virus outbreaks are attributed to infestations with the *B. tabaci* cryptic species MEAM1/Med, presence of these invasive whitefly species, albeit earlier reported, was not confirmed in India or in Thailand. Only in Vietnam an invasion of *B. tabaci* MEAM1 in northern Vietnam with North-South direction was found which probably originates in China. The results from the studies will be discussed in light of the increasing problems of whitefly transmitted viruses in crop production in Europe.

Keywords: Begomovirus, *Bemisia tabaci*, climate change, resistance screening

Contact Address: Monika Götz, Leibniz Institute DSMZ-German Collection of Microorganisms and Cell Cultures, Plant Virus Department, Messeweg 11/12, 38104 Braunschweig, Germany, e-mail: monika.goetz@jki.bund.de

Endophyte Microbiome of Banana Roots Reveals High Diversity and Potential for Agricultural Uses

MIGUEL DITA[1], AYLA SCHILLY[2], JORGE VARGAS[3], NANCY CHAVES[4], MAURICIO GUZMÁN[5], JORGE SANDOVAL[5], CHARLES STAVER[6]

[1]*Brazilian Agricultural Research Corporation (EMBRAPA), Cassava & Fruits, Brazil*

[2]*University of Hohenheim, Inst. of Phytomedicine, Germany*

[3]*University of Cordoba, Plant Pathology, Colombia*

[4]*Bioversity International, Costa Rica*

[5]*Corporación Banananera Nacional - CORBANA, Costa Rica*

[6]*Bioversity International, France*

Similar to humans, plants are populated with different sets of microorganisms with potential roles on host and ecosystem functions. Endophytic microorganisms colonize root tissues inter- and/or intracellularly producing a wide range of compounds useful for plants growth as well as for protection against biotic and abiotic stresses. Clonally propagated crops such as banana are frequently multiplied by using tissue culture techniques in order to get uniform, pathogen-free plants. This process, however, also eliminates the endophyte beneficial microbiota and might have their fitness altered. To understand the microbial functional diversity of *Musa* spp., and its potential application in banana production systems, root-associated endophytic microorganisms (360 bacteria and 143 fungal) were isolated from 20 *Musa* spp. genotypes of the *ex situ* collection in CORBANA, Guapiles, Costa Rica. Analyses of specific genome regions (16S rDNA for bacteria and tefa-1α or ITS for fungi) revealed 21 different bacterial genera, with *Klebsiella*, *Enterobacter*, *Bacillus*, *Acinetobacter* and *Burkholderia* as the most frequent. *Trichoderma* spp. and *Fusarium oxysporum* prevailed among the 12 genera of fungi identified. Most isolates are known to be associated with banana, but genera such as *Sphingobacterium*, *Grimontella*, *Providencia*, *Pleosporaceae* have not been reported previously. Microorganisms with no significant similarities to the analysed database (04 bacteria and 03 fungi) were found and will probably constitute new descriptions. Some endophytes were more frequent or uniquely found on certain banana genotypes, but endophyte-host specificity needs to be further verified. Partial characterisation of the collection showed that *T. asperellum* isolates from cv. Yangambi Km5 (AAA) can significantly inhibit (up to 80.5 %) the mycelial growth of the banana pathogen *Fusarium oxysporum* f. sp. *cubense*. When a set of selected bacteria was inoculated in the tissue culture plants of the commercial cultivar Cavendish, three bacterial isolates (*Bacillus aryabhattai*, *Burkloderia* spp. and unknown) significantly increased the dry root weight. These results revealed a high and multifunctional diversity of culturable endophytes from *Musa* spp. roots, with a strong potential for new product developments and methods to enhance productivity in banana. Opportunities also exist to explore *Musa* genotypes in their native habitat and to characterise non-culturable microorganisms.

Keywords: Biological control, endophytic microorganims, *Fusarium*, *Musa* spp

Contact Address: Miguel Dita, Brazilian Agricultural Research Corporation (EMBRAPA), Cassava & Fruits, 13820 Jaguariúna, Brazil, e-mail: miguel.dita@embrapa.br

Cocoyam Root Rot Disease Caused by *Pythium myriotylum* in Nigeria

FEYISARA OLORUNLEKE[1], AMAYANA ADIOBO[2], JOSEPH T. ONYEKA[3], MONICA HÖFTE[1]

[1]*Ghent University, Dept. of Crop Protection: Phytopathology Laboratory, Belgium*
[2]*Institute for Agricultural Research for Development (IRAD) Ekona, Biotechnology Laboratory, Cameroon*
[3]*National Root Crops Research Institute (NRCRI), Plant Pathology Unit, Nigeria*

In Nigeria, Cocoyam (*Xanthosoma sagittifolium*) is an important staple which besides being a food crop, serves as a major source of income for rural households. Yield losses due to cocoyam root rot disease (CRRD) remains a major constraint to increased cocoyam production in Nigeria. Until now, this disease has been attributed to a pathogen complex including *Fusarium solani* and *Rhizoctonia solani*. However, symptoms observed are similar to those caused by the oomycete, *Pythium myriotylum* on diseased cocoyam plants in Cameroon and Costa Rica. The aim of this study was to determine the primary causal pathogen of CRRD disease in Nigeria. In this study, stunted cocoyam plants with premature leaf yellowing were observed in August 2013 at Umudike, Abia State, Nigeria. Uprooted plants showed nearly non-existent roots which were indicative of the CRRD. Isolations were carried out in the area from roots of plants with flagging symptoms. Two Isolates, NGR02 and NGR03 were obtained, sub-cultured on PDA plates and examined 2–3 days later. Morphology characters of the isolate included a typical powdery appearance following which the mycelium became fluffy after four days. PCR amplification of the internal transcribed spacer (ITS) region of rDNA using ITS5-ITS4 primers were sequenced and analysed using BLASTn query. There was 100 % and 99 % identity with several *P. myriotylum* isolates from Cameroon and Costa Rica respectively. To test for pathogenicity of NGR02 and NGR03, three 4mm plugs of a 5-day old plate of *P. myriotylum* were applied per plant by mixing blended mycelia with volcanic soil. Subsequently, 8-week old tissue culture-derived cocoyam plantlets were transplanted into infected soil while control plants were treated with sterile water. Ten plants were used for each treatment and were maintained at 25°C. After 10 days, all inoculated plants showed typical CRRD symptoms whereas control plants remained healthy. *P. myriotylum* was consistently re-isolated from root lesions of both isolates. The experiment was repeated three times. To the best of our knowledge, this is the first report of CRRD caused primarily by *P. myriotylum* in Nigeria. The confirmation of this pathogen is a significant step towards management recommendations for farmers.

Keywords: *Pythium myriotylum*, root rot, *Xanthosoma sagittifolium*

Contact Address: Monica Höfte, Ghent University, Dept. of Crop Protection: Phytopathology Laboratory, Coupure Links 653, 9000 Ghent, Belgium, e-mail: monica.hofte@ugent.be

Response of the Abundance of Nitrifying Prokaryotes to *Fusarium oxysporum* f.sp. *strigae* in a Maize Rhizosphere

MARY MUSYOKI[1], GEORG CADISCH[1], ESTHER ENOWASHU[2], JUDITH ZIMMERMANN[1], ESTHER KATHINI MUEMA[1], HENRY WAINWRIGHT[3], BERNARD VANLAUWE[4], FRANK RASCHE[1]

[1] *University of Hohenheim, Inst. of Plant Production and Agroecology in the Tropics and Subtropics, Germany*

[2] *University of Hohenheim, Inst. of Soil Science and Land Evaluation, Germany*

[3] *The Real IPM Ltd, Kenya*

[4] *International Institute of Tropical Agriculture (IITA), Natural Resource Management, Kenya*

The parasitic weed *Striga hermonthica* adversely affects production of several cereals (*e.g.*, maize, sorghum) that are cultivated in sub-Saharan Africa. The integration of resistant crop varieties and *Fusarium oxysporum* f.sp. *strigae* (Foxy-2) strains as biological control agent (BCA) has shown to be an effective control. Most studies have examined the efficacy of the BCA and its interactions with host crops, while overlooking the interplay among key microorganisms in the soil nitrogen (N) cycle. Hence, we postulated that: (i) Foxy-2 poses a threat to the indigenous plant root-associated microbial communities involved in N cycling through competition for nutrients, and (ii) the application of high quality organic residues would compensate these effects. The objective of this study was thus to assess the potential impact of Foxy-2 on indigenous nitrifying prokaryotes in maize rhizosphere cultivated on distinct soils (sandy Alisol versus clay Nitisol, Acrisol and Phaeozom) from central and western Kenya. The soils from central Kenya were used in a rhizobox experiment while field experiments were done in western Kenya. Soils were treated with or without Foxy-2, *Striga* and high quality organic residue (*i.e.*, *Tithonia diversifolia*) as N source. Using quantitative polymerase chain reaction (qPCR), the responses of ammonia-oxidising archaea (AOA) and bacteria (AOB), total bacteria and archaea abundance was recorded at three pre-defined sampling dates. Contrary to our expectations, a distinct stimulative, but no resource competition effect of Foxy-2 on the abundance of AOA, as well as total archaeal and bacterial communities was observed in the sandy soil of the rhizobox experiment. AOB only showed increases in the sandy soil when organic residue was added. Under field conditions, however, preliminary results indicated that Foxy-2 had no negative effect on studied nitrifying prokaryotes abundance. Although we found indications that Foxy-2 influences prokarytotic abundance, it did not become clear which underlying mechanisms were responsible for the stimulative effect. Since it is known that antagonistic *Fusarium* are genetically stable and able to survive over long periods in foreign environments, further research is required to evaluate the effects of external factors including contrasting seasons (long rains versus short rains seasons) and also crop growth stages.

Keywords: Biological control, *Fusarium oxysprorum* f.sp. *strigae*, nitrifying prokaryotes, quantitative PCR, rhizosphere, *Striga hermonthica*

Contact Address: Mary Musyoki, University of Hohenheim, Inst. of Plant Production and Agroecology in the Tropics and Subtropics, Garbenstrasse 13, 70599 Stuttgart, Germany, e-mail: marykamaa2002@yahoo.com

Combination of Soil-Applied Azadirachtin with Entomopathogens for Integrated Management of Western Flower Thrips, *Frankliniella occidentalis*

JACINTER ATIENO OTIENO[1], HANS-MICHAEL POEHLING[2]

[1]*Leibniz Universität Hannover, Inst. of Horticultural Production Systems, Dept. of Phytomedicine, Germany*

[2]*Leibniz Universität Hannover, Inst. of Plant Diseases and Plant Protection, Germany*

Biological control has received more attention due to increasing concern about overuse of pesticides in controlling Western Flower thrips (WFT). However there is no satisfactory and reliable single biological control technique that can efficiently control WFT, particularly on high value crops because of their low damage threshold levels. Therefore including low-risk pesticides with selective application seems to offer a sustainable control strategy. This study aims to develop an integrated system for control of Western Flower thrips (WFT) *Frankliniella occidentalis*. We tested the potential of biocontrol agents such as soil applications of Entomopathogenic Nematodes *Steinernema carpocapsae* Nemastar® (E-Nema GmbH, Germany), isolates of *Metarhizium anisopliae* (IPP 2539 & ICIPE-69) and *Beauveria bassiana* (Naturalis® - BioGard, Italy) and two Neem formulations, Neem Azal-T (1 % Azadirachtin A) and Neem pellets (7 % Azadirachtin in inert carrier material) (Trifolio-M GmbH, Germany) alone and in combinations. All possible single and combined treatments were analysed for inducing acute mortality and we checked surviving individuals for retarded development of mycosis as possible cause of secondary mortality. In addition interactive effects amongst different combination treatments were also analysed using a general linear model (GLM). The bioassay results of the single treatments indicated between 40 % to 60 % control with NeemAzal-T solution proving to be the most efficient one. However all the cadavers with EPF treatments showed development of mycosis. Therefore the total mortality attributed to the Entomopathogenic fungi amounted > 87 %. Combinations of treatments with Steinernema, NeemAzal-T and Metarhizium (ICIPE) further improved fast control effects and resulted in total mortalities between 95–97 % when late mortality by mycosis was considered too. Out of 7 treatment combinations between *S. carpocapsae*, *M. anisopliae* ICIPE-69 and both Neem Azal-T and Neem pellets, 2 gave synergistic response, 4 additive and one antagonistic response. The combined use of Neem Azal-T with the entomopathogens may be the most promising to increase the efficacy and reliability of biocontrolling WFT.

Keywords: Azadirachtin, soil application, western flower thrips

Contact Address: Jacinter Atieno Otieno, Leibniz Universität Hannover, Inst. of Horticultural Production Systems, Dept. of Phytomedicine, Herrenhaeuser Str. 2, 30419 Hannover, Germany, e-mail: otieno@ipp.uni-hannover.de

Technology Transfer and Scaling up with Partners: The Plastic Barrier Technology for Pest Control in Community-Based Organic Potato Production in the Peruvian Andes

THOMAS MIETHBAUER[1], JÜRGEN KROSCHEL[2], YANET GARAY[3], SILVESTRE QUISPE[3]

[1] *International Potato Center (CIP), Social and Health Sciences / Agroecology-IPM, Peru*

[2] *International Potato Center (CIP), Global Program of Integrated Crop and Systems Research, Peru*

[3] *Centro de Desarrollo Integral de Comunidades (CEDINCO), Peru*

In the Andes, potato (*Solanum tuberosum* L.; *Solanum* spp.) is cultivated on about 640,000 ha and the larger share of this takes place at altitudes between 3000 and 4200 m, where potato constitutes the main food and cash crop of small-scale farmers and their families. The Andean potato weevil (*Premnotrypes* spp.) is the major pest to potato production and food security since almost all that production area, especially at altitudes above 3800 m, is heavily affected. Physical barriers made from plastic material and wooden sticks - a technology investigated and developed by the International Potato Center (CIP) - can effectively control the pest thereby reducing damage levels, improving the quality of the produce and reducing the use of hazardous insecticides. Guided by training from CIP, NGOs have opted for that technology in their promotion of certified organic production of native potato varieties by farmers organised at the community and above community level (secondary-level association); thus, the NGO intervention serving as the entry point for scientific knowledge. Simulation-analysis based on empirical evidence (6 communities, 240 households) from monitoring the dissemination and adoption of the plastic barrier technology showed that net economic benefits in terms of damage abatement and cost effects depend significantly on market conditions and collective action has an important role to play. In an "optimistic" scenario benefits of more than US$ 8000/ha can be obtained through the substitution of plastic barriers for the use of insecticides in Andean potato weevil control. From a strategic perspective of research and development in the area of Integrated Pest Management the present study supports the vision to conceptualise strategy design and implementation in the wider context of social capital creation, market incentives and partnerships between agents seeking development outcomes in the rural area.

Keywords: Collective action, integrated pest management (IPM), market conditions, net benefit, potato

Contact Address: Thomas Miethbauer, International Potato Center (CIP), Social and Health Sciences / Agroecology-IPM, Av. La Molina 1895, 12 Lima, Peru, e-mail: t.miethbauer@cgiar.org

Use Pattern of Insecticides in Eggplant and their Residues in Farm Gate and Market Samples

MARUFA FATEMA[1], MD. MAHBUBAR RAHMAN[2], KAMAL HUMAYAN KABIR[3]

[1] *University of Bonn, Agriculture (ARTS), Germany*

[2] *Bangabandhu Sheikh Mujibur Rahman Agricultural University, Dept. of Entomology, Bangladesh*

[3] *Bangladesh Agricultural Research Institute, Entomology Division, Bangladesh*

A survey was conducted in intensive eggplant (*Solanum melongena*) growing areas like Jessore district of Bangladesh on the insecticide use pattern of farmers on this crop. On the basis of questionnaires, 96 farmers were interviewed concerning the types of insecticides used, the frequency and pre-harvest interval of insecticide application and the major insect pests observed in their eggplant field. About 100 % farmers reported that the eggplant shoot and fruit borer (BSFB) was the major pest of eggplant and other minor pests were epilachna beetle, aphid, thrips, leaf hopper and mite. Twenty eight insecticides belonging to different groups were found to be commonly used on Eggplant by the respondent farmers to control these pests. The commonly used insecticides were Cartap (Suntap 50 SP), Carbaryl (Sevin 85 SP), Carbosulfun (Marshal 20 EC), Chloropyrifos (Dursban 20 EC), Fenitrothion (Sumithion 50 EC), Quinalphos (Korulux 25 EC), and Cypermethrin (Ustaad 10 EC, Ripcord 10 EC, Cymbush 10 EC). As a general practice, the eggplant growers used different combinations of insecticides instead of single insecticide. All of the insecticides used in different combinations were non-selective and highly toxic to both pests and natural enemies. In the eight selected locations, 8.3 to 41.7 % farmers applied different insecticides everyday and in some cases even twice a day on eggplant. On an average, 47 % farmers in those study areas applied insecticides at a frequency range of 131–160 times per cropping season. In order to assess the residue levels of insecticides, fresh fruits, leaves, and soil and water samples were collected from the farmer's fields and markets of 8 selected locations in Jessore. The residue analysis of such 28 samples was carried out in the Pesticide Analytical laboratory, Entomology Division of Bangladesh Agricultural Research Institute (BARI), Gazipur. Among these samples, 12 samples contained insecticides residue. Out of these 12 samples, 4 had insecticide residue above maximum residue limits (MRLs). The detected insecticides residues in those samples were of Malathion, Quinalphos, Fenitrothion and Cypermethrin.

Keywords: Farm gate & market sample, insecticide, MRL, residue

Contact Address: Marufa Fatema, University of Bonn, Agriculture (ARTS), Steinweg 44 Room Number 364, 53121 Bonn, Germany, e-mail: marufa201@yahoo.com

Determining Tolerance of non-GM Cotton Cultivars Towards Cotton Bollworm in Central India

SERAINA VONZUN[1,3], MONIKA M. MESSMER[1], DHARMENDRA WELE[2], YOGENDRA SHRIVAS[2], THOMAS BOLLER[3], HANAMARADDI G. KENCHARADDI[4], MANJULA S. MARALAPPANAVAR[4], SHREEKANT S. PATIL[4]

[1]*Research Institute of Organic Agriculture (FiBL), Switzerland*

[2]*bioRe Association India, India*

[3]*University of Basel, Plant Physiology, Switzerland*

[4]*University of Agricultural Science (UAS) Dharwad, India*

The cotton bollworm is one of the major pests in cotton causing dramatic yield losses worldwide. In recent years, this led to the widespread adoption of genetically modified (GM) cotton, expressing *Bacillus thuringiensis* toxin, which is less susceptible to the bollworm, and to a neglect of breeding in non-GM cultivars especially towards bollworm resistance. Cultivation of "organic cotton" depends on effective bollworm control based on inherent tolerance and treatments with botanical pesticides. Even though India is the world's largest producer of organic cotton, stakeholders from this sector face serious problems because they do not find suitable non-GM cultivars in the Indian market. Therefore a GM-free seed supply chain has to be re-established. For the support of organic cotton farmers participatory programs for cotton breeding and cultivar evaluation have been initiated in Madhya Pradesh in Central India to increase the genetic diversity of cultivated *Gossypium* species.

This study focuses on pest resistance and especially on the bollworm incidence in different non-GM cotton cultivars. More than 100 cotton cultivars representing different species and plant types (hybrids and varietal lines) of *Gossypium hirsutum* and *Gossypium arboreum* were screened for bollworm damage under irrigated heavy soil and rain fed light soil conditions. It was found that at harvest time, on average 70 % of the assessed capsules were damaged by the cotton bollworm. Significant differences in the susceptibility of the different cotton cultivars were observed ranging from 39 to 91 %. Therefore breeding for improved bollworm resistance together with improved management systems ("push-pull method", bio-pesticides) has a big potential for organic cotton production. Breeding for pest resistance may also be important for GM cotton, as sucking pests, which are not controlled by the Bt toxin, still have to be encountered by pesticides in conventional farming. Since cotton is an essential cash crop in India enormous economic benefits for local farmers could be achieved by providing them with seeds of resistant cultivars and in addition by strengthening their awareness of sustainable crop production.

Keywords: Cotton, Bt toxin, *Gossypium* spp., organic farming, smallholder farmer

Contact Address: Seraina Vonzun, Research Institute of Organic Agriculture (FiBL), Ackerstrasse 113, Frick, Switzerland, e-mail: seraina.vonzun@fibl.org

Potential of Rhizobacteria for Promotion of Sorghum Growth and Suppression of *Striga* Development

LENARD MOUNDE, MICHAEL YONGHA BOH, MARC COTTER, JOACHIM SAUERBORN

University of Hohenheim, Inst. of Plant Production and Agroecology in the Tropics and Subtropics, Germany

The objective of this study was to screen the potential of four rhizobacteria strains for growth promotion in sorghum (*Sorghum bicolor*) and suppression of *Striga hermonthica* development. Plant growth promoting rhizobacteria (PGPR) *Bacillus subtilis* Bsn5, *B. subtilis* GBO3, *B. amyloliquefaciens* FZB42 and *Burkholderia phytofirmans* PsJN were evaluated under controlled environmental conditions in a growth chamber. Two day-old sorghum seedlings and preconditioned *Striga hermonthica* seeds were placed in fiber glass filter papers (20×6 cm length and width and respectively) between a transparent plexiglas lid and a PVC root chamber ($20 \times 6 \times 2$ cm length, width and depth, respectively) , allowing the observation of sorghum roots and the *Striga* underground stages. The chambers were filled with sterilized sand. Each plant received prepared PGPR inoculum according to treatments. Blank ringer solution was used as control. The effect of PGPR on sorghum plant height, SPAD chlorophyll value, dry biomass yield, *Striga* germination, attachment and tubercle development was analysed after 28 days. Sorghum plants treated with PGPR were significantly ($p < 0.05$) taller with relatively higher SPAD chlorophyll values and dry biomass yield in the controlled treatment compared to the treatments where *Striga* as root parasite was added. Compared to the control treatment, *Striga* seed germination was by 18 and 14 % significantly lower in the *B. subtilis* GBO3- and *B. amyloliquefaciens* FZB42-treated plants, respectively. Of the germinated *Striga* seeds, the percentage that attached to the sorghum plant was least (23 %) in the *B. subtilis* GBO3-treatment compared to all other treatments. *Striga* tubercle death percentages in PGPR treatments ranged between 35 and 59 % compared to <3 % in control plants. This study identified *B. subtilis* GBO3, and *B. amyloliquefaciens* FZB42) and *Burkholderia phytofirmans* PsJN as having the highest potential in both sorghum growth promotion and *Striga* suppression abilities. It is recommended their mechanisms of growth promotion and *Striga* suppression be investigated in future studies.

Keywords: Biological, host-parasite interaction, hyperparasite, plant growth promoting rhizobacteria, weed control

Contact Address: Lenard Mounde, University of Hohenheim, Inst. of Plant Production and Agroecology in the Tropics and Subtropics, Garbenstrasse 13, Stuttgart, Germany, e-mail: moundel05@yahoo.com

Changes in *Magnaporthe oryzae* Transcriptome During Rice Infection at High Temperature

GEOFFREY ONAGA[1], KERSTIN WYDRA[2], BIRGER KOOPMANN[1], YACOUBA SERE[3], ANDREAS VON TIEDEMANN[1]

[1]*Georg-August-Universität Göttingen, Dept. of Crop Sciences, Germany*

[2]*Erfurt University of Applied Sciences, Horticulture - Plant Production and Climate Change, Germany*

[3]*Africa Rice Center, Benin*

Future predictions indicate that extreme annual daily maximum temperature will increase by about 1–3 °C by mid-twenty-first century and by about 2–5 °C by the late twenty-first century. Such changes are predicted to lead to evolution of new pathogen strains, increase pathogen populations, spread of the diseases to new areas and increase susceptibility of plants. Rice blast, caused by *Magnaporthe oryzae* is the most destructive disease of rice worldwide. *M. oryzae* infects rice by regulating protein secretion, which enables the pathogen to either avoid recognition by the plant resistance proteins or to turn off the plant defenses. It is expected that elevated temperature may affect the biological processes leading to pathogenicity in *M. oryzae*. However, the direction of high temperature effect on pathogen fitness is not well understood. Here, we analysed the effect of temperature on the transcriptome of *M. oryzae* during invasive growth in the rice cultivar Nipponbare at 35 °C and 28 °C. We detected a higher number of putative effectors in plants exposed to 35 °C than in plants infected at 28 °C. The same was found for classical cell wall degrading enzymes. The qPCR relative quantification of in planta fungal biomass did not indicate any difference between 28 °C and 35 °C. However, plants grown and inoculated at 28 °C showed delayed symptom development in contrast to 35 °C, indicating that high temperature hastened biological processes geared towards necrotrophy more than normal temperature. Additionally, elevated temperature induced morphological transitions of *M. oryzae* during growth on the host, which could be related to survival and virulence dynamics.

Keywords: High temperature, *Magnaporthe oryzae*, pathogenicity, rice

Contact Address: Kerstin Wydra, Erfurt University of Applied Sciences, Horticulture - Plant Production and Climate Change, Leipziger Str. 77, 99085 Erfurt, Germany, e-mail: kerstin.wydra@fh-erfurt.de

Practices and Use of Pesticides by Smallholder Potato Farmers in Uganda: A Cross Sectional Survey

JOSHUA OKONYA[1], THOMAS MIETHBAUER[2], JÜRGEN KROSCHEL[2]

[1]*International Potato Center (CIP), Global Program of Integrated Crop and Systems Research, Uganda*

[2]*International Potato Center (CIP), Social and Health Sciences / Agroecology-IPM, Peru*

Potato (*Solanum tuberosum* L.) is a major food and cash crop in Uganda with an annual production of 0.8 million tonnes. In response to increased pest and disease problems, potato farmers use pesticides which could rise environmental and health concerns. This study sought to promote proper and safe pesticide handling practices as part of an Integrated Pest Management (IPM) programme by providing data needed to guide pesticide regulation policy and training for extension staff and farmers. Therefore, a household baseline survey was conducted in 2013 in six major potato growing districts of Uganda (Kabale, Kisoro, Kapchorwa, Mbale, Mubende and Kyegegwa). Farmers were interviewed about the type and source of pesticides used in potato, the frequency of application, the use of protective clothes and cases of pesticide poisoning. The types of pesticides used in potato were fungicides (72 %), insecticides (62 %) and herbicides (3 %). Also highly hazardous (Class 1b) insecticides such as dichlorvos 100 % were used but use of moderately hazardous (Class II) insecticides was more common (77 %). Insecticides and fungicides were routinely applied by 35 % of the farmers. On average, insecticides, fungicides and herbicides were applied 4.5±0.2, 3.8±0.2 and 1.0±0.0 times per cropping season, respectively. However, some farmers applied insecticides, and fungicides up to 12 and 18 times per cropping season, respectively. Use of personal protective equipment was low, i.e. gumboots (73 %), gloves (7 %), face masks (16 %) and long sleeve shirts (42 %). Forty three percent of farmers who applied pesticides reported having experienced skin itching, 25 % skin burning sensation, 43 % coughing, 60 % a runny nose, 27 % teary eyes or eye irritation and 42 % dizziness or headache. Sixty two percent were illiterate and not able to read the pesticide labelling; almost all respondents (91 %) were not able to explain the toxicity label. An IPM approach only involving moderately to slightly hazardous pesticides considering all safety measures during application and storage only when pests and disease pressure has reached economic injury levels would be environmentally friendly and result in reduced health risks.

Keywords: Fungicides, insecticides, integrated pest management, occupational health, protective equipment

Contact Address: Joshua Okonya, International Potato Center (CIP), Global Program of Integrated Crop and Systems Research, Plot 47, Ntida II Road, Naguru, Kampala, Uganda, e-mail: j.okonya@cgiar.org

Integrated Pest Management in Cabbage in the Tamale Metropolis, Northern Ghana

BENJAMIN K. BADII[1], JERRY A. NBOYINE[2], CHARLES ADARKWAH[1]
[1] *University for Development Studies, Dept. of Agronomy, Ghana*
[2] *CSIR-Savanna Agricultural Research Institute, Ghana*

Pesticides application method depends on the nature of the target pest, the characteristic of the target site, the properties of the pesticides, the suitability of the application equipment, and the cost of efficiency of the alternative methods. The intensive use of agro-insecticides by farmers in the Tamale metropolis in northern Ghana has resulted in the detection of high insecticide residues in vegetables, local health hazards and environmental pollution. This study investigated the knowledge and practices of cabbage growers regarding the use of insecticides in the management of insect pests of cabbage. A survey of 70 cabbage farmers was conducted in seven different production sites in the metropolis. Cabbage farming system typically consisted of smallholder farmers growing one or two cabbage varieties. The diamondback moth, *Plutella xylostella* remained the major insect pest in cabbage. More than 90 % of farmers applied pesticides for pest control. There were 12 major types of insecticides used in pest control and each farmer usually used 3–4 types of insecticide over a season. Both high and low toxicity pesticides, with EIQ values ranging between 10.0 and 52.5, were used. Pesticide spray frequency was higher during wet seasons than in the dry seasons. The study also revealed that hypermarkets play an important role in marketing of fresh cabbage in the food chain. Regulations on pesticide residue monitoring need to be applied in order to help address the high insecticide residues on fresh products and their impact on animal and human health in the metropolis.

Keywords: Cabbage, Ghana, insecticides, pest management, Tamale metropolis

Contact Address: Charles Adarkwah, University for Development Studies, Dept. of Agronomy, P.O. Box TL 1882, Tamale, Ghana, e-mail: dr.cadarkwah@uds.edu.gh

Mode-of-Action of Fungal Endophytes in Controlling the Root-Knot Nematode Infection in Tomato

CATHERINE WANJA BOGNER[1], BEYENE ZWEDIE[1], GEORGE KARIUKI[2], ALEXANDER SCHOUTEN[1], FLORIAN M. W. GRUNDLER[1]

[1]*University of Bonn, Inst. Crop Sci. and Res. Conserv. (INRES) - Molecular Phytomedicine, Germany*

[2]*Kenyatta University of Agriculture and Technology, Dept. of Agriculture, Kenya*

Vegetable production has become increasingly significant in the coastal humid tropics of East Africa, in which tomato (*Solanum lycopersicum*) is one of the most important and appreciated crops. Plant parasitic nematodes, especially root-knot nematodes pose a major problem to the tomato production. The use of habitat-adapted endophytic fungi may provide a safe, efficient, reliable and affordable approach to control root-knot nematodes.

Green house biocontrol experiments aimed at screening tomato (cv. Moneymaker) against the root-knot nematode *Meloidogyne incognita* were carried out using 26 isolates, 21 of them having been newly isolated from tomato in Kenya and characterised to the genus or species level. In particular, isolates from the genera *Trichoderma* and *Fusarium* significantly reduced nematode gall formation and egg densities by 20 to 50 % when compared to the non-inoculated control. This indicated that these isolates can also affect the development of the nematode after a successful infection. The two isolates that tended to perform best were selected for further screening of 'AVRDC–The World Vegetable Center' and favourite Kenyan tomato varieties.

In order to gain a deeper understanding of the induced defense responses in the plant, leading to this reduction in nematode infection, specific tomato mutants that are impaired in the jasmonic acid or salicylic acid mediated defense pathways were tested for responses against nematodes after endophyte inoculation. Also, the expression of several marker genes and the accumulation of specific marker enzymes, indicative for particular induced defense responses were followed in the presence and absence of endophytes and nematodes. Also, the effect of specific fungal metabolites on *M. incognita* and the initiation of induced defense responses in tomato was studied.

Keywords: Endophytic fungi, fungal metabolites, induced defense responses, jasmonic acid or salicylic acid, Plant parasitic nematodes, several marker genes, tomato

Contact Address: Alexander Schouten, University of Bonn, Inst. Crop Sci. and Res. Conserv. (INRES) - Molecular Phytomedicine, Karlrobert Kreiten Strasse 13, 53115 Bonn, Germany, e-mail: aschout@uni-bonn.de

Correlation and Path Coefficients in Tomato (*Solanum lycopersicon* Mill) under Fruitworm (*Helicoverpa zea* Buddie) Infestation in Line x Tester Breeding

ADAMU USMAN IZGE[1], YUSUF GARBA[2]

[1]*Federal University Dutse, Dept. of Crop Science, Nigeria*

[2]*College of Education Hong, Agricultural Education,*

Field experiments were conducted under irrigation during 2010 to 2011 at Lake Allau, Borno State (11°6' N, 13°17' E) and Hong, Adamawa State (10°15' N, 13°20' E) in Nigeria to evaluate the parents F1 hybrids of tomato developed through line × tester for fruit yield and resistance to *Helicoverpa zea*. The study determined the association between fruit yield and other yield components. It also determined path coefficients between fruit yield and other traits. Correlation revealed that relationship between numbers of trichomes was negative and significant genotypically and phenotypically associated with damaged fruits. The higher the number of trichomes the less damage was observed due to worm infestation in tomato. Further result indicated that association between numbers of leaves/plant, and percentage damaged fruits was significant negative. Number of fruits/plant was positively and significantly genotypically correlated with fruit yield and percentage damaged fruits. Genotypic correlation values were higher in magnitude than the corresponding phenotypic values, thus establishing a strong genetic relationship among the traits. Path coefficient analysis revealed that, number of flower clusters/plant exhibited highest direct effect on fruit yield. Even though correlation between number of flower clusters and fruit yield was positive, it was not statistically significant. It is suggestive from the result of this study that the direct effect of trichome count, number of flower clusters/plant and days to final harvest and indirect effects of trichome count, number of leaves/plant and plant height could be considered concurrently for amenability fruit yield. This investigation is not unmindful that more agronomic traits and their relationship with yield need to be investigated while selecting for better fruit yield under worm infestation in parts of Nigeria. Further evaluation is recommended in that respect.

Keywords: Correlation, fruit yield, line x tester, northeastern Nigeria, path analysis, trichome

Contact Address: Adamu Usman Izge, Federal University Dutse, Dept. of Crop Science, Aliyu Bye Pass Dutse, Dutse, Nigeria, e-mail: bamsyizge@yahoo.com

Effect of Endophytic Entomopathogenic Fungi as Biological Control Agents on the Production of Phytohormons in Tomato and Cotton

DALIA MUFTAH ALKHAYAT[1], KATHARINA DÖLL[2], PETR KARLOVSKY[2], STEFAN VIDAL[1]

[1]*Georg-August-Universität Göttingen, Dept. of Crop Sciences, Division of Agricultural Entomology, Germany*

[2]*Georg-August-Universität Göttingen, Dept. of Crop Sciences, Division of Molecular Phytopathology and Mycotoxin Research, Germany*

This research aimed to establish two strains of the entomopathogenic fungus *Metarhizium anisopliae* 150 and 153 endophytically in tomato and cotton plants as an innovative biological control strategy against several pests and diseases taking into consideration the possible interaction between these fungi and their hosting plants. Therefore, two inoculation methods were applied using fifteen plants per treatment for a tomato experiment and ten plants per treatment for a cotton experiment; for the seed inoculation method, tomato and cotton seeds were soaked in a mixture of fungal spore suspension with an adjusted concentration to 107 spore ml^{-1} and an adhesion material for two minutes. Dry seeds were then planted in 11 cm pots and left to grow for one week under greenhouse conditions. A root inoculation method was conducted by establishing two treatments with clean tomato seedlings at the third leaf growth stage. Roots were washed and dipped in the same mixture for two minutes and re-planted in 11 cm pots. Cotton and tomato leaves were sampled for both inoculation methods. At the same time the same procedure was repeated with tomato plants which were additionally inoculated with *Phytophthora infestans*, the causal agent of the late blight disease. The plants were grown for two weeks under suitable conditions to develop the disease symptoms. Thereafter, leaves were also sampled. Collected samples were extracted for multiple phytohormons' analyses including salicylic acid, abscisic acid, jasmonic acid, indolic acetic acid and gibberellins using LC-MS. Our results demonstrated that phytohormons levels change in relation to plant species, inoculation method, pathogen presence and fungal bio-agent strain.

Keywords: Biological control, Endophytic entomopathogenic fungi, LC-MS, *Metarhizium anisopliae*, phytohormons, *Phytophthora infestans*

Contact Address: Dalia Muftah Alkhayat, Georg-August-Universität Göttingen, Dept. of Crop Sciences, Division of Agricultural Entomology, Göttingen, Germany, e-mail: daliakhayat@yahoo.com

Organic Pest Management Strategies to Control the Cocoa Mirid (*Monalonion dissimulatum* Dist.), Alto Beni, Bolivia

LEONE MINIATO FERRARI[1], ANDRÉS FLORES[2], FORTUNATO VELASQUEZ[3], MONIKA SCHNEIDER[4], CHRISTIAN ANDRES[4], JOACHIM MILZ[3], GERMÁN TRUJILLO[3], FREDDY ALCON[3], INGRID FROMM[1]

[1]*Bern University of Applied Sciences, Swiss College of Agriculture, Dept. of International Agriculture, Switzerland*

[2]*Siempre Association, Bolivia*

[3]*ECOTOP, Consulting on Successional Agroforestry, Bolivia*

[4]*Research Institute of Organic Agriculture (FiBL), Dept. of International Cooperation, Switzerland*

The cocoa mirid (*Monalonion dissimulatum*) is one of the major pests in cocoa cultivation in Alto Beni, Bolivia. The most common control method is the manual removal of the nymphs. This practice is time-consuming, and therefore farmers often do not follow it. Hence there is an urgent need for more efficient practices to control this important pest.

This study evaluated the pathogenicity of two strains of *Beauveria bassiana* for the control of *M. dissimulatum* on cocoa: a non-native, commercialised strain (Probiobass MR, Probiotec S.R.L.), and a locally isolated, native strain of Alto Beni, which is not yet commercialised. Moreover, a silicon-based product (TECSIL PM®) was tested. In addition, the effect of different degrees of infestation with *M. dissimulatum* on different stages of cocoa pod development was examined. In order to investigate these questions, several field trials were carried out at the experimental station of Sapecho between June and September 2013.

The foreign *B. bassiana* strain was the most effective bio-pesticide with a mortality rate of 63.3 % in adults and 49.1 % in nymphs. Cocoa pods in their early stages of development were highly susceptible to attack by *M. dissimulatum*. On the other hand, fully developed cocoa pods showed a rather strong resistance to attacks: no effects on cocoa wet bean yield were recorded up to about 70 % of damaged tissue on the surface of the cocoa pods. However, when the damage increased above 70 %, it had a strong impact on yield, amounting up to 50.4 % loss. Damaged pods started desiccating, and fully damaged pods completely desiccated causing total yield loss.

It is concluded that the foreign strain of *B. bassiana* may be the most efficient to control *M. dissimulatum* in the field. More on-farm field trials need to be conducted over longer periods of time in order to elucidate whether the observed effects will be reflected in higher cocoa yields in the farmer's context. It is recommended to perform harvesting operations at regular intervals of two weeks in order to minimise losses caused by the desiccation of damaged cocoa pods.

Keywords: *Beauveria bassiana*, *Monalonion dissimulatum*, organic pest management, *Theobroma cacao*

Contact Address: Christian Andres, Research Institute of Organic Agriculture (FiBL), Dept. of International Cooperation, Ackerstrasse 113, CH-5070 Frick, Switzerland, e-mail: christian.andres@fibl.org

Evaluation of a Visual Vitality Assessment to Detect Indicators for Stress and Yield for Cacao

NORA KÄGI[1], MONIKA SCHNEIDER[1], FRANCO WEIBEL[2]

[1]*Research Institute of Organic Agriculture (FiBL), Dept. of International Cooperation, Switzerland*

[2]*Research Institute of Organic Agriculture (FiBL), Horticultural Science, Switzerland*

In a field trial, situated on a commercial farm in Malaysia, the performance of three cacao clones is evaluated under three production systems mainly characterised by diversification levels (mono culture to high diversity agroforestry). At the beginning of the project the canopy of the twenty-two-year-old trees was pruned back to the leader structure and then rebuilt. The plantation surrounding the trial proved to be a constant source for diseases and pests impairing the recovering trees. To monitor stress levels and to compare the performance of the different clones under the applied production systems, a tool to compare physiological condition in quantifiable terms is advantageous. In other studies the concepts of tree vigour and vitality are often used for this purpose.

Definitions of vigour and vitality as well as methods on how to assess them, are numerous and vary considerably in their scope. Reported parameters include tree height, stem circumference, carbohydrate content in sap, visual assessment of growth vigour, crown density, flowering intensity, and so on. Studies from environmental surveys show that a close observation of visually assessable vigour parameters could help to appraise quickly and non-destructively the status of a tree, to detect stress factors such as diseases, pests and nutrient deficiencies and to forecast yield levels. For agricultural tree crops the term vigour is mainly used to describe the vigorousness of tree growth, which relates to maintenance efforts. The ability to efficiently and comprehensively detect stress factors and reliably quantify stress levels would certainly be useful, nevertheless the general vitality of tree crops is seldom assessed. For cacao no comparable tree vitality study is known. Therefore a suitable assessment tool encompassing a variety of vitality indicators had to be developed and tested as part of the experiment.

The difficulty was firstly to identify and measure suitable indicators of vitality, secondly to assess the strength of the stress and thirdly to determine the absolute or relative level of vitality. First results compare the correlation of yield performance and tree vitality, along with the evaluation of clone performance and identification of potential characteristic problems related to the three production systems.

Keywords: Cacao, production system comparison, tree vitality assessment

Contact Address: Nora Kägi, Research Institute of Organic Agriculture (FiBL), Dept. of International Cooperation, Ackerstrasse 113, 5070 Frick, Switzerland, e-mail: nora.kaegi@fibl.org

Grouping of Bacteria Isolated from Dieback-Affected *Dalbergia sissoo* in Bangladesh by Phylogenetic Analyses and ARDRA

HANNY TANTAU[1], HANS-PETER MÜHLBACH[1], ANNIKA STUBBE[1], RAKHA HARI SARKER[2], SHEIKH SHAMIMUL ALAM[2], SALIM KHAN[3], M. IMDADUL HOQUE[2]

[1] *University of Hamburg, Biocentre Klein Flottbek and Botanical Garden, Germany*

[2] *University of Dhaka, Department of Botany, Bangladesh*

[3] *Bangladesh Council of Scientific and Industrial Research (BCSIR), Tissue Culture Laboratories, Bangladesh*

Among plant pathogenic bacteria the 'genus' *Pseudomonas* is one of the most diverse taxonomic groups, which very often underwent revision in the past. In our studies on the bacterial community associated with dieback-affected sissoo trees (*Dalbergia sissoo* Roxb.) in Bangladesh, DNA based approaches were applied which can reveal genetic diversity in much finer details than classical taxonomic traits. However, using short sequence stretches (320 bp) of the 16S ribosomal RNA (rRNA) gene allowed genera discrimination but not species identification. Multilocus sequence typing by using several housekeeping genes gave a better resolution, but annotation of individual isolates to *Pseudomonas* species was inconsistent, when different genes were applied. Finally, taxonomic identification of 32 selected *Pseudomonas* isolates was addressed by sequencing the almost complete 16S rRNA gene (1506 of 1537 bases) and by 'Amplified Ribosomal DNA Restriction Analysis' (ARDRA). 16S rRNA sequences allowed grouping of the isolates into only two main clusters. The major one consisted of 19 isolates related to *P. oryzihabitans*, while in the minor one eight isolates related to *P. putida* were found together with very few other pseudomonads. ARDRA of the 1506 bp long PCR product of 16S rDNA showed three clusters of similar restriction fragment profiles. The first one harboured 19 isolates, all related to *P. oryzihabitans*, the second one was built from 10 isolates, eight of them related to *P. putida* and two to other pseudomonads. The third, more heterogeneous cluster, harboured three different *Pseudomonas* isolates. These strategies showed that the majority of isolates from dieback-affected sissoo samples, which exhibited pathogenic activity on test plants as well as on *sissoo* seedlings (Valdez et al., Bangladesh J. Bot. 42: 1–16, 2013), were closely related to the species *Pseudomonas oryzihabitans*.

Keywords: 16S rRNA, amplified ribosomal DNA, Bangladesh, *Dalbergia*, dieback disease, *Pseudomonas*, restriction analysis,

Contact Address: Hans-Peter Mühlbach, University of Hamburg, Biocentre Klein Flottbek and Botanical Garden, Ohnhorststrasse 18, 22609 Hamburg, Germany, e-mail: hans-peter.muehlbach@uni-hamburg.de

Self-Made Pest Control Products for Organic Cotton Production in Nimar Region, Madhya Pradesh, India

Claudia Utz[1], Juliana Zweifel[2], Lokendra Singh Mandloi[3], Rajeev Verma[3], Christian Andres[4], Gurbir S. Bhullar[4], Christoph Studer[1]

[1]*Bern University of Applied Sciences, School of Agricultural, Forest and Food Sciences (HAFL), Switzerland*

[2]*Zurich University of Applied Sciences (ZAHW), Inst. of Natural Resource Sciences (IUNR), Switzerland*

[3]*bioRe Association, Research Division, India*

[4]*Research Institute of Organic Agriculture (FiBL), Dept. of International Cooperation, Switzerland*

Homemade organic pest control products offer an ecological, healthy and low-cost alternative to ready-made products. Yet the recipes are not standardised and the products vary in quality and concentration of the active ingredients. bioRe®, together with the Research Institute of Organic Agriculture (FiBL), engages in research activities to address this challenge and improve pest management strategies in organic farming.

During the cotton cropping season 2013–14 one on-station and two on-farm trials were conducted with the objective of comparing different spraying intervals of the most commonly used home-made organic pest control products in order to identify an optimum level of crop protection. The study focused on the effect of the spraying intervals on the most important sucking pests. Besides sucking pest incidences, data on plant stress symptoms and yield formation as well as economic parameters were also collected. Additional on-station trials were established to investigate different measures of early stage crop protection and to detect specific effects of three self-made products against certain sucking pests.

The products were prepared according to recipes standardised by bioRe® after careful research and hands-on experience of its associated scientists and extension workers. This knowledge was reproduced in pictorial technical leaflets, which are easy-to-understand for the local farmers. A total of 11 leaflets — on seed treatments, early stage protection measures, pest control sprays, effective spraying technique and growth promoter were designed in both English and Hindi and will be used for dissemination activities.

On-station results were inconclusive due to low pest pressure in this season, as well as the small size of the trial plots. Results of on-farm trials revealed that a suitable strategy for pest monitoring is needed for farmers to determine at what time point pest control interventions are indicated. Further research is needed to understand the specific effects of homemade products on the different insect species. Optimised dosage and application techniques have to be worked out along with other options for integrated pest control (e.g. bird perches, border crops, soil enhancement practices) that could reduce the frequency of time-consuming spraying. These activities would best be conducted in on-farm trials.

Keywords: Cotton, organic pest management, participatory technology development (PTD), self-made pest control products

Contact Address: Claudia Utz, Bern University of Applied Sciences, School of Agricultural, Forest and Food Sciences (HAFL), 8044 Zurich, Switzerland, e-mail: claudia.utz@hispeed.ch

Crude Cotton Seed Oil as an Alternative for Coconut Mite Management in Brazil

ADENIR VIEIRA TEODORO[1], MARIA DE JESUS SOUSA SILVA[2], JÉSSICA FONTES VASCONCELOS[3], CARLOS ROBERTO MARTINS[1]

[1]*EMBRAPA Coastal Tablelands, CPATC, Brazil*
[2]*Maranhão State University, Graduate Programme in Agroecology, Brazil*
[3]*Federal University of Sergipe, Agronomy, Brazil*

The coconut mite *Aceria guerreronis* (Acari: Eriophyidae) is a major coconut pest in northeastern Brazil. Outbreaks of the coconut mite usually occur in the dry season leading to high economic losses mainly to smallholder coconut producers. Naturally-occurring predatory mites of the family Phytoseiidae contribute to the biological control of the coconut mite, but their efficiency may be greatly impaired by non-selective pesticides. We aimed at evaluating the potential of crude cotton seed oil as an alternative pesticide to control the coconut mite as well as its selectivity to the phytoseiid predatory mite *Typhlodromus ornatus*, which is found inhabiting coconut palms in this region. Toxicity and repellent bioassays were conducted under laboratory conditions to comparatively evaluate the crude cotton seed oil with four additional pesticides (based on the active ingredients abamectin, azadirachtin, espirodiclofen, and fenpyroximate) to both mites. Crude cotton seed oil toxicity to the coconut mite was over 10-fold higher than that to *T. ornatus*. Crude cotton seed oil was as efficient as other pesticides in controlling the coconut mite besides being less toxic to the predatory mite *T. ornatus*. Similarly to toxicity results, crude cotton seed oil repelled the coconut mite more strongly than the predatory mite *T. ornatus*. Field experiments comparing the relative efficiency of crude cotton seed oil with other pesticides are currently underway. In conclusion, our toxicity and repellent bioassays indicate that crude cotton seed oil could be used by coconut producers as an alternative pesticide as it efficiently controls the coconut mite besides being selective to the predatory mite *T. ornatus*.

Keywords: Alternative pesticide, conservative biological control, smallholder coconut farmers

Contact Address: Adenir Vieira Teodoro, EMBRAPA Coastal Tablelands, CPATC, Av. Beira-Mar 3250 Jardins, 49025-040 Aracaju, Brazil, e-mail: adenir.teodoro@embrapa.br

Viruses in Orphan Crops of the Tropics and their Discovery

MARION LIEBRECHT, PIRASTEH PAHLAVAN, STEPHAN WINTER
Leibniz-Institute, German Collection of Microorganisms and Cell Cultures Gmbh, Plant Virus Department, Germany

The project "adapting clonally propagated crops to climatic and commercial change" of the International Network of Edible Aroids (INEA) consolidates different researchers and institutes from around the world to work on the genetic improvement of Taro (*Colocasia esculenta*) and to specifically address tolerance / resistance against abiotic stress, mainly drought and on *Phytophtora colocasiae*, Taro leaf blight, a real threat to Taro cultivation. The centre of Taro origin and use is in the South pacific, the main breeding activities are on Fiji and Papua New Guinea islands and from there lines are send for adaptation trials to partners in South America and Africa. The exchange of germplasm however must ensure freedom of pathogens to prevent inadvertent introduction of new pests and diseases. The task of the DSMZ Plant Virus Department is to identity viral pathogens in Taro and to subsequently develop diagnostic tests which permit detection of viruses prior to shipment across continents. By use of transcriptome sequencing of RNA samples from Taro we were able to detect two hitherto undescribed viruses from the genera Nucleorhabdovirus and Tenuivirus as well as a number of known viruses. The entire genomes of the viruses were reconstructed and molecular as well as serological tests were developed. Currently these tests are validated for their routine applicability. In addition, a plant hopper transmitted rhabdovirus was found in several plants with severely deformed leaves and suspicious for "Bobone" disease, a very serious disease with a so far unclear viral aetiology. The "Bobone" disease is endemic only in the Solomon Islands and Papua New Guinea and its occurrence prevents exchange of material from those islands. Its symptomatology is similar to a deadly Taro disease, "Alomae" and hence the elucidation of the aetiology and powerful detection methods would present a major step towards a facilitation of the international exchange of Taro germplasm and breeding materials. The INEA Taro virus project and the progress made on the aetiology of the diseases will be reported.

Keywords: Deep sequencing, diagnostics development, nucleorhabdovirus, orphan crops

Contact Address: Marion Liebrecht, Leibniz-Institute, German Collection of Microorganisms and Cell Cultures Gmbh, Plant Virus Department, Inhoffenstrasse 7b, 38124 Braunschweig, Germany, e-mail: marion.liebrecht@dsmz.de

Containing Nematode Diseases in Crops by Fungal Endophytes: Current Standings and Prospects

ALEXANDER SCHOUTEN, CATHERINE WANJA BOGNER, FLORIAN M. W. GRUNDLER

University of Bonn, Inst. Crop Sci. and Res. Conserv. (INRES) - Molecular Phytomedicine, Germany

Plant-parasitic nematodes, particularly root-knot nematodes, cause major problems in important crops in the tropics and subtropics. To control nematode diseases, different strategies are being applied, including chemical and various cultural practices. In spite of these measurements, nematode populations are difficult to contain for numerous reasons. Additionally, the application of nematicides is becoming increasingly restricted due to human health and environmental concerns. Supplementary approaches to control nematode diseases are therefore necessary. Over the past two decades, screening of crop plants in the tropics has led to the identification of several interesting fungal endophytes that have the ability to reduce nematode infection. Although the responsible mechanisms are in most cases still obscure, there are strong indications that these isolates may affect nematode development in several ways: directly, by producing nematicidal metabolites, indirectly, by inducing specific plant defense mechanisms, or both. Biological, molecular and biochemical studies now indicate that the effects of some endophytes against nematodes are indeed multifactorial. Endophyte inoculated roots can negatively affect nematode infection, development fecundity and female-male ratio. Root exudates of endophyte inoculated plants can repel nematodes and some endophytes can produce nematistatic or nematicidal metabolites. With all these elements combined, this can lead to a significant containment of the nematode population in the long term. The molecular and chemical characterisation of these individual elements will at the same time contribute to a better and faster screening of endophytes and plant genotypes and therefore an optimal endophyte nematode mediated resistance in plants can be achieved. The use of habitat-adapted endophytic fungi may thus provide a safe, efficient, reliable and affordable approach to control nematode diseases in crops, which can be combined with other integrated pest management strategies.

Keywords: Biocontrol, crop protection, endophytes, induced resistance, integrated pest management, plant-parasitic nematodes

Contact Address: Alexander Schouten, University of Bonn, Inst. Crop Sci. and Res. Conserv. (INRES) - Molecular Phytomedicine, Karlrobert Kreiten Strasse 13, 53115 Bonn, Germany, e-mail: aschout@uni-bonn.de

Agrobiodiversity and plant genetic resources II

Animal science

Animal feeding and nutrition

Effect of Dietary Sodium Diformate on Growth Performance in Giant Freshwater Prawn under Controlled Conditions

CHRISTIAN LÜCKSTÄDT[1], MARIA LOURDES A. CUVIN-ARALAR[2]
[1]*ADDCON, Germany*
[2]*SEAFDEC, Binangonan Freshwater Station, Philippines*

Aquaculture of the Giant Freshwater Prawn, *Macrobrachium rosenbergii* (De Man 1879) started only in the mid nineteen-eighties, but has grown to more than 203,000 t, worth around 1.1 million USD in 2010 – mainly in Asia and the Americas and is still expanding rapidly, especially in Asia. Most of this production is carried out in monoculture in earthen ponds. Commercial diets include up to 35 percent crude protein. High stocking densities and non-optimal water quality, poor sanitation and non-existent or inadequate quarantine procedures may impair prawn health and growth performance. Growth may be improved through the application of high quality feeds, and sustainability of feed ingredient use is one of the main factors for future successful aquaculture operations. Adding sodium diformate (NDF), a double salt of formic acid, to the supplemental diet is expected to improve health and growth performance of the Giant Freshwater Prawn.

A laboratory trial was set up at the South East Asian Fisheries Development Center (SEAFDEC), Binangonan Freshwater Station in Rizal, Philippines. Prawns were kept with 15 individuals per tank with 4 replicate tanks per group. NDF was added to a commercial diet at a dosage of 0.5 %, while the diet without NDF served as a negative control. The initial weight of *M. rosenbergii* was 0.65±0.01 g. Prawns were kept and fed according to normal pond management for 71 days' culture. At the end of the trial, prawns in the treated group had a similar final weight of 4.1±0.1g and similar weight gain compared to the negative control group, whereas the survival rate and FCR improved significantly (77±3 v. 87.5±5 % and 2.05±0.14 v. 2.43±0.19, respectively; $p < 0.05$). The productivity index (PI = weight gain × survival / (10 × FCR)) was also significantly improved, by 35 %.

These results show significantly improved performance in Giant Freshwater Prawns fed with sodium diformate. Similar results have already been reported in diformate-fed white-leg shrimp in Thailand, further supporting the use of NDF in a sustainable aqua-feed industry, contributing to economic prawn production.

Keywords: Growth performance, *Macrobrachium* culture, sodium diformate

Contact Address: Christian Lückstädt, ADDCON, Kaiserstrasse 1a, 53113 Bonn, Germany, e-mail: christian.lueckstaedt@addcon.com

Response of African Catfish, *Clarias gariepinus* to Diets of African Yam Bean (*Sphenostylis stenocarpa*) subjected to two Processing Methods

JOHNNY ONYEMA OGUNJI[1], JOAN OZIGBO[1], ANGELA OSSAI[1], STEPHEN OCHANG[2]

[1]*Ebonyi State University, Dept. of Fisheries and Aquaculture, Nigeria*

[2]*Cross River University of Technology, Dept. of Fisheries and Aquatic Science, Nigeria*

This study assesses the response of African Catfish (*Clarias gariepinus* Burchell 1822) to diets of African yam bean (*Sphenostylis stenocarpa*) subjected to two processing methods. Mature African yam bean (AYB) was boiled and fermented. Their meals were evaluated as a protein source for *Clarias gariepinus* fingerlings. Five diets were formulated to contain 44.01±0.46 % crude protein (Mean ± SD) and 19.03±0.05 kJ g^{-1} gross energy (Mean ± SD) respectively. Fishmeal in the diets was substituted with each of the two processed AYB meals at 40 % and 45 % levels. Control diet did not contain AYB. Nine fingerlings (initial average weight 12.28±0.18 g) were stocked per experimental tank. Experimental diets were fed to triplicate groups of catfish fingerlings at 10 % body weight for 56 days. Quantity of feed was adjusted forth nightly after bulk weighing of experimental fish. Experimental data, samples of fish and feedstuff were analysed at the end of experiment. Results indicated that fermentation process improved crude protein percentage and amino acid profile of AYB. Specific growth rate (SGR) was highest at 45 % replacement of fermented yam bean (3.32±0.20) compared to control (3.17±0.44). Carcass composition of experimental fish varied significantly ($p < 0.05$) between diet treatments but was better than in control group. Body protein accumulation was highest (57.82±0.02 %) at 45 % boiled AYB replacement and significantly different ($p < 0.05$) above control. This was followed by 45 % fermented AYB diet replacement (54.73±0.02 %). Mean values for haematological parameters (PCV, HB, WBC and RBC) significantly increased ($p < 0.005$) above the initial status and control group. Haematological values for fish fed 40 % inclusion level of fermented and boiled AYB in diet were the highest. However, damage to epithelial mucosa of the fish was observed in group fed 45 % inclusion level of boiled and fermented AYB diet respectively. This study shows that fermentation and boiling are effective methods of reducing anti-nutrient in AYB and can enhance fish growth. However, based on the histological results processed AYB should not be included beyond 45 % inclusion level.

Keywords: African catfish, African yam beans, alternative protein source, hematology, histology

Contact Address: Johnny Onyema Ogunji, Ebonyi State University, Dept. of Fisheries and Aquaculture, PMB 053 Abakaliki, Nigeria, e-mail: ogunjijo@yahoo.com

Apparent Digestibility of Earthworm Meal in Plant-Based Feeds for Nile Tilapia, *Oreochromis niloticus* (L.)

JOHANNES PUCHER[1], EVGENIYA NIKOLAEVSKAYA[1], ULFERT FOCKEN[2]
[1]*University of Hohenheim, Life Science Center, Germany*
[2]*Thuenen-Institute for Fisheries Ecology, Ahrensburg Branch, Germany*

Fishmeal is a limited resource and restricts the development of aquaculture especially in rural areas which have no established markets to supply suitable feed resources. Previous studies have shown that earthworm might be used to replace fishmeal in plant-based feeds. Aim of this study was to evaluate the apparent digestibility of earthworm meal in plant-based feeds for Nile Tilapia.
Four iso-nitrogenous (36 % crude protein) and iso-lipidic (10.5 % crude lipid) feeds were formulated mainly based on plant ingredients with 20 % animal derived crude protein from fishmeal and/or earthworm meal. From feed 1 to 4, 0 %, 33 %, 66 % and 100 % of fishmeal protein was replaced by protein from freeze-dried earthworm (*Perionyx excavatus*). All feeds contained 1 % TiO_2. 24 aquaria of 40 L each were equipped with a separation wall and were stocked with one Nile Tilapia of 40 g body mass in each sector. Water flow-through was adjusted at a rate of 6–7 L min^{-1}. The light was adjusted to 12 hours light 12 hours dark. Water temperature was 27.5 ± 0.5°C. Dissolved oxygen was kept at above 4 mg L^{-1} and pH between 7.0 and 8.0. Trial lasted for 56 days. Weekly, fishes were weighed and adjusted feed amounts were fed by automatic feeders. At a feeding ratio of 5-times maintenance, faeces was collected in all aquaria and pooled per aquarium over two replicated 7-days periods. Dry matter, crude ash, crude fibre, crude lipid, crude protein, gross energy and TiO_2 content was analysed for feeds. Faeces was analysed for dry matter, crude ash, crude protein and TiO_2 content. Feed conversion ratio, growth rate and apparent digestibility coefficients for crude protein and dry matter were tested statistically with ANOVAs.
Earthworm showed similar crude protein and even better essential amino acid contents and was digested as well as fishmeal. Earthworm-based feeds significantly reduced growth. Assimilation of earthworm-based feeds into fish mass was lower than of fishmeal-based feeds. This suggests a higher catabolism of nutrients in fish fed by earthworm-based feeds which is potentially caused by feed related stress. To utilise earthworm as feed source, pre-treatments of earthworm should be evaluated to reduce anti-nutritional effects.

Keywords: Alternative feed resource, aquaculture, fish nutrition

Contact Address: Johannes Pucher, University of Hohenheim, Life Science Center, Wollgrasweg 43, 70593 Stuttgart, Germany, e-mail: johannes.pucher@daad-alumni.de

Effects of Phytogenic Feed Additive on Growth Performance, Feed Utilisation and Nutrient Digestibility of Nile Tilapia (*Orechromis niloticus*) Fingerling

KHALED MOHAMED[1], MOHAMED MEGAHAD[2]

[1]*Suez Canal University, Animal and Fish Production, Egypt*

[2]*National Institute of Oceanography and Fisheries (NIOF), Aquaculture, Egypt*

Potential benefits of phytogenic feed additive (PFA) as a natural alternative growth promoter to antibiotics have been gaining interest worldwide to improve fish health and productivity in aquaculture. Specifically, a study was carried out at Fish Research Center, Suez Canal University to evaluate the effects of Digestarom® P.E.P. MGE as PFA on growth performance, feed utilisation and nutrient digestibility of Nile tilapia (*Oreochromis niloticus*) fingerlings. A total of 300 all male Nile Tilapia (mean body weight ca. 10 g) were randomly divided to 5 dietary treatments. Each treatment was conducted in three replications with 20 fish each. Diet without PFA was performed as control. Diets 2 to 5 each contained Digestarom® at levels of 100, 200, 300 and 400 mg kg^{-1}, respectively. The fish were fed on diets containing 30 % crude protein and 410 GE kcal/100 g. The experiment lasted for 56 days. Generally, growth performance of Nile tilapia was not significantly different ($p > 0.05$) in all treatments receiving Digestarom® but were different from control. Feed conversion ratio, protein efficiency ratio and protein retention efficiency were improved ($p < 0.05$) for tilapia fingerlings fed on diets supplied with Digestarom® as compared to fish fed on the control diet. The apparent protein and lipid digestibility were improved significantly ($p < 0.05$) for tilapia fingerlings fed on diets supplied with Digestarom® compared to fish fed on the control diet. In terms of blood measurements, no significant differences were detected in plasma total protein, plasma albumin and plasma total globulins of fish fed on the experimental diets. In conclusion, this study demonstrated that the inclusion of Digestarom® in feed was effective in improving growth performance, as particularly feed conversion and nutrient digestibility of Nile tilapia fingerlings improved.

Keywords: Feed additives, feed utilisation, growth performance, phythoginc, tilapia

Contact Address: Khaled Mohamed, Suez Canal University, Animal and Fish Production, 41522 Ismailia, Egypt, e-mail: khelo20022002@yahoo.com

Development of Aquafeeds for Tilapia and Carp Using Detoxified *Jatropha curcas* Meal as Protein Source

CARSTEN KROME[1], KIM JAUNCEY[2], ULFERT FOCKEN[1]

[1]*Thuenen-Institute for Fisheries Ecology, Ahrensburg Branch, Germany*

[2]*University of Stirling, Institute of Aquaculture, United Kingdom*

Productivity of rural fish ponds in tropical countries is many times low due to low feed quality. Since it is these same countries, which disproportionately often suffer from protein deficiency within their population, higher fish yields of aquaculture operations could significantly add to a solution of this problem.

Jatropha curcas is a tropical shrub that is increasingly cultivated on marginal land in several African and Asian countries. Its seeds are harvested to retrieve oil; the remaining press cake can be detoxified to leave a high-protein meal with a balanced essential amino acid composition. In a series of feeding trials, we tested the suitability of detoxified *Jatropha curcas* kernel meal (JKM) as a protein source in comparison to fishmeal in diets for carp and tilapia.

Two types of diets were tested for both species: A diet containing only fishmeal as a protein source as well as a diet where fishmeal only supplied 25 % of the protein. In all trials, fishmeal was replaced in incremental steps from 30 % to 100 % with JKM. For both diet types and species, fish grew generally well throughout all JKM inclusion levels, however, a linear decline of growth could be observed the more JKM was included in the diet. This was assumed to be caused by anti-nutritional factors, namely phytate and oxalate, which have been shown to be present in three- and ten-fold concentrations, respectively, compared to soybean meal as a reference feedstuff (3 % vs. 1 % and 2.5 % vs. 0.25 %).

Closer investigation of dietary phytate revealed no effect of growth in 100 % JKM based diets, however, a strong negative impact on mineral availability.

Dietary addition of oxalate also showed no impairment of growth, but severely influenced energy metabolism, decreasing body lipid, energy and plasma cholesterol content at inclusion levels of 1.5 % and higher.

In conclusion, JKM can be used as a protein source in carp and tilapia feeds, especially in rural areas where fishmeal is scarce. The exact compound responsible for its reduced growth performance compared to fishmeal remains unknown, however, new interesting insights of these compound could be gained.

Keywords: Antinutrients, aquaculture, aquafeeds, biofuels, carp, tilapia

Contact Address: Ulfert Focken, Thuenen-Institute for Fisheries Ecology, Ahrensburg Branch, Wulfsdorfer Weg 204, 22926 Ahrensburg, Germany, e-mail: ulfert.focken@ti.bund.de

Evaluation of the Effect of Milk Thistle (*Silybum marianum*) Supplement on Fattening Performance and Health Status of Broiler Rabbits

PETRA SILBEROVÁ[1], ADÉLA DOKOUPILOVÁ[2], KAREL JANDA[2], KAREL MACH[3], LUKÁŠ JEBAVÝ[2], DANIELA LUKEŠOVÁ[1]

[1]*Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Dept. of Animal Science and Food Processing, Czech Republic*

[2]*Czech University of Life Sciences Prague, Fac. of Agrobiology, Food and Natural Resources, Dept. of Husbandry and Ethology of Animals, Czech Republic*

[3]*Czech University of Life Sciences Prague, Fac. of Agrobiology, Food and Natural Resources, Dept. of Genetics and Breeding, Czech Republic*

Production of broiler rabbits, as a very dietetic type of meat with low content of fat and cholesterol, could be a very important source of high quality protein for human nutrition. It seems that the use of phytoadditives and their extracts in rabbit breeding offers an acceptable way to improve welfare and health of animals. Milk thistle (*Silybum marianum*) extract contains silymarin - flavolignans, with hepatoprotective and canceroprotective properties, neurodegenerative and neurotoxic repressing functions. The aim of this study was to evaluate the influence of milk thistle fruit extract in Silyfeed®Basic supplement on the growth of broiler rabbits and their health status. There were 120 HYLA broiler rabbits divided into three groups in the experimental university farm (Czech University of Life Sciences Prague). Animals were fed by a standard diet for rabbit fattening without any supplement (group I), and with the supplement of 0.2 % Silyfeed®Basic for group II and 1 % for group III. The experiment started at 42 days of rabbit age and finished when achieved 2.6 kg of live weight. No statistical significant differences were found between control and experimental groups for the parameters growth performance and the carcass yield. Morbidity and mortality were significantly lower in group III (1 % of Silyfeed®Basic). Also blood biochemistry, especially parameters for liver metabolism, and liver tissues showed no statistical significant differences between the groups. These tests will continue, but first results show that 1 % of the milk thistle extract supplemented in the feed ration for broiler rabbits could be a suitable substitute for chemical drugs commonly used.

Keywords: Growth performance, health status, metabolism, rabbits, *Silybum marianum*

Contact Address: Petra Silberová, Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Dept. of Animal Science and Food Processing, Kamýcká 129, 16521 Prague 6 - Suchdol, Czech Republic, e-mail: silberova@ftz.czu.cz

Canavalia Brasiliensis Forage Meal in Broilers' Finishing Diets: *in vivo* Digestibility and Animal Performance

MAURICIO SOTELO[1], NELSON JOSÉ VIVAS QUILA[2], SIRIWAN MARTENS[1], LUZ STELLA MUÑOZ[3], EDWIN ARLEY VIVAS OROZCO[2], MARIO CUCHILLO HILARIO[1]

[1]*International Center for Tropical Agriculture (CIAT), Tropical Forages, Colombia*

[2]*University of Cauca, Dept. of Agricultural Sciences, Colombia*

[3]*Universidad Nacional de Colombia (UNAL), Dept. of Animal Science, Colombia*

Cereal grains are the bases for monogastric animal feeding. However, further utilisation of such high-quality sources of protein and energy would be heavily modulated by direct competition with human consumption. Therefore, it is necessary to find alternative resources to feed animals while avoiding competition with human food. We evaluated the inclusion of *Canavalia brasiliensis* (CIAT-17009) forage meal on poultry finishing diets. 120 male birds (Cobb 500) of 18 days of age were arranged: 1) control group (CON) fed with corn-meal (66.1 %), soybean-meal (22.3 %), fish-meal (5.1 %), bentonite (1.9 %), phosphorous [Biofoss (1.0 %)], Calcium carbonate (1.1 %), palm oil (1.0 %), vitamins-minerals (1.0 %), salt (0.4 %), DL-methionine (0.1 %) and L-lisine (0.1 %). The experimental group fed 2) the same components as CON, but Canavalia meal (20.0 %) was included (CAN). There were six replicates (experimental unit) with 10 birds each per treatment. A completely randomised design was employed. The experiment lasted 22 days in total. An adaptation phase (10 days) was followed by the experimental phase (12 days). Animals were fed at 0730, 1200 and 1600h. Feces were sampled (at 0700 and 1800h) along the last eight days of the finishing period. Diet digestibility was higher in CON (62.0 %, $p = 0.006$) than in CAN (57.4 %). However, the inclusion of Canavalia in the diet increased apparent protein digestibility (52.5 % and 40.5 % for CAN and CON, respectively). No differences were found for gross-energy digestibility (CON=68.5 % and CAN=62.1 %). Crude-fiber digestibility was lower ($p = 0.0001$) in CAN (7.2 %) than in CON (35.4 %). In line with these results, CON recorded the best feed conversion (2.5) in contrast to CAN (3.7)($p = 0.0001$). Better average daily live-weight gain ($p = 0.0001$) was observed in CON (90g/animal/d) compared to CAN (62.4 g/animal/d). Final-weight of birds averaged 1745 g for CON while CAN recorded 1463 g. Cost of diet was lower including Canavalia (0.38 vs. 0.50 USD kg^{-1} for CAN and CON, respectively). Though diets including *Canavalia brasiliensis* showed in general lower digestibility parameters, this forage might be a valuable alternative as protein source. Graded levels of inclusion of Canavalia on diet should be tested before discard or recommend this legume for poultry feeding.

Keywords: *Canavalia brasiliensis*, digestibility, legumes, poultry, tropical forages

Contact Address: Mauricio Sotelo, International Center for Tropical Agriculture (CIAT), Tropical Forages, A A 6713 Cali, Colombia, Cali, Colombia, e-mail: m.sotelo@cgiar.org

Carcass, Organ and Palatability Characteristics of Broiler Fed with Graded Levels of Cowpea Testa Based Diets

PATIENCE OLUSOLA FAKOLADE, BANWO ALABI, OLUMUYIWA JACOB OSUNKEYE, AKINDURO VICTOR OLABISI

Osun State University, Dept. of Animal Science and Fisheries, Nigeria

The over dependency on soybean meal or any other protein source in most developing country like Nigeria, as one of the key conventional proteins for feeding livestock especially poultry is currently threatening the development of the industry and has resulted in an increase in price and consequently cost of livestock feeds and livestock products. To combat the problem of food insecurity, alternative feed stuffs / non conventional feed stuffs are used to reduce cost of feed and livestock product. Cowpea testa is a relatively cheap feedstuff with crude protein of 17 % and 1005 kcal kg^{-1} dry matter metabolisable energy. One hundred and twenty (120) one-day old Arbor acre broiler birds were used for this study, they were randomly allocated to 4 treatments of cowpea testa meal (CTM) to substitute soyabean meal at 0 %, 15 %, 30 % and 50 % as T1, T2, T3 and T4 respectively, having 30 birds per treatments with 3 replicates with 10 birds each. Results showed that T2 had significantly lower weight for heart, kidney, spleen, intestine, and liver as compared to T1, T3 and T4. But T2 had significant higher ($p < 0.05$) values for proventriculus of 0.99 g, against 0.60 g, 0.81 g and 0.85 g for T1, T3 and T4, respectively. For the carcass analysis, T2 had significant lowest values of breast weight with 14.89, than T1, T3 and T4 with 17.52g, 15.71g and 16.28g respectively; however, the differences between the three latter treatments was not significant. The thigh, drumstick, wings and back weight was found to be highest for T3 with 12.32 g, 10.66 g 10.34 g and 21.04 g, respectively; against (9.80 g, 9.39 g, 8.32 g, and 21.37 g), (10.00 g, 8.71 g, 9.05 g and 17.71 g) and (11.22 g, 9.58 g, 9.63 g and 17.89 g) for T1, T2, and T4, respectively. The cholesterol level of T3 appeared to be the significantly highest while T4 had the significantly lowest cholesterol level. Palatability value score for T1 and T2 had higher values for colour, flavour, tenderness, juiceness, texture and overall acceptability as compared to T3 and T4. Cowpea testa could be an alternative feedstuff in broilers nutrition to replace soybean meal up to 15 % without significant differences in organ, carcass analysis and palatability / sensory characteristics.

Keywords: Broilers, carcass analysis, cholesterol, cowpea, palatability study

Contact Address: Patience Olusola Fakolade, Osun State University, Animal Science and Fisheries, 13 Oladele Ajao Street Box 4849 Dugbe., 0234 Ibadan, Nigeria, e-mail: twinsfakolade@yahoo.com

Effect of Dietary Sodium Diformate in Broilers on the Productivity Index Against a Positive Control

CHRISTIAN LÜCKSTÄDT[1], NICOLAS GREIFFENSTEIN[1], RONNIE DARI[2]
[1]*ADDCON, Germany*
[2]*Salus, Brazil*

Gastrointestinal diseases pose a serious threat to commercial poultry production. In the past this hazard was controlled by the prophylactic use of antibiotics. Since the EU ban on antibiotic growth promoters (AGP) in 2006, which led other markets to consider similar steps, new strategies against gastrointestinal diseases in livestock have been developed. Organic acids and their salts are commonly used to suppress gastrointestinal disorders. Potassium diformate for instance, is the first substance with EU-approval as a non-antibiotic growth promoter for pigs. In a new commercial study, sodium diformate (NDF) was tested against a positive control (AGP) in order to demonstrate similar effects in poultry.

The trial was conducted under large scale conditions in Ceará, Brazil in 2013 and aimed to test NDF against a commercial broiler diet containing an antibiotic growth promoter (Colistin). Feed and water were available *ad libitum*. Around 500,000 one day old birds from 33 different houses were included in the study and were compared to the same number of birds (from the same houses) and their subsequent performance from the previous year. Performance data were measured at the end of the trial and the European Broiler Index (EBI) calculated as: EBI = ADG [g] $\times$ Survival [%] / (10 $\times$ FCR). The average growth period was 45 days. The positive control group used 60 g Colistin per t of feed for the first 21 days, while the treatment group added 0.1 % NDF during the same time period. EBI data were analysed using the t-test. The results are given as mean $\pm$ SD with a confidence level of 95 %.

EBI in the houses with 0.1 % NDF was increased by 5.1 % ($p = 0.006$). Due to the inclusion of sodium diformate, EBI in 10 out of 33 houses reached a value above 300 (max. 331), whereas the Colistin-treated houses attained only a maximum EBI of 297.

These findings lead to the conclusion that the addition of 0.1 % sodium diformate considerably improves overall broiler performance, combining effects on daily gain, survival and feed efficiency, even when compared to the use of an AGP.

Keywords: Colistin, European broiler index, poultry, sodium diformate

Contact Address: Christian Lückstädt, ADDCON, Kaiserstrasse 1a, 53113 Bonn, Germany, e-mail: christian.lueckstaedt@addcon.com

Nutritional and Economic Implications of Cashew Reject Meal in Diets of Laying Chickens

TAIWO AKANDE[1], AKINYINKA AKINWUMI[2], TAYE ABEGUNDE[1]

[1]*Obafemi Awolowo University, Animal Science, Nigeria*

[2]*Ladoke Akintola University of Technology, Animal Nutrition and Biotechnology, Nigeria*

The nutritional and economic implication of cashew rejects meal (full fat and defatted) as replacement for groundnut cake (GNC) in the diets was evaluated. Eighty four brown shavers at 25 weeks of age were randomly allotted into seven dietary treatments each containing six replicates of two birds. The seven diets prepared included diet 1, a control with GNC at 220 g kg^{-1} as main protein source in the diet. Diets 2, 3 and 4 consisted of gradual replacement of GNC with defatted cashew reject meal (DCRM) at 50 %, 75 % and 100 % on weight for weight basis, respectively, while diets 5, 6 and 7 consist of gradual inclusion of full fat cashew reject meal (FCRM) to replace 25 %, 35 % and 50 % of GNC protein, respectively. Each group was allotted a diet in a completely randomised design in a study that lasted eight weeks during which records of the chemical constituent of the test ingredients, performance characteristics, egg quality traits and economic indicators were measured. Results showed that the crude protein were 22.1 and 35.4 % for FCRM and DCRM, respectively. Gross energy of DCRM was 5035 kcal kg^{-1} compared to GNC, 4752 kcal kg^{-1}. Result of aflatoxin B1 revealed moderate level between 10 and 17μg kg^{-1} in CRM and GNC samples, respectively. Birds on control diet gained 10 g, while those on DCRM and FCRM gained about 35 g and 120 g, respectively. Feed intake declined ($p < 0.05$) with increased level of FCRM. Hen day production was highest in birds fed DCRM, followed by control and lowest value ($p < 0.05$) was recorded for FCRM. No significant change ($p > 0.05$) was observed for egg weight and shell thickness. Fat deposition and cholesterol content increased ($p < 0.05$) with increasing level of FCRM. The cost of feed per kilogram decreased gradually with increased inclusion level of CRM. The prediction equation showed the relative worth of DCRM compared to GNC was 92.3 % whereas the actual market price of GNC triples that of DCRM. It was recommended that GNC could be completely replaced by DCRM in layer's diets in regions where this by product is abundant. However, FCRM should be cautiously used in diets of laying chickens.

Keywords: Cashew rejects meal, chemical constituents, economy, laying hens, performance

Contact Address: Taiwo Akande, Obafemi Awolowo University, Animal Science, Ile-ife, Nigeria, e-mail: yakandetaiwo@yahoo.com

The Impact of the Seabuckthorn (*Hippophae rhamnoides*) Supplement in the Feed Ration on the Quality of Poultry Products

AKHIR PEBRIANSYAH, PETRA SILBEROVÁ

Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Dept. of Animal Science and Food Processing, Czech Republic

Seabuckthorn (*Hippophae rhamnoides*) (SB) is a shrub which belongs to the family Elaeagnaceae, it have been used in Asia, Europe, and North America for human consumption, cosmetics, and also animal feeding as a dried by-product after fruit processing for juices. This study aimed to find effects of the SB supplement in feed ration on the laying hens' productivity and egg quality. Two experiments were conducted at the ITP (International Testing of Poultry) in Ústrasice, Czech Republic. Total number of laying hens was 2160. In the first experiment 1440 hens were divided into 48 pens - 7 periods with a diet containing 5 % of SB (T) vs. a diet without SB (control). During the second experiment 720 hens were divided into 12 pens - over 2 periods with a diet containing 13.5 % SB (T) vs. a control group without SB. The data collected was analysed by statistical software SAS System 9.3. Parameters of the production of eggs, quality of eggs, live weight of hens and also feed consumption were measured. There were no statistical significant differences between groups of hens fed by 5 % of SB in a diet vs. control group in egg production and egg weight during the first experiment, but significant decrease of egg productivity and egg weight was found in T group (13.5 % of SB) during the second experiment ($p < 0.01$). The colour of yolk increased significantly – more orange, in the diet with SB for both experiments ($p < 0.01$). The feed consumption was the highest in the group fed 13.5 % of SB, but the feed conversion was not better in this group. Overall, some positive effects of 5 % SB inclusion in the diet were found: promotion of a more orange yolk colour, higher productivity of laying hens, and decreasing number of disorders in eggs. However, 13.5 % of SB in a diet decreased the egg quality and productivity of hens, so we cannot recommend this higher concentration of SB in a diet for laying hens.

Keywords: Feed, laying hens, poultry products, quality of eggs, seabuckthorn

Contact Address: Akhir Pebriansyah, Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Dept. of Animal Science and Food Processing, Kamýcká 129, 16521 Prague 6 - Suchdol, Czech Republic, e-mail: avanbenjamin89@gmail.com

Early Stage Identification of Rumen Microorganisms from Selected Nigerian Breeds of Cattle

O. I. ADEYOSOYE[1], A. K. AKINTOKUN[2], OLANIKE ABIOLA-OLAGUNJU[3], K. D. AFOLABI[4], ELIZABETH OMOKOSHI JOEL[5]

[1]*Obafemi Awolowo University, Dept. of Animal Sciences, Nigeria*

[2]*Federal University of Agriculture, Abeokuta, Dept. of Microbiology, Nigeria*

[3]*Olabisi Onabanjo University, Ayetoro Campus, Dept. of Home and Hotel Management, Nigeria*

[4]*Rubber Research Institute of Nigeria, Research Outreach, Nigeria*

[5]*University of Ibadan, Dept. of Animal Science, Nigeria*

The kinetics of fermentative activities in the rumen justified the need for microbial assessment of members of rumen community during early stage of fermentation in selected breeds of cattle commonly raised or found in Nigeria. A total of four breeds of cattle was selected for this study comprising of both male and female species of Bunaji (White Fulani), Futumi (Keteku), Bokolo (N'dama) and Djeli (Sokoto Gudali). Total heterophilic bacteria (THB) on nutrient agar ranged between 9.1×10^{8}cfu g^{-1} - 125×10^{11} cfu g^{-1} with the highest count recorded for male Djeli (Dm) and the least count for female Djeli (Df), respectively. Total heterophilic fungi (THF) on malt extract agar recorded the highest count (6.0×10^{5} spores g^{-1}) for female Bunaji (Bf) and no growth was observed for female Bokolo (Bkf). The rumen pH ranged between 5.65 and 6.90 for female Futumi (Ff) and male Bunaji (Bm), respectively. Significant difference ($p < 0.05$) was observed for pH and total microbial counts based on sex. Standard methods of colonial and biochemical assessments led to the isolation, characterisation and identification of bacterial species of the genera: *Klebsiella*, *Proteus*, *Pseudomonas* and *Shigella*. *Klebsiella edwardsii* had the highest occurrence (24.24%). *Proteus morganella*, *Shigella dysentariae* and *Shigella sonnei* occurred least (3.03%). Fungal species of the goup: *Aspergillus*, *Botrytis*, *Cladosporium*, *Cephalosporium*, *Paecilomyces*, *Penicillium*, *Pullularia*, *Rhizoctonia* and *Trichophyton* were also isolated and identified. *Aspergillus glaucus* and *Pullularia pullulans* both had the highest occurrence (17%) while *A. fumigatus*, *A. niger*, *Botrytis* spp., *Cladosporium herbarium*, *Penicillium camemberti*, *Trichophyton mentagrophytes*, *T. rubrum* and *Rhizoctonia solani* occurred least at the level of 5%. In conclusion, breed as a factor was found to have significant effects on the percentage occurrence, type and total load of rumen bacteria and fungi at the early stage of fermentation. The use of fistulated animals is recommended for microbial screening at different stages of fermentation without the need to sacrifice the animals.

Keywords: Conventional methods, fermentation, Nigerian cattle breeds,

Contact Address: O. I. Adeyosoye, Obafemi Awolowo University, Dept. of Animal Sciences, Ile-Ife, Nigeria, e-mail: adeyosoye@oauife.edu.ng

The Effects of Feeding Silage on Assaf Sheep Milk Quality and Quantity

IYAD BADRAN[1], RAMI ALQAISI[1], MUAYAD SALMAN[2], MAHMOUD FATAFTA[2]

[1]*National Agriculture Research Center, Animal Production, Palestine*

[2]*Ministry of Agriculture, General Directorate of Extension and Rural Development, Dept. of Livestock Production, Palestine*

Silage activities are one of the main activities of Palestinian Ministry of Agriculture through several projects such as Middle East Regional Agricultural Programme (MERAP) - animal wealth component. However silage was made from different kinds of crops and byproducts using both barrel and trench method. Feed trail was conducted to study the effect of feeding silage on Assaf sheep milk quantity and quality was implemented through EVAP project which is funded by JICA. However, twenty one lactating Assaf ewes were divided according to daily feed intake to three groups: group A one fed concentrate and wheat hay as roughage source, group B fed concentrate, and roughage (50 % hay, and 50 % silage), and group C fed concentrate and the source of roughage was 100 % silage. Total milk yield to 90 days of lactation TMY90, total milk yield to 120 days of lactation TMY120, and total milk yield to 150 days of lactation TMY150 were estimated. Milk samples were analyzed for fat, protein, minerals, lactose, and non-solid fat percentage. Data were analysed using SPSS 16 for windows. The results showed no significant difference ($p > 0.05$) in milk production between group A and group B, the difference was between groupC and the other two groups ($p < 0.05$) which produced more milk. Also the percentage of fat was significantly higher in group B ($p < 0.05$) compared to group A and group B. Moreover, feeding silage raised milk production by 14 % and lowered the cost of feed by 10.6 - 21.3% in group B and group C respectively. It was concluded that substitution wheat hay by 50 % of silage on lactating Assaf ewes feed increased milk production and decreased daily ration cost. More feed trails are needed to study the effect of replacing part of concentrate and roughage with sufficient amount of silage.

Keywords: Milk, performance, sheep, silage

Contact Address: Iyad Badran, National Agriculture Research Center, Animal Production, Qabatya, 009790 Jenin, Palestine, e-mail: moayednas@yahoo.com

Effects of Dietary Potassium Diformate on Growth and Gastrointestinal Health in Weaned Piglets in Vietnam

CHRISTIAN LÜCKSTÄDT

ADDCON, Germany

Organic acids have been used for decades in commercial compound feeds, mostly in feed preservation. Experience has shown that acidifiers are the most reliable product group of the non-antibiotic growth promoters available in Europe and can also be used safely and effectively with other additives. Potassium diformate (KDF) is currently the only acidifier which can legally claim performance enhancing effects in the whole pig production chain, thus covering sows, piglets and fatteners. The current study tested the efficacy of KDF under tropical conditions.

Seventy eight 28-day old weaned piglets with an initial weight ranging from 8.0 to 8.3 kg, of the same sex and breed, were allocated to 3 equal groups with 26 piglets each. Piglets were kept at an experimental farm in Southern Vietnam for 28 days, receiving a commercial diet from 28 to 50 days of age with 19 % crude protein (CP) and 3100 kcal kg^{-1} metabolisable energy (ME), while from day 50 onwards till the end of the trial (56 days of age), a diet containing 20.8 % CP (3000 ME kcal kg^{-1}) was fed. Diet 1 contained no additive and served as negative control, while diets 2 and 3 contained 0.4 % and 0.5 % KDF respectively. Feed and water were available ad libitum. At the end of the trial, final weight, daily weight gain, feed conversion and the diarrhoea rate of piglets, as well as pH-data from the gastro-intestinal tract were obtained and analysed statistically using ANOVA.

The final weight of the piglets fed 0.4 % and 0.5 % KDF was significantly increased compared to the control ($p < 0.05$). The lowest KDF inclusion improved the final weight compared to the control by more than 11 %. Furthermore, a numerical improvement of the feed conversion ratio of at least 15 % was monitored. Finally, the overall days of diarrhoea per group were significantly reduced with the KDF treatments from 40 days (control) to only 25 and 21 days, respectively.

The findings of the present study support the use of dietary KDF as an effective and sustainable growth-promoter in post-weaned piglets. Current findings suggest that KDF can be used to enhance growth and reduce post-weaning diarrhoea.

Keywords: Diarrhoea, gastrointestinal pH, growth performance, post-weaned piglets, potassium diformate

Contact Address: Christian Lückstädt, ADDCON, Kaiserstrasse 1a, 53113 Bonn, Germany, e-mail: christian.lueckstaedt@addcon.com

Opportunities for Feeding Forages to Pigs in Uganda

BRIGITTE L. MAASS[1], JOLLY MARY KABIRIZI[2], DANILO PEZO[3], NATALIE CARTER[4], EMILY OUMA[3], EMMANUEL ZZIWA[5], WANJIKU CHIURI[6]

[1]*International Center for Tropical Agriculture (CIAT), Tropical Forages Program, Kenya*

[2]*National Livestock Resources Research Institute (NaLIRRI), Animal Nutrition, Uganda*

[3]*International Livestock Research Institute (ILRI), Animal Sciences for Sustainable Productivity, Uganda*

[4]*University of Guelph, Dept. of Population Medicine, Ontario Veterinary College, Canada*

[5]*Association for Strengthening Agricultural Research in Eastern and Central Africa, Livestock and Fisheries Programme, Uganda*

[6]*International Center for Tropical Agriculture (CIAT), Rwanda*

Pigs can play an important role in risk diversification and livelihood security of many smallholder and poor households in Uganda. Women and youth/children provide most of the pig-production labour, especially for forage collection, feeding and watering; and they are responsible for about 90% of pigs produced in Uganda. In the smallholder production systems practised both in rural and peri-urban areas, a variety of forage species are traditionally used for pig feeding, the majority of them being gathered for several hours every day. Overall, there is an over-reliance on feeding crop residues, 'weeds' and forages both through collection and scavenging/tethering, usually not meeting the nutritional requirements of pigs, which results in slow growth rates. Data on feeding pigs in Uganda were collected during focus group discussions and key informant interviews in three districts, Masaka, Mukono and Kamuli, during the years 2013–2014.

In Uganda, there has been generally limited research on pigs and pig systems, while forage research has traditionally focused on feeding ruminants. A comprehensive literature review on feeding forages to pigs in the tropics revealed that it is mainly animal nutritionists who concern themselves with nutritional effects of forages on the animals and their suitability as pig feeds; aspects of integrating cultivated forages into crop-livestock production systems, labour requirements, gender issues, and economic returns are essentially not considered. Despite the widely recognised constraint of insufficient animal feeds, especially during dry seasons, adoption of cultivated forages in the tropics has been generally slow, and hindering factors have not been fully understood. Some cultivated forages show nutritional attributes suitable for pigs, technically making them an option to supplement pigs with farm-grown forages instead of purchased concentrates. A paradox of feeding forages to pigs in Uganda has been identified, though, that suggests a decreasing use potential of forages along a gradient from extensive (mostly rural) to intensive (more urban) smallholder systems, whereas CIAT's Tropical Forages Program presumes an increasing forage adoption potential along a gradient from subsistence- to market-oriented smallholder systems. Investigating this paradox carefully may help better understand reasons and conditions of smallholders under which cultivated forages may be adopted or not.

Keywords: Crop-livestock production system, cultivated forages, extensive - intensive production systems, monogastric animal, pig, smallholder farmer

Contact Address: Brigitte L. Maass, International Center for Tropical Agriculture (CIAT), Tropical Forages Program, P.O. Box 823, 00621 Nairobi, Kenya, e-mail: b.maass@cgiar.org

Nutritional Performance of West African Dwarf Goats Fed Wild Sunflower Leaf Meal Supplemented Diet

JOHN ODEDIRE, FEMI OLIDI

Obafemi Awolowo University, Dept. of Animal Sciences, Nigeria

An experiment was conducted to investigate the effect of feeding wild sunflower (*Tithonia diversifolia*) as a dry season forage supplement on the growth and other nutritional parameters of West African Dwarf (WAD) goats, offered a basal guinea grass (*Panicum maximum*) diet.

Leafy portions and soft stems of wild sunflower forage was harvested, air- dried and ground in a hammer mill to produce a leaf meal. The wild sunflower leaf meal (WSLM) was incorporated into a concentrate diet as supplement to a basal guinea grass diet in the ratio 2:3.

Twenty WAD goats with age range of 5–7 months and with an average weight of 6.94 ± 0.37 kg, were randomly allotted to a soybean based concentrate diet containing maize, palm kernel cake, groundnut cake and bone meal in graded levels of 0, 10, 20 and 30 % levels of WSLM inclusion. The experiment lasted 16 weeks and parameters determined include feed intake, weight gain, digestibility, nitrogen utilisation and feed conversion ratio.

Results obtained indicate no significant difference ($p > 0.05$) in the dry matter intake (DMI), weight gain and dry matter digestibility of the goats on the different diets. However, the crude protein digestibility and nitrogen utilisation of goats on 0 % and 10 % WSLM inclusion were higher ($p < 0.05$) than those on 20 % and 30 % WSLM diet.

It can be concluded that wild sunflower leaf meal can serve as a forage supplement to the WAD goats up to 30 % level of inclusion without any deleterious effect.

Keywords: Digestibility, dry season, nitrogen utilisation, WAD goats

Contact Address: John Odedire, Obafemi Awolowo University, Dept. of Animal Sciences, 35 Line 2 Ooni Layout Ibadan Express Way., 22005 Ile- Ife, Nigeria, e-mail: oadeolu1@gmail.com

Body Measurements of Desert Sheep Fed Urea Treated Groundnut Hulls and Molasses under Range Conditions

ABDELBAGI AHMED[1], IKHLAS NOUR[2], IBRAHIM TIBIN[2]

[1]*West Kordofan University, Animal Production, Sudan*

[2]*University of Khartoum, Meat Production, Sudan*

The study was conducted to evaluate the effect of feeding urea-treated groundnut hulls (silage) and molasses on body measurements of Hammari desert sheep lambs, at Elnuhood Desert Sheep Research Station, North Kordofan State, to meet the feed shortage during summer. The duration of the experiment was ninety days. Sixty desert sheep lambs (thirty males + thirty females) of 6 months age and 23.4 kg average live weight were divided into three equal groups (A, B and D). Groundnut hulls treated with 5 % urea was ensiled for 30 days. The lambs were fed a ration containing 77 % silage and 23 % molasses. Group A offered 400 g silage and 120 g molasses per day, group B offered 200 g silage and 60 g molasses per day and group C (the control) was left to graze the natural pasture freely. The effects of feeding management were determined. The results reveal that, the slaughter weights were not significantly different among the treatments, group A gave the highest weight (26.25 kg) followed by group B (23.69 kg) while group C, the control had the lowest weight (22.25 kg). The body measurements were not significantly different among the supplemented groups except the heart girth which was significantly higher in group A (68.9 cm) compared with group B (67.1 cm) and the control group C (67.4 cm). Height at wither, heart girth and body length were positively correlated with the body weight. The study concluded that urea-treated groundnut hulls (silage) and molasses can be used as feeding supplement for desert sheep lambs during summer under range conditions.

Keywords: Body measurements, desert lamb, grazing, groundnut silage, range

Contact Address: Abdelbagi Ahmed, West Kordofan University, Animal Production, University street, nct available Elnuhood, Sudan, e-mail: abdelbagib@gmail.com

Efficient Feeding of Crop Residue and Livestock Productivity: An Experimental Study in an Eastern Indian State

NIRANJAN PANDA[1], BRAJA SWAIN[2], NILS TEUFEL[3], PRADEEP SAHOO[2], PRAKASH BEHURA[1]

[1]*Odisha University of Agriculture and Technology (OUAT), Animal Nutrition, India*

[2]*International Livestock Research Institute (ILRI), India*

[3]*International Livestock Research Institute (ILRI), Kenya*

In most developing countries like India, livestock ownership is more equitable than landholding size, 80 percent of livestock population are owned by landless, marginal and small landholders, providing about 40 percent of their annual income. However, with increasing the cost of commercial feed, unavailability of land for growing green fodder and stagnating milk prices farmers in Odisha have few incentives to intensify the livestock production. Nevertheless, opportunities have been identified which enable farmers to make more efficient use of their existing resources leading to considerable productivity increases. The study presents the experimental results on the impact of straw chopping in combination with feeding mineral mixture on livestock productivity.

Two stage sampling method has followed to select 85 dairy farmers from 4 villages in Puri district of Odisha state for the experiment, lasting 73 days. First we selected villages based on dairy cattle population and milk market. After selection of villages, 20–25 farmers having 1–2 dairy cattle were selected from each village. One cattle was selected from each farmer for better monitoring. The experiment period was divided into four phases (pre-deworming, deworming period, period with feeding chopped straw with and without mineral mixture). The results indicated that deworming the animal has positive impact on milk yield but not significant. However significant difference in milk yield were observed between chopping and non-chopping period. Similar results were observed while comparing the milk yield between the period of feeding chopped straw with and without mineral mixture. It was observed that average milk yield per dairy cattle increased from 5.5 to 6.3 $\mathrm{L\,d^{-1}}$. Along with milk yield, fat% and serum calcium status also improved after feeding chopped straw. Farmers not only benefited from increasing milk yield but also managed to save 7–8 bundles of rice straw per day and cattle. The statistics of cost benefits analysis showed that farmers improved their income by 0.30 dollar per day per cattle by feeding chopped straw. Though farmers in these experimental villages are practising chopping, steps should be taken to promote this feeding measure in other areas as the demand for straw is increasing for other purposes.

Keywords: Crop residue, India, livestock productivity, smallholder

Contact Address: Braja Swain, International Livestock Research Institute (ILRI), 9th floor, Aggarwal Corporate Tower, 23 Rajendra Place, 110008 New Delhi, India, e-mail: brajacds@gmail.com

Status, Challenges and Opportunities for Sustainable Utilisation of Pulse Crop Residues in Ethiopia

ASHRAF ALKHTIB[1], YAHYA KAYSI[1], MUHANNAD MUNA[2], JANE WAMATU[3]

[1] *University of Damascus, Dept. of Animal Production, Syria*

[2] *General Commission of Scientific Agricultural Research, Animal Wealth Research Administration, Syria*

[3] *International Center for Agricultural Research in Dry Areas (ICARDA), DSIPS, Ethiopia*

Mixed crop and livestock production is common to most smallholder farming systems in developing countries. The farmers in Ethiopia depend substantially on crop residues of cereal and pulse crops to meet the nutritive requirements for maintenance, growth, draft and lactation of their livestock, especially during the dry seasons when pasture for grazing and naturally occurring fodders are scarce. Farmers mix pulse crop residues (chickpea, lentils, faba bean, field peas) with cereal straws (teff, barley and wheat) and store them for up to one year. Pulse crops are used to augment the nutritive value of the cereal straws. However, there is limited and scanty information on farmers' perceptions on crop residues utilisation and management.

The objectives of this study is to assess perceptions of smallholder farmers on the utilisation of residues from pulse crops as livestock feed by collecting baseline information on the type and quantities of crop residues produced, the extent of utilisation, farmer preferences for pulse crop types and varieties for livestock feeding, feeding strategies, management and conservation practices as well as related constraints. Past and current trends over the last 5 years will be discussed.

Potential opportunities based on farmer preference studies and trade-off analyses will be documented. The overall information collected from this study will help in identifying the most important paradigm changes of pulse residue usage by farmers including collection, storage, upgrading and feeding and lead researchers and development workers to more holistic approaches to design appropriate and sustainable interventions in livestock feeding in the perspective of farmers and the total mixed crop-livestock farming system.

Keywords: Crop residues, legumes, livestock, smallholder farmers, utilisation

Contact Address: Jane Wamatu, International Center for Agricultural Research in Dry Areas (ICARDA), DSIPS, 5689, Addis Ababa, Ethiopia, e-mail: j.wamatu@cgiar.org

Feeding 'Balanced Concentrate Feed' to Increase Livestock Productivity: An Experimental Study in Bihar, India

DHIRAJ KUMAR SINGH[1], S.P. SAHU[2], NILS TEUFEL[3]

[1]*International Livestock Research Institute (ILRI), India*

[2]*Bihar Veterinary College (BVC), BAU, India*

[3]*International Livestock Research Institute (ILRI), Kenya*

Dairying is an integral part of small-holder farming systems as well as an important source of subsidiary income for most households in Bihar, India and most farmers keep 2-3 cattle. Nevertheless, the per-capita milk availability in Bihar is very low (175 g d^{-1}) compared to the Indian average (290 g d^{-1}) in 2011-12 as productivity is low, mainly because current feeding is based mainly on crop residues (wheat and rice straw). Constraints to improving these feeding practices include limited farm resources, weak support services and poor knowledge on nutrient requirements and contents. The present study examines the effect of a balanced concentrate feed on livestock productivity in Samastipur and Muzaffarpur districts of Bihar, in comparison to existing feeding practices. Hereby, farmers supplement residues with either individual concentrate components (brans, crushed grains etc.) or locally available commercial concentrates. The new balanced concentrate consists of crushed grains (37 %), cereal brans (30 %), pulse husks (10%), oil cakes (20 %) and minerals. This results in higher levels of metabolizable energy and digestibility compared to the available commercial feeds according to laboratory analysis. This new feed was introduced through a combination of participatory trainings on nutrition and feeding, demonstrations on feed preparation and farm-based dairy feeding trials which included 400 crossbred dairy cattle kept by 400 farmers. On average, farmers were feeding 4.2 kg commercial and/or home-made concentrate feed per dairy animal/day, adjusted to individual milk yields. After replacing the existing supplements with a reduced amount (3.4 kg) of new concentrate feed, average milk yield, fat % and solids-not-fat (SNF) % increased by 14 %, 23 % and 5 %, respectively. Data analysis suggests that dairy farmers can simultaneously reduce their cost of milk production (reducing the amount by 24 % more than offsets the price difference of 18 %) and increase their revenue from increased milk sales. The new concentrate feed also showed better palatability as well as positive effects on health and reproductive performance in terms of animal appearance and early conception. Finally, the new feed does not require cooking, a common practice. Methods are explored to disseminate this balanced concentrate feed to a larger section of farmers in the state.

Keywords: Balanced concentrate feed, experimental, livestock productivity, SHGs

Contact Address: Dhiraj Kumar Singh, International Livestock Research Institute (ILRI), 904, 9th Floor, Aggarwal Corporate Tower, 23 Rajendra Place, 110008 New Delhi, India, e-mail: d.singh@cgiar.org

An Analysis of Dissemination of Livestock Feed Technology: The Case of Bihar an Eastern Indian State

DHIRAJ KUMAR SINGH[1], BRAJA SWAIN[1], NILS TEUFEL[2]

[1]*International Livestock Research Institute (ILRI), India*

[2]*International Livestock Research Institute (ILRI), Kenya*

Despite dairying in Bihar being a major income source for small and marginal farmers, livestock productivity is low compared to other states in northern India, mainly due to inefficient feeding practices (e.g. concentrate components are traditionally fed separately) and the limited quality of available commercial concentrates. For these, ILRI's laboratory analysis indicates quality limitations especially in regard to metabolizable energy and digestibility. In this context, a balanced compound feed has been formulated, based on locally available components and nutritionally superior to the commercial concentrates available in local markets. It consists of 37 % crushed cereal grains, 30 % cereal brans, 20 % oil cakes, 10 % pulse husks and some minerals. The technology was introduced to farmers through various training modules, group discussions and trials in 2011. Initially, 400 dairy farmers from Samastipur district (Bihar), selected for its milk production and marketing potential, were trained in the preparation of the new balanced compound feed, followed by two-month farmer trials. To assess the adoption and the impact of the developed feed technology, relevant data were collected through a survey of 360 randomly selected households in the target area. Of these, 159 farmers had participated in trainings and trials. A binary logit model was used to determine the adoption of the technology by farmers. The results indicate that though most farmers who had participated in trainings and trials have some knowledge about ILRI's feed technology, only 60 % of these actually remember the formula or the main message. Further, only 24 % were continuing with feeding the new feed. On the other hand, 28 % of the non-trial/training farmers in the sample have knowledge on ILRI's feed with 6 % of these also feeding it. In regard to adoption determinants the results show that farmers who had received training were more likely to adopt the new technology. Participation in feed trials further increased the likelihood of remembering training messages while spill-over was hardly observed. Nevertheless, awareness of and training on balanced feeds among farmers should be further improved to increase adoption.

Keywords: Bihar, dissemination, feed technology, livestock

Contact Address: Dhiraj Kumar Singh, International Livestock Research Institute (ILRI), 904, 9th Floor, Aggarwal Corporate Tower, 23 Rajendra Place, 110008 New Delhi, India, e-mail: d.singh@cgiar.org

Animal breeding and husbandry

Analysis of Lamb Survival in Indigenous Sheep and their Crosses with Awassi under Farmers Management in Ethiopia

TESFAYE GETACHEW[1], GÁBOR MÉSZÁROS[2], SOLOMON GIZAW[3], MARIA WURZINGER[1], AYNALEM HAILE[3], BARBARA RISCHKOWSKY[4], JOHANN SÖLKNER[1]

[1] *University of Natural Resources and Life Sciences (BOKU), Dept. of Sustainable Agricultural Systems, Austria*

[2] *University of Edinburgh, Royal Dick School of Veterinary Studies: The Roslin Institute, United Kingdom*

[3] *International Livestock Research Institute (ILRI), Ethiopia*

[4] *International Center for Agricultural Research in the Dry Areas (ICARDA), Syria*

A Weibull proportional hazard model was used to analyse breed and non-genetic factors influencing lamb survival. Data was obtained from the on-farm indigenous with Awassi sheep crossbreeding project in the highlands of Ethiopia. The data consisted of 5530 records collected from three different locations (Menz, Chacha, Wollo). Explanatory variables included in the model were year of birth, season of birth, lamb sex, location, breed of dam and breed of the lamb. Proportion of censored data at weaning age was 87.8 %. Among the effects fitted year, season, sex and location effects were significant ($p < 0.05$) on lamb survival to weaning age whereas the breed of dam as well as the breed of the lamb itself were not significant ($p > 0.05$). Risk of lamb death to weaning age was highest in Menz area compared with the other two locations. Considering location Menz as the reference with risk ratio of 1.00, the risk of death in Chacha and Wollo was lower ($p < 0.05$) with risk ratios of 0.51 and 0.84, respectively. The dry season (March to May) was found more risky ($p < 0.05$) than the other three seasons. The risk of death of lambs born during the dry season was 1.8 times higher than during the wet season (September to November). The risk of death was 38 % higher for male lambs compared to females. High risk of death associated with non-genetic factors would have a negative effect on genetic improvement programs as well as reduce profitability of the farm. Thus management practice should be employed to improve lamb survival in a way of giving special consideration for the unfavourable non-genetic causes of risk.

Keywords: Crossbred, Ethiopia, lamb survival, proportional hazard, survival analysis

Contact Address: Tesfaye Getachew, University of Natural Resources and Life Sciences (BOKU), Dept. of Sustainable Agricultural Systems, Gregor Mendel Straße 33, Vienna, Austria, e-mail: tesfayegecho@yahoo.com

Presence of Middle East Respiratory Syndrome (MERS) Coronavirus Antibodies in East African Dromedary Camels

ANNE LILJANDER[1], VICTOR MAX CORMAN[2], BENJAMIN MEYER[2], MARIO YOUNAN[3], MOHAMMED YAHYA SAID[1], ILONA GLUECKS[4], ERIK LATTWEIN[5], BEREND-JAN BOSCH[6], JAN FELIX DREXLER[2], SET BORNSTEIN[7], MARCEL A. MÜLLER[2], JOERG JORES[1], CHRISTIAN DROSTEN [2]

[1]*International Livestock Research Institute (ILRI), Kenya*

[2]*University of Bonn Medical Centre, Germany*

[3]*Vétérinaires sans Frontières Germany (VsF G), Kenya*

[4]*Vétérinaires sans Frontières Suisse, Kenya*

[5]*EUROIMMUN AG, Germany*

[6]*Utrecht University, Dept. of Infectious Diseases and Immunology, The Netherlands*

[7]*National Veterinary Institute, Sweden*

In 2012, a deadly viral disease called Middle East Respiratory Syndrome (MERS) was reported in Saudi Arabia. Since then, at least 250 human infections including 93 deaths have been reported. Most of the people that have been confirmed to have an infection with MERS-CoV developed severe respiratory illness. MERS is caused by a coronavirus called MERS-CoV. The evolutionary origins of MERS-CoV belonging to the Betacoronavirus clade C were attributed to insectivorous bats. Dromedary camels are the source of MERS-CoV infections in humans and may thus constitute a zoonotic animal reservoir. Seventy five percent of the world population of the one humped dromedary camel lives in the Greater Horn of Africa from where the majority of camelids on the Arabian Peninsula is imported. The role of dromedaries, as the one of the most important livestock species for nutrition in arid and semi-arid areas of Eastern Africa is likely to increase since the predicted climate change is in favour of this resilient species. Pastoralist communities that keep camels live in very close proximity with their livestock, potentially facilitating zoonotic transmission between camels and humans. Here we show that camels sampled in different regions in Kenya between 1992–2013 harbour antibodies to MERS-CoV. High camel population density correlated significantly with elevated seropositivity and might be a factor predicting long-term virus maintenance. Additionally, we detected antibodies to MERS-CoV in dromedary samples from Somalia and Sudan dating back to 1983, which supports the finding that a MERS-CoV or a closely related virus has been circulating in African camel populations for more than 30 years.
Together with the molecular data from African bat viruses, an evolutionary origin of MERS-CoV in Africa is supported by our data.

Keywords: Antibodies, coronavirus, dromedary camel, MERS, seropositivity

Contact Address: Anne Liljander, International Livestock Research Institute (ILRI), Nairobi, Kenya, e-mail: a.liljander@cgiar.org

Technical Efficiency in Beef Cattle Production in Botswana: A Stochastic Metafrontier Approach

SIRAK BAHTA

International Livestock Research Institute (ILRI), Botswana

As a consequence of harsh climate and relatively poor soils, Botswana's agriculture is dominated by livestock production, which accounts for over 80 per cent of the agricultural sector's output. The harsh climatic conditions manifested by low and unreliable rainfall and poor soils render crop production both risky and unprofitable. Within the livestock sector the dominant sub-sector is beef, which is one of the country's major foreign exchange earner and contributes about 57 per cent of agricultural value added. In addition, the beef sector is a sector in which many indigenous Batswana have participated in, hence important for wealth creation and poverty eradication especially in the rural areas where poverty is more pronounced. However, reduction of EU beef support prices and the high cost of sanitary and phyto-sanitary (SPS) and a series of livestock diseases outbreaks such as foot and mouth disease (FMD) have led to low beef supply to foreign markets.

The study used survey data of about 600 farm households from three districts of Botswana to estimate technical efficiency (TE), hence to fill the gap on analytical evidence on efficiency levels of farmers in various production systems. The stochastic metafrontier model was applied to estimate TE and technology gaps across farms. Subsequently, possible determinants of TE were assessed using a Tobit model.

Results show that there is significant inefficiency in both the small and medium livestock farm systems, but less in large scale livestock farms. Further, in contrast with the other two farm sizes, large scale farms are found to have higher meta-technology ratios (MTRs). The average pooled TE with respect to the metafrontier is estimated to be 0.62, which suggests that there is considerable scope to improve beef production in Botswana. The main factors that are found to have a positive influence on TE include: income from crop activities, age of household head, use of controlled cattle breeding method, access to market information, access to credit, off-farm income and larger herd size.

Keywords: Beef production, Botswana, stochastic metafrontier, technical efficiency

Contact Address: Sirak Bahta, International Livestock Research Institute (ILRI), Private Bag 0033, Gaborone, Botswana, e-mail: s.bahta@cgiar.org

Trypanosomosis Rational Chemotherapy - TRYRAC: Improved Trypanosomoses Management in a Community-Based Approach

ANTJE HOPPENHEIT[1], BURKHARD BAUER[2], PETER-HENNING CLAUSEN[1], HERMANN WAIBEL[3], SABINE LIEBENEHM[3], DÉTHIÉ FAYE[4], CYRILLE PISSANG[4], ZAKARIA BENGALY[5], HERVÉ SÈNA VITOULEY[5], THOMAS CHERENET[6], TELAHUN TEKLE[6], MARINDA OOSTHUIZEN[7], LUIS NEVEZ[7], KOMLA BATAWUI[8], EYABA TCHAMDJA[9], ABALO KULO[9], FERNANDO CHANISO[10], RAFFAELE MATTIOLI[11], ANNETTE MCLEOD[12], JAN VAN DEN ABBEELE[13], VINCENT DELESPAUX[13]

[1]*Freie Universität Berlin, Institute for Parasitology and Tropical Veterinary Medecine, Germany*

[2]*Independent Scientific Consultant, Germany*

[3]*Leibniz Universität Hannover, Inst. of Development and Agricultural Economics, Germany*

[4]*Vétérinaires Sans Frontières Belgique, Belgium*

[5]*Centre International de Recherche-Developpement sur l'Elevage en Zone Subhumide, Burkina Faso*

[6]*National Animal Health Diagnostic and Investigation Centre, Ethiopia*

[7]*University of Pretoria, South Africa*

[8]*Direction de l'Elevage, Togo*

[9]*Université de Lomé, Togo*

[10]*Universidade Eduardo Mondlane, Mozambique*

[11]*Food and Agriculture Organization of the United Nations (FAO), Italy*

[12]*University of Glasgow, United Kingdom*

[13]*University of Antwerp, Inst. of Tropical Medicine, Belgium*

TRYRAC is a 5-year project (2012–2017) funded by the Global Programme on Agricultural Research for Development (ARD) of the European Commission. Its main objective is improving trypanosomoses management of African livestock smallholders by providing state-of-the-art African Animal Trypanosomoses control strategies to smallholder livestock keepers in tsetse-infested areas of Togo, Ethiopia and Mozambique. Thereby, the project targets the following national and international structures: veterinary diagnostic laboratories, veterinary and extension services, agricultural development parastatals, NGOs and farmer groups, policy makers and international organisations and alliances. During the first year of the project, AAT prevalence and trypanocidal resistance have been determined in Togo and Ethiopia. Also, trypanocidal drugs from veterinary pharmacies and informal markets were sampled in both countries and sent to be analysed by an OIE reference laboratory in Senegal. Fur-

Contact Address: Antje Hoppenheit, Freie Universität Berlin, Institute for Parasitology and Tropical Veterinary Medecine, Robert-Von-Ostertag-Str. 7-13, 14163 Berlin, Germany, e-mail: antje.hoppenheit@fu-berlin.de

thermore, fact finding missions to Togo and Ethiopia were conducted during autumn 2013 in order to explore veterinary services, trypanocide usage, farmers' awareness and tsetse habitats. There, limited accessibility to professional veterinary care, abundance of trypanocides with unknown quality and gaps in smallholder knowledge were identified as major constraints to a better disease management. The compiled findings were communicated to the African target groups through stakeholder meetings that were held in the vicinity of AAT hotspot regions of Togo and Ethiopia in spring 2014. During these meetings farmers' associations and communities were encouraged to form committees for revolving-funds-based insecticidal/acaricidal spraying as part of a best bet strategy package. Targeted vector control, alongside the selection of effective trypanocides, promotion of rational drug use, targeted and strategic deworming of young cattle are part of this package which is currently being provided to smallholder farmers. These model herds will serve as demonstration plots during farmers' workshops, regularly held by community-based organisations, while rational drug use is being disseminated throughout the study area. Impact assessment will take place by longitudinal studies that include biological monitoring and questionnaires. WEBSITE: http://www.trypanocide.eu/

Keywords: AAT, Ethiopia, rational drug use, targeted spraying, Togo, trypanosomosis, vector control

Reproductive Dynamics of the Common Sole *Solea solea* (Linnaeus, 1758) from Bardawil Lagoon, North Sinai, Egypt

SAHAR MEHANNA

National Institute of Oceanography and Fisheries, Fish Population Dynamics, Egypt

The soles (family Soleidae) are one of the most important fish species inhabiting Bardawil lagoon, North Sinai, Egypt. Sole catch composes of two species from which the common sole, *Solea solea* is the most common one. They are being exploited by the usage of trammel nets (locally known as Dabba) and earning up to 10 million Egyptian pound annually. Reproduction is an important biological aspect among fishes, where the recruitment and stock abundance depend on. Therefore maturity, spawning season, fecundity, length and age at first sexual maturity and sex ratio of *S. solea* in Bardawil lagoon were studied. The monthly gonado-somatic indices and macroscopically investigated maturity stages indicated that *S. solea* spawns in the late autumn to the early spring from November to April with peak in December. The overall sex ratio throughout the study period was 1:2.11 males to females, which was significantly different from 1:1. The absolute fecundity ranged from 270,000 to 1,200,000 eggs in females with total weights varying from 31 to 400 g. The size at 50 % sexual maturity (L50) was 18.7 and 19.6 cm TL for males and females, respectively. It was found that about 58 % of *S. solea* were caught before reaching their first sexual maturity. The estimated L50s indicate that the current minimum legal length in Bardawil lagoon is not appropriate for managing this species. The study recommends reduction of fishing pressure especially during spawning season and reevaluated the mesh sizes of dabba nets used in the lagoon as well as prohibited trawling in the lagoon.

Keywords: Bardawil lagoon, length at first sexual maturity, management, sex ratio, *Solea solea*, spawning season

Contact Address: Sahar Mehanna, National Institute of Oceanography and Fisheries, Fish Population Dynamics, P.O. Box 182, Suez, Egypt, e-mail: sahar_mehanna@yahoo.com

Response to Elevated Temperature - Organogenesis of the Reproductive Tract of All-Female Tilapia (*Oreochromis niloticus*)

AULIDYA NURUL HABIBAH[1], STEPHAN WESSELS[1], FRANK PFENNIG[2], WOLFGANG HOLTZ[1], GABRIELE HÖRSTGEN-SCHWARK[1]

[1]*Georg-August-Universität Göttingen, Dept. of Animal Sciences, Germany*

[2]*Technische Universität Dresden, Institute of Zoology, Germany*

The Nile tilapia, a maternal mouth brooder with high fecundity, is a tropical warm-water fish gaining in popularity as a candidate for freshwater fish production worldwide. In order to overcome stunted growth in ponds, production of all-male stocks in aquaculture is highly recommended. All-male progeny, however, are often obtained through the use of hormone feeding to the sexually undifferentiated fry. Recent studies show, that temperature-treatment might be a sustainable alternative to induce female-to-male sex reversal. The possibility to reach high male ratios via temperature-treatment and selection of highly responsive families has been proven possible. Furthermore in light of global warming, biased sex ratios might also occur in feral populations. Therefore, this study addresses the organogenesis of the reproductive tract of genetically all-female (XX) Nile tilapia reared at elevated temperature of 36°C or control (28°C) during the critical phase of sex differentiation (10–20 days post fertilisation). Groups of 24 fish were sacrificed at different stages of gonadal development, gonadal morphology, gonadosomatic index (GSI), and hepato-somatic index (HSI) were assessed and compared to their control full-sibs. The temperature treatment lead to female-to-male sex reversal resulting in a male proportion of 37 %, compared to only females in the control group. The body weight, GSI, and HSI were comparable among both groups, while showing an age-related increase in either group. The histological investigation of ovarian cross sections revealed a more advanced development in the control groups. Immunohistochemistry indicated early developmental differences (at 90 dpf) between groups subjected to high temperature treatment and controls. Therefore, although only subtle differences in phenotypic appearance of fish were observed, gonadal development of female fish showed a retarded trend of development when treated at high temperature. Retarded gonad development of females might be beneficial in aquaculture. Fitness of feral Nile tilapia populations, however, might be negatively affected on the long run in face of increasing temperatures due to global warming.

Keywords: All-female, elevated temperature, *Oreochromis niloticus*, organogenesis

Contact Address: Aulidya Nurul Habibah, Georg-August-Universität Göttingen, Dept. of Animal Sciences, Albrecht Thaer Weg 3, 37075 Göttingen, Germany, e-mail: ahabiba@gwdg.de

Security Issues, Protection and ISO Certification of the Genetic Improvement Program

MOHAMED MEGAHAD, MAI WASSEL
National Institute of Oceanography and Fisheries (NIOF), Aquaculture, Egypt

Part or all of the breeding company operation is to be ISO certified. The ISO standards for documentation and repeatability are exactly what will be required when breeding company begins to sell genetic products (e.g. fry or fingerlings) on the basis of a proven and repeatable improvement in performance. This will enable the breeding company to demonstrate the reliability of its statistical analyses as well as of the data themselves. The objective should be to make it as easy as possible for a person to exercise professional "due diligence" when buying genetic products for the breeding company or calculating the value of the breeding genetics programme as a corporate asset. There have to be security issues and protection of the breeding company strains. For physically protecting the strains, the inbred lines can be protected against unauthorised reproduction by distributing only the F1 hybrids between two or more lines. Furthermore, the hybrids will be hormonally sex reversed. If the hybrids are reproduced by a "hijacker" the resulting F2 generation will be less uniform and generally inferior to their parents both in form and in growth rate. However, the breeding company has to maintain very high biosecurity over its pure males and females lines. For legal protection and registration, the legal procedure for officially registering or patenting a new genetic variety requires a demonstration of the uniqueness, stability and uniformity of the variety. DNA markers can be used for this purpose and the number of DNA marker loci developed for tilapia is more than adequate. However, it will be necessary to collect DNA samples from every generation of breeders and store them in a safe place even if there is no immediate plan to analyse them. In this context it is important to accumulate DNA samples and data each generation. Since marker systems keep changing and are to some extent dependent on the company that does the genetic analysis, it is important for the breeding company to keep DNA samples of its own, on its own premises, for later analysis.

Keywords: Breeding program, DNA markers, security issues, strain protection, tilapia

Contact Address: Mohamed Megahad, National Institute of Oceanography and Fisheries (NIOF), Aquaculture, Al Zahraa village, 42521 Ismailia, Egypt, e-mail: aquageimprove@gmail.com

Comparative Evaluation of the Functionality of Non-Synonymous Substitutions in MHC DRB Gene of Nigerian Goats

ABDULMOJEED YAKUBU

Nasarawa State University, Dept. of Animal Science, Nigeria

The Major Histocompatibility Complex (MHC) contains highly variable multi-gene families, which play a key role in the adaptive immune response within vertebrates. Among the Capra MHC class II genes, the expressed DRB locus is highly polymorphic, particularly in exon 2, which encodes the antigen-binding site. Models of variable non-synonymous/synonymous rate ratios among sites may provide important insights into functional constraints at different amino acid sites and may be used to detect sites under positive selection. Many non-synonymous single nucleotide polymorphisms (nsSNPs) at the DRB locus in goats are suspected to impact protein function. This study, therefore, aimed at comparing the efficiency of three computational approaches to predict the likelihood of a particular non-synonymous (amino acid change) coding SNP to cause a functional impact on the protein. This involved the use of SNAP (screening for non-acceptable polymorphisms), PANTHER and PROVEAN bioinformatics analytical tools in detecting harmful and beneficial effects at H57G, Y89R, V104D and Y112I substitutions in the peptide binding region of the DRB gene of Nigerian goats. The results from PANTHER analysis revealed that H57G, Y89R and Y112I substitutions (Pdeleterious= 0.113, 0.204 and 0.472, respectively) were beneficial; while that of V104D was deleterious (Pdeleterious= 0.756), an indication that it was non-neutral. As regards the SNAP approach, H57G and Y89R substitutions were returned neutral with expected accuracy of 53 and 69 %, respectively while V104D and Y112I substitutions were harmful. However, only H57G substitution was found to be beneficial under PROVEAN method. Although, the PANTHER and SNAP approaches appeared to be better, there is need for standardisation for easy comparison of the efficiency of the analytical tools employed to detect the functional effects of amino acid substitutions. The present information may be used in search of disease resistant genotypes at the DRB locus of Nigerian goats.

Keywords: Bioinformatics tools, DRB gene, goats, Nigeria, non-synonymous substitutions

Contact Address: Abdulmojeed Yakubu, Nasarawa State University, Dept. of Animal Science, Flat 3 Musa Shabu House, 950101 Lafia, Nigeria, e-mail: abdul_mojeedy@yahoo.com

Impact of Management Systems and Breeds on Milk Yield and Herd Structure of Dromedary Camel

IBRAHIM DOWELMADINA[1], IBTISAM E. M. EL ZUBEIR[2]
[1] *University of Gezira, Dept. of Animal Breeding and Genetics, Sudan*
[2] *University of Khartoum, Dept. of Dairy Production, Sudan*

Camels (*Camelus dromedarius*) contribute significantly to the livelihood of pastoralists and agro-pastoralists living in the fragile environments of the deserts and semi desert of Asia and Africa. In Sudan, the four camel management systems include traditional nomadic system, transhumance or semi-nomadic system, sedentary or semi-sedentary system and the intensive system. This study investigated the impact of breed on milk yield, herd size and herd composition of she camels reared within two different production systems: The first was the dominant traditional nomadic system at Sinnar State (Nefidia breed) and Gezira State (Butana breed). The second was the newly developed semi-intensive system at Khartoum state (Kenana, Anafi and Bishari breeds). The milk yield was significantly ($P \leq 0.05$) affected by production systems and types of camel breed as the overall mean of daily milk yield in the semi-intensive system was 3.49 ± 0.89 L day^{-1} compared to that reported in traditional nomadic system (2.73 ± 0.65 L day^{-1} and 3.30 ± 1.12 L day^{-1} for Butana camel and Nefidia camel, respectively). Moreover camel herders in semi-intensive system practised three times milking per day, whereas in nomadic system adopted two times milking per day. The herd size under semi-intensive system was significantly ($P \leq 0.05$) smaller than that kept under the nomadic systems (61.5 ± 40.1 vs 132.5 ± 117.6 and 71.3 ± 34.3). This study showed the impact of management systems and types of breed on milk yield, herd size and herd structure of camels in Sudan. Therefore, factors associated with camel breed, population and production should be considered when addressing the potentiality of camel for milk production.

Keywords: Camel breed, camel production systems, herd composition, milk yield, Sudan

Contact Address: Ibtisam E. M. El Zubeir, University of Khartoum, Dept. of Dairy Production, 13314 Khartoum North, Sudan, e-mail: ibtisammohamed@hotmail.com

Forces Driving Change in Ethiopian Smallholder Livestock Production: Implications for Policy and Practice

ASAMINEW TASSEW[1], JOHANN SÖLKNER[2], MARIA WURZINGER[2]

[1]*University of Natural Resources and Life Sciences (BOKU), Centre for Development Research (CDR), Austria*

[2]*University of Natural Resources and Life Sciences (BOKU), Dept. of Sustainable Agricultural Systems, Austria*

Livestock production is an integral part of mixed-farming systems throughout northwestern Ethiopia. Yet, it has received little research and development attention. Thus, describing the changes in livestock production and the driving forces are important steps for diagnosing the status and trends of the systems, and thus to develop interventions that will result in positive changes. This study was conducted at Wujraba, Godinge and Mezega watersheds in northwestern Ethiopia. The research approaches include use of secondary and primary data and the data was collected for a time frame of 10 years. The primary data was collected; including key informant interviews, focus group discussions, workshops, and field observation. Qualitative data analysis was done by using ATLAS-ti version 7. The results reveal the most important changes as follows: farmers kept diversity of livestock species which are an indication of the different functions played by each livestock species; reducing the number of livestock herd or flock size; shift in livestock species composition and purpose, such as focusing on sheep in Wujraba, using horses and mules for different purposes in Godinge and Mezega, and using horses for transport in Wujraba; abandoning livestock species such as goats in all watersheds, donkeys in Godinge and Mezega, and mules in Wujraba; the productivity of livestock has decreased; however, some farmers have attempted to improve the livestock husbandry. These changes are attributed by various driving forces working alone and or in synergy with other driving forces. The findings show that technical support, farmers' awareness, access to transport, access to credit, and climate variability are impacting driving forces. While, animal health services, feed technology, and improved livestock breeds are influenced driving forces. On the other hand, land use change, demand for livestock products, watershed development, and government emphasis for livestock development are critical driving forces. Therefore, interventions to be made by concerned stakeholders (farmers, development practitioners, researchers, policy makers, etc.) to improve smallholder livestock production system in northwestern Ethiopia need to focus on addressing these factors.

Keywords: Changes, driving forces, interventions, livestock herd or flock size

Contact Address: Asaminew Tassew, University of Natural Resources and Life Sciences (BOKU), Centre for Development Research (CDR), Gregor Mendel-Strasse 33, 1180 Vienna, Austria, e-mail: atassew2005@yahoo.com

Uptake of Artificial Insemination and Non-Indigenous Cattle in Small to Medium Scale Farms in Senegal

STANLY FON TEBUG[1], ISABELLE BALTENWECK[1], ELIZABETH JANE POOLE[1], AYAO MISSOHOU[2], PATRICK JOLLY NGONO EMA[2], JARMO JUGA[3], MIIKA TAPIO[4], KAREN MARSHALL[1]

[1]*International Livestock Research Institute (ILRI), Kenya*

[2]*Inter-State Veterinary School of Dakar, Senegal*

[3]*University of Helsinki, Department of Agricultural Sciences, Finland*

[4]*MTT Agrifood Research Finland, Biotechnology and Food Research, Finland*

Milk production in Senegal is dominated by low-input low-output systems. These systems are characterised by the use of indigenous cattle breeds with low milk production potential. Under a government initiative to sustainably improve dairy cattle productivity, artificial insemination (AI) using exotic dairy cattle breeds were introduced in the mid-1990s. Since then, government sponsored AI programs (public AI services) and private veterinarians (private AI services) continue to provide AI services to farmers. However, AI uptake and use of non-indigenous cattle remains modest or low. We aimed to determine factors that could influence the use of AI and non-indigenous cattle breeds in small to medium scale dairy cattle farms in Senegal.

Data were collected from 270 cattle farmers in Thies and Diourbel regions in a baseline survey conducted as part of larger research project "Senegal Dairy Genetics" (http://senegaldairy.wordpress.com/). Multiple logistic regression models were used to determine which farmer demographic, socio-economic and location factors could influence the uptake of AI, or use of non-indigenous cattle, in the last 5 years.

Use of AI and non-indigenous cattle breeds varied with farmer's characteristics. Irrespective of AI service provider, farmers were less likely to use AI if they belong to the traditional Fulani ethnic group and if the first non-indigenous cattle was not acquired via AI. Farmers with large families, who depend on crop production for subsistence, and those located farther from AI service providers, were more likely to rely on public AI services. The use of private AI services depends positively on wealth indicators such as monthly income earnings and land owned. Similarly, adoption of non-indigenous cattle depends on farmer's ethnicity and monthly income earnings. On the other hand, adoption of AI and non-indigenous crossbred cattle rearing was independent of farmer's education, labour availability, herd size and duration of dairy farming.

This study highlights the need to focus on farmer's ethnicity and wealth in future programs promoting AI and / or non-indigenous cattle breeds.

Keywords: Adoption, artificial insemination, dairy cattle, Senegal

Contact Address: Stanly Fon Tebug, International Livestock Research Institute (ILRI), P.O.Box 30709, Nairobi, Kenya, e-mail: s.tebug@cgiar.org

Genomics for Improved Productivity Within Developing Country Livestock Production Systems

KAREN MARSHALL, STEVE KEMP
International Livestock Research Institute (ILRI), Kenya

The productivity of developing country livestock production systems lags well behind that of the developed world. Addressing this issue is one important route to poverty alleviation, improved food security and environmental sustainability (because, generally, the lower the productivity of livestock systems the higher the environmental impact per unit of product). Low productivity can be attributed to a number of interrelated factors including (depending on the system) high disease burdens and weak animal health-care systems, poor quality and insufficient animal feed, use of breed-types that are not optimal, and other social and economic constraints.

This paper describes how the rapidly developing field of genomics can contribute to improved productivity in developing country livestock production systems. Rather than attempt an exhaustive review, the paper focuses on selected promising applications, and it is understood that to achieve impact at scale any resultant intervention would need to be applied within a systems context.

In relation to improving animal health, two key applications of genomics stand-out: the use of genomics to identify genes or gene networks conferring disease resistance with the subsequent creation of new resistant breed-types by transgenic or genome editing approaches; and the use of genomics to better understand host-pathogen interactions and mechanisms of immunity, contributing to the development of new vaccines and therapeutics. On the ruminant feeding side, genomic approaches can and are being used to improve the nutritive value of crop stovers (a common feed source in developing countries) and rumen microbial genomics may improve rumen function for better utilisation of low quality feed. In regard to breed-use, genome based assays for breed composition have facilitated *in-situ* comparisons of breed-types which were previously difficult in the absence of pedigree data, breeds developed with the input of genomic approaches (typically in developed countries) are increasingly used as inputs into cross-breeding systems, and genomic approaches can help ensure breeds are fit for future changed climates. Finally, in relation to economic barriers arising from food safety concerns, the use of genomics to trace or authenticate livestock products may open new markets or remove trade restrictions.

Keywords: Environmental sustainability, genomics, livestock, productivity

Contact Address: Karen Marshall, International Livestock Research Institute (ILRI), Nairobi, Kenya, e-mail: k.marshall@cgiar.org

Evaluation of Performance and Estimation of Genetic Parameters for Milk Yield and some Reproductive Traits in Sheep Breeds and Crosses in the West Bank

MUAYAD SALMAN[1], JIHAD ABDALLAH[2]

[1]*Ministry of Agriculture, General Directorate of Extension and Rural Development, Dept. of Livestock Production, Palestine*

[2]*An Najah National University, Palestine*

This study was conducted to evaluate sheep productivity in the West Bank, and estimate genetic parameters (heritability and repeatability) for milk yield and prolificacy traits. The data included a total of 1711 milk records from 1243 ewes and a total of 3682 lambing records from 1837 ewes of the Awassi breed (AW), two Awassi-derived-lines (Improved Awassi, IA and Afec Awassi, AA), Assaf breed (AF) and Awassi × Assaf crosses (XB). The data were from the demonstration farms of the Small Ruminant Middle East Regional Program in the West Bank, collected during the years 2003 to 2010.

The data were analysed using two linear models: a fixed-effects model for testing breed differences and other fixed environmental effects, and a mixed-model for estimation of genetic parameters. Genetic parameters were estimated using REML procedure. The fixed effects investigated for milk traits were: location-breed (LB), parity (PR), year-season of lambing (YS), treatment for induction of estrus (TRT: natural or PMSG sponges), number of lambs born per ewe lambing (NLB), number of milking tests (NMT), and lactation length (LL). For prolificacy traits, the fixed effects were: LB, PR, YS, and TRT.

The results of milk traits showed that LB, PR, and YS had high significant effects on all milk traits ($p < 0.001$), while the effect of NLB was not significant ($P > 0.05$) for any milk trait. The effect of LL was highly significant ($P < 0.001$) on TMY, while NMT was not significant ($p > 0.05$). For prolificacy traits, LB, PR, and YS had significant effects ($p < 0.05$) for all studied traits, while TRT was significant for NLBA only.

Estimates of heritability (h^2) of TMY ranged from 0 in XB to 0.11 in AW. For TMY120 and TMY150, heritability ranged from 0 in XB to 0.16 in AW. Estimates of h^2 of NLB varied form 0 in XB to 0.09 in AW, and for NLBA it ranged from 0 in XB to 0.15 in AW. For LI it was 0.03 in AW and 0 for other breeds and crosses.

The results of this study indicate that Assaf and Awassi × Assaf sheep are the recommended breeds for raising in the northern areas of the West Bank. The study also emphasizes the need for full recording of performance and pedigree data in sheep farms as part of good management practice which should be part of a national recoding system.

Keywords: Assaf, Awassi, genetic parameters, lambing interval, total milk yield, West Bank

Contact Address: Muayad Salman, Ministry of Agriculture, General Directorate of Extension and Rural Development, Dept. of Livestock Production, Al Balooa, Ramallah, Palestine, e-mail: moayednas@yahoo.com

African Trypanosomiasis Resistance in Cattle by a Transgenic Approach

MINGYAN YU[1], CHARITY MUTETI[1], MOSES OGUGO[1], WILLIAM A. RITCHIE[2], JAYNE RAPER[3], STEVE KEMP[1]

[1]*International Livestock Research Institute (ILRI), Genetics Group, Biosciences, Kenya*
[2]*Roslin Embryology Limited Company, United Kingdom*
[3]*City University of New York, Hunter College, Dept. of Biological Sciences, United States of America*

African trypanosomiasis, caused by extracellular protozoan parasites (*Trypanosoma*), is a major disease in cattle that affects agricultural production in broad regions of Africa. The parasites are transmitted between mammals by infected tsetse flies (*Glossina* sp.) during blood feeding. Both wild and domestic animals are potential reservoirs of the parasites for human infection resulting in human sleeping sickness. In order to control the disease, we proposed a new strategy for creating resistance in cattle to African trypanosomiasis by a transgenic approach. Using the technique of somatic cell nuclear transfer (cloning), we aim to establish genetically modified cattle on the background of a Kenyan indigenous breed – Kenyan Boran, which carry a gene that imparts resistance to African trypanosomes. The gene, apoL-1, encodes the key trypanolytic component of baboon's protective Trypanosome Lytic Factor (TLF) against both cattle and human infective trypanosomes. TLFs are only found in humans, gorillas, sooty mangabys, mandrills and baboons and govern resistance to different African trypanosome species. Baboons are remarkably resistant to all African trypanosomes due to its TLF, specifically apoL-1. Previous research with transgenic mice has shown that the baboon apoL-1 product was able to confer protection to the mice against trypanosome infection. Therefore, we hypothesise that expression of baboon apoL-1 in cattle will also endow endogenous resistance to trypanosomes. As the proof of concept step, we have successfully set up and tested the platform for somatic cell nuclear transfer using Boran bovine embryonic fibroblasts (BEFs). In total, two cloned calves were born by caesarean section operation. One calf survives up to today and is in good health. Attempts are ongoing to introduce the apoL-1 gene into two of the BEFs lines for future production of transgenic cattle.

Keywords: African trypanosomiasis, apoL-1, Kenyan Boran, somatic cell nuclear transfer

Contact Address: Mingyan Yu, International Livestock Research Institute (ILRI), Genetics Group, Biosciences, Old Naivasha Road Uthiru, 00100 Nairobi, Kenya, e-mail: m.yu@cgiar.org

Mitigation of the Impacts of Rift Valley Fever through Targeted Vaccination Strategies

JOHN GACHOHI, BERNARD BETT
International Livestock Research Institute (ILRI), Kenya

The rapid evolution of Rift Valley fever (RVF) outbreaks generates exceptional challenges in its mitigation and control. A decision-support tool for prevention and control of RVF in the Greater Horn of Africa identifies a series of events that indicates increasing risk of an outbreak and matches interventions to each event. Using a 2-host (cattle and sheep) and 2-vector (Aedes and Culex species) RVF virus transmission model, we simulated the impact of vaccinating either 50 % or 75 % of the host population implemented over a period of 11 and 15 days respectively at different time points identified in the tool. The time points include issuance of RVF early warning representing a lead time of 11 weeks based on the recent outbreak in 2006/2007 in Kenya, onset of heavy rains with a lead time of 6 weeks, occurrence of mosquito swarms and first RVF cases in livestock at outbreak onset and laboratory RVF virus confirmation 3 weeks after outbreak onset. The impact is measured by estimating the area under incidence curve (AUC). The results show that vaccinating 50 % of the host population at these time points, that is, early warning, onset of heavy rains, first RVF cases and laboratory confirmation leads to proportional reductions in AUC of 79 %, 79 %, 77 % and 66 % respectively in cattle and 65 %, 70 %, 42 % and 1 % respectively in sheep, relative to the baseline (no control) scenario. Increasing vaccination coverage to 75 % during the same time points resulted in moderately higher reductions of 81 %, 91 %, 82 % and 71 % in cattle and 75 %, 85 %, 77 % and 36 % in sheep respectively. Delaying 50 % vaccination by a week following the onset of outbreak resulted in reductions of 72 % and 31 % in cattle and sheep respectively. The results suggest that targeted vaccination can be effective in mitigating the impacts of RVF outbreaks. However, challenges associated with prediction of the outbreak, availability and delivery of vaccines need to be addressed. Impacts appear to depend on host diversity, with sheep potentially requiring more intensive vaccination coverage. If confirmed by empirical studies, these findings have important implications for the implementation of risk-based RVF interventions.

Keywords: Impacts, Rift Valley fever, vaccination, Kenya

Contact Address: John Gachohi, International Livestock Research Institute (ILRI), Food Safety and Zoonoses, Old Naivasha Rd P.O. Box 30709-00100, Nairobi, Kenya, e-mail: j.gachohi@cgiar.org

Productive Performance and Parasitic Infection in Native Hair Sheep Mated with Dorper Rams

JULIANO ISSAKOWICZ[1], ANA CLAUDIA KOKI SAMPAIO[1], MAURO SARTORI BUENO[2], LUCIANA MORITA KATIKI[2], RICARDO LOPES DIAS DA COSTA[2], CONCEPTA MCMANUS[3], ADIBE L. ABDALLA[1], HELDER LOUVANDINI[1]

[1]*University of São Paulo (USP), Centre of Nuclear Energy in Agriculture (CENA), Brazil*

[2]*Institute of Animal Science and Pastures / APTA / SAA-SP, Centre of Research in Diversified Animal Science, Brazil*

[3]*Universidade de Brasília (UNB), Faculty of Agronomy and Veterinary Medicine, Brazil*

The aim of the experiment was to evaluate productive performance and parasitic infection in Morada Nova (MN) and Santa Inês (SI) sheep mated with sires of their own genetic group or Dorper (D) rams. The experiment was carried out at Instituto de Zootecnia, located in São Paulo State, Brazil. 51 MN sheep (live weight: 33.1 $\pm$ 4.98 kg) and 52 SI sheep (live weight: 51.8 $\pm$ 7.07 kg) were used in a controlled mating system. The sheep were kept in *Panicum maximum* pasture and, in the final third of gestation and lactation they were housed in collective pens and had *ad libitum* access to corn silage and concentrate (400 g/animal/day). During gestation, at parturition and in lactation, the body condition score (BCS) and blood beta-hydroxybutyrate (β-OH) concentration was assessed. The amount of lambs weaned per ewe was calculated. The eggs per gram of feces (EPG), coproculture, Famacha© and hematological evaluations (hematocrit, hemoglobin, plasma protein and fibrinogen) were carried out. The BCS was lower in MN sheep in all experiment ($p < 0.05$). The blood (β-OH) concentration was higher at 115 and 130 days of gestation and 20 days postpartum in MN sheep ($p < 0.05$). The amount of lambs weaned was similar between the crossing MNxD and SIxSI ($p > 0.05$), but lower than the SIxD ($p < 0.05$). At final third gestation period all breed increased the EPG and 30 days *postpartum* the EPG was higher in SI than MN sheep ($p < 0.05$). The genus *Haemonchus* was predominante in both breeds followed by *Trichostrongilus*. Famacha© and hematological evaluation did not differ between breeds ($p > 0.05$), but fluctuated along the trial. The MN sheep crossed with Dorper rams showed similar productive performance to Santa Ines sheep mated with ram of their own genetic group, however, lower than sheep from SIxD group. No differences were found between breeds for parasitic infection.

Keywords: Crossing, *Haemonchus*, lambs, Morada Nova, Santa Inês

Contact Address: Juliano Issakowicz, University of São Paulo (USP), Centre of Nuclear Energy in Agriculture (CENA), Arlindo Casassa 62, 13460000 Nova Odessa, Brazil, e-mail: issakowicz@cena.usp.br

Using Choice Experiments: Facilitating Priority Setting in Provision of Animal Health Services

IMMACULATE OMONDI[1,3], KERSTIN ZANDER[2], SIEGFRIED BAUER[1], ISABELLE BALTENWECK[3]

[1]*Justus-Liebig University Giessen, Inst. of Farm and Agribusiness Management - Project and Regional Planning, Germany*

[2]*Charles Darwin University, School for Environmental Research, Australia*

[3]*International Livestock Research Institute (ILRI), Kenya*

Livestock sector is one of the drivers of poverty reduction in developing countries owing to its contribution to agricultural employment, its role in the economic welfare of rural families, as well as the nutritional importance of food products of animal origin. Consequently, increasing livestock productivity and production is one of the major means of improving the livelihoods of poor livestock keepers, reducing poverty, and attaining food security. Livestock development in Africa is, however, seriously constrained by animal diseases, with major economic, nutritional, and health consequences. For farmers and especially the poorest ones, animal health services, especially for the poorest farmers, is generally not accessible, and of poor quality. Dairy hubs (organised, farmer-owned collective marketing systems) are initiatives that work towards enhancing farmer access to milk markets and dairy related services (including animal health services) in East Africa. In an effort to provide a better understanding of farmer decision making when faced with animal health service choices, we applied choice experiment, a multi-attribute preference eliciting method, to identify preferences for adopting animal health services in the dairy hubs in Kenya (a dairy industry model for neighbouring African countries). The results reveal that, dairy farmers prefer to have animal services offered rather than having no service. In order of priority, based on the estimated welfare gains from the service characteristic, the farmers prefer animal health services that are offered alongside training or advice on animal husbandry, follow-ups on animal health after treatment, vaccination and deworming of animals, and offered by the dairy hubs rather than by private agents not affiliated to the hubs. Farmers would like some flexibility in payment systems which include input credit. These findings reveal that farmers attach different values to different animal health service characteristics and would therefore inform policy makers and development agents, of the types of services to prioritise in cases of resource constraints. By quantifying the welfare impacts of the preferred animal health service characteristics, the findings of the study can inform the design of the delivery of high quality and cost-effective animal health services.

Keywords: Animal health services, choice experiments, dairy hubs, Kenya, priority setting

Contact Address: Immaculate Omondi, Justus-Liebig University Giessen, Inst. of Farm and Agribusiness Management - Project and Regional Planning, Giessen, Germany, e-mail: Immaculate.Omondi@agrar.uni-giessen.de

Characterisation of the Production System of Dairy and Beef Farmers from Iporá and Neighbourhood, Goiás State, Brazil

EDUARDO RODRIGUES DE CARVALHO[1], PAULO ALEXANDRE PERDOMO SALVIANO[1], ALCIDO ELENOR WANDER[2]

[1]*Federal Institute of Education, Science and Technology, Iporá Campus, Brazil*
[2]*Brazilian Agricultural Research Corporation (EMBRAPA), National Rice and Beans Research Center (CNPAF), Brazil*

Dairy farming has contributed to family livelihood with a monthly income, although it demands intensive labour in milking, feeding, and young stock rearing. On the other hand, beef cattle production system in Brazil is very diverse, with no single recommendation that can be largely applied throughout the country. The objective of the present study was to carry out the diagnosis of the production system of dairy and beef farmers from Iporá and neighbouring municipalities. Two hundred and forty farmers were interviewed between April 2013 through April 2014 in rural communities meetings, agricultural retail stores, during the campaign of vaccination against the foot and mouth disease and in the 28th Agricultural Exhibition of Iporá. Average milk production/farm is 213.1 L/day with a productivity of 7.9 L/cow/day. Most of the dairy farmers (n=133) milk their cows manually in uncovered sheds with soil floor (n=88). Some dairy farmers have adopted certain practices that may reduce milk quality during milking, such as dry the calf saliva on the teats with the cow tail (n=45), remove the calf saliva on the teats by hand and dry it on the cow hair (n=57), and remove the calf saliva on the teats by hand and dry it on the pants (n=59). The most predominant production system in beef farming is calf rearing (n=40), followed by rearing, breeding and finishing animals (n=28), and pasture-based breeding heifers (n=25), where Nelore is the most employed breed in all production systems (n=82). A few dairy and beef farmers have vaccinated their animals against leptospirosis (n=25 for dairy; n=19 for beef), bovine virus diarrhea (n=22 for dairy, n=17 for beef), infectious bovine rhinotracheitis (n=19 for dairy; n=15 for beef) and neosporosis (n=6 for dairy; n=9 for beef), which are known to cause abortion. The predominant labour used in dairy (n=108; 67.1 %) and beef (n=48; 45.7 %) farms is the family members. The production system of dairy and beef farmers from Iporá and neighbourhood outputs low productivity levels. Additional research and efficient extension services are needed to improve the production system and increase the productivity and income of these farmers.

Keywords: Beef production, dairy production, farming system

Contact Address: Alcido Elenor Wander, Brazilian Agricultural Research Corporation (EMBRAPA), National Rice and Beans Research Center (CNPAF), Rodovia GO-462, km 12, 75375-000 Santo Antonio de Goias, Brazil, e-mail: alcido.wander@embrapa.br

Using a System Dynamics Framework to Assess Disease Risks of Pig Value Chains in Vietnam

THI THU HUYEN NGUYEN[1], NAM HA DUONG[1], VAN HUNG PHAM[1], THI DUONG NGA NGUYEN[1], FRED UNGER[2], KARL RICH[3], LUCY LAPAR[2]

[1]*Hanoi University of Agriculture, Dept. of Quantitative Analysis, Vietnam*

[2]*International Livestock Research Institute (ILRI), Vietnam*

[3]*Lab 863, Czech Republic*

In Vietnam, there are more than 4 million households producing pigs and pork. This accounts for 57 % of quantity of meat consumed. One of the most critical constraints to pig production is the presence of animal disease. Pig disease outbreaks are a regular occurrence in various parts of the country, with the industry affected by diseases such as foot and mouth disease, porcine reproductive and respiratory syndrome, classical swine fever, porcine high fever disease, and swine influenza. In addition, food safety issues related to pig diseases and pork-borne diseases have also increasingly become more important concerns for consumers. Recent studies have shown significant changes in consumption behaviour in response to disease outbreaks. For instance, at least half of urban consumers stop consuming pork in times of pig disease epidemics and/or shift consumption to other meat substitutes such as poultry or fish. Disease risks thus have both public health and livelihoods impacts that are important to understand for appropriate policy and practice response.

A proposed methodology for investigating disease risks uses a system dynamics analysis framework. System dynamics models are particularly relevant in the study of livestock systems, as they capture the diverse actors and feedbacks present in value chains and their interface with disease risk and behaviour. A system dynamics model is developed that will describe different scenarios of disease risks and the consequences of different interventions to mitigate these risks.

Data from a sample of 1000 farmers and value chain actors including all actors in the pig value chain in Vietnam was collected with support from an ACIAR-funded project on Reducing Disease Risks and Improving Food Safety in Smallholder Pig Value Chains in Vietnam. We propose to test the hypotheses that disease risk is affected by type of production system, feeding system and types of feed uses, access to inputs and services, and selected socio-demographic variables associated with farmers and location.

Keywords: Disease risk, pig value chain, system dynamics model

Contact Address: Lucy Lapar, International Livestock Research Institute (ILRI), Hanoi, Vietnam, e-mail: L.Lapar@cgiar.org

Calving Time and Birthweight of Bali Cattle under Semi-Intensive Rearing System in West Timor, Indonesia

HENDERIANA BELLI[1], PETRUS KUNE[1], I GUSTI NGURAH JELANTIK[1], MARTHEN LUTHER MULLIK[2]

[1] *University of Nusa Cendana, Dept. of Animal Production, Indonesia*

[2] *University of Nusa Cendana, Dept. of Animal Nutrition, Indonesia*

Studies have revealed that high calf mortality rate and slow growth rate of Bali cattle under extensive rearing system in West Timor, Indonesia, is attributable to wrong mating time (September-November) and calving time (July-October) when nutritional inadequacy is apparent. Thus, improving nutritional status of the dams would have a positive effect on calf. This experiment aimed at assessing calving time and birth weight of Bali cattle calves under semi-intensive rearing system where nutrient deficiency is not an issue. A total of 162 productive cows were monitored in the period of 2012–2013. The cows were grazed in groups consisted of 25–30 cows and one tested bull per group. Eight paddocks (approximately 1 ha) of *Bothriochloa timorensis* dominated native grass pasture were rotationally grazed during the course of the study. The cows and bulls were allowed to graze in the morning from 8.00h to 12.00h, and in the afternoon from 15.00h to 19.00h. All cattle were kept in a 4 m $\times$ 50 m collective pen during non-grazing time. Chopped palm pith were offered in the morning before the 1st grazing period, and freshly harvested king grass (*Pennisetum purpureum*) was provided to cows when they reentered the pen at midday and after the afternoon grazing. The amount of palm pith and king grass offered was not measured. Body condition score of the cows were recorded monthly and at the time of giving birth. Calf birth weight was recorded soon after the birth. The results showed that 49.9 % calves were born in dry season (July-October). The mean birth weight was 12.72 kg with no difference between male (12.86 kg) and female (12.61 kg) calves. There was no correlation between body condition score of the dam and calf birth weight. It might be concluded that calving time and calf birth weight of Bali cattle under semi-intensive rearing system were not different from those of extensive rearing system in West Timor, Indonesia.

Keywords: Bali cattle, birth weight, calving time, semi-intensive system

Contact Address: Henderiana Belli, University of Nusa Cendana, Dept. of Animal Production, Jalan Frans Seda Rt 23 Rw 8 Kelapa Lima, 85228 Kupang, Indonesia, e-mail: henderiana@yahoo.com

Farmers' Perception of Water Availability for Goat Production in Southern Jordan

JA'FAR AL-KHAZA'LEH, CHRISTOPH REIBER, ANNE VALLE ZÁRATE
University of Hohenheim, Inst. of Animal Production in the Tropics and Subtropics, Germany

Goats are well adapted to the diverse agro-ecological zones in Jordan and play a significant role for the food security of rural households. Provision of sufficient quantity of good quality drinking water is important for goats to maintain feed intake and production. Jordan is among the poorest countries in the world in terms of water scarcity with no positive prognosis due to its vulnerability to the impacts of climate change. This study aimed to assess water availability for goat production as perceived by farmers in the southern agro-ecological zones of Jordan. Data were collected from a total of 120 of purposely selected goat keepers (59 and 61 in mountain and semi-desert zones, respectively) from June to October 2012 using a survey based on structured questionnaires, group discussions and secondary data. The mean ranks for constraints of goat production were calculated based on the priority of problem importance perceived by respondents. The results showed that the top ranked problems limiting goat production in the mountain zone were feed shortage, disease, drinking water shortage and high feed prices, while in the semi-desert zone the top ranked constraints were high feed prices, feed shortage, rangeland shortage and water shortage. The majority of respondents in both zones perceived water as being scarce for goats particularly during the dry season. Long travel distances to the water sources, long waiting time at watering points and high fuel and labour costs were the key reasons associated with the problem. Boreholes, springs and wadis (streams) are the main water sources used for goats in the mountain zone during dry season, whereas boreholes are the only water source used during dry season in the semi-desert zone. Goat keepers perceived Mountain Black and Dhaiwi goats to have higher water tolerance compared to Damascus goats and their crosses. Though no direct negative impact of water availability on goat performance was found, the production cost, and thus, the profitability of goat production is impaired.

Keywords: Dry season, goats, Jordan, water scarcity, water sources

Contact Address: Ja'far Al-Khaza'leh, University of Hohenheim, Inst. of Animal Production in the Tropics and Subtropics, Garbenstrasse 17, 70599 Stuttgart, Germany, e-mail: jkhazaleh1981@yahoo.com

Risk Perception of Cattle Keepers in Southern Mali

SEKOU AMADOU TRAORÉ, CHRISTOPH REIBER, ANDRÉ MARKEMANN, ANNE VALLE ZÁRATE

University of Hohenheim, Inst. of Animal Production in the Tropics and Subtropics, Germany

In southern Mali, cattle play an important role to the livelihoods of many rural households. This study explores farmers' perceptions of risk related to raising cattle considering different breeds and different seasons, and analyses whether household and farmer characteristics relate to these perceptions.

A survey with 160 households keeping N'Dama, Zebu and/or crossbred cattle was carried out between November and December 2012 in the communes Garalo and Sibirila in southern Mali. Household heads were asked to identify important risks to their cattle husbandry. Subsequently they were asked to rank the stated risks for each of the breeds they have knowledge about, as well as for the dry and rainy season. Perceived risks were analysed using an exploded logit model (PHREG procedure).

Lack of water, theft and lack of pasture were perceived as the most important risks during the dry season, while cattle disease, farmer-herder conflict and theft were the most important risks during the rainy season. The main differences between the cattle breeds regarding perceived risk were that cattle disease was ranked higher for Zebu, while theft and farmer-herder conflict were ranked higher for N'Dama. Risk perceptions were affected to varying extent by diverse household and farmer characteristics. Cattle keepers in Garalo were more concerned by lack of water and theft and less concerned by low prices for cattle than cattle keepers in Sibirila. Bambara ethnic group perceived theft as bigger threat than the Fulani. Cattle keepers whose main activity was cropping were less concerned by lack of pasture and lower selling price for their cattle compared to those involved mainly in raising cattle.

Assessment of risks based on farmer perception, offer good opportunity for development researchers and policymakers to formulate adequate measure to help mitigating the risk these farmers are facing.

Keywords: Mali, N'Dama, risk perceptions, risk ranking, Zebu

Contact Address: Sekou Amadou Traoré, University of Hohenheim, Inst. of Animal Production in the Tropics and Subtropics, 70593 Stuttgart, Germany, e-mail: traoresekou@hotmail.de

Small Ruminant Performance in Different Agro-Ecological Zones of Egypt

HELMY METAWI[1], ELSAID OUDAH[2]

[1]*Animal Production Research Institute, Sheep and Goats Research, Egypt*

[2]*Mansoura University, Fac. of Agriculture, Dept. of Animal Production, Egypt*

The suitability of an area for either animal or crop production, and the type of animal or crop to be produced depends on the agro-ecological conditions of the area. The extent of cropping and the type of crop, in turn, determine the quantity, quality and distribution of animal feed resources throughout the year. This paper intended to asses small ruminant performance under different feeding strategies. Questionnaire was conducted with 162 households in three agro-ecological zones located in the North coastal zone of Egypt: (i) the rain fed area in the West, (ii) the dry area in the middle, and (iii) the irrigated area in the East. Barki sheep and Barki goats are the prevailing breeds raised in these zones. Herd owners in the East use large proportion or all their land to cultivate fodder crops for their small ruminants. Herd differed in size and composition among different agro-ecological zones. Analysis of data showed that the drought in the middle region lead to reduce small ruminant productivity by 16 % to 28 %, compared to both other regions. Improvement of the feeding level conventionally achieved through the use of concentrate could not be cost-effective at the Bedouins level. Alternative feeding strategies are therefore needed in these arid environments. This paper reports on some nutrition technologies which should be implemented in this area in order to improve small ruminant performance. Urea and ammonia treatments of straw, the use of fodder shrubs and agricultural by-products might be considered within feeding strategies to improve reproductive efficiency when animals graze poor pastures. Adoption of these technologies is constrained by many household and farm characteristics.

Keywords: Agro-pastoral system, crop-livestock system, drought, pastoral system, small ruminants, technological interventions

Contact Address: Helmy Metawi, Animal Production Research Institute, Sheep and Goats Research, 5 Nadi Elsaid Str.Dokki, Giza, 16128 Dokki Cairo, Egypt, e-mail: hrmmetawi@hotmail.com

Multivariate Path Analysis of Body Dimensions of Khaki Campbell and Pekin Ducks in Nigeria

ABDULMOJEED YAKUBU[1], M.M. MUHAMMED[2], MOHAMMED MAIKANO ARI[1]
[1]*Nasarawa State University, Dept. of Animal Science, Nigeria*
[2]*College of Agriculture, Animal Science, Nigeria*

The study aimed at describing objectively the interdependence between body weight (BWT) and morphometric traits in Khaki Campbell and Pekin ducks using multivariate path analysis technique. Measurements were taken on one hundred and ninety seven (197) randomly selected 10-week old Khaki Campbell and Pekin ducks of both sexes in Plateau State, Nigeria. The body parts measured were, body length (BDL); thigh length (THL); thigh circumference (THC); breast circumference (BTC); bill length (BLL); neck length (NKL); neck circumference (NKC); shank length (SHL); shank width (SHW); total leg length (TLL) and wing length (WL). General linear model was used to study genotype and sex effects. Pekin ducks had a superior advantage ($p < 0.05$) over their Khaki Campbell counterparts in all the body parameters estimated. Sexual dimorphism ($p < 0.05$) was in favour of male ducks. Pairwise phenotypic correlations between BWT and morphometric traits were positive and significant ($p < 0.01$), ranging from 0.38–0.95 and 0.35–0.92 for Khaki Campbell and Pekin ducks, respectively. Path analysis revealed that BDL was the variable of utmost importance directly influencing BWT in male Khaki Campbell and Pekin ducks (path coefficient= 0.535 and 0.508, respectively; $p < 0.01$) while BTC and SHL were the most responsible parameters affecting BWT in female Khaki Campbell and Pekin ducks [path coefficient= 0.594 ($p < 0.01$) and 1.197($p < 0.05$), respectively]. However, the optimum regression models for the prediction of BWT in Khaki Campbell ducks included BDL, SHL, BTC and NKC (male) and BDL, WNL and BTC (female); while in their Pekin counterparts, BDL, BLL and BTC (male) and BDL and SHL (female) were incorporated. These morphometric traits could be used in breeding programmes as a measure of direct selection for ducks with better BWT traits for improved egg and meat production, although this should be consolidated with a genetic study to provide information about the heritability and genetic correlation of these variables with BWT.

Keywords: Exotic ducks, morphometric traits, multivariate analysis, Nigeria, phenotypic correlation

Contact Address: Abdulmojeed Yakubu, Nasarawa State University, Dept. of Animal Science, Flat 3 Musa Shabu House, 950101 Lafia, Nigeria, e-mail: abdul_mojeedy@yahoo.com

Reaction to Predators in Guinea Pigs (*Cavia porcellus*)

ANETA BAKLOVÁ, EVA BARANYIOVÁ

Czech University of Life Sciences Prague, Faculty of Tropical AgriSciences, Czech Republic

Wild cavy of South America, the feral ancestor of domestic guinea pig, is a social mammal with a well developed social system. Its spatial organisation is an efficient adaptation to high predation pressure. Wild cavies live in small groups that reduce the risk of detection by predators; they may be attacked from the air, on the ground, and from the water. Cavies make three types of alarm calls when a predator approaches – *drrr* to warn close individuals, chirrup and alarm whistle to intimidate potential predators at long distances.

The aim of our study was to test the reaction of domestic guinea pigs to terrestrial and aerial types of predators. We used 27 (14 male, 13 female) animals. Each individual was exposed to contact with a dog (border collie), to an imitation of bird of prey and a human as a control and we monitored four types of reaction (freezing, moving, head moving toward stimulus and vocalisation). The Principal Component Analysis (PCA) was used to assess the variations in the data and their correlations. Non-parametric Kruskal-Wallis test was used to test the reaction of individuals to each predator type. Only two guinea pigs responded to presence of predator by vocalisation (*drrr* as reaction to dog presence and alarm whistle in presence of aerial bird of prey). Guinea pigs reacted significantly ($p < 0.01$) more often and longer by moving in presence of an aerial predator model than to the presence of the terrestrial one. Longer time of freezing occurred upon exposure to dog. Likewise, guinea pigs moved the head towards terrestrial predator significantly ($p < 0.01$) more often and longer than towards the aerial one. In conclusion, the animals may have shown different reactions to our models of predators in the laboratory setting but it is also possible that domestication influenced their reactions to some extent.

Keywords: Alarm call, guinea pigs, reaction to predators, recognition of predators, wild cavy

Contact Address: Aneta Baklová, Czech University of Life Sciences Prague, Faculty of Tropical AgriSciences, 140 00 Prague, Czech Republic, e-mail: antenka@email.cz

Seed Germination Test for Pregnancy Diagnosis from Urine in Alpacas (*Vicugna pacos*)

ANNA KUBÁTOVÁ, IVA SKÁLOVÁ, TAMARA FEDOROVA

Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Dept. of Animal Science and Food Processing, Czech Republic

Collecting of urine belongs to non-invasive research methods, which are popular nowadays. They enable to collect data without handling or capturing animals. The aims of this research were to examine the possibility of catching fresh urine directly from female alpacas (*Vicugna pacos*) and to evaluate the seed germination test as a pregnancy diagnostic test. The research was carried out in the period from April 2013 to February 2014 on the three Czech private farms. Urine was collected non-invasively into plastic cups fastened on a rod, in 6–8 week intervals. In total, 60 urine samples were collected from twelve alpacas. For the seed germination test, mung beans (*Vigna radiata*) and winter wheat seeds (*Triticum aestivum*) were used and urine was diluted to 1:4 and 1:14 ratios. Germination rates were counted 24, 48, 72, 96, and 120 hours after establishment of experiments. Lengths of shoots were measured after 120 hours. It was found out that urine of alpacas inhibited germination and growth of seeds in general. The inhibitory effect of urine on seed germination and growth was higher with the usage of urine with 1:4 concentration than with 1:14 concentration. Usually, seeds germinated and grew better in urine of pregnant females than in urine of non-pregnant females. Germination rates of mung beans treated with urine with 1:4 concentration counted 24, 48, and 72 hours after establishment of experiment were significantly lower in urine of non-pregnant females than in urine of pregnant females (Mann-Whitney U test: $p < 0.05$). However, season seemed to be an important factor, which could influence the results of the seed germination test. This fact should be considered especially in case of using this test in tropics, because the results could vary under different conditions. Further research was recommended, but it seems that mung beans treated with urine with 1:4 concentration could be usable for pregnancy diagnosis in alpacas by both seed germination rates counting and shoot lengths measuring.

Keywords: Gestation, mung bean, non-invasive methods, shoot length, wheat

Contact Address: Tamara Fedorova, Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Dept. of Animal Science and Food Processing, Kamýcká 129, 16521 Prague 6, Czech Republic, e-mail: fedorova@ftz.czu.cz

Non-Invasive Urine Sampling and Pregnancy Diagnosis in Domestic Cattle and Alpacas

IVA SKÁLOVÁ, ANNA KUBÁTOVÁ, TAMARA FEDOROVA

Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Dept. of Animal Science and Food Processing, Czech Republic

Monitoring of reproduction and pregnancy diagnosis are very important and decisive tasks for successful breeding of every mammalian species in captivity. However, many methods require veterinarian assistant, animal cooperation or sedation. Urine is usually obtained by catheter, which is uncomfortable for animals and it should be done by well trained breeders. Non-invasive urine sample collection into plastic cup fastened on a telescopic rot was tested in this experiment. Consequently urine was examined by Cuboni reaction and Barium chloride test for determination of pregnancy or non-pregnancy status in animals. Twelve female alpacas from Czech private farms and twenty pregnant and twenty non-pregnant Fleckvieh heifers were included in this study. Urine samples were obtained repeatedly in regular intervals. In case of heifers (*Bos taurus*) the results of Barium chloride tests were influenced by pregnancy (Pearson's chi-sq.: 28.2427, DOF=1, $p < 0.0001$). Urine of pregnant animals reacted negatively, the test marked animals truthfully as pregnant, in 79.7 % cases. On the other hand, reliability in detection of non-pregnant females was 50 % only. The connection between Cuboni reaction and accurate pregnancy diagnosis was not confirmed (Pearson's chi-sq.: 0.570268, DOF=1, $p > 0.05$). In case of alpaca females (*Vicugna pacos*), no relationship was found between the real reproductive status of alpacas and the results of the barium chloride test or the Cuboni reaction, even if the accuracy was assessed for non-pregnancy versus the whole period of pregnancy, halves of pregnancy or thirds of pregnancy. It was concluded that the barium chloride test and the Cuboni reaction are not suitable for pregnancy diagnosis in alpacas. Barium chloride test examined in Fleckvieh cows showed a potential of this method for pregnancy diagnosis in contrast to Cuboni reaction.

Keywords: Barium chloride test, Cuboni reaction, gestation, heifer, lama, reproduction

Contact Address: Tamara Fedorova, Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Dept. of Animal Science and Food Processing, Kamýcká 129, 16521 Prague 6, Czech Republic, e-mail: fedorova@ftz.czu.cz

Pastoral livestock production

Phenotyping of a Bi-Parental *Brachiaria humidicola* Population for its Biological Nitrification Inhibition Potential

JACOBO ARANGO[1], JONATHAN NUÑEZ[1], DANILO MORETA[1], HANNES KARWAT[2], ASHLEY AREVALO[1], MANABU ISHITANI[1], LUCIA CHAVEZ[1], JOHN MILES[1], GUNTUR SUBBARAO[3], MICHAEL PETERS[1], IDUPULAPATI RAO[1]

[1]*International Center For Tropical Agriculture (CIAT), Colombia*

[2]*University of Hohenheim, Inst. of Plant Production and Agroecology in the Tropics and Subtropics, Germany*

[3]*Japan International Research Center for Agricultural Sciences (JIRCAS), Japan*

Nitrification is an oxidation process, part of the larger nitrogen (N) cycle in the soil, and is mediated by microorganisms that transform ammonium (NH_4^+) to the water soluble nitrate (NO_3^-), producing nitrous oxide (N_2O, a potent greenhouse gas) as a by-product. Researchers at CIAT-Colombia, in collaboration with JIRCAS-Japan, reported that the tropical forage grass, *Brachiaria humidicola* (Bh), has the ability to inhibit the nitrification with chemical exudates from their roots into the soil. This capacity of *Brachiaria* grasses is known as biological nitrification inhibition (BNI) and this function could increase N efficiency in crop-livestock systems by improving recovery of applied N, while reducing NO_3^- leaching and N_2O emissions. Recently, we have been able to improve methodologies for more reliable quantification of the BNI trait in order to accelerate the process of identifying phenotypic differences in BNI ability.

Our aim is to quantify phenotypic differences in BNI capacity of a bi-parental hybrid population (n=134) of two Bh accessions with different BNI capacities, CIAT 26146 (medium to low BNI with sexual mode of reproduction) × CIAT 16888 (high BNI with apomictic mode of reproduction), in an attempt to identify QTLs (quantitative trait loci) associated with BNI trait. The phenotyping methodologies used were: 1) A bioassay using a recombinant *Nitrosomonas europaea* strain engineered to detect changes in nitrification *in vivo* in the presence of Bh root exudates; 2) A reliable and rapid soil incubation method to determine changes in nitrification in soil where Bh plants were grown; and 3) A molecular method where both DNA and RNA from soil nitrifying microbes are co-extracted. First, DNA is used to size the nitrifier populations as an indicator for the amount of nitrification inhibitors released by the Bh roots. Second, cDNA is synthesized using the RNA as template, to enable expression analysis of ammonia monooxygenase gene (responsible enzyme for NH_4^+ oxidation to NO_3^-) as a functional molecular marker for nitrification process. By using these different phenotyping methodologies we found high phenotypic variability in BNI capacity among hybrids. The importance of these results in regulating BNI function in *Brachiaria* will be discussed.

Keywords: Ammonia mono-oxygenase (amoA), brachialactone, *Brachiaria humidicola*, nitrous oxide, phenotyping, root exudates

Contact Address: Jacobo Arango, International Center for Tropical Agriculture (CIAT), Tropical Forages, A A 6713 Cali, Colombia, NA Cali, Colombia, e-mail: j.arango@cgiar.org

Nitrogen Fixation and Drought Resistance of Selected Forage Legumes for Smallholder Farmers in Uganda

NICOLE WRAGE-MÖNNIG[1], JOHN KIGONGO[2], JUSTINE NAMBI-KASOZI[3], BIRTHE PAUL[4], JOHANNES ISSELSTEIN[5], BRIGITTE L. MAASS[4]

[1]*University of Rostock, Grassland and Fodder Science, Germany*
[2]*National Livestock Resources Research Institute, Uganda*
[3]*Makerere University, Uganda*
[4]*International Center for Tropical Agriculture (CIAT), Tropical Forages Program, Kenya*
[5]*Georg-August-Universität Göttingen, Dept. of Crop Sciences: Forage Production and Grassland Management, Germany*

To improve feed availability for smallholder farmers in East Africa, we investigated the biomass production, drought resistance and nitrogen fixation of five forage legumes (*Lablab purpureus*, *Desmodium uncinatum* cv Silverleaf, *Desmanthus virgatus*, *Macroptilium bracteatum* cv Burgundy bean, and *Canavalia brasiliensis*) in a field trial in Uganda. The crops were grown under rain-fed conditions (control) and with additional irrigation (irrigated) and harvested five times at two-monthly intervals (first harvest in the wet season, two following in the dry season, last two in the wet season again). On average, the soil water content of the control plots was about 14 % lower than in the irrigated ones (measured at five occasions throughout the season). Before herbage harvests, the youngest leaves of the forage crops were sampled for stable carbon (C) and nitrogen (N) isotope analysis for an indication of intrinsic water-use efficiency and N fixation, respectively. The total herbage dry matter production of the legumes was on average about 600 g m^{-2}, with small, albeit not significant differences among species and between irrigation treatments (6.2 versus 5.7 kg ha^{-1} in irrigated and non-irrigated treatments, respectively). N yields were largest from *L. purpureus* and *C. brasiliensis* due to a combination of large biomass production and N content. The N isotopic values were most depleted for *L. purpureus* and *D. uncinatum*, intermediate for *M. bracteatum* and *C. brasiliensis* and most enriched for *D. virgatus* ($p < 0.001$), suggesting a potentially larger proportion of N derived from air for *L. purpureus* and *D. uncinatum*. *Canavalia brasiliensis* had most enriched C signatures. This suggests an efficient
intrinsic water use of this forage legume. Based on yields, N fixation and water use, *L. purpureus* and *C. brasiliensis* seem the most promising legumes under the conditions tested.

Keywords: Intrinsic water-use efficiency, irrigation, stable isotopes, yield

Contact Address: Nicole Wrage-Mönnig, University of Rostock, Grassland and Fodder Science, Rostock, Germany, e-mail: nicole@wrage-online.de

Is High Impact Grazing-Trampling a Management Option to Reduce Excess Standing Biomass in Argentinean Grasslands?

DITMAR BERNARDO KURTZ[1,2], MARCUS GIESE[2], MARIA FABIANA NAVARRO RAU[3], FOLKARD ASCH[2]

[1]*National Institute of Agricultural Technology (INTA), Natural Resources, Argentina*

[2]*University of Hohenheim, Institute of Plant Production and Agroecology in the Tropics and Subtropics, Germany*

[3]*National Institute of Agricultural Research (INTA), Institute of Soils, Argentina*

Northern Argentinean grasslands are very productive but, due to low stocking rates, standing dead biomass accumulates every year. Fire with negative effects on the system's carbon and nitrogen balance is often used to eliminate dead biomass and therefore, alternative sustainable management options are highly requested. By implementing elements from the holistic grassland management approach, short-term, high-intensity grazing could be used as an alternative to reduce standing dead biomass thereby improving grassland productivity and green / standing dead biomass ratios. At the INTA Corrientes experimental station we designed a three times replicated 18 ha grazing- experiment. In each month of the year, a different area of 0.5 ha was subjected to three days high animal impact with 150 cattle ha^{-1} and traditionally grazed thereafter with 0.5 cattle ha^{-1}. Grass re-growth was monthly sampled inside and outside moving exclosure cages. We analysed the effect of trampling and impact timing (spring, summer, autumn and winter) on accumulated green and standing dead biomass compared to biomass pools on adjacent traditionally managed grassland.
Independent of timing, the trampling resulted in up to 60 % reduced standing dead biomass pools compared to the control. The effect was significant for at least 3 months after the impacts in winter and spring. At peak biomass time (December - February) standing dead to green biomass ratios were between 1.4 and 13.8 for the control site and between 0.1 and 4.4 on treated paddocks. However, none of the trampling impacts resulted in higher green biomass accumulation compared to the control site. High impact grazing-trampling is an alternative management tool to reduce standing dead excess biomass. Best effects were attained for the winter and spring impacts. Surprisingly, accumulated standing dead biomass seems not to interfere with net primary production of northern Argentinean grasslands. However, improved green biomass accessibility and fodder quality via species composition change might be key effects of trampling or fire impacts, which deserve further analysis.

Keywords: Biomass, cattle, rangelands, vegetation dynamics

Contact Address: Ditmar Bernardo Kurtz, National Institute of Agricultural Technology (INTA), Natural Resources, Ruta 12 Km 1008 C.C. 57, 3400 Corrientes, Argentina, e-mail: kurtz.ditmar@inta.gob.ar

Is Traditional Transhumance an Adapted Strategy or an Overhauled Way of Rangeland Management in the Chinese and Mongolian Altay?

GRETA JORDAN[1], TSEVEGMED MUNKHNASAN[2,3], ANDREAS BUERKERT[1], EVA SCHLECHT[3]

[1]*University of Kassel, Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, Germany*

[2]*Mongolian State University of Agriculture, School of Biological Resources and Management, Mongolia*

[3]*University of Kassel / Georg-August-Universität Göttingen, Animal Husbandry in the Tropics and Subtropics, Germany*

Changes in climate and modification in herd composition are assumed to affect the quantity and quality of fodder plants on pastures and consequently the transhumant livelihood system in the Chinese-Mongolian Altay Mountains. The management of a herd, typically consisting of goats, sheep, cattle, horses and camels, is characterized by seasonal grazing periods in the desert steppe, mountain steppe and alpine belt. Due to their economic importance for the herders, we tracked the movement of one representative cow and one goat herd with a long-duration global positioning system collar to record their grazing itineraries and activities from May 2012 to September 2013. To determine pasture productivity, 850 sampling locations were chosen to record above-ground biomass in the different grazing areas. In China, the temporal and spatial movement of herders was mainly ruled by the government at the local administration level, whereas in Mongolia herding strategies were primary determined by the individual herders. In the Chinese Altay the herds moved around 285 km (cattle) and 572 km (goats), and grazed up to 11 different pastures per year. In the Mongolian Altay the cattle and goat herds moved around 389 km and grazed 6 different pastures. The biomass availability on the main spring, summer, autumn and winter pastures averaged 2010 kg ha^{-1} in China and 1097 kg ha^{-1} in Mongolia. The duration of stay for goats at the individual pastures ranged from 6 to 83 days in China and 40 to 103 days in Mongolia. Regulation of animal numbers and duration of stay on pasture as well as allocation of pastures to individual herders seem to maintain pasture quality in China. However, this system could prevent flexible adaptation to local environmental constraints. In contrast, the high number of especially cashmere goats and grazing of pastures before flowering of the herbaceous plants decreased pasture productivity in Mongolia. In conclusion, an optimized mixed species composition of the herds and a flexible adaptation to environmental constraints may foster the productivity and sustainability of the transhumance system in the Altay Mountains.

Keywords: Biomass production, Central Asia, communal pastures, GPS tracking

Contact Address: Eva Schlecht, University of Kassel / Georg-August-Universität Göttingen, Animal Husbandry in the Tropics and Subtropics, Steinstraße 19, 37213 Witzenhausen, Germany, e-mail: tropanimals@uni-kassel.de

An Agro-Silvo-Pastoral Production System in Brazil

MARIANA PEREIRA[1], DAVI JOSE BUNGENSTAB[2], ROBERTO G. ALMEIDA[2], HORST JÜRGEN SCHWARTZ[3]

[1]*Federal University of Mato Grosso Do Sul, Animal Science, Brazil*
[2]*EMBRAPA Beef Cattle, Integrated Production Systems, Brazil*
[3]*Humboldt-Universität zu Berlin, Department of Livestock Ecology, Germany*

Extensive beef production with grazing cattle kept exclusively on sown pasture is one of the main economic activities in Central-Brazil. Poorly managed systems, besides the evident inefficient use of local natural resources, lead to environmental degradation. Alternatives for recovering such areas are being developed, among them, some complex integrated production systems. EMBRAPA beef cattle leads technology research for beef cattle husbandry in Brazil, for such, a 12 years agro-silvo-pastoral experiment was implemented in 2009 to identify the most appropriate combinations of species and cultivars, tree densities and stocking rates, as well as cultivation techniques for local conditions. An 18 ha trial combining *Brachiaria* pastures with Eucalyptus trees (227 trees per ha) having soybeans cultivation periodically to improve pastures was implemented at EMBRAPA beef cattle experimental station in Campo Grande-MS, Brazil. Preliminary results available from the on-going experiment show that the system is able to keep stocking rates above average of previous traditional pastures (1.3 versus 0.8 AU ha^{-1}). Forage availability and quality is above regional averages, reaching 4.964 kg DM ha^{-1} and crude protein content of 8.97 %, also above regional averages, resulting in cattle live-weight gains of 172 kg ha^{-1} $year^{-1}$ against regional averages of 70 kg ha^{-1} $year^{-1}$. Grain crop production between months 38 to 42 using no-tillage seeding over *Brachiaria* grass between tree rows resulted in soybean yields of 2880 kg ha^{-1}, which are close to regional averages (3200 kg*ha^{-1}). Forest production results showed DBH of 16 cm and 38 m^3 ha^{-1} at month 36. Estimated carbon storage by the system for the same period was 40 metric tons of CO_2 equivalents per ha.
These results show that despite being more complex and therefore not applicable to all situations as a general solution for improving sustainability of cattle husbandry in Central-Brazil, agro-silvo-pastoral systems, when properly implemented and well managed, can result in beef production yields high above regional averages while generating extra incomes for farmers through cash crops and forestry.

Keywords: Beef cattle, *Brachiaria*, Eucalyptus, integrated systems, soy bean

Contact Address: Horst Jürgen Schwartz, Humboldt-Universität zu Berlin, Department of Livestock Ecology, Asternplatz 2a, 1220ß Berlin, Germany, e-mail: schwartzhj@gmail.com

Agent-Based Modelling of Transhumant Cattle Herd Movements in Southwestern Madagascar

PASCAL FUST, TOBIAS FELDT, EVA SCHLECHT

University of Kassel / Georg-August-Universität Göttingen, Animal Husbandry in the Tropics and Subtropics, Germany

Managing natural resources sustainably in grazing systems requires a sound understanding of the limiting factors and dynamics of the herbivore-influenced ecosystem. Due to the high spatial heterogeneity and the high stochasticity in precipitation and resource distribution, deterministic models have shown shortcomings in depicting this dynamics in semi-arid and arid environments.

Traditionally, seasonal water and forage shortage constrained animal husbandry of zebu (*Bos indicus*) herds by the pastoralists of the area surrounding the Tsimanampetsotsa National Park in southwest Madagascar to extensive levels, and transhumant herd movements between coastal and inland grazing grounds largely followed the seasonal availability of natural resources. In recent times, however, population increase and lack of security due to cattle rustling in certain areas of the region led to a change in spatial and temporal pasture use and thereby unsustainable demands for resources. To assess the potentially degrading impact of domestic herbivores on the ecosystem within framework of change in land use, we developed a spatially explicit agent-based model on the herbivore-vegetation interactions within the agropastoral/transhumant grazing mode of herders of the Mahafaly plateau.

In a first step, the temporal variability in availability of natural resources and the foraging activities of the zebu herds have been simulated and parameterised on a daily resolution for one village incorporating GIS, high-resolution remote sensing and field-based validation data. Based on the animals' metabolic energy and protein needs and expenditures for maintenance, growth and movements, the agent-based model simulates the interacting effects between herd demography and resource availability in terms of quality and quantity. In a future version, the agent-based model will be applied to analyse the ecosystem response under different livestock management strategies as well as future climate and land use change scenarios.

Keywords: Herbivore-vegetation interactions, herd demography, resource availability, spatio-temporal modelling

Contact Address: Eva Schlecht, University of Kassel / Georg-August-Universität Göttingen, Animal Husbandry in the Tropics and Subtropics, Steinstraße 19, 37213 Witzenhausen, Germany, e-mail: tropanimals@uni-kassel.de

Post-Grazing Secondary Succesion Dynamics of a Tamaulipian Thornscrub

MIGUEL ANGEL PEQUEÑO LEDEZMA[1], ALEJANDRO VALDECANTOS DEMA[2], EDUARDO ALANIS RODRIGUEZ[1], JAVIER JIMENEZ PEREZ[1], MARCO AURELIO GONZALEZ TAGLE[1], ISRAEL YERENA YAMALLEL[1]

[1] *Universidad Autónoma de Nuevo León, Dept. of Silviculture, Mexico*

[2] *Centro Estudios Ambientales del Mediterráneo, Dept. of Forestry Research, Spain*

Succesional trayctory after an abandon under semi arid conditions is still not well understood. In arid and semi arid zones, rain and water available in the soil for plants has been described as one of the most decisive factors in the productivity and heterogeneity in the distribution and living forms of the plants. On a regional scale, Tamaulipas shrubland used in livestock production affects natural regeneration in some of the species, as a result there is a secondary succession in the ecosystem. The results of this research manifests that the areas with passive regeneration after livestock use in Linares municipality are conformed predominantly by the Fabaceae family and the *Prosopis* sp. *genera*. In total, 16 families, 23 genera and 27 species were registered in the successional estate, where the most abundant species were *Vachellia farnesiana*, *Diospyros texana* and *Prosopis laevigata*, being *V. farnesiana* the only one present in the three states and in the reference area. A direct relationship between the species richness and abandon time was observed in the study areas. In any case, a major number of timber species was found in the reference area compared with the other three studied áreas (F=28.1, $p < 0.001$). The same effect was found for the two biodiversity indexes, with higher values of the Shannon (F=21.9, $p < 0.001$) and Margalef (F=46.3, $p < 0.001$ variances not homogeneous) indexes in the ever grazed than in any of the grazed sites. Density values showed a not significant decreasing trend over time since grazing stopped with a 45 % reduction in the number of woody individuals in the 30-yr site in relation to the 10-yr site. However, the highest values in density were found in the reference site. Both basal area and projected cover were significantly lower in the youngest ecosystem. The greatest differences were found between 10-yr and 30-yr for basal area (more than 5 times higher; F=7.99, $p = 0.003$) and 10-yr and the reference for canopy cover (2.5 times higher; F=4.48, $p = 0.025$). Passive restoration through grazing exclusion triggers the recovery of biodiversity and structure of the woody component of Mexican Tamaulipan thornscrub, although these two ecosystem services change at different rates, the structure faster as the diversity. Active restoration by non-aggressive techniques may represent a suitable action for the establishment of late-successional species.

Keywords: Livestock, Fabaceae, Margalef, Shannon, Tamaulipas shrubland

Contact Address: Miguel Angel Pequeño Ledezma, Universidad Autónoma de Nuevo León, Dept. of Silviculture, Anahuac # 109, 67710 Linares, Mexico, e-mail: mikepequeno@hotmail.com

Does High Impact Grazing and Trampling Affect Grasslands Floristic Composition?

DITMAR BERNARDO KURTZ[1,2], MARÍA CRISTINA GOLDFARB[1], OSCAR QUIROS[1], FRANCISCO NUÑEZ[1], FOLKARD ASCH[2]

[1]*National Institute of Agricultural Technology (INTA), Argentina*

[2]*University of Hohenheim, Inst. of Plant Production and Agroecology in the Tropics and Subtropics, Germany*

In northern Argentina traditional management of extensive grazing system, result in large accumulation of dead material (DM). Short duration grazing-trampling (herd effect), have been suggested as being able to increase productivity while maintaining or improving other grassland characteristics, such as floristic composition (FC). The objectives of this study were to examine the changes on FC and the spectral response (SR) of the North-western Corrientes tall grasslands, after intensive grazing-trampling experiment. For that, at the INTA Corrientes experimental station we designed a three times replicated 18 ha grazing experiment, where in each month of the year a different area is subjected to three days high impact grazing (150 cattle ha^{-1} day^{-1}). Grassland attributes were recorded monthly, prior to, and one year of the treatment. FC by the dry weight rank method and the trend and cover index (INTECO) were calculated. The above ground biomass (AGB) was gathered by clipping five 0.25 m^2 quadrates in each replicate. AGB was hand separated, weighed and oven dried at 60°C until constant weight. SR was measured with a field radiometer and normalised difference vegetation index (NDVI) was calculated. Both, INTECO and NDVI have been widely used in Argentina for rangeland monitoring. Statistical analyses indicate that, after one year and independent of the month of impact, there was no significant effect on the INTECO, the total dry matter, the proportion of grass, weeds and grass-like species (α=0.05). Different to what was expected, INTECO and NDVI were not related. Nevertheless, in most cases the NDVI was significantly different after the impact (α=0.05). Finally, the preliminary results indicate that the high trampling is an alternative management option which does not significantly affected FC. But as the INTECO does not include minor species, further and deeper studies on biodiversity are needed.

Keywords: Biomass, INTECO, NDVI

Contact Address: Ditmar Bernardo Kurtz, National Institute of Agricultural Technology (INTA), Natural Resources, Ruta 12 Km 1008 C.C. 57, 3400 Corrientes, Argentina, e-mail: kurtz.ditmar@inta.gob.ar

Implications of Site Characteristics and Herding Practices on Rangelands Management in Semi-Arid Areas of Sudan

ABDELAZIZ GAIBALLA[1], MAHGOUB SUELIMAN[2], DARELNIEM RAMADAN[3]
[1]*Sudan University of Science and Technology, Range Science, Sudan*
[2]*Sudan University of Science and Technology, Forestry Department, Sudan*
[3]*University of Bakht Elrida, Range Science, Sudan*

This study was conducted in the northwestern part of White Nile State of central Sudan in an area West of the white Nile bank (13° 59' N and 32° 18' E). The objective was to study the means of participatory and sustainable rangeland management that involves herding practices of the pastoralists' communities entering the area and the rangelands' site characteristics. The area represents the repeated pattern of the typical semi-arid natural rangelands that are ecologically heterogeneous at different spatial scales dictated by variable rainfall, different terrain and different soil types. Irrational land-use, excessive utilisation levels, in addition to climatic factors, led to the deterioration of rangelans resources and disturbances of the pastoralist's livelihood and herding pattern that used to be environmentally friendly.
Three sites representing the main range types were selected to study the spatial heterogeneity of vegetation (sandy rangelands, flat (clay/sandy) and depressed sites). Vegetation measurements mainly herbaceous cover, composition and trees density were measured. Information on herding practices were collected using PRA. Remote sensing data (MODIS/TEERA (MOD13Q1) NDVI 250 m.16 days' image product) was used to study variations between different sites over the years, using the Normalized Difference Vegetation Index (NDVI).
The study results showed variations in vegetation composition, plant cover and biomass, in addition to patterns of utilisation among the different rangeland types as indicated by different species and different herding periods and practices adopted by the pastoralists. This will have implications on management prescriptions to be adopted. Values of Normalized Vegetation Index (NDVI) for the herbaceous density as indicated by phenological stages of the plants growing at each site,showed changes in NDVI values within each season. Based on the results range management may favour the use of clay/sandy sites earlier than the use of sandy rangelands as related to time of use by pastoralists. Understanding and characterisation of different range types help for better identification of sustainable and participatory rangeland management prescriptions.

Keywords: Natural rangeland, NDVI, semi-arid areas, soil types

Contact Address: Abdelaziz Gaiballa, Sudan University of Science and Technology, Range Science, Amarat, Khartoum, Sudan, e-mail: gaiballa@gmail.com

Characterisation of Agro-Pastoralist Households Along the Bulgan River in the Altay Region of Western Mongolia

TSEVEGMED MUNKHNASAN[1,3], MARTIN WIEHLE[2], EVA SCHLECHT[3]

[1]*Mongolian State University of Agriculture, School of Biological Resources and Management, Mongolia*

[2]*University of Kassel, Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, Germany*

[3]*University of Kassel / Georg-August-Universität Göttingen, Animal Husbandry in the Tropics and Subtropics, Germany*

The livelihoods of 1.5 million Mongolian citizens - almost half of Mongolia's population - depend on animal husbandry. A sole dependency on livestock implies problems related to inter- and intra-annual variability in weather, water and forage availability. Recent socio-economic developments furthermore changed farming practices and product preferences and partly induced a loss of traditional and appropriate herding knowledge. The present survey characterised 225 agro-pastoral households along the Bulgan River Valley of western Mongolia in terms of their livelihood strategies and farm and livestock management. Interviews were conducted using semi-structured questionnaires; data were subjected to CATPCA and two-step cluster analysis. Results revealed a wide diversity of farm management approaches, a variable species composition of the households' livestock herds and a very strong focus on cashmere wool production. The annual livestock transhumance patterns partly reflect traditional herding practices, though it became evident that annual tracking distances are declining. Cropping activities played a secondary role, but were an additional and even alternative livelihood strategy. Four farm types could be distinguished, namely commercial livestock keeping (cL, 31 %), commercial livestock keeping plus semi-commercial field cropping (cLscC, 11 %), commercial field cropping (cC, 7 %) and semi-commercial livestock keeping plus subsistence field cropping (scLsC, 51 %). Cluster cL comprised households with a pure pastoralist lifestyle. For cLscC households, livestock was most important for generating cash income, while little additional income was supplied by field crops. cC farmers owned animals that were herded by other people; their focus was on cereal and vegetable production. Households of cluster scLsC dominated in the surveyed area with intermediate herd sizes and moderate importance of crop production activities. This first assessment of farming strategies provides the basis for a more detailed analysis of current opportunities and constraints of farmers' livelihood strategies in this very remote region with difficult infrastructure.

Keywords: Animal husbandry, farm classification, livelihood strategies

Contact Address: Eva Schlecht, University of Kassel / Georg-August-Universität Göttingen, Animal Husbandry in the Tropics and Subtropics, Steinstraße 19, 37213 Witzenhausen, Germany, e-mail: tropanimals@uni-kassel.de

Current Living Status and Social Use of Livestock in Nomadic Herders' Communities in Western Mongolia

TAKUYA SOMA[1], ANDREAS BUERKERT[2], EVA SCHLECHT[1]

[1] *University of Kassel / Georg-August-Universität Göttingen, Animal Husbandry in the Tropics and Subtropics, Germany*

[2] *University of Kassel, Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, Germany*

Nomadic herders in Mongolia are facing ongoing climatic and socio-economic changes, but little is known how these affect their livelihood and risk management strategies. This study was conducted to fill this knowledge gap.

Data collection consisted of 50 structured "face to face" interviews of individual households (HH) carried out in Khovd and Bayan Ölgii Province, western Mongolia. These were distributed across four settlements on high altitude summer pastures ($>$ 2000 m a.s.l.) which were visited during 24/06 – 20/08/2013.

The four locations (Altztai Holoo, Sunkar Nuur, Hoshoot, and Dont-Temult) were mainly inhabited by the three ethnic groups of Kazakh, Torguud, and Uriankhai. Based on their total livestock possession (herd size), HHs were subdivided into large, medium and small livestock keepers (L, M, S). Herd size was $>$200 head for L, $>$100 – 200 head for M and $<$100 head for S. These differences were largely paralleled by ethnic divides whereby Torguud dominated the L stratum (70 %) and had a higher living status as well as a more powerful socio-economic status than Kazakh and Uriankhai. The later made up for 90 % of HHs in the S cluster. In 2012 a HH consumed on average 15.6 head of mostly sheep and goats (plus occasionally one calf), whereby L and M slaughtered 22.3 and 20.9 animals compared to only 13.1 slaughtered by S. Across all herds and species, an average of 78.3 animals were born in L herds in 2012, 47.5 in M and 15.2 in S herds. HHs of stratum S (67 % of all HH) consumed 86 % of their annual stock increase and might face severe problems of food security at times of crisis such as disease outbreaks or harsh winters. As a consequence of their tight living conditions, the social use of livestock for donation and exchange that used to firmly bind kinship and neighbour relationships is vanishing, especially among S households.

Strategies are urgently needed that open up new livelihood options without compromising herders' mobility and (food) culture.

Keywords: Food security, livestock, Mongolia, social customs

Contact Address: Eva Schlecht, University of Kassel / Georg-August-Universität Göttingen, Animal Husbandry in the Tropics and Subtropics, Steinstraße 19, 37213 Witzenhausen, Germany, e-mail: tropanimals@uni-kassel.de

Reproducive and Growth Performance of Extensively Managed Goat Herds in Southwestern Madagascar

TOBIAS FELDT[1], REGINA NEUDERT[2], EVA SCHLECHT[1]

[1] *University of Kassel / Georg-August-Universität Göttingen, Animal Husbandry in the Tropics and Subtropics, Germany*

[2] *Brandenburg University of Technology Cottbus-Senftenberg, Inst. of Botany and Landscape Ecology, Germany*

Livestock keeping plays a key role for people's livelihoods in semi-arid Southwestern Madagascar. While zebu cattle are mostly kept to fulfil social and cultural obligations and to buffer extreme times of need, sheep and especially goats are of higher importance from an economic perspective and contribute to people's regular income. However, the very extensive animal husbandry system is liable to several constraints such as seasonal water and forage shortage as well as livestock diseases, and thus bears risks of loss for herd owners. Furthermore, limited market access due to poor infrastructure lowers the breeders' revenues. We therefore analysed the live weight development and reproductive performance of local goats along with herders' culling strategies to determine herd dynamics and opportunities for economic development.

In early 2013 interviews were conducted to determine the progeny history of 449 does and their 1,241 kids in six villages located on the Mahafaly Plateau and along the coastal zone near Tsimanampetsotsa National Park. Together with live weight data of 804 male and 1,625 female animals across four bodyweight categories, results were fed into the species-independent PRY Herd Life Model to calculate variables such as litter size, age at first parturition, kidding interval and mortality rate. Model results were merged with further socio-economic information from structured and semi-structured interviews to assess the economic performance of goat keeping using a Monte Carlo simulation model.

Preliminary results indicate early maturity of the breeding females and short parturition intervals across the whole region. Low kid mortality rate before and after weaning seems to be a major factor influencing the system whereas the seasonal kidding has no perceptible effect on herd performance. The economic analysis indicates that the local goat husbandry system is profitable under the given circumstances, mainly due to favourable reproductive performance, low labour costs and large herd size. Therefore a good management, particularly with regard to veterinary care ensuring good health of does and kids, might enhance the incomes of goat-breeding households.

Keywords: Goat husbandry, herd demography, herd productivity, Monte Carlo model, progeny history records, PRY herd model, southwestern Madagascar

Contact Address: Eva Schlecht, University of Kassel / Georg-August-Universität Göttingen, Animal Husbandry in the Tropics and Subtropics, Steinstraße 19, 37213 Witzenhausen, Germany, e-mail: tropanimals@uni-kassel.de

Resource Use and Resilience of Goat Production Systems in Pernambuco, Northeast Brazil

KARIN STOCK DE OLIVERIA SOUZA[1], CHRISTOPH REIBER[1], MARIANNA SIEGMUND-SCHULTZE[2], ANNE VALLE ZÁRATE[1]

[1] *University of Hohenheim, Inst. of Animal Production in the Tropics and Subtropics, Germany*

[2] *Technische Universität Berlin, Environmental Assessment and Planning Research Group, Germany*

The construction of the Itaparica dam affected the agricultural production systems in the semi-arid Itaparica region, São Francisco river basin. Fertile land has been inundated and thousands of farmers had to resettle. Traditional production systems – mainly a combination of cropping in the river floodplains and extensive livestock (mainly goat) farming in the adjacent dryer areas, based on the available natural resources – were partly replaced by irrigated cropping as a compensation measure. The study evaluates the implications of resource use on the resilience of different goat production systems affected by the Itaparica dam. Hundred-twenty goat keepers were interviewed. They represent five types: resettled farmers in irrigation schemes; resettled farmers and non-resettled farmers outside of these schemes, both with and without irrigation. Labour demand of goat production was low in all production systems and the natural vegetation (Caatinga) served as primary feed source. According to farmers, plant density has decreased over time leading to a lower feed supply. Due to the extended drought in 2011/2012, additional fodder had to be bought to maintain the goats, nevertheless 7 % died. The share of income from goat production on total income was low (3–4 % in the three groups of resettled and 6 % in the two groups of established farmers). The economic efficiency of goat production was however higher in farms within the irrigation schemes, where feed supply was slightly better due to the higher availability of crop by-products. Here, two-thirds used dung as fertiliser for cropping. In comparison, 41 % of established farmers with own irrigation and 4–13 % of the remaining farmers outside these schemes made use of the goat dung. The stronger integration of goat with crop production sustained the survival of animals and thus the resilience of goat production within irrigation schemes. Likewise, using dung as fertiliser contributed to nutrient cycling within these systems. The majority of the goat flock is however kept outside the newly established irrigation schemes. The resilience of these production systems is more crucial since recurring droughts may lead to further scarcity of natural feed resources.

Keywords: Caatinga, irrigation schemes, resilience, semi-arid, small ruminants

Contact Address: Karin Stock de Oliveria Souza, University of Hohenheim, Inst. of Animal Production in the Tropics and Subtropics, Garbenstrasse 17, Stuttgart, Germany, e-mail: karinsos@yahoo.de

Monitoring Vegetation Index Dynamics in Semi-Arid Rangelands Using Rainfall, Ground Survey and MODIS Data

MICHAEL ELIAS MGALULA[1], UWE RICHTER[1], OLIVER HENSEL[1], CHRISTIAN HÜLSEBUSCH[2], BRIGITTE KAUFMANN[2], OLIVER WASONGA[2]

[1]*University of Kassel, Agricultural Engineering, Germany*

[2]*German Institute for Tropical and Subtropical Agriculture (DITSL), Germany*

Vegetation in the rangelands are greatly altered by human activities such as grazing pressure, deforestation, encroachment of land for cultivation and natural factors such as spatial and temporal variability in rainfall. Interaction of man-made and natural factors predominantly affects vegetation structure and composition in the ecosystem. Among the major concern that faces Eastern Africa rangelands is the growing of land degradation attributed to the increase of cultivation activities. This is a serious concern because rangelands are getting more fragile and vulnerable to environmental changes, thus threatening the pastoralists' livelihood. It is, therefore, imperative to understand the extent and magnitude of changes in vegetation composition over time. This is central for improving landscape conservation. The present research was aimed to examine the extent of vegetation composition changes for Borana plain, in southern Ethiopia. The study assessed the temporal phenological changes of vegetation index (VI) in the croplands and that of natural vegetative land. Rainfall and ground survey data supplemented with MODIS NDVI satellite images with 250 m spatial resolution of 16 days composite of January through December 2002 and 2012 were used to analyse vegetation index employing pixel based approach.

Results showed higher vegetation index (VI) in April, May, November, December and lower VI between March, July, August and September in the grass, bush, shrub, crop land covers with exception of the woodland. The fluctuation in VI is significantly correlated with rainfall ($p<0.003$) in 2002 and ($p < 0.017$) in 2004 (Pearson Correlation Coefficient test). There is also significant differences ($p < 0.000$) in mean VI in cropland (0.345), grassland (0.365), bushland (0.388) and woodland (0.525), (One way ANOVA), as vegetation growth passes through various phenological stages. The results suggest that the higher VI between April, May, November and December correspond with precipitation trend of the same study area. Temporally, the mean VI varied over years, 2002 (0.386), 2003(0.432), 2004 (0.411), 2006 (0.419) and 2012 (0.380). This variation is attributed to conversion of natural rangelands in other uses e.g. cultivation and variability in rainfall. The study demonstrates that pixel based and crop phenology are robust approaches for discriminating and classifying crops from natural vegetation, i.e. forestry, woody trees, grass and herbs.

Keywords: Crop cultivation, crop phenology, remote sensing, vegetation changes

Contact Address: Michael Elias Mgalula, University of Kassel, Agricultural Engineering, Nordbahnhofstr.1a, D-37213 Witzenhausen, Germany, e-mail: mgalulamike@yahoo.com

Nutritional Value of two Native Shrub Species That Grow in the Tamaulipan Thornscrub from Mexico

TILO GUSTAVO DOMÍNGUEZ GÓMEZ[1], ARTURO SAUL JUÁREZ REYES[1], MARIA ANDREA CERRILLO SOTO[1], MARIBEL GUERRERO CERVANTES[1], HUMBERTO GONZALEZ RODRIGUEZ[2], ROQUE G. RAMIREZ LOZANO[3], MARIA DEL SOCORRO ALVARADO[3]

[1] *Universidad Juárez del Estado de Durango, Fac. of Veterinary Medicine, Mexico*

[2] *Universidad Autónoma de Nuevo León, Fac. of Forest Sciences, Mexico*

[3] *Universidad Autónoma de Nuevo León, Fac. of Biological Sciences, Mexico*

Due to the dynamic nature of vegetation and the provision of adequate forage for grazing, small ruminants and wildlife experience periods of varying food availability, which affect the ruminant productivity. However, available data on nutritive value of plants and shrubby forages from hot arid climates are not sufficient. The aims of this study were to determine the chemical composition and fermentation kinetics of two native shrubby species (*Acacia amentacea*, and *Parkinsonia texana*) and to determine whether the species can meet the maintenance requirements of ruminants in extensive systems. Samples were collected from three undisturbed grazing sites (China, Linares and Los Ramones) of the state of Nuevo Leon, Mexico. Monthly sample recollection of mature leaves through 2009 was undertaken at browsing height (1.5 m) from five individual, randomly selected plants of each species. Forage quality determinations included neutral detergent fiber (NDF), condensed tannins (CT), crude protein (CP), *in vitro* true organic matter digestibility (IVTOMD), metabolisable energy (ME) and gross energy losses (GEL %, as methane production). The fermentation parameters evaluated were the total gas volume A, the rate constant of gas production c, lag phase L, purines and partitioning factor (PF); all fermentation parameters were estimated with and without PEG (6000). Data were analysed using a one-way analysis of variance with a tri-factorial arrangement, being the factors the sites (3), months (12) and shrub species (2). Values for *A. amentacea* were higher for NDF (42 %), CT (19 %), purines (9 μ mol), PF (6.1) and GEL (6.7 %), whilst *P. texana* was higher in CP (18 %), IVTOMD (82 %), ME (2.1 Mcal kg^{-1} DM), A (183 ml), c fraction (0.071 /h) and L (0.868 h). Addition of PEG increased the ME values, A, c and L; on the contrary, values of purines and PF diminished. Although the content of CT and GEL are higher in *A. amentacea*, their values of purines and PF lead to higher microbial protein synthesis. Thus, data suggest that both species could be a good combination for supplying the nutritional requirements for adult small ruminant and wildlife, managed in the Tamaulipan thornscrub.

Keywords: Chemical composition, fermentation parameters

Contact Address: Arturo Saul Juárez Reyes, Universidad Juárez del Estado de Durango, Fac. of Veterinary Medicine, Apartado Postal, 34620 Durango, Mexico, e-mail: ajuarez5215@yahoo.com.mx

Livestock-based options for sustainable food and nutritional security and healthy lives (ILRI session)

Setting the Context

DIETER SCHILLINGER

Animal Health Consultancy, Germany

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Keywords: Lorem ipsum

Contact Address: Dieter Schillinger, Animal Health Consultancy, Stuecklenstr. 16a, D-81247 Munich, Germany, e-mail: dieter.schillinger@googlemail.com

Refocusing Livestock AR4D to Address Food and Nutritional Security Challenges

THOMAS RANDOLPH, MICHAEL KIDOIDO, ISABELLE BALTENWECK, STEVE STAAL, DELIA GRACE

International Livestock Research Institute (ILRI), Kenya

Livestock research conducted by the International Livestock Centre for Africa (ILCA), the International Laboratory for Research on Animal Diseases (ILRAD) and the International Livestock Research Institute (ILRI) has largely focused on the main productivity constraints that limit the ability of the poor to use livestock to improve their livelihoods through more efficient farming systems and higher income. With the 2007 food price scare and increasing awareness of the challenge of feeding the projected world population of 10 billion by 2050, this traditional focus has been expanding to consider how livestock research will ensure that developing-country populations in 2050 have adequate access to affordable animal-source foods for an adequately nutritious and diverse diet.

This reorientation leads to two fundamental questions to sharpen our research agenda: (1) Will smallholder production and associated small-scale marketing systems have an important role in feeding the future? (2) If yes, can we enable these small-scale production and marketing systems to respond to rapidly growing demand in a context of decreasing resources? That the poor largely source their animal-source food locally and that small-scale systems are still, and projected to remain, important and competitive in supplying these foods argues the pragmatism of maintaining a focus on these systems and facilitating their transition to commercial scale. To produce the needed growth in better quality animal-source foods, these small-scale systems must intensify and add value. The contribution of research to improving productivity in livestock systems, especially in Africa, has been disappointing. To improve the focus and impact of livestock agricultural research for development (AR4D), we describe a value chain approach that consolidates lessons learned over the last four decades.

Keywords: Animal source food, intensification, livestock research, smallholder

Contact Address: Thomas Randolph, International Livestock Research Institute (ILRI), PO Box 30709, 00100 Nairobi, Kenya, e-mail: t.randolph@cgiar.org

Healthy Lives: Tackling Food-Borne Diseases and Zoonoses at ILRI

DELIA GRACE[1], KRISTINA ROESEL[2], BERNARD BETT[1], FRED UNGER[3]
[1]*International Livestock Research Institute (ILRI), Kenya*
[2]*International Livestock Research Institute/ Freie Universitaet Berlin, Kenya*
[3]*International Livestock Research Institute (ILRI), Vietnam*

The International Livestock Research Institute (ILRI) was created in the early 1990s, and, like CGIAR crop centres, its major goal was increasing productivity. Animal health was believed to cause about one-fourth of the yield gaps seen in developing countries, but almost all research centreed on just two diseases thought to have greatest impacts on productivity: trypanosomosis and East Coast fever. Human health impacts were explicitly not a priority. By 2000 ILRI began actively to address zoonoses, but only in the context of their threat to intensifying smallholder production. By 2004, human health was an objective in its own right and the first research programme dedicated to zoonoses and food safety at ILRI began in 2011.

During the period of increasing focus on the human health implications of smallholder livestock production, some major research achievements were made, including: the first pro-poor ranking of zoonoses research priorities; reliable assessments of milk safety in Kenya's informal markets; use of participatory disease surveillance methods for avian influenza; applications of risk-based approaches to food safety in informal markets; development of new diagnostic tests for pig tapeworm; a global mapping of poverty and zoonoses; and deployment of a decision-support tool for control of Rift Valley fever.

Evidence generated over the last decade and a half shows the three most important livestock-associated human health problems are food-borne disease, emerging infectious disease, and nutritional problems associated with eating too much or too little animal-source food. Current research on these topics by ILRI and partners extends from upstream projects hunting for viruses and generating vaccines, to the development, marketing and testing of diverse livestock technologies, to piloting practical approaches to disease surveillance and control in resource-scarce environments.

Keywords: Disease surveillance in resource poor environment, food borne diseases, zoonoses

Contact Address: Delia Grace, International Livestock Research Institute (ILRI), Nairobi, Kenya, e-mail: d.grace@cgiar.org

Environmental Sustainability of Livestock Systems – Challenges and Prospects

EVA SCHLECHT

University of Kassel / Georg-August-Universität Göttingen, Animal Husbandry in the Tropics and Subtropics, Germany

Greenhouse gas emissions, eutrophication of water bodies, pathogen contamination of vegetables fertilised with animal dung, and rangeland degradation through overgrazing are only a few of the many environmental threats ensuing from livestock production systems that have been summarised in FAO's report "Livestock's long shadow" published in 2006. Livestock scientists have long before started to investigate such challenges and identified options to substantially reduce or mitigate these. Yet, even if technically feasible strategies are available that, for example, lower methane emissions from rumen fermentation of cereal residues or reduce nitrogen volatilisation and leaching from herbivore manure, their adoption by farmers may be very low if livestock husbandry practices have to be changed substantially in order to establish the proposed improvements. In such cases the monetary and/or non-monetary benefits to be reaped by the extra efforts have to be immediate, tangible, and reproducible in order to assure farmers' adoption; these benefits must be honoured by the market, for example by better pricing of eco-friendly products, or transfer payments via governments or the international community. While in regions or countries with a stringent control system of animal husbandry systems, such as northern America, the EU and Australia the enforcement of adoption of specific husbandry practices through governmental legislation and punishment of non-compliance is common practice, such an approach seems not advisable for most of the resource-poor countries.

By focusing on such countries' smallholder livestock systems and addressing some of the environmental challenges that ensue from these, the range of mitigation options proposed by scientists is critically screened for their technical effectiveness, social acceptability, and economic advantages at the household scale. Since it is clear that any of the available options can mostly address several, but not all problems at once, the priorities to be set and approaches to be selected in a specific case will depend on the agro-ecological and socio-economic as well as institutional setting.

Keywords: Enteric fermentation, gaseous emissions, livestock, manure, nutrient leaching

Contact Address: Eva Schlecht, University of Kassel / Georg-August-Universität Göttingen, Animal Husbandry in the Tropics and Subtropics, Steinstraße 19, 37213 Witzenhausen, Germany, e-mail: tropanimals@uni-kassel.de

Panel Discussion: Ensuring That Livestock Research Translates into Development Outcomes

SHIRLEY TARAWALI
International Livestock Research Institute (ILRI), Directorate, Kenya

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Keywords: Lorem ipsum

Contact Address: Shirley Tarawali, International Livestock Research Institute (ILRI), Directorate, P O Box 30709 00100, Nairobi, Kenya, e-mail: s.tarawali@cgiar.org

Dynamizing Development Processes through Livestock Innovation Systems Research

ANN WATERS-BAYER

ETC Foundation, Prolinnova International Secretariat, Germany

From its beginnings in the 1970s, the International Livestock Centre for Africa (ILCA) – a forerunner of the present-day International Livestock Research Centre (ILRI) – engaged in research designed for impact on development practice. Scientists were encouraged to work on the ground in the midst of livestock production systems – together with farmers, herders and other development actors – as the presenter herself did in central Nigeria with the ILCA Subhumid Research Program. Since that experience, she has worked for the past 25 years with a Netherlands non-governmental organisation focused on strengthening links between research and development – both 'formal' and 'informal' – and retained contact with ILCA, later ILRI, in exploring innovative approaches in this sphere.

A quick overview is given of the evolution from ILCA's 'livestock systems research' in the 1970s and 1980s into ILRI's 'Innovation Works' initiative and the research in and on livestock-related 'innovation platforms'. These involve multiple stakeholders in research and development – including the private sector – in alliances for learning and action. These reflections on the development-oriented approaches of ILCA/ILRI over the decades highlight both the achievements and the challenges. Particular emphasis is given to the social (including gender), economic and institutional aspects of research and development in smallholder mixed farming and pastoral livestock systems. It is shown how livestock innovation systems research – in which relevant technical innovation related to livestock is embedded – can dynamize development processes to improve the livelihoods of rural and urban resource-poor families. Moreover, it is shown how the development impacts of this approach to research can reach far beyond aspects of livestock, crop and forage production and related marketing to include more fundamental transformation in gender relations and community empowerment.

Keywords: Development impacts, livestock innovation system research

Contact Address: Ann Waters-Bayer, ETC Foundation, Prolinnova International Secretariat, Rohnsweg 56, 37085 Göttingen, Germany, e-mail: waters-bayer@web.de

Pastoralism: Animal Health and Food Safety Situation Analysis, Kenya and Tanzania, 2014

JAMES WAKHUNGU[1], DELIA GRACE[1], GEORGE MSALYA[2], FRED UNGER[3], JOMO JESCA[4], SILVIA ALONSO[1]

[1]*International Livestock Research Institute (ILRI), Kenya*
[2]*Sokoine University of Agriculture, Livestock Production, Tanzania*
[3]*International Livestock Research Institute (ILRI), Vietnam*
[4]*Kenyatta University of Agriculture and Technology, Kenya*

Pastoralism is a farming system in societies that derive majority of their food and income from livestock production. This form of farming system is practised in the world's arid and semi arid lands (ASALs). It is estimated that 70 % of the landmass in the Horn of Africa is dry land; in Kenya 80 % of the landmass is classified as ASAL while approximately half of Tanzania consists of dry land. These dry lands can only be effectively utilised when used for livestock rearing, supporting wildlife resource harvesting and tourism.

In this paper we present a current situation analysis of animal health and its implication on food safety based on primary data collected from pastoralists in Kajiado County, Kenya and in Tanga and Morogoro regions in Tanzania. Less than 10 % of pastoralists in these communities engage in crop farming to supplement household income, and with their high dependency on livestock rearing, animal health challenges are a significant problem. We report on the livestock diseases with high prevalence and postulate their effects on food safety and food security in pastoral communities. We also explore the extent of species rearing diversification, pastoralist trade orientation, and practices that may expose the community and their trading partners to animal and zoonotic infections. We also assess access to animal health service providers within these pastoral areas and veterinary drug usage that may have significant implications on animal health and food safety.

Keywords: Animal health, food safety, Kenya, pastoralism, Tanzania

Contact Address: James Wakhungu, International Livestock Research Institute (ILRI), Nairobi, Kenya, e-mail: Jameswakhungu@yahoo.com

Room to Adapt: Enhancing Food Security in East Africa

SILVIA SILVESTRI[1], PATTI KRISTJANSON[2], MARIANA CRISTINA RUFINO[3], SABINE DOUXCHAMPS[4], MAREN RADENY[1], WIEBKE FÖRCH[1], JOASH MANGO[2], IANETTA MUTIE[1], ANTHONY NDUNGU[2], CARLOS QUIROS[1]

[1]*International Livestock Research Institute (ILRI), Kenya*

[2]*World Agroforestry Centre (ICRAF), Kenya*

[3]*Center for International Forestry Research (CIFOR), Kenya*

[4]*International Livestock Research Institute (ILRI), Burkina Faso*

What is the room to adapt? Can we learn from the food secure households? Are there factors that have more control over food security? What are the agricultural options and management strategies that are likely to benefit smallholders? This study aims at giving an answer to these questions by exploring the differences in food security between farmers. In doing so we use a gender lens, targeting female-headed households in particular. This analysis is based on a detailed farm characterisation survey carried on in three sites and 600 households in three countries of East Africa (Kenya, Uganda and Tanzania) across a range of agricultural systems and environments. This unique dataset allows us to explore a wide range of indicators that capture different aspects of household performance and well-being and differences in these measures between households, including food security, activity diversity, market orientation, assets, income, and labour use.

We found that food-secure farmers appear to be the ones that diversify the most, have a variety of crops on their farms, and are engaged in a range of income generating activities. In addition, a different range of covariates explains the food security status of men and female head of household. Yet, different livelihood portfolios are pursued by male and female head of household, with women less likely to grow high-value crops then men and with a less diversified crop portfolio. These findings will inform the targeting of national and regional policies to enhance adaptation in agricultural smallholder systems of East Africa.

Keywords: Adaptation, climate change, crops, food security, livestock, smallholders

Contact Address: Silvia Silvestri, International Livestock Research Institute (ILRI), Old Naivash Road P.O. Box 30709, 00100 Nairobi, Kenya, e-mail: s.silvestri@cgiar.org

Sustainable Intensification: Implications for the Emergence and Maintenance of Zoonotic Diseases

DELIA GRACE[1], BERNARD BETT[1], HUNG NGUYEN[2], FRED UNGER[2], KATE JONES[3]

[1]*International Livestock Research Institute (ILRI), Kenya*

[2]*International Livestock Research Institute (ILRI), Vietnam*

[3]*University College London, United Kingdom*

Currently new human diseases are emerging at the rate of one every four months. Around 20 % of human emerging diseases are caused by antimicrobial resistant pathogens and around 75 % are zoonotic. Diseases are also emerging in livestock, companion animals, wildlife and plants.

A systematic literature review was conducted to synthesize best available scientific knowledge about zoonotic disease transmission through direct or indirect domestic livestock-wildlife interaction, with emphasis on risk factors, drivers and trajectories of transmission, and promising interventions for controlling important zoonoses based on managing livestock-wildlife interaction.The study found complex associations with agricultural intensification and disease emergence:

• Biodiversity, bush meat consumption, expanding ecotones, increases in synanthropoic species, land use change and livestock intensification are commonly cited and inter-related causes of emerging infectious diseases.

• Societies with intensified agriculture bear a much lower burden of human endemic zoonotic disease and globally the burden of human endemic zoonotic disease is decreasing.

• Massive under-reporting constrains our ability to detect endemic and emerging diseases in livestock and wildlife.

• Since the 1930s most disease emergence has been reported from countries with intensive systems.

• In the last ten years, proportionally more emergence events are reported from developing countries.

• Countries most at risk for disease emergence from livestock intensification were India, Myanmar, Pakistan, Bangladesh and China.

Priorities identified for better understanding and managing the risks of agricultural intensification and disease emergence included: targeting hotspots and increasing surveillance in these areas; identification of risk factors and disease drivers in order to mitigate them; generating evidence on the costs of emerging disease and its prevention.

Keywords: Disease emergence. risk factors, sustainable intensification, zoonoses

Contact Address: Delia Grace, International Livestock Research Institute (ILRI), Nairobi, Kenya, e-mail: d.grace@cgiar.org

The Business Case for One Health

DELIA GRACE[1], HUNG NGUYEN[2], JOHANNA LINDAHL[1], FRED UNGER[2], PURVI MEHTA[3]

[1]*International Livestock Research Institute (ILRI), Kenya*

[2]*International Livestock Research Institute (ILRI), Vietnam*

[3]*International Livestock Research Institute (ILRI), India*

One Health is a broad movement that recognises the fact that human, animal and ecosystem health are interdependent and that multidisciplinary collaborations are often necessary in order to attain optimum health solutions. The objective of this study was to outline the business case for One Health in order to promote its continued uptake. We developed a framework for identifying areas where One Health is likely to make a difference and conducted a literature review to estimate the possible additional costs and benefits of using a One Health approach.

We identified five areas where substantial benefits could be obtained by investments in One Health. These were: (1) sharing health resources between the medical and veterinary sectors; (2) controlling zoonoses in animal reservoirs; (3) early detection and response to diseases emerging from animals; (4) prevention of zoonotic pandemics; and (5) generating insights and adding value to health research and development.

Examples are given for each category along with preliminary estimates of the potential savings from adopting the One Health approach. Most benefits can be obtained by controlling zoonoses in animal reservoirs (USD85 billion of benefits for USD21 billion of costs per annum), and the likelihood of obtaining these benefits is high. Next most important is through averting pandemics (USD30 billion of benefits for USD3.4 billion of costs) but the likelihood of obtaining benefits is lower.

The literature reviewed suggests that one dollar invested in One Health can generate five dollars worth of benefits and a global investment of USD25 billion over 10 years could generate benefits worth at least USD125 billion.

Keywords: Benefits, multidisciplinary collaboration, One Health

Contact Address: Delia Grace, International Livestock Research Institute (ILRI), Nairobi, Kenya, e-mail: d.grace@cgiar.org

Aflatoxins: Serious Threats to Food Safety and Food Security. But Is it Related to Livestock?

JOHANNA LINDAHL, JAGGER HARVEY, DELIA GRACE
International Livestock Research Institute (ILRI), Kenya

Globally, crops are being infested with molds. In tropical regions, Aspergillus species commonly occur, some of which produce aflatoxins. Aflatoxins are hepatotoxic, nephrotoxic and carcinogenic to different degrees in livestock as well as humans, causing acute fatal disease as well as chronic illness. Cattle are relatively resistant due to metabolism of toxins in the rumen, while poultry is highly susceptible. Chronic exposure to aflatoxins may cause reduced growth and immunosuppression and is associated with stunting in children and reduced production in livestock. In addition to exposure from crops, metabolites are transferred to breast milk and animal products, especially dairy.

Thus, aflatoxins pose health risks to humans when consumed through crops or animal-source food. The impacts of aflatoxins on animal health have consequences on food production and livelihoods of farmers. However, since some animals are less sensitive than humans, feeding contaminated crops to animals diverts it from humans. Livestock may therefore be considered simultaneously as suffering from the toxins, as a way to utilise contaminated products and save humans, and as a potential risk for humans.

How does the International Livestock Research Institute (ILRI) approach this complex topic?

- Carrying out extensive literature-based reviews and mapping of aflatoxins.
- In collaboration with the International Food Policy Research Institute (IFPRI), a series of 2020 policy briefs by leading experts were released in 2013.
- The Biosciences eastern and central Africa (BecA)-ILRI Hub has established a shared mycotoxin-research platform in Nairobi, Kenya, that is widely used by partners in the region and beyond.
- The BecA-ILRI Hub is working with Kenyan, Tanzanian, other African, Australian and US partners to develop better sampling and diagnostics, develop models and maps of risk and breed, for less susceptible maize varieties.
- Projects assessing health risks and economic costs of aflatoxins in the feed dairy chain are underway in Kenya
- In collaboration with the International Institute of Tropical Agriculture (IITA), technical packages on aflatoxins and livestock for the East Africa region are being prepared.
- Carrying out assessments of the knowledge of, and attitudes to, aflatoxin among milk traders and consumers, and willingness-to-pay for aflatoxin-free milk.

Contact Address: Johanna Lindahl, International Livestock Research Institute (ILRI), Nairobi, Kenya, e-mail: j.lindahl@cgiar.org

• Conducting surveys of aflatoxins in marketed dairy products.
• Assessing aflatoxins in commercial pig feed in Uganda and possible effects on growth.
With this research portfolio, the complex problem of aflatoxins as a threat to animal and human health, and to food production, security and safety, will be better understood.

Keywords: Aflatoxins

Capacity Building on 'Ecohealth' in Southeast Asia — Successes and Challenges

FRED UNGER[1], DELIA GRACE[2], RAINER ASSE[3], KORAPIN TOHTUBTIANG[3], JEFFREY GILBERT[4]

[1]*International Livestock Research Institute (ILRI), Vietnam*
[2]*International Livestock Research Institute (ILRI), Kenya*
[3]*International Livestock Research Institute (ILRI), Thailand*
[4]*International Livestock Research Institute (ILRI), Laos*

To address current challenges related to disease emergences in livestock and humans, new integrated approaches are needed to promote collaboration between involved actors and groups towards more effective control. Southeast Asia is considered a hotspot for diseases emergence as demonstrated with Highly Pathogenic Avian Influenza (HPAI) and Severe Acute Respiratory Syndrome (SARS). Such new approaches include the 'ecohealth' (EH) concept, an approach pioneered over the last decades by the International Development Research Centre, Canada (IDRC).

To promote EH in the region, the International Livestock Research Institute (ILRI) implemented, between 2008 and 2013, a capacity building project (EcoZD) funded by IDRC targeting six Southeast Asia countries. Apart from this, also the added value of EH was evaluated. The overall objective was 'to increase the knowledge, skills and capacity of research and infectious disease control personnel in Southeast Asia to understand the risks and impacts of emerging infectious diseases (EIDs) and how feasible options can best be implemented and adapted' via a 'learning by doing' approach. ILRI's role throughout the project was a mentoring one. The initial step included identifying partners from various disciplines in each country. Research teams were formed and requested to reach an internal consensus of what zoonotic disease(s) they priories for research. Following this, each team developed specific research proposals. Outcome mapping was used to measure aspiration of EH into research. In a subsequent step to address lack of EH capacity on academic level, two ecohealth resource centres were established in universities.

All teams have presented their case studies at international conferences; Writing of publications in local languages and submitting to international peer-reviewed journals is ongoing. In addition, follow-up EH research proposals have been developed and funded for selected teams. Implemented EH case studies provide an excellent reference for other ecohealth initiatives. Challenges throughout the project were various and complex, such as 'loose' definitions of ecohealth, consensus on research topics, language and cultural barriers, silo thinking, lack of qualitative research skills but also on proposal writing, study design and analysis.

Keywords: Capacity building, ecohealth, Southeast Asia

Contact Address: Fred Unger, International Livestock Research Institute (ILRI), 17 A Nguyen Khanh, Hanoi, Vietnam, e-mail: f.unger@cgiar.org

Integrated HPAI Control in Kampong Chicken in Indonesia — An Overview on ILRI's Research and Lessons Learned

FRED UNGER[1], BERNARD BETT[2], ELLY SAWITRI SIREGAR[3], SYAFRISON IDRIS[3], THOMAS RANDOLPH[2]

[1]*International Livestock Research Institute (ILRI), Vietnam*
[2]*International Livestock Research Institute (ILRI), Kenya*
[3]*Directorate General of Livestock and Animal Health Services (DGLAHS), Indonesia*

Highly pathogenic avian influenza (HPAI) caused by H5N1 was first detected in poultry in Indonesia in 2003. HPAI affected all production systems from parent stocks to village (kampong) chickens. The island of Java hosts 60 % of the poultry population of the country. Avian influenza in poultry is considered to be endemic and fatal cases in humans are sporadic since its introduction. In an attempt to support the Indonesian government in making decisions to limit the spread of HPAI while minimising its impact on different socio-economic groups, research by the International Livestock Research Institute (ILRI) has focused on two main areas: (a) village chicken vaccination and (b) risk reduction strategies suitable for pro-poor households with backyard chicken.

The vaccination component, supported by the World Bank, the Indonesian government and the United States Agency for International Development (USAID), used an operational research approach, with the objective to determine the efficacy of backyard mass vaccination by testing alternative regimes under field conditions. The mass vaccination carried out between 2007 and 2009 in 16 districts of Java was supported by targeted studies such as, the value of booster vs. non-booster vaccination, the effect of single dosage (antigen content) vs. double dosage vaccine formulations and a cost-benefit analysis of backyard vaccination. Research on pro-poor HPAI risk reduction strategies, jointly carried out from 2007–2011 with the International Food Policy Research Institute (IFPRI) and supported by the UK Department for International Development (DFID), followed an integrated research design with four main components: disease risk, institutional analysis, livelihood impacts, and synthesis (risk mitigation analysis). Within the components a number of focused studies from epidemiology, to socio-economic and livelihood impacts were implemented focusing on the districts of Bogor and Bogor Kota. Key results indicate the need for an avian influenza booster vaccination with a quarterly re-vaccination schedule due to high population turnovers in kampong chicken. Risk assessment demonstrated the value of an appropriate biosecurity and visitor's control.

Keywords: Control, HPAI, Indonesia, Kampong chicken

Contact Address: Fred Unger, International Livestock Research Institute (ILRI), 17 A Nguyen Khanh, Hanoi, Vietnam, e-mail: f.unger@cgiar.org

Characterising Pig Value Chains in Vietnam (Descriptive Analysis from Survey Data)

NAM HA DUONG[1], THI THU HUYEN NGUYEN[1], NINH XUAN TRUNG[1], TRAN VAN LONG[1], ANH DUC NGUYEN[1], VU KHAC XUAN[1], THI DUONG NGA NGUYEN[1], VAN HUNG PHAM[1], KARL RICH[2], FRED UNGER[3], LUCY LAPAR[3]

[1]*Hanoi University of Agriculture, Dept. of Quantitative Analysis, Vietnam*

[2]*Lab 863, Czech Republic*

[3]*International Livestock Research Institute (ILRI), Vietnam*

The traditional pig sector plays a significant role in Vietnam's economy from production, especially for farmers in rural areas, to consumption (more than 90 % of pork consumed is supplied by conventional wet markets). At the same time, the traditional pig sector is under threat from animal health and food safety risks that impact both its profitability and future viability. However, little research exists on defining key intervention points that could manage risks in a pro-poor, cost-effective manner. Our study highlighted and reviewed the contrast between pig value chains in two provinces (Hung Yen and Nghe An) that represent different levels of economic development in the county. Based on semi-structured questionnaires, 400 pig producing farmers and 400 pork consumers were surveyed in both provinces during July and August 2013, paying particular attention to typologies of production and consumption in rural, semi-urban, and urban zones. We also obtained information on 200 other intermediary value chain actors through semi-structured and in-depth interviews.

Preliminary descriptive analysis revealed the main characteristics of various actors in the sampled value chains, including (vet and feed) input suppliers, producers, traders, slaughterhouses (or abattoirs), processors, retailers, and consumers. In particular, we found that actors in Hung Yen are more likely to be active and commercialised in pig value chains than those in Nghe An. At the same time, Nghe An is exposed to operate its chains more 'self-sufficiently', with own-produced inputs, particularly feeds, and has more state-owned farms involved in breed supply. In both study sites, middlemen often perform multiple functions and are generally the most powerful actors in the surveyed chains since they have better access to information and dominate value-added activities. This may imply a potential control point for risk management in response to diseases transmitted in short-term as well as (pro-poor) profit distribution in longer-term. Moreover, the behaviours of actors in these two provinces are dissimilar in terms of production and consumption practices as a result of differences in production scale, knowledge, attitude and habits. Information from this study will provide more insightful understanding of these existing value chains and serve as the base for further economic and risk analysis.

Keywords: Descriptive analysis, pig value chains, Vietnam

Contact Address: Nam Ha Duong, Hanoi University of Agriculture, Dept. of Quantitative Analysis, Trau Quy, Gia Lam District, Hanoi, Vietnam, e-mail: duongnamha@gmail.com

Participatory Research for Development to Upgrade Smallholder Pig Value Chains in Uganda

EMILY OUMA[1], KRISTINA ROESEL[2], MICHEL DIONE[1], NATALIE CARTER[3,1], DANILO PEZO[1], FRANCIS EJOBI[4], DELIA GRACE[5]

[1] *International Livestock Research Institute (ILRI), Animal Sciences for Sustainable Productivity, Uganda*
[2] *International Livestock Research Institute/ Freie Universitaet Berlin, Kenya*
[3] *University of Guelph, Dept. of Population Medicine, Ontario Veterinary College, Canada*
[4] *Makerere University, Uganda*
[5] *International Livestock Research Institute (ILRI), Kenya*

Our vision is to improve the livelihoods of smallholder pig value chain actors in Uganda by showcasing how existing livestock value chains can be upgraded for the benefit of all actors in the system, especially the many poor. Very little has been documented about how pig value chains operate in Uganda, except that pork consumption has exploded over the past three decades and is foremost in sub-Sahara Africa today. Who are the actors in the current system? What are the input and output channels? Who benefits and who bears economic and health risks? Which problems do the various actors face, how do they deal with them and can these problems provide opportunities?

In a multi-disciplinary and overarching gender-disaggregated approach and with the help of numerous local partners we conducted an initial scoping of different pig value chain systems through participatory rural appraisals with 1,400 farmers and interviews with more than 300 key informants. This was followed by in-depth questionnaire surveys with 1,200 households and more than 300 other value chain actors. Screening of more than 1,000 pigs and pork at different nodes of the value chain for pathogens aimed to complete the assessment.

Eighty per cent of the pigs are kept by smallholder farmers and piggery is a primary income generator, especially in peri-urban areas. We found that most of the constraints are related to lack of knowledge and prerequisites: pig keeping is not a traditional livestock activity in Uganda, and farmers do not have a sound understanding of good husbandry practices and have poor access to advisory services about the components for pig breeding, feeding and health management. Entrepreneurs venturing into the market at all stages of the value chain lack the necessary experience and equipment. The value chain is highly fragmented and underutilised. Interventions will focus on capacity development of the various value chain actors in conjunction with piloting of technical and institutional related interventions on select aspects that mainly target women, who bear 60 % of the workload involved in piggery, and the youth who are involved in the post-production nodes of the value chain.

Keywords: Gender, pigs, poverty alleviation, smallholders, Uganda, value chains

Contact Address: Emily Ouma, International Livestock Research Institute (ILRI), Animal Sciences for Sustainable Productivity, P.O. Box 24384 , Kampala, Uganda, e-mail: E.A.Ouma@cgiar.org

Competitive Smallholder Livestock in Botswana: Results of a Livestock Value Chain Survey in Central District

SIRAK BAHTA[1], DEREK BAKER[2], BAITSI PODISI[3], MAROBELA ORWELL[4]

[1]*International Livestock Research Institute (ILRI), Botswana*
[2]*University of New England, School of Business, Economics and Public Policy, Australia*
[3]*Center for the Coordination of Agricultural Research and Development in Southern Africa, Botswana*
[4]*Dept. of Agricultural Research, Botswana*

Livestock production in Botswana is usually subdivided into commercial (fenced grazing areas) and traditional (communally grazed areas focused on borehole-centred cattle posts) farming. More than 80 % of all cattle reared in Botswana (about 2.1 million heads) are bred in the traditional system. Although the smallholder or traditional farming system primarily involves cattle, it is likely that an even greater share of the country's small stock (sheep and goats) is also run in the traditional system.

Despite the aforementioned advantage, the smallholder livestock sector faces a big challenge in exploiting the growing national and regional demand for meat, as well as preferential access to the EU market. The incentives for value addition in pursuit of these markets appear to be limited. There is also limited evidence of innovation in the value chain, particularly for small stock. An observed result is that imported small stock meat is frequently seen on retail shelves around the country.

To identify, understand and utilise the potential benefit for value addition and poverty reduction in Botswana's livestock sector, the study explores the existing value chains in which livestock products are produced and traded. Producers, butchers, retailers, input suppliers and consumers from Central District were brought together for a workshop and individuals surveyed to assess the country's markets and interaction of value chain actors, the roles of key players, and the critical constraints that limit the growth and competitiveness of smallholder livestock production system. The survey results, among others, are:

• Producers' demographic makeup in the Central District is presented as: predominantly male and with little education; some two thirds under the age of 60; and some 90 % are operating on unfenced land.

• Producers' market channel choices are influenced by lack of information and dysfunctional implementation of Livestock Identifications (LITS).

• Marketing is little guided by quality and consumer demand, with even retailers being poorly informed about consumer demand.

• Profitability of smallholder production is markedly different across scales of smallholder operation. However, this is not a simple relationship and is likely to be related to intensification as well as size.

Keywords: Botswana, competitiveness, livestock, smallholder, value chain

Contact Address: Sirak Bahta, International Livestock Research Institute (ILRI), Private Bag 0033, Gaborone, Botswana, e-mail: s.bahta@cgiar.org

Uncovering the Potential of Maize Value Chain in Northwest Vietnam: Implications for Research and Development

AZIZ KARIMOV[1], JO CADILHON[2]

[1]*International Livestock Research Institute (ILRI), Vietnam*
[2]*International Livestock Research Institute (ILRI), Kenya*

Numerous studies on agrifood value chains in Vietnam have proposed several interventions and policies. However, recent input and output price alterations, increasing impact of climate change, continuing environmental degradation, and increasing poverty in rural areas warrant renewed and deeper investigations of the Vietnamese agrifood value chains.
This study carries out an assessment of the maize value chain and of the linkages in the agrifood sector of Sơn La Province of Vietnam. Sơn La province has the largest concentration of maize production in the country. Maize is a vital source of feed for the rapidly booming livestock industry in Vietnam. It plays an important role in the livelihood of farmers, especially the poor and ethnic minorities. Key to relevant value chain diagnostics in fragile upland areas is a good overview of the economic benefits that drive actors' behaviour along the chain and better understanding of relationships between farmers, market and consumers.
The maize value chain assessment study used the two first steps of the LINK methodology. The preliminary analysis shows that maize is often utilised within the boundaries of farm households and part of the harvest is traded within the commune or district through collectors to animal producers and feed mills. Value chain mapping indicates that the higher maize productivity and trade in Sơn La is strongly related to the province's animal production development. The study of business models used by chain actors shows the economic benefit to farmers of using collectors as market intermediaries: collectors pay for transport from remote farmgates to market and buy all the maize available. In the context of rapidly increasing demand for feed, interventions should target increasing actors' efficiency in the maize value chain and improving trade linkages in each part of the chain taking into account other elements of the agrifood system. Findings also recommend developing an improved seed sector and effective extension delivery system, which would further enhance income, lessen poverty and improve livelihoods of farming households.

Keywords: Maize, value chain, Vietnam

Contact Address: Aziz Karimov, International Livestock Research Institute (ILRI), Hanoi, Vietnam, e-mail: az.karimov@cgiar.org

Integrated Assessment of Human and Animal Waste

HUNG NGUYEN[1], PHUC PHAM DUC[2], LE THU[2]

[1]*International Livestock Research Institute (ILRI), Vietnam*

[2]*Hanoi School of Public Health, Vietnam*

We developed a conceptual framework for improving health and environmental sanitation using an approach combining health, ecological, socio-economic assessments. The framework has three main components: health status, physical environment, and socio-economic environment. Information on each of these three components can be obtained using standard disciplinary methods and an innovative combination of these methods. In this way, analyses lead to extended characterisation of health, ecological and social risks while allowing the comprehensive identification of critical control points. Interventions deriving from the comprehensive analysis consider biomedical, engineering and social science perspectives or a combination of them. Moreover, interventions encompass not only technical solutions but also behavioural and social changes, which are derived from the identified resilience patterns. The framework is conceptualised and validated for the context of urban and peri-urban settings in developing countries focusing on waste, such as excreta, wastewater, and solid waste, their influence on food quality, and their related pathogens, nutrients and chemical pollutants.

We have applied this framework for integrated human and animal waste assessment in Vietnam. We conducted a combined assessment of the impact of human excreta and animal manure reuse in agriculture on health, environment and society to propose sustainable and adapted interventions for improving health and environmental sanitation. Thus, health impact was assessed by microbial risk analyses. Environmental impact was assessed for sanitation and agriculture systems focusing on nutrient flows. Perception and behaviour on health risk and ability of people to prevent health risk caused was evaluated. Results from this case study and insights on proposed intervention will be presented.

Keywords: Agriculture intensification, environmental sanitation, health risk and impact, integrated approach, urban, waste management

Contact Address: Hung Nguyen, International Livestock Research Institute (ILRI), Hanoi, Vietnam, e-mail: h.nguyen@cgiar.org

The Known and the Unknowns: A Multipathogen Survey to Identify Diseases in Cattle Herds in Tanzania

SILVIA ALONSO[1], PHIL TOYE[1], JOERG JORES[1], JAMES WAKHUNGU[1], GEORGE MSALYA[2], DELIA GRACE[1], FRED UNGER[3]

[1]*International Livestock Research Institute (ILRI), Kenya*

[2]*Sokoine University of Agriculture, Livestock Production, Tanzania*

[3]*International Livestock Research Institute (ILRI), Vietnam*

Livestock farmers in Africa are facing enormous challenges in animal health. The capacity and infrastructure of government services for disease identification and control are often limited. In the absence of systematic surveillance systems for animal diseases, the information on pathogens affecting livestock has been filled by targeted surveys conducted in certain locations and for specific conditions. The picture provided by these ad hoc surveys can be distorted with a bias towards the most widely known diseases or towards those for which diagnostic methods are more readily available.

Participatory rural appraisals with cattle farmers in Tanzania revealed that disease in livestock is one of the main factors contributing to limited productivity and income generation. Often, the causes of livestock disease are unknown and differential diagnosis is not conducted resulting in mistreatment of animals and long-term negative economic impact. In response to this concern, a multipathogen survey was conducted among cattle farmers in two regions in Tanzania to (i) confirm the presence of well-known cattle pathogens, and (ii) investigate the presence of cattle pathogens rarely looked for in the area before. Sick cattle (n=400) were actively searched among cattle herds and blood samples collected along with information on farming practices. ELISA diagnostic kits were used to detect antibodies against the following cattle pathogens: contagious bovine pleuropneumonia (CBPP), anaplasmosis, theileriosis (x2), babesiosis, brucellosis, Rift Valley fever, Q fever, neospora, infectious bovine rhinotracheitis, bovine viral diarrhea (BVR) and bovine respiratory syncytial virus (BRSV).

The results of the survey will be presented. The relative presence of each of the studied pathogens will be presented and the characteristics of the farming populations and factors that may be associated with the relative presence discussed. Finally we will discuss the implications of farming management practices on the presence/absence of certain pathogens.

Keywords: Cattle, multipathogens, Tanzania

Contact Address: Silvia Alonso, International Livestock Research Institute (ILRI), ILRI Campus Old Naivasha Road, 00100 Nairobi, Kenya, e-mail: s.alonso@cgiar.org

Humidtropics Strategic Research Theme 1: System Analysis and Global Synthesis activity 1.1 — Situational Analysis

JO CADILHON[1], AZIZ KARIMOV[2]

[1]*International Livestock Research Institute (ILRI), Kenya*

[2]*International Livestock Research Institute (ILRI), Vietnam*

The CGIAR Research Program on Humidtropics aims to help poor farm families in tropical Africa, Asia and Americas to boost their income from integrated agricultural systems' intensification while preserving their land for future generations. The situational analysis is one of the first research activities implemented in the field within Humidtropics. The objective of the situational analysis is to provide a broad set of information that will inform future agricultural research for development (R4D) activities in the next phases of the Program. Also, because the Program aims to work in a consultative manner through partners in all aspects of its work, the situational analysis also strives to support the process of establishing strong and sustained linkages with stakeholders at multiple levels.

Given the context above, there are two primary objectives for the situational analysis:

1. Broadly characterise all the important aspects of relevance to the Program within the target action sites, and through that, generate information to inform all other Program activities in the context of attaining the Program's intermediate development objectives, as well as to inform ongoing field site selection.
2. Initiate and facilitate engagement with stakeholders and partners as part of the R4D platform development that is needed for the long-term success and scalability of the Program.

A Humidtropics situational analysis is based on a literature review of existing research or development reports, and on the collection and analysis of secondary data and statistics on the different aspects of the production, marketing and natural resources management systems to identify their constraints. Preliminary results are validated for local relevance through focus group discussions and key information interviews, which also help complement the analysis from the literature review and secondary data with a local stakeholder perspective so as to draw a complete picture of the current situation.

Keywords: Humidtropics, situational analysis

Contact Address: Jo Cadilhon, International Livestock Research Institute (ILRI), Nairobi, Kenya, e-mail: j.cadilhon@cgiar.org

Planting the Orchard: ILVAC – An ILRI Livestock Vaccine Initiative

VISH NENE

International Livestock Research Institute (ILRI), Vaccine Biosciences Group, Kenya

High mortality and morbidity rates due to livestock diseases are an impediment to the livelihoods of smallholder farmers who struggle to attain nutritional and economic security. Vaccines are among the most successful medical and veterinary disease interventions known. The easy vaccines, the 'low-hanging fruit' have by and large been made. To crack the 'difficult-to-make' vaccines we need to invest in planting an orchard of basic 'vaccinology' research, take advantage of paradigm shifts that are occurring in biosciences and harvest from a deeper understanding of diseases and the processes that protect against them. Unfortunately, livestock vaccine research often lacks a critical mass of researchers and is insufficiently funded, contributing to the dearth of vaccines accessible to smallholder farmers in developing countries.

We propose to take advantage of rapid advances in biosciences and vaccine development, and new quantitative laboratory tools that make comparisons among vaccine studies feasible, to expand the livestock vaccine pipeline and produce a new generation of vaccines. High-priority disease targets include the major livestock diseases African swine fever (ASF), contagious bovine pleuropneumonia (CBPP), East Coast fever (ECF), peste des petits ruminants (PPR) and zoonotic diseases, which are transmitted between livestock and people such as Rift Valley fever (RVF).

The vaccine initiative provides a rare opportunity to unite high-quality basic laboratory facilities with highly relevant fieldwork with access to a diverse range of pathogens and exotic and indigenous livestock species. The initiative also proposes to facilitate strategic collaborations between partners engaged in human and livestock vaccine research, providing synergies and links that have been missing in the past. Two main public good outputs will accrue from the vaccine initiative: candidate vaccines for livestock diseases of high priority to smallholder farmers and increased knowledge in the field of vaccinology. Towards these goals, the vaccine initiative will encompass research in the pathway from discovery to delivery.

Keywords: Africa, livestock diseases, vaccines

Contact Address: Vish Nene, International Livestock Research Institute (ILRI), Vaccine Biosciences Group, Nairobi, Kenya, e-mail: v.nene@cgiar.org

Forage Diversity: An Essential Resource to Support Forage Development

JEAN HANSON

International Livestock Research Institute (ILRI), Forage Diversity, Ethiopia

Poor-quality feed, fluctuating feed supplies and seasonal feed shortages are the major constraints to increasing livestock productivity in many tropical countries. Forage diversity is an essential resource for the selection and breeding of superior forages for use in smallholder farming to alleviate these constraints. Forages have a key role in natural resource management through positive effects on soil fertility and carbon sequestration for improving system resilience and sustainable land management in crop-livestock systems.

The collection maintained at the International Livestock Research Institute (ILRI) includes about 19,000 accessions of forages from over 1400 species of forage grasses, legumes, fodder trees and shrubs as a global public good, held in trust under the International Treaty on Plant Genetic Resources for Food and Agriculture. This is one of the most diverse global collections of forages and includes the world's major collection of African grasses and tropical highland forages.

The forage diversity activities in ILRI focus on three areas:

Save: Seeds of most accessions are stored at low seed moisture contents in laminated aluminum foil packets at 8°C for medium-term storage and at -20°C for long-term storage at the genebank, while grasses that rarely produce seeds or whose seeds are short-lived are maintained in field genebanks. These seeds are also safety duplicated at the International Center for Tropical Agriculture (CIAT) in Colombia and at the Svalbard Global Seed Vault in Norway.

Study: The forage resources are characterised for suitability as livestock feed and evaluated for systems adaptation. This involves assessing phenotypic traits, yield, disease and drought tolerance in the field and linking with genomic and nutritional studies in the laboratory.

Use: ILRI distributes about 1,000 samples of germplasm globally each year for evaluation, forage development and use. Two accessions of Napier grass with resistance to smut disease from the ILRI in trust collection are already being used in Kenya and other accessions have been identified as tolerant to Napier grass stunt disease.

In order to promote use and adoption of forages, ILRI is a partner in the development of on-line knowledge tools and information sheets and is supporting capacity development efforts in forage diversity.

Keywords: Forage development, forage diversity

Contact Address: Jean Hanson, International Livestock Research Institute (ILRI), Forage Diversity, Addis Ababa, Ethiopia, e-mail: ilribox03@cgiar.org

Improving Greenhouse Gas Emission Estimates from Livestock Production in Smallholder Farming Systems

David Pelster[1], Klaus Butterbach-Bahl[2,1], Mariana Cristina Rufino[3], Todd Rosenstock[4]

[1]*International Livestock Research Institute (ILRI), Livestock, Systems and Environment, Kenya*

[2]*Karlsruhe Institute of Technology, Institute for Meteorology and Climate Research, Atmospheric Environmental Research, Germany*

[3]*Center for International Forestry Research (CIFOR), Kenya*

[4]*World Agroforestry Centre (ICRAF), Climate Change and Land Health Decisions, Kenya*

Agriculture in Kenya is a key economic sector, contributing 24 % to the GDP and 70 % to the creation employment. Approximately 60 % of the agriculture sector is comprised of small-scale farms that are often highly heterogenous in cropping, fertiliser, livestock, and manure management strategies. We know that management strategies alter methane, nitrous oxide and carbon dioxide (greenhouse gases — GHG) rates and patterns from large farming systems, however how these affect GHG emissions from smallholder systems is still unknown. Landscape position, soil characteristics, and general land classification may also affect soil GHG emission rates.

Here, we present our systems approach to characterise land-use and livestock production and show how different management strategies and systems affect GHG emission rates. We measured CO_2, CH_4 and N_2O flux rates from soils at 60 different farms in western Kenya using static chambers for nine months. Farms (plots) were selected based on a combination of geographical location (highlands, lowlands and mid-slopes), management strategy (low, moderate and high management effort), vegetation type (annual crops, perennial crops and grazing land) and land classification derived from remote sensing. Auxiliary data including soil inorganic N concentration (0–5 cm), crop type (including seeding and harvest date), soil C stores down to 1 m depth were also collected. The *in situ* monitoring was supplemented with incubations of intact soil cores (0–5 cm depth) at 5 different water-holding capacities to try to estimate emission potentials. Preliminary results indicate that *in situ* emissions and emission potentials differed by geographical location, management and land classification.

Keywords: Agricultural soils, manure management, nitrous oxide

Contact Address: David Pelster, International Livestock Research Institute (ILRI), Livestock, Systems and Environment, Nairobi, Kenya, e-mail: dpelster@cgiar.org

More Meat, Milk and Fish by and for the Poor: Solution-Driven Research with Development

THOMAS RANDOLPH

International Livestock Research Institute (ILRI), Kenya

Meat, milk and fish are critical to poor people as food and income and provide critical inputs in people's diets, especially those who are malnourished. The vision of the CGIAR Research Program on Livestock and Fish is for the health, livelihoods and future prospects of the poor and vulnerable, especially women and children, to be transformed through consumption of adequate amounts of meat, milk and fish, and through benefits from improved incomes and livelihood by participating in the associated animal source food value chains. The programme seeks to achieve this by increasing the productivity of small-scale livestock and fish production systems and improving the performance of their associated value chains.

Four key elements are employed in the program's 'solution-driven research with development' approach. These are, a whole value chain approach; a focus on a few selected livestock and fish value chains with potential for pro-poor transformation to demonstrate impact; working with development partners to use research to design integrated interventions for taking to scale; basic and adaptive research on animal nutrition, genetics, animal health, gender and learning, and targeting for sustainable interventions, prioritised by the needs of the target value chain. Research is based around nine value chains in nine countries in Africa, Asia and Central America.

Key results include progress in contributing to new technologies and improved practices such as, release of new tilapia strains widely used in Asia, distribution of East Coast fever vaccines in the sub-Saharan Africa dairy value chains and proof-of-concept in breeding of tropical pasture grass that can significantly suppress greenhouse-gas emissions.

The Livestock and Fish programme is led by the International Livestock Research Institute (ILRI). CGIAR partners are WorldFish, the International Center for Tropical Agriculture (IITA) and the International Center for Research in the Dry Areas (ICARDA).

Keywords: Agricultural research for development, animal-source foods, aquaculture, livestock, value chains

Contact Address: Thomas Randolph, International Livestock Research Institute (ILRI), PO Box 30709, 00100 Nairobi, Kenya, e-mail: t.randolph@cgiar.org

Managing the Health Risks Associated with Agriculture: An Overview of Research by the International Livestock Research Institute

TEZIRA A. LORE, DELIA GRACE
International Livestock Research Institute (ILRI), Kenya

Over 60 % of the newly identified infectious diseases that have affected people over the past few decades have been caused by pathogens originating from animals or animal products. In agricultural areas that use more water, people face increased risk of infectious diseases, especially through zoonotic diseases (diseases transmissible from animals to people) as well as water-borne and vector-borne diseases.
The CGIAR Research Program on Agriculture for Nutrition and Health (A4NH) carries out research to maximise the nutritional and health benefits of agricultural development. The programme has four research themes: value chains, biofortification, control of agriculture-associated diseases, and integrated programs and policies.
The International Livestock Research Institute (ILRI) leads the research theme on the prevention and control of agriculture-associated diseases. This research theme generates evidence on the prevalence, dynamics and burdens of agriculture-associated diseases by developing and testing the tools and approaches needed to better manage such diseases. Key areas of focus of this theme are:
• Food safety: participatory risk assessment in milk and meat value chains in informal markets as well as risk and economic assessment of aflatoxins.
• Neglected zoonoses: epidemiology, ecology and socio-economics of disease emergence in urban areas.
• Emerging infectious diseases: mapping the risk of vector-borne diseases; determining the drivers of disease emergence and transmission; and modelling of disease transmission to improve decision-making towards preventing and controlling diseases.
The research outputs will be used by value chain actors, policymakers, development programme implementers, and governments to improve animal-source food value chains and prevent and control infectious diseases. Ultimately, this will lead to improved nutrition and health, especially among women and children.

Keywords: Human health

Contact Address: Tezira A. Lore, International Livestock Research Institute (ILRI), Nairobi, Kenya, e-mail: t.lore@cgiar.org

The Feeding Component in Rural and Peri-Urban Smallholder Pig Systems in Uganda

DANILO PEZO[1], EMILY OUMA[1], MICHEL DIONE[1], BEN LUKUYU[2], NATALIE CARTER[3,1], KRISTINA ROESEL[4]

[1]*International Livestock Research Institute (ILRI), Animal Sciences for Sustainable Productivity, Uganda*

[2]*International Livestock Research Institute (ILRI), Kenya*

[3]*University of Guelph, Dept. of Population Medicine, Ontario Veterinary College, Canada*

[4]*International Livestock Research Institute/ Freie Universitaet Berlin, Kenya*

In the last 30 years, Uganda has had a massive growth in pig population, from 190,000 in the late 90's to 3.2 million pigs in 2008, and currently has the highest per capita consumption of pork in East Africa (3.4 kg year). The majority of Uganda's pig farmers are smallholders (1.2 million households raise pigs), practicing low input/ low output systems. In the three districts of Kamuli, Masaka and Mukono, where the study was carried out, results of focus group discussions conducted in 35 villages showed that regardless of the setting, whether rural or peri-urban, the smallholder pig production systems are typical crop-livestock system, with high dependence on crop residues, i.e. sweet potato vines, cassava leaves, yam leaves, and *Amaranth* spp. for pig feeding. However, the relative contribution of those crop residues is strongly affected by rainfall seasonality, which in turn influences crop production. The bulk ($>95\,\%$) of crop residues used for feeding pigs is produced on farm. Trading of crop residues is minimal hence comprising only $<2\,\%$ hence they can be obtained from farms for free. Women and children are mostly responsible for pig feeding and management, as well as for collecting crop residues for pigs (85.8 and 78.6 % of farms in rural and peri-urban settings, respectively). Kitchen leftovers, including banana peelings, provide 18–20 % of the total ration, whereas forages (i.e., Napier grass) represented 20–28 %, and compounded feeds (commercial and home-mixed) 25–27 %, with maize bran as the main ingredient. The main feeding constraints identified by farmers are: dry season fodder shortages (crop residues and forages); risk of parasite infestation through forages, either grazed or cut and carried. In the case of concentrates, constraints include high cost of commercial feeds, price fluctuation of feed ingredients, and poor quality of purchased feeds. There is a need for enhancing knowledge on feeding strategies and fodder conservation among farmers, but also on proper feed formulation for farmers and feed stockists. The implementation of quality control of feeds available in the market is urgently needed.

Keywords: Concentrates, crop residues, forages, gender, kitchen leftovers, pigs

Contact Address: Danilo Pezo, International Livestock Research Institute (ILRI), Animal Sciences for Sustainable Productivity, c/o Bioversity International, Plot 106 Katalima Road, Nakagwa, Kampala, Uganda, e-mail: d.pezo@cgiar.org

Gender Research at ILRI: An Overview of Developments in the Last Decade

ALESSANDRA GALIÈ[1], ISABELLE BALTENWECK[1], SHEILA ONZERE[1], DORINE ODONGO[1], IMMACULATE OMONDI[1], JEMIMAH NJUKI[2]

[1]*International Livestock Research Institute (ILRI), Kenya*

[2]*International Development Research Centre (IDRC), Kenya*

The poster presents an overview of milestones in the development and integration of gender research at the International Livestock Research Institute (ILRI) in the last decade. It outlines the steps undertaken by ILRI to move from a lack of gender capacity in 2002 towards the first gender efforts in 2005 when a gender audit was commissioned. Between 2006 and 2009, a gender task force was created to develop a research agenda on women and livestock issues, and between 2009 and 2011, more consistent efforts were undertaken to grow the capacity of the gender team and gender research by hiring gender scientists and focusing on resource mobilisation for gender specific research.

In the last few years, CGIAR's introduction of Research Programs (CRPs) has entailed a stronger support for engaging in integrating gender in ILRI's livestock work and also conducting gender strategic research. Gender strategies have been prepared with detailed research plans, dedicated budgets and personnel. In addition, research efforts across the CRPs and CGIAR centres have been undertaken to raise the profile of gender evidence in agricultural research for development to a global level. The poster highlights challenges encountered and effective efforts that are currently underway to further develop and implement these strategies. Ultimately, the presented poster shows the critical role gender research plays as a driver to achieving ILRI's goal of improving food security and reducing poverty in developing countries through research for better and more sustainable use of livestock.

Keywords: Gender resarch, gender strategy

Contact Address: Alessandra Galiè, International Livestock Research Institute (ILRI), Nairobi, Kenya, e-mail: a.galie@cgiar.org

Animal breeding and husbandry II

Natural resources management

Forest management and agroforestry

The Roles of Agroforestry System and Coffee Certificate in Improving Farmers' Economic and Environmental Benefits in Sumatra, Indonesia

BUSTANUL ARIFIN[1], KATSUYA TANAKA[2], RYOHEI KADA[3], HANUNG ISMONO[1]
[1]*University of Lampung (UNILA), Agricultural Economics, Indonesia*
[2]*Shiga University, Research Center for Sustainability and Environment, Japan*
[3]*Research Institute for Humanity and Nature (RIHN), Environmental Risks, Japan*

This study examines the roles of coffee agroforestry system and coffee certificates in improving farmers' economic and environmental benefits in Upper Sekampung Watershed in the Province of Lampung, Sumatra-Indonesia. Way Sekampung is the main watershed and major food basket and is therefore important for agricultural exports of the province. This watershed covers an area of 484 thousand hectare, of which 49 percent is degraded land, 34 percent has the potential to degrade and only 17 percent of non-degraded land. The rate of soil erosion in the watershed is probably the highest in the country, averaging 67.5 ton per hectare per year, far higher than the tolerable rate of 25 ton per hectare per year.

The study applies quasi-experimental impact evaluation method using a propensity score matching (PSM) technique by analysing 408 farm households practicing agroforestry systems and coffee certificates in two subdistricts of Pulau Panggung and Pugung in Tanggamus Districts of Lampung. PSM constructs a statistical comparison group by modelling the probability of participating (known as propensity score) in the programme on the basis of observed characteristics unaffected by the program. The PSM technique basically compares farm adopters of coffee agroforestry system, i.e. 216 famers (53 %) who have grown 100 shade trees per hectare and multi-purpose tree species (MPTS) and adopting coffee certification and control group of 92 farmers (47 %) that grow less than 100 MPTS and/or not apply shade trees. About 203 households have joined coffee certification (mostly Rainforest Alliance and 4C certificates) and the rest are in the process of adoption. The impact evaluation shows that both agroforestry systems and coffee certificates have positive significant impacts on improving economic benefits. Coffee agroforestry systems have positive significant impacts on improving environmental benefits, but coffee certificates have non-significant impacts for environmental benefits. The study calls for a more structured and comprehensive action-research and development activities that facilitate the reward transfers for environmental services generated from coffee agroforestry systems in the watershed.

Keywords: Coffee agroforestry system, impact evaluation, Indonesia, Sumatra

Contact Address: Bustanul Arifin, University of Lampung (UNILA), Agricultural Economics, Jl. Sumanri Brojonegro No.1, 15225 Bandar Lampung, Indonesia, e-mail: barifin@uwalumni.com

Can Science Contribute to Smallholder Management of Complex Systems? Lessons from Agroecological Intensification of Multi-Strata Coffee with Banana

CHARLES STAVER[1], PABLO SILES[2], OSCAR BUSTAMANTE[3], NELSON CASTELLON[4], CARLOS CERDAN[5], HILDEGARD GARMING[6], JÜRGEN BURKHARDT[7]

[1]*Bioversity International, France*
[2]*CIAT, Nicaragua*
[3]*Universidad Nacional Agraria, Nicaragua*
[4]*private consultant, Nicaragua*
[5]*Xalapa Universidad Veracruzana, Fac. de Ciencias Agrícolas, Mexico*
[6]*Thünen Institute of Farm Economics, Germany*
[7]*University of Bonn, Inst. Crop Sci. and Res. Conserv. (INRES), Germany*

Banana intercropped in multi-strata coffee agroforestry, a technology developed by farmers, offers multiple livelihood benefits – a monthly income, a shade component easy to establish and manage, and food security. More than a million smallholder households associate bananas in their coffee fields, in spite of countervailing technical recommendations. Between 2009–2013, with financing from GIZ, scientists and groups of farmer experimenters in seven zones of Honduras, Nicaragua, Costa Rica and Peru collaborated to develop approaches to improve the productivity and value of banana as part of the agroecological intensification of their shaded coffee. Growers and scientists diagnosed the structure and function of the tree-bananas-coffee association, providing the basis for a work agenda which was implemented over three experimentation cycles. Five agroecosystem-based decision tools to intensification resulted – optimisation of light resource partitioning among trees, banana and coffee; macronutrient input-output analysis, including nitrogen contribution of leguminous trees; banana bunch, stem and mat management; landscape, farm and plot management of *Fusarium* wilt to reduce impact on Gros Michel, the preferred market banana; and strategies for increased banana prices and margins. The process of prototype development bringing together seven grower groups, advanced institute and local banana and coffee scientists and German and Latin American students was analysed to identify lessons for the contribution of science to farm household management of the complex field and farm coffee agroforestry-based agroecosystem. First, iterative, adaptive learning approaches should focus on first-generation prototypes which guide improved decision making while also building capacity for the ongoing generation of more dynamic, improved prototypes. Second, complementary frameworks drawn from agroecosystems, gender- and generational-based livelihoods, and small business should be integrated into the experimentation process. Third, analysis should

Contact Address: Charles Staver, Bioversity International, Parc Scientifique Agropolis II, 34397 Montpellier, France, e-mail: c.staver@cgiar.org

be grounded in linkages between farm decision-making and neighbouring farms, the local territory and the institutional and innovation system. Fourth, stakeholder participatory processes should be enriched with results of formal studies, conceptual and quantitative model building and visioning exercises. Finally, complexity should be addressed through scenario building under variable and uncertain futures resulting from different combinations of climate change, prices for commodities, energy and inputs and investments in social capital, governance and innovation.

Keywords: Agroecological intensification, banana, coffee agroforestry, complex systems, participatory experimentation

Struggle Over the Diminishing Teak Forest of Java: The People, the State and the Forest

WIENE ANDRIYANA, KARL HOGL

University of Natural Resources and Life Sciences (BOKU), Institute of Forest Environmental and Natural Resource Policy (INFER), Austria

In Indonesia, for more than 30 years the authority over state owned teak forests on Java Island has been granted to State Forest Corporation amid the fact that the state forests are surrounded by communities highly dependent on forest land for their livelihood. Therefore the struggle over teak forest utilisation between communities and the state has long been documented with different patterns and intensities. This research analyses the extent and the causal pathways along which the practices of teak forest management in Java have undergone changes after reformation era. The research design builds on extensive review of policy and written documents and two major phases of fieldwork in two selected districts in Central Java. The expert interview was used to explore four dimensions of Policy Arrangement Approach (actors, rules, power and discourses) in the Collaborative Forest Management Programme (CFMP), which is seen as the only existing mechanism for the community to access the state owned teak forest. This study reveals that although actors hold different perceptions concerning the programme, there have been changes in the power-relation structure between the State Forest Corporation and communities through the new mode of CFMP. Interestingly, many of the actual changes are taking place through more informal mechanisms rather than formal ones. The study shows that informal rules and power of the community may overrule the formal ones of the state, and the reformation era had a role as trigger and stimulant to that situation. In conclusion, this research shows that amid general view of the 'status quo' situation of Java's forest management after reformation era, institutional changes have actually taken place and have had an impact on the day-to-day teak forest management practices.

Keywords: Collaborative forest management, forest community, institution, Java, policy arrangement approach

Contact Address: Wiene Andriyana, University of Natural Resources and Applied Life Sciences, Institute of Forest Environmental and Natural Resource Policy (INFER), Hutweidengasse 46/1/16, 1190 Vienna, Austria, e-mail: wiene.andriyana@gmail.com

The Impact of Forest Degradation: Recovery of Carbon Stocks and Tree-Species Diversity under Forest Conservation

FRANZISKA SCHIER, STEPHAN A. PIETSCH

University of Natural Resources and Life Sciences (BOKU), Forest- and Soil Sciences, Austria

It is evident that forest degradation affects the diversity and structure of the Congo Basin rainforests. Yet actual carbon and biodiversity implications of forest degradation are less well known than those of deforestation. Biodiversity plays an important role in climate regulation as it potentially influences forest biomass production and thus determines the forests' capacity for carbon sequestration. Particularly with regard to REDD+ as an opportunity to support forest conservation through climate change mitigation funding, robust information on the effects of degradation on the carbon storage capacity and the forest restoration potential after disturbances is fundamental. Against this backdrop, this study examines the impact of repeated selective timber harvesting, the dominant driver of forest degradation in the Congo-Basin forest, on key forest properties as well as on forest structure and tree-species diversity. It further highlights the regeneration potential of an exploitation forest under protection. Thus, this study makes an important contribution to increase knowledge on the long-term implications of forest degradation in the Congo Basin. The study analysis is based on forest data recorded in 1993 and 2011. Additional information on mature rainforests serves as benchmark for assessing the state of the forest. Data analysis proves the ongoing forest recovery. After 40 years of natural regeneration, stem counts, basal area, forest biomass and carbon stocks approximate those of mature forests in the region. Signs of selective logging persist in the horizontal and vertical forest structure. In addition, repeated exploitations had led to a decline in forest diversity. Resource overuse and local extermination of certain animal and plant species impedes the natural tree species recovery. However, the results suggest that in the present case declining biodiversity has no long-term effects on the biomass carbon stocks. Since most of the carbon in tropical forests is stored in the stems, increasing timber volume due to proceeding forest maturation directly results in carbon benefits. On account of this, the study concludes that under proper forest management the restoration of essential ecosystem functions and services (e.g. biomass production and carbon storage) comparable to primary levels is possible.

Keywords: Biodiversity, forest carbon stocks, forest conservation, forest degradation, forest restoration, REDD+

Contact Address: Franziska Schier, University of Natural Resources and Life Sciences (BOKU), Forest- and Soil Sciences, Vienna, Austria, e-mail: franziska.schier@students.boku.ac.at

Moving Window-Based Topographic Normalisation for Landsat 8 Imagery in Mountainous Forest

DENGKUI MO, HANS FUCHS, LUTZ FEHRMANN, HAIJUN YANG, CHRISTOPH KLEINN

Georg-August-Universität Göttingen, Chair of Forest Inventory and Remote Sensing, Germany

The launch of Landsat 8 maintains and enhances a continuous environmental-monitoring record. With the free policy of data distribution, Landsat 8 imagery becomes the most important public data source and will be used in wider fields by scientists around the world. As a global scale monitoring data, spectral distortion mainly caused by the terrain models and solar illumination geometry needs to be studied and corrected.
Topographic normalisation models have been widely studied for optical satellite imagery to correct for differences in illumination condition (IC). These approaches aim at adjusting the spectral reflectance for a given land cover class as a function of topographic and illumination characteristics such that image classification is facilitated – and more accurate. Various topographic normalisation models were introduced, where most of the wavelength dependent models (such as C-correction, Minnaert and Rotation-correction model) outperform the wavelength independent ones. For wavelength dependent models, the quality of topographic normalisation depends on the quality of the DEM and global parameter estimation methods tend to overcorrection.
This study focuses on development and evaluation of a moving window-based rotation-correction topographic normalisation model. We tested the algorithm with newest Landsat 8 imagery in Lin4Carbon project study area, a highly forested region in Shitai County, Anhui Province, China, which is characterised by a rough terrain with very steep slopes. We used the ASTER Global Digital Elevation Model Version 2 (ASTER GDEM V2) for the correction algorithm, because its spatial resolution is close to that of Landsat 8 optical bands. Visual comparison and statistical analysis showed that the local moving window-based rotation-correction method applied had a better performance at a range of window sizes compared to uncorrected data or applied global correction methods. The heterogeneity of spectral signatures inside each land cover class could notably be reduced which is probably also due to the fact that a site specific parameterisation was used. The performance did not vary notably with window size in the selected range. The parameter estimation for Topographic Normalisation using moving window is simple and straightforward so that this technique may be a suitable option as a standard pre-processing step for Landsat imagery.

Keywords: ASTER GDEM, empirical parameter estimation, Landsat 8, moving window, rotation-correction model, topographic normalisation

Contact Address: Dengkui Mo, Georg-August-Universität Göttingen, Chair of Forest Inventory and Remote Sensing, Büsgenweg 5, 37077 Göttingen, Germany, e-mail: dmo@gwdg.de

Sustainable Intensification in Cocoa Agroforests

WILMA BLASER[1], EDWARD YEBOAH[2], JOHAN SIX[1]

[1]*ETH Zurich, Dept. of Environmental System Science, Switzerland*

[2]*Soil Research Institute, Council for Scientific and Industrial Research, Ghana*

The inclusion of trees in cocoa agroecosystems has great potential to improve ecosystem functioning and maximise long-term crop production. The benefits trees can provide may not only be dependent on absolute shade cover but also on particular traits (*e.g.* nitrogen fixing capacity, deep rooting, fruit production) of the trees included in cocoa agroforests. Despite these potential positive effects of trees, agricultural intensification has traditionally led to the reduction of tree cover in many agroforestry systems worldwide. While this provides farmers with short term positive effects on overall crop production, the removal of trees may lead to negative long term effects on yields, resilience to climate change, and ecosystem service delivery. Trade offs between short- and long-term beneficial effects of the inclusion or removal of trees - and trees with specific traits in particular - of agroforests are still poorly understood. To fill some of these knowledge gaps, we investigated how the inclusion of trees affects cocoa production systems in Ghana, one of the worlds leading cocoa producers. More specifically, we quantified the links between cocoa yields, soil functions (*e.g.* stability, soil C stabilisation, nutrient retention), ecosystem services (water and nutrient provision) and vegetation structure (cover and traits of shade trees) along tree cover gradients of cocoa based agroforests. We present first results of the effects of agroforests differing in shade cover and tree trait combinations on cocoa yields, cocoa nutritional status, soil carbon, nitrogen and phosphorus, nitrogen and phosphorus availability, exchangeable cations, soil aggregation, water holding capacity, and infiltration; and estimated resulting nutrient and water use efficiencies. Our results yield a better preliminary understanding of the short- and long-term beneficial effects of the inclusion or removal of trees in cocoa agroforets.

Keywords: Agroforestry, carbon sequestration, ecosystem services, intensification, soil degradation, soil restoration, sustainability, *Theobroma cacao*

Contact Address: Wilma Blaser, ETH Zurich, Dept. of Environmental System Science, Tannenstrasse 1, 8092 Zurich, Switzerland, e-mail: wilma.blaser@usys.ethz.ch

Challenges Towards Sustainable Cocoa Production in Indonesia

ASTARI WIDYA DHARMA[1], SOVIANA[2]

[1] *University of Kassel, Fac. of Organic Agricultural Sciences, Germany*

[2] *Justus-Liebig University Giessen, Institute of Farm and Agribusiness Management, Germany*

In order to fulfil the global demand of cocoa in 2020, there is a need to increase cocoa production by 100–120 thousand tons each year. Indonesia is the third largest cocoa producer in the world, after Ivory Coast and Ghana. Since 1970, cocoa sector in Indonesia has indicated a steady progression and showed a big potential to take the lead in cocoa production. Nearly 90 % of cocoa producers in Indonesia are smallholders, while 8 % is public plantation and only 5 % is private estates. The annual average income of Indonesian cocoa farmers is only about 650 €. Some general challenges faced by cocoa farmers have been researched, but finding an effective solution to sustain the cocoa production is still a big challenge.

Despite the general knowledge about the challenges known so far, the authors are motivated to have a closer look and a deeper examination particularly on the Indonesian cocoa production by means of case study method. The objectives of this paper are (1) to have a better understanding of the challenges in the cocoa production in Indonesia (in Sulawesi and Kalimantan Islands) and (2) to identify potential alternative solutions to tackle the challenges.

The study has identified several challenges such as low farmers‘ empowerment, ecological degradation, weak marketing power, and poor infrastructure. Accordingly, some alternative solutions have suggested, including both technical and organisational measures. Some examples of technical solutions are improving the cultivation technique, as well as providing training on handling pest and disease. Furthermore, since most cocoa farmers in Indonesia are small farmers, a potential organisational solution is the establishment of producer organisations for collective production and marketing. Besides, a strong and transparent supply chain plays an important role to motivate the farmers to improve their product's quality.

Keywords: Cocoa production, Indonesia, producer organisation, sustainability

Contact Address: Soviana, Justus-Liebig University Giessen, Institute of Farm and Agribusiness Management, Senckenbergstrasse 3, 35390 Giessen, Germany, e-mail: s.soviana@yahoo.com

Cocoa in Full-sun Monocultures vs. Shaded Agroforestry Systems under Conventional and Organic Management in Bolivia

MONIKA SCHNEIDER[1], CHRISTIAN ANDRES[1], GERMÁN TRUJILLO[2], FREDDY ALCON[2], PATRICIA AMURRIO[3], RENATE SEIDEL[3], FRANCO WEIBEL[4], JOACHIM MILZ[2]

[1]*Research Institute of Organic Agriculture (FiBL), Dept. of International Cooperation, Switzerland*

[2]*ECOTOP, Consulting on Successional Agroforestry, Bolivia*

[3]*University Mayor San Andres, Inst. of Ecology, Bolivia*

[4]*Research Institute of Organic Agriculture (FiBL), Horticultural Science, Switzerland*

Cocoa is a crucial export commodity for many developing countries and provides income for millions of smallholders. However, cocoa cultivation has resulted in habitat destruction, biodiversity loss and soil degradation. While much of the world's cocoa is produced in arguably unsustainable full-sun monoculture systems, shaded agroforestry systems may be an alternative for sustainable cocoa production. However, data-based information on advantages and limitations of different cocoa production systems are limited and pairwise comparisons on the long-term performance of cocoa monocultures and agroforestry systems under conventional and organic management are literally inexistent. The Research Institute of Organic Agriculture (FiBL) is pioneering to fill this knowledge gap with a unique long-term field trial in tropical Bolivia. The trial was established in 2008 and consists of six systems: two monocultures (MONO CONV/ORG) and two agroforestry systems (AF CONV/ORG) under conventional and organic management, one successional agroforestry system (SAFS, organic only) with dynamic shade management, and a fallow system of the same age serving as a reference for biodiversity and soil fertility studies. The systems aim to represent current smallholder cocoa farmers' practices. Parameters such as the tree development, yield of cocoa and by-crops, incidences of pests and diseases, soil fertility, carbon stocks, nutrient balances, economic data and biodiversity are regularly assessed. Five years after planting, results showed significantly shorter tree circumference (18 % and 33 %) in AF systems and SAFS, respectively, compared to MONO systems. Tree circumference correlated strongly with cocoa dry bean yield which was, as expected, highest in MONO CONV (603 kg ha^{-1}). By-crops such as plantain, cassava, pineapple, etc. were harvested in AF systems and SAFS, which may compensate for lower cocoa yields in the first years. Future research will investigate cocoa performance after the establishment phase and thus provide indications on the long-term sustainability of the different systems.

Keywords: Cocoa, long-term experiment, smallholders, systems comparison

Contact Address: Monika Schneider, Research Institute of Organic Agriculture (FiBL), Dept. of International Cooperation, Ackerstrasse, 5070 Frick, Switzerland, e-mail: monika.schneider@fibl.org

Transition to Agroforestry in the Mid-Hills of Nepal: Implications for Livelihoods and Environment

Niels Schwab[1,6], Eva Wieners[1], Alina Schick[2,6], Nina Kiese[3,6], Vera Kremer[4], Kristina Roth[5], Peter Borchardt[1,6], Udo Schickhoff[6,1]

[1]*University of Hamburg, CEN Center for Earth System Research and Sustainability, Inst. of Geography, Germany*

[2]*University of Hohenheim, Inst. for Social Sciences in Agriculture, Germany*

[3]*Karlsruhe Inst. of Technology, Inst. for Geography and Geoecology, Germany*

[4]*University of Bonn, Fac. of Agriculture, Germany*

[5]*University of Erlangen-Nürnberg, Inst. of Geography, Germany*

[6]*Kaule e.V., Organisation for Socially Sustainable Agro-Projects, Germany*

Agroforestry, the purposeful cultivation of trees and crops in interacting combinations, is receiving increasing attention as a sustainable land management option. In Nepal, where farming systems are still largely conventional, further extension of agroforestry practices is needed to counteract unsustainable agricultural intensification. Farmers are increasingly encouraged to adopt agroforestry farming systems. Kaule e.V., a Nepalese-German NGO for socially sustainable agro-projects, initiates and supports the transition to agroforestry practices in Kaule village, Nuwakot District. In addition, Kaule e.V. conducts concomitant scientific studies aiming at analysing the transition process from social and natural sciences' perspectives. A detailed actor and social network analysis, embedded in the methodologies of transition management and backcasting, revealed a profoundly differentiated disposition of local farmers to adopt more resilient and sustainable lifestyles and income generation in the long term. After the adoption of agroforestry practices, soil quality and soil productivity has been significantly ameliorated, with positive effects appearing shortly after the conversion from conventional monocropping systems. Significant differences in soil pH, exchangeable aluminium content, base saturation, electric conductivity, organic matter and nitrogen content, and cation exchange capacity indicate more favourable soil properties and more fertile soil conditions in agroforestry soils. Field experiments showed that fallow legumes have the potential to restore degraded terrace soils by biomass accumulation and nitrogen fixation. Species richness and diversity of trees, shrubs and herbs is significantly higher in agroforestry systems. Categories of alpha and beta diversity show distinctly higher levels only two years after transition. Results of a market evaluation and survey indicate a high potential of income generation by organic cash crop cultivation (kiwi fruit, cardamom, asparagus) within agroforestry systems. In conclusion, the adoption of agroforestry practices contributes to natural resource and socio-economic sustainability by meeting subsistence requirements, increasing land productivity, providing other ecosystem goods and services, and improving economic conditions and livelihood security of households.

Keywords: Agroforestry practices, income generation, social network analysis, soil fertility, species diversity, sustainability

Contact Address: Udo Schickhoff, University of Hamburg, CEN Center for Earth System Research and Sustainability, Institute of Geography, Bundesstraße 55, 20146 Hamburg, Germany, e-mail: schickhoff@geowiss.uni-hamburg.de

Certified Carbon Small-Scale Agroforestry around Mount Kenya Region: Determinants of Adoption by Smallholder Farmers

EMMANUEL BENJAMIN[1], MATTHIAS BLUM[2]

[1]*Bergische University of Wuppertal (BUW), Macroeconomic Theory and Politics, Germany*

[2]*Technische Universität München (TUM), Agriculture and Food Economics, Germany*

Sub-Saharan Africa remains one of the most vulnerable regions to climate change threating agriculture, food security and income of smallholders. The contribution of climate mitigation strategies such as certified small-scale agroforestry projects and corresponding payment for ecosystem services (PES) may therefore be crucial for smallholders. What role does awareness play in facilitating adoption of this innovation amongst smallholders? As economic and non-monetary factors influence smallholder's adoption decision of such projects. Is participation therefore restricted to a selected group of small farmers? This analysis explores the objectives of smallholder conservation programs which, amongst others, seek to alleviate poverty while preserving the environment.

This paper uses a random utility model and a probit/logit regression to investigate the factor that influences agroforestry adoption. We investigate non-monetary factors, amongst others information spillover, that influence the decision to adopt conservation. We collected data in a non-government run agroforestry mitigation program with PES from the Mount Kenya region. A total of 210 smallholder farmers were interviewed, approximately half of the farmers participated in small-scale agroforestry with PES and the other half were non-participating conventional smallholder farmers. Participation by smallholders is not influenced by education, land and asset endowment rather by spread of information and peer involvement in such programs. Non-government project developers and relevant institutions may have developed an operation model which precludes selection bias in programme participation.

Formulation of climate mitigation policies for developing countries should target social capital to increase the adoption rate amongst smallholders, deploying a bottom-up strategy which encourages inclusiveness.

Keywords: Climate smart agriculture, household decision-making, payment for ecosystem services, small-scale agroforestry adoption, social capital

Contact Address: Emmanuel Benjamin, Bergische University of Wuppertal (BUW), Macroeconomic Theory and Politics, Gaußstr. 20, D-42119 Wuppertal, Germany, e-mail: 910614@uni-wuppertal.de

Influence of Biophysical and Socio-Economic Factors on Fruit Tree Diversity in Machakos County, Eastern Kenya

KEN NJOGU, STEPHA MCMULLIN, PARVEEN ANJARWALLA, ROELAND KINDT, KATJA KEHLENBECK

World Agroforestry Centre (ICRAF), Tree Diversity, Domestication and Delivery, Kenya

Growing fruit trees on smallholder farms can contribute a lot to income generation and nutrition security for the farming households. Fruit tree species richness and diversity, however, are influenced by many biophysical and socio-economic factors. Programs aiming at promoting cultivation and consumption of fruits need to understand and consider these factors. To identify influencing factors and their complex interactions, a baseline survey of 300 randomly selected households was performed in four agro-ecological zones in Machakos County, eastern Kenya. Households were selected from three strata/groups; one group exposed to a programme promoting fruit cultivation ('FRUIT'), one group exposed to a hygiene programme ('WASH') and one other group not exposed to any programme ('Control'). Interviews were performed to gather basic socio-economic data and information on the fruit species and tree individual numbers per farm. Statistical analyses included U- and H-tests, correlation and regression analyses.

A total of 56 different fruit tree species were mentioned in the surveyed farms, including 30 indigenous fruit species (54%). Out of the total of 20,457 fruit tree individuals mentioned, only 10% were of indigenous species. The most frequently mentioned fruit tree species were *Mangifera indica*, *Carica papaya* and *Persea americana*, occurring on 96, 65 and 54% of the farms, respectively. Median number of fruit species and individuals per farm were six and 32, respectively. Respondents in the two surveyed lower midland agro-ecological zones mentioned significantly more indigenous fruit tree species and individuals on their farms (1 species and 2 individuals per farm, respectively) than those in the two upper midland zones (0 and 0; $p < 0.000$). Respondents being members of the 'FRUIT' or the 'WASH' groups mentioned less fruit tree species (medians 5 and 5 per farm, respectively) and individuals (medians 23 and 35 per farm, respectively) than the 'CONTROL' group respondents (7 and 43; $p < 0.000$ and $p = 0.002$, respectively). Household poverty index, farm size, age of household head and distance to the nearest market were among the factors influencing fruit tree species richness and abundance variables. This study will contribute to develop better programs that enhance wealth and health of smallholder farmer families by improving fruit production and consumption, particularly of the largely underutilised indigenous fruit tree species.

Keywords: Food and nutrition security, indigenous fruit trees, regression

Contact Address: Katja Kehlenbeck, World Agroforestry Centre (ICRAF), Tree Diversity, Domestication and Delivery, United Nations Avenue, 00100 Nairobi, Kenya, e-mail: k.kehlenbeck@cgiar.org

Agroforestry Practices in Kyrgyzstan

KLARA DZHAKYPBEKOVA, HORST WEYERHAEUSER

Aga Khan Foundation, University of Central Asia, Mountain Societies Research Center, Kyrgyzstan

Accepted as a new term for old practices, agroforestry became very popular in many countries, being a source of additional income, higher yields, combating poverty and ensuring food security. The environmental role of agroforestry also should not be underestimated, since it plays a significant role in conservation of soil, carbon fixation and decreasing pressure on natural forests. The given research aimed to analyse existing research and determine and practical value possibilities of agroforestry in Kyrgyzstan.

Trees play an important role in agriculture being a source of fruits, timber, protecting yields as wind breaks, maintaining biodiversity, accumulating water in soil, protecting slopes from run-off, sourcing local communities by non-timber products, and being an aesthetic asset. It should also be mentioned, that there are number of practices demonstrating the role of trees in rehabilitating arid, salinized or water-logged land (degraded lands), enabling such plots for agricultural use. Unstable fodder production in Kyrgyzstan has led to the degradation of pastures, the main source for livestock sector. Arable lands are limited (12 % of total land area is classified as agricultural), with a high risk of slope ersion and an increasing area of degraded land. All this make Kyrgyzstan a region were all kinds of agroforestry systems could be applied.

The poster will cover the issues described above providing figures and tables to support the use of agroforestry in the country and its potential from socio-economic and environmental points of view.

Keywords: Agroforestry, environment protection, food security, Kyrgyzstan, land degradation

Contact Address: Klara Dzhakypbekova, Aga Khan Foundation, University of Central Asia, Mountain Societies Research Center, Arstanbap 171, 720082 Bishkek, Kyrgyzstan, e-mail: klara.dzhakypbekova@ucentralasia.org

The Vegetation Structure and Effect of Crown Shade to Microclimatic Conditions of Coffee Plantation in Villa Rica, Peru

LENKA EHRENBERGEROVÁ[1], JAN TROCHTA[2], HANA HABROVÁ[1]

[1]*Mendel University in Brno, Dept. of Forest Botany, Dendrology and Geobiocoenology, Czech Republic*

[2]*The Silva Tarouca Research Inst. for Landscape and Ornamental Gardening, Dept. of Forest Ecology, Czech Republic*

Coffee is one of the most important crops cultivated in South America. The aim of this paper is to evaluate a vegetation structure and to assess effect of crown shade on microclimatic conditions of a coffee plantation. The research is placed at a coffee plantation named Ave Fénix (8.35 ha) located at an altitude of 1550 m a.s.l. near the town of Villa Rica, Pasco region, Peru. Microclimatic parameters such as air humidity, air and soil temperature were measured for three years (from January 2011 to January 2014) and a full census of all trees with a crown projection was carried out in 2011.
The amount of shade is expressed by la ow frequency moving filter (side 10 m). The resultant map of shade was divided into quartiles and the first one (with less than 25 % of shade) was selected as an area without shading (0.98 ha) and a shaded area ($>$ 25 % of shade; 7.37 ha).
The tree vegetation structure on the shaded area is composed mainly of *Inga* spp. (63.8 t ha^{-1}) followed by *Acrocarpus fraxinifolius* (9.8 t ha^{-1}) and *Pinus* spp. (7.2 t ha^{-1}). The density of coffee shrubs in the shaded area is 6,833 shrubs ha^{-1} and 5,327 shrubs ha^{-1} in the non-shaded area. The microclimatic conditions in shaded and non-shaded areas are different. The shaded area temperature is less affected by direct sunlight and thus temperature of air and soil is lower than in the non-shaded area. On the other side, higher humidity was observed in places without shade. The results bring better insight into agroforestry systems and deeper understanding of the role of shading.

Keywords: Agroforestry, coffee plantations, microclimate, Peru, tree crown cover

Contact Address: Lenka Ehrenbergerová, Mendel University in Brno, Dept. of Forest Botany, Dendrology and Geobiocoenology, Zemedelská 3, 613 00 Brno, Czech Republic, e-mail: nenidoma@seznam.cz

The Distances Rural People Travel to Collect Forest Foods from Timber Trees in Cameroon

PAULUS MAUKONEN, PAULINE DONN, LAURA SNOOK
Bioversity International, Forest Genetic Resources, Cameroon

A quarter of the 169 million hectares of Congo Basin lowland dense forest have been allocated to logging concessions. Over 80 tree species are commercially felled for timber in Cameroon, and 1.2 m cubic meters of timber are consumed annually on informal domestic markets in Central African cities. However, 61 % of timber species in the Congo Basin also bear locally used non-timber forest products (NTFP). Amongst these are the fruits of *Baillonella toxisperma* and edible caterpillars hosted by *Entandrophragma cylindricum* and *Erythrophleum suaveolens*. A participatory inventory of these species was conducted around two villages adjacent to each of two logging concessions in Cameroon to map trees of these species from which local men and women gather food resources on one-day collection trips. The distance from villages to trees was measured to determine the spatial overlap between NTFP collection and logging concessions.

The distance between the villages and the trees varies by village, gender of the collector and the tree species, ranging 390 m-6.2 km, with 95 % of the trees located within a range of 5 km. Only 10 % of these trees fall within concession boundaries, but multi-day trips take place to collect these resources further within logging concessions, and the overlap of concession boundaries with a 5 km 'resource shed' ranges from 22 ha to 3777 ha, and could have an impact on the one-day collection distance. Although collection of these resources was generally not found to be a gender-specific activity, 10 % of the trees were collected from by men at 4.1–6.2 km and by women at a distance of under 3km as a result of the spatial spread of other gendered activities. Using a 2.8 km (average) collection radius from the village to represent a resource shed for 4111 mapped villages in the forests of Cameroon, an area of over 10 m ha of forest is required to safeguard forest-dependent livelihoods, and 495000 ha of this will overlap with logging concession boundaries. Currently under 2 m ha have been designated as community or communal forests, and this gap should be addressed using participatory mapping in order to improve forest resource access and tenure through stakeholder dialogue and local geospatial knowledge.

Keywords: Cameroon, collection distance, logging concessions, non-timber forest products, rural communities

Contact Address: Paulus Maukonen, Bioversity International, Forest Genetic Resources, c/o CIFOR IITA Campus Nkolbisson, P.O. Box 2008 Messa Yaounde, Cameroon, e-mail: p.maukonen@cgiar.org

Acacia seyal var. *seyal*: A Multipurpose Tree Species for Rural Development, Hunger and Poverty Alleviation in Sudan

HANADI MOHAMED SHAWGI GAMAL[1,2], CLAUS-THOMAS BUES[2]

[1] *University of Khartoum, Dept. of Forest Products and Industries, Sudan*

[2] *Technische Universität Dresden, Institute of Forest Utilisation and Forest Technology, Germany*

Acacia seyal var. *seyal* is considered as one of the most widely distributed tree species in Sudan; nevertheless rural populations are not benefiting much from its wood. *Acacia seyal*'s uses concentrate in charcoal, firewood and fuel wood due to the lack of information on its wood properties. Despite the richness of Sudan in most of basic factors required to establish forest based industries it still depend almost entirely on imports to satisfy its needs for pulp and paper, fiberboard,. . .etc . There is an urgent need to evaluate the available locally raw materials as potential sources for forest based industries. This would not only reduce imports, but it would also promote rural development, alleviate poverty and improve livelihoods of local communities.

The present study was carried out to investigate the wood properties of *Acacia seyal* var. *seyal* and assess its suitability for pulp, paper and flooring industries. Wood materials were collected from different zones in Sudan and anatomical, mechanical and physical properties investigated. The results indicated the suitability of the investigated tree species for pulp, paper and flooring industries. As *Acacia seyal* var. *seyal* is widely distributed it can easily be propagated on large areas in Sudan. This could enhance the establishment of wood industry in rural areas and enhance rural development.

Keywords: *Acacia seyal* var. *seyal*, forests based industries, rural development

Contact Address: Hanadi Mohamed Shawgi Gamal, University of Khartoum, Dept. of Forest Products and Industries, Khartoum, Sudan, e-mail: hanadishawgi1979@yahoo.com

Analysis of Biomass Production of Tamarind Trees and their Role in Local Communities of South-Western Madagascar

TAHIRY RANAIVOSON[1], BAKOLIMALALA RAKOUTH[1], ANDREAS BUERKERT[2], KATJA BRINKMANN[2]

[1] *University of Antananarivo, Dept. of Biology and Plant Ecology, Madagascar*

[2] *University of Kassel, Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, Germany*

The tamarind (*Tamarindus indica* L.) is a multipurpose tree in many countries of Asia, Africa and South America. On the Mahafaly Plateau of south-western Madagascar, tamarind is one of the most important species used for charcoal production and its overuse during the past years threatens the natural stock and regeneration. For nature conservation and land management planning, information on the traditional use of this species, the species distribution, biomass and regeneration potential is needed.

Semi structured interviews (n=61) were conducted in several villages of the study region to obtain information about the traditional and actual utilisation of tamarind trees. During field surveys, the diameter at breast height (dbh), height, exploitable wood volume and stem biomass were measured for already logged tamarind trees (n= 22). Additionally, standing tamarinds trees (n = 513) were inventoried in four villages within a 16 km^2 sample area and the dbh, height and GPS locations were measured. Using high resolution Pléiades satellite images from 2012 and Google Earth satellite images from 2004 the crown area of all tamarind trees was identified and calculated. Based on regression analysis the relationships between dbh, crown surface, wood volume and biomass were calculated.

Tamarind trees are used mainly for charcoal production (wood), but also as food (fruit) and medicinal plant (leaves) and for traditional ceremonies (sacred tamarind). There is a high correlation between wood volume, stem biomass and dbh. Regression analysis revealed high coefficients of determination for the relationship of crown area and dbh (r^2= 0.72) and crown area and stem biomass (r^2= 0.71). Altogether, 0.07–0.43 tamarind trees ha^{-1} were observed, but young trees were scarce. From 2004 to 2012, many tamarind trees were logged resulting in 10–25 % stem biomass losses. Charcoal production activities and a low regeneration rate are major threats for stands of tamarind trees on the Mahafaly Plateau.

Keywords: Mahafaly Plateau, stem biomass, *Tamarindus indica*

Contact Address: Katja Brinkmann, University of Kassel, Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, Steinstraße 19, 37213 Witzenhausen, Germany, e-mail: tropcrops@uni-kassel.de

Integrated Crop-Livestock-Forestry Systems: A Brazilian Experience for Sustainable Farming

DAVI JOSE BUNGENSTAB[1], ROBERTO G. ALMEIDA[1], HORST JÜRGEN SCHWARTZ[2]

[1]*EMBRAPA Beef Cattle, Integrated Production Systems, Brazil*

[2]*Humboldt-Universität zu Berlin, Department of Livestock Ecology, Germany*

Agroforestry, silvo-pastoralism, and agro-silvo-pastoralism are seen and promoted as means to increase food production while simultaneously providing valuable ecosystem services. It is claimed that such systems halt and even revert widespread land degradation, improve and diversify the range of farm products, and safeguard local and regional biodiversity. Brazil in its turn has pioneered some important agricultural technologies in the world, as the no-tillage system, which allows two harvests a year in many parts of the country. Intending to contribute with information regarding such integrated systems, a publication was produced by the Brazilian Agricultural Research Corporation – Embrapa. Titled "Integrated Crop-Livestock-Forestry Systems" it is a richly illustrated, 282 page book, with 20 chapters involving many scientists from different institutions, approaching the major themes related to the subject, addressing technologies available and their potential for further improvement and expansion. Brazilian integrated systems are somehow unique in the way they operate, especially regarding component's rotation time and investments payback capability. They have been showing to be a great alternative for soils recuperation/improvement in transition areas not apt for regular cash crops, but too expensive for simple extensive cattle systems. One of the important features is to provide revenues diversification, thus helping to stabilise farmer's finances.

The Brazilian model, using *Brachiaria* or *Panicum* grasses, soybeans and maize as crops and eucalyptus as tree component can run a full cycle in periods as short as four years. Besides soil improvement, annual crops and cattle sales provide constant cash flow to the farm, while timber brings high financial returns at the end of the cycle, i.e. allowing future investments with farmer's own funds. The Brazilian integrated systems are still under development in several aspects and substantial research has been carried out to study the behaviour of the different components when integrated. However, they can be considered mature enough to be presented and tested as an alternative for sustainable farming in other areas especially of Latin America and in sub-Saharan Africa.

Keywords: Crop-livestock-forestry, revenue diversification, soil improvement

Contact Address: Horst Jürgen Schwartz, Humboldt-Universität zu Berlin, Department of Livestock Ecology, Asternplatz 2a, 1220ß Berlin, Germany, e-mail: schwartzhj@gmail.com

The Rationales, Knowledge Forms and Biophysical Outcomes of Community Forest Management in Nepal's Mid-Hills

YEMI ADEYEYE

University of Copenhagen, Food and Resource Economics, Denmark

The use of local knowledge has been widely reported in natural resources management in many indigenous communities around the world. In Nepal, studies have indicated similar occurrence. The application of local forest related knowledge in forest management as oppose to the adoption of community forest management operational plans, which was a legal tool, with which a particular forest management authority is transferred to a particular community forest user group (CFUG). Despite the suggestions in recent literature that these local knowledge application lead to forest conservation outcomes, the rationale behind the adoption of these local knowledge as well as the biophysical outcomes of the community forest management is still unclear. Using a case study approach, the following questions are being explored in four CFUGs: Which characteristics the forest related knowledge held and used by the communities in community forest management? What are the differences between the actual management practices adopted by the local people and the technical content of their OP? Have the observable temporal effects on tree crown cover of the de facto management been expected and intended by the CFUGs? Multidisciplinary approach that combines qualitative and quantitative research methods was used. Data were collected through semi structured interviews, focus group discussions, household questionnaire survey and field observations. Preliminary results show that the communities are fully aware of some technical inadequacies in the operational plan, which translated into non-implementation of the plan. Results also indicate that communities are fully aware of their environment and its history, as a result, local forest-related knowledge which has been developed over time was resorted to in management paradigm, which in turn suggests that the observed change in forest cover was intended by the communities, as demanded by the topographical difference and community needs in the study area. This study intends to contribute to the general understanding of 'why people do what they do' in terms of community forest management. Forest policy professionals and sociologist could use the result in enhancing effective integration of local knowledge with scientific knowledge to promote locally meaningful and bio-physically sustainable natural resources management.

Keywords: Community forest management, community forest management operational plan, community forest user groups, local forest-related knowledge

Contact Address: Yemi Adeyeye, University of Copenhagen, Food and Resource Economics, Rolighedsvej 25, 2100 Copenhagen, Denmark, e-mail: yemi.ifsa@gmail.com

Influencing Factors on Forest Utilisation under Participatory Forest Management Regimes in Nepal

JUTTA LAX, MARGRET KÖTHKE

Johann Heinrich von Thünen Institute, Inst. of International Forestry and Forest Economics, Germany

Despite the crucial role of agriculture in developing countries for the provision of food assets, communities in rural settings are still heavily dependent on forest products. This dependency on forest resources is often argued to be the main driver for small scale deforestation and forest degradation. This study investigates the needs and behaviour of those households who are on the one side affected by forest loss and degradation and are on the other side impacting the resource themselves. It analyses the drivers determining the forest utilisation intensity of rural households organised in participatory forest user groups. Additionally, it is tested whether the forest dependency hypothesis holds true and which role poverty and the availability of product and income substitutes play for the forest use intensity.

The study is based on data collected by a survey of 358 households organised in 8 participatory forest user groups in the Chitwan district in southern Nepal. The survey data covers internal and external household related variables from all five livelihood capitals (*i.e.*, natural, human, physical, financial and social capital).

Our results reveal that the remote households, which have the greatest access to the forest resource combined with the lowest access to alternatives, show the greatest forest utilisation intensity. They are driven by external influences (natural and social capital). The availability of direct forest product substitutes, either from subsistence production (physical capital) or achievable by sale (financial capital) has proven to be the most influential on the overall forest product collection and on the fuel wood collection. This proves the existence of a resource dependency due to a lack of alternatives. Fodder collection is driven by livestock demand and labour allocation (human capital).

Poverty, expressed by total household income (direct and in kind), does not play a significant impact on the forest utilisation intensity. In the considered low income setting of the tested household sample, forest dependency is enhanced by limited access to income and product alternatives not necessarily by plain poverty of the household.

Keywords: Community forestry, forest dependency, regression analysis, rural livelihood strategies, subsistence

Contact Address: Margret Köthke, Johann Heinrich von Thünen Institute, Institute of International Forestry and Forest Economics, Leuschnerstr. 91, 21031 Hamburg, Germany, e-mail: margret.koethke@ti.bund.de

The Role of Forests in Combating Rural Poverty in Nepal: Panel Data Evidence on Asset Accumulation from Four Villages

SOLOMON ZENA WALELIGN, MARTIN REINHARDT NIELSEN, HELLE OVERGAARD LARSEN

University of Copenhagen, Department of Food and Resource Economics, Denmark

Forest resource use contributes substantially to rural households' livelihood strategies and forest income often serves to reduce income inequality in the developing world. It is, however, still debated whether forest income constitutes a pathway out of poverty. In this paper, we examine the contribution of forest income to household asset accumulation, as a measure of poverty reduction, in four locations in Nepal. Using unique Poverty Environment Network (PEN) environmentally augmented panel data reflecting households' annual cash and subsistence income portfolios, we model change in the value of five selected assets that accumulate over time and the value of which could be quantified. To accommodate efficiency concerns in relation to modelling each asset type separately, we employed a systems model approach — i.e. Seemingly Unrelated Regression (SUR). Results indicate that although forest resources on average contribute 16 % of the total household income, there is no significant relation between forest income and change in cash savings or the value invested in land, livestock, implements and jewelry from 2006 to 2009. Increase in asset values were instead explained by other income sources, i.e. agricultural, wage and business income. Most forest income was furthermore obtained as subsistence income. This suggests that the forest resources that people have access to present little opportunity for profit generation and hence that forest income does not constitute a pathway out of poverty under the current set of regulations and tenure regimes. Our data confirms, however, that forest income may be disproportionally important for poor segments of communities and function as a safety net in times of crisis and as gap filler in lean periods. We conclude that the opportunities for commercialisation of forest resources should be enhanced if forest based poverty reduction is a political aim.

Keywords: Asset accumulation, forest income, Nepal, poverty reduction/alleviation, seemingly unrelated regression

Contact Address: Solomon Zena Walelign, University of Copenhagen, Department of Food and Resource Economics, Rolighedsvej 23, 1958 Frederiksberg C, Denmark, e-mail: szw@ifro.ku.dk

Towards Community Forest Management in Agricultural Frontiers: The Case of Quintana Roo, Mexico

RENÉ FÖRSTER, BENNO POKORNY

University of Freiburg, Inst. of Forest Sciences: Chair of Silviculture, Germany

Agricultural frontiers are, by nature, hotspots of forest conversion. While an important body of knowledge exists concerning drivers of land use change in agricultural frontiers, little is known about how to position the management of forests as a feasible land use alternative for the local population. Against this backdrop, this study analyses forest management experiences in Quintana Roo, known as an outstanding global example of community forestry. Here, land was granted to newly forming communities (ejidos) throughout the 20th century. Today, ejidos own more than 70 % of forest lands, but only a minority is actively managing their forests.

Methodologically, a mixed, multidisciplinary design was applied. In a historical analysis, the main determinants of the emergence, maintenance or abandonment of community forest ownership and management are described. Then, based on a survey of all 75 community forest owners in the study region, differences are identied between those that currently are managing their forests and those that are not. Finally, in selected in-depth case studies of single communities, the paths towards or away from community forest management have been studied.

Results indicate three critical issues for sucessful engagement of communities in forest management: land grant design, community agency, and extension systems. In the course of a continously advancing agricultural frontier, many communities achieved timber extraction rights only when their forests had already been logged several times by private contractors, thus seriously reducing commercially available timber volumes. This fact added to weak state controls and internal problems led many communities to opt for a quick capitalisation of their forests through overharvesting, abandoning forest management afterwards. Ill conceived state policies have further increased the barriers to engaging in sustainable forest management. In practice, community forestry is currently restricted solely to communities with the highest ressource endowmends, although recently, alliances among smaller communities and local extension workers have allowed for some promising forest management intiatives. It can be concluded that community forestry is a feasible alternative in regions of agricultural frontier, if certain preconditions regarding the structure of legal instruments and an adequate relationship between technical extension bodies and communities are met.

Keywords: Agricultural frontier, community forest management, extension services, Mexico, public policy, silviculture

Contact Address: René Förster, University of Freiburg, Inst. of Forest Sciences: Chair of Silviculture, Tennenbacher Str. 4, 79085 Freiburg, Germany, e-mail: far@uqroo.mx

Small Scale Forest Enterprises with Social Responsibility – Non-Destructive Forest Use and Poverty Alleviation

ELENA MECHIK

University of Hamburg, Research Unit Sustainability and Global Change, Germany

The objective of this study was to develop a theory of how tropical forest communities can overcome poverty while using the forest in a non-destructive way. We used the Grounded Theory as a methodology for achieving this objective. Three data acquisition methods were used: literature review, problem centred in-depth group discussions, and focused observation in forest communities of Brazil, India, and Thailand. The acquired data was coded and put into interrelations between the causes for poverty and destructive forest use, the possible intervening conditions and the action strategy in order to overcome them, and the possible consequences of the action strategy.

As the result the action strategy could be formulated as the establishment of Small Scale Forest Enterprises with Social Responsibility (SSFESR). SSFESR imply obligatory forest monitoring and non-destructive forest management and creation of working places which depend on an intact ecosystem. We suggest the processing and the marketing of Non Timber Forest Products (NTFP) as a way for income creation in the SSFESR. Thereby various, complementary NTFP should be worked with in order for communities not to become dependent on only one source of income. We see SSFESR as a possibility of how sustainable development can be implemented into economic activities of tropical forest communities. SSFESR provide an environmental benefit as the forest conservation and forest monitoring, an economic benefit as the creation of working places and increase of income, and a social benefit in regard with infrastructure development, professional training etc.

The development of SSFESR is only possible under the conditions of (1) legal rights for forest management, (2) targeted investments and initial capital for the organisation of economic activities with social responsibility, and (3) organisational, technical, and methodical support. In order to validate the theory we suggest developing a mathematical model which would run with real case data showing the interdependencies between the investments into the enterprise development, the number of conserved hectares of forest, and the number of created working places.

Keywords: Non-timber forest products, poverty alleviation, small scale forest enterprises, social responsibility, sustainable development, tropical forest communities

Contact Address: Elena Mechik, University of Hamburg, Research Unit Sustainability and Global Change, Wolgaster Strasse 8, 13355 Berlin, Germany, e-mail: elena.mechik@zmaw.de

Effects of Land Use Changes on Forest Use in the Rural Village Mentu Mawang, Malaysia

MARA LINDTNER[1], TINA JENSEN[2], LOET RAMMELSBERG[1], EMMANUEL ASANE OTOO[1], JOSÉ EGAS[3]

[1]*University of Copenhagen, Agricultural Development, Denmark*

[2]*Roskilde University, Environmental Biology, Denmark*

[3]*University of Copenhagen, Sustainable Tropical Forestry, Denmark*

South East Asia is facing immense land use changes, out of which the most remarkable are the establishment of large scale oil palm plantations along with deforestation. Consequently, the aim of this case study was to identify the effect of land use changes on forest use by rural communities. The study was conducted in the rural village Mentu Mawang in Sarawak, Malaysia.

To answer the research question, a biodiversity assessment of woody species and a forest resource assessment were conducted on three different sites (primary forest, secondary forest & oil palm plantation) with three replicate plots. Both of the assessments included individual trees with a trunk diameter of 5 cm. Apart from that, 4 semi-structured interviews with the headmen and guides, a questionnaire with 30 respondents, 4 participatory rural appraisals (transect walk, village map, timeline & Venn diagram), a focus group discussion with women and participant observation have been carried out.

The results show that a shift from subsistence to cash crops has taken place since 1974, mainly due to governmental promotion of the tree/shrub crops pepper, rubber, cocoa and oil palm. This has led to a decrease of both secondary as well as primary forest along with a loss of biodiversity. Primary and secondary forests were found to have a higher biodiversity then oil palm plantations with Shannon Index scores of 2.14, 1.39 and 0.28, respectively. Furthermore, primary forest was reported to have more biomass (815 t ha^{-1}) and thus carbon storage (408 t ha^{-1}) than secondary forest (136 t ha^{-1}; 68 t ha^{-1}) and oil palm plantation (150 t ha^{-1}; 58 t ha^{-1}).

Coupled with access to modern products, the decrease in forest extension and biodiversity has resulted in a decline of forest use, loss of indigenous knowledge and less value attributed to the forest by the villagers. For the primary forest that is still left, the main reason for protection is drinking water conservation as it is located right above the community's dam.

For future forest preservation, both value rebuilding within the community as well as governmental forest protection programmes seem to be necessary.

Keywords: Biodiversity, cash crops, deforestation, forest use, indigenous knowledge, land use changes, oil palm, rural communities

Contact Address: Mara Lindtner, University of Copenhagen, Agricultural Development, Amagerfaelledvej 50 B 306, 2300 Copenhagen, Denmark, e-mail: mara.lindtner@gmx.at

The Response of Formal Institutions to Forest Governance Issues in the Bolivian Amazon

APPIE VAN DE RIJT[1], WALTER CANO CARDONA[2], TINA BAUER[1], NORBERT WEBER[3]

[1]*Technische Universität Dresden, Inst. of International Forestry and Forest Products: Tropical Forestry, Germany*

[2]*Centre for International Forest Research (CIFOR), Indonesia*

[3]*Technische Universität Dresden, Inst. of Forest Economics and Forest Management Planning: Forest Policy and Forest Resource Economics, Germany*

This poster reviews the academic knowledge on the under-representation of local needs in forest policy in Bolivia and the response of formal institutions. It is positioned in the process of adapting forest management policy to the rights and necessities of forest dependent communities. The rights of peasant and indigenous communities are recognized by the 1996 forest law, but the right to use forest resources was limited. The law had a strong focus on industrial timber extraction, and did not provide an equitable access to forest resources, nor did it correspond with rural communities' needs. For instance, communities were only allowed to commercialise their timber resources via forest management or deforestation plans. To comply with these requirements communities mostly depended on large companies to design and execute the management plans or had to sell their timber rights directly to the company. Both cases often result in disadvantageous deals for the communities. These shortcomings have been pointed out by academics and NGOs since the implementation of the forest law in 1996. These findings have been supported by an increasing amount of literature. In response, various ad hoc forest regulations have been designed and implemented in an attempt to satisfy local needs, such as small authorisations for community members to commercialise timber individually. The responses from both governmental and non-governmental institutions during the last 18 years have been analysed. The findings are based on a research conducted between March and June 2014 in cooperation with CIFOR, as part of a MSc thesis for TU Dresden. The study contributed CIFOR's project which aims to understand the dynamics between timber markets and investment in the Western Amazonian region. Fieldwork consisted of interviews with key-actors such as governmental and non-governmental institutions, community representatives and community members involved in the small scale timber production in either peasant or indigenous rural communities.

Keywords: Bolivia, forest policy, formal institutions, rural needs

Contact Address: Appie van de Rijt, Technische Universität Dresden, Inst. of International Forestry and Forest Products: Tropical Forestry, Pienner Str. 7, 01737 Tharandt, Germany, e-mail: appievanderijt@gmail.com

Characterising Spatial Structure of Natural Forests in Mexico

OSCAR ALBERTO AGUIRRE CALDERON, JAVIER JIMENEZ PEREZ, ISRAEL YERENA YAMALLEL

Universidad Autónoma de Nuevo León, Dept. of Silviculture, Mexico

Stand structure is related to the spatial and temporal arrangement of individual trees in a forest stand. The spatial structure defines the organisation of the trees in space while temporal structure refers to successional patterns over time. The study presents a characterisation of spatial structure and intertype analysis of tree locations in natural forests of greater diversity and of high ecological significance in Durango, Mexico. These forests, with rare conifers including the species: *Picea chihuahuana*, *Abies durangensis* and *Pseudotsuga menziesii*, are found on particular sheltered, humid sites. Two different spatial statistics, know as nearest neighbour analysis F(r) and Ripley's K(r) function have been used for analysing the tree-mapped data. Patterns and spatial interactions for trees in different species, sizes, and dominance classes were analysed separately. The results show that both methods are complementary and give a detailed description about the types and scales of the observed tree patterns. However, Ripley's K(r) analysis better revealed different aspects of the spatial process for the analysed classes of trees within the plots when compared to the nearest neighbour statistic and is a powerful tool for analysing the spatial relationships between different classes of trees. The examples presented here indicate: a significant dependence or attraction between species. Trees in the smallest class significantly avoid trees in the tallest height class, and there is a positive association between suppressed trees and co-dominant and dominant trees, reflecting the presence of self-thinning within the plots. Positive spatial associations (aggregation) in this forest seem to be highly linked with seed dissemination processes, the relative shade tolerance of some species, and specific preferences for soil patches. On the other hand, repulsive interactions (spatial regularity) could be an indication of competition processes that imposes a minimum distance between trees.

Keywords: Nearest neighbour analysis, Ripley's K(r) analysis, spatial tree distribution

Contact Address: Oscar Alberto Aguirre Calderon, Universidad Autónoma de Nuevo León, School of Forest Sciences, Carretera Nacional km. 145, 67700 Linares, Mexico, e-mail: oscar.aguirrecl@uanl.edu.mx

Root Layering in a Tropical Forest after Logging (Central Vietnam)

ZDENEKK CERMÁK

Mendel University in Brno, Czech Republic

Indigenous stands of tropical rain forests in the region of Kon Ha Nung are one of the most preserved forests in Vietnam. Despite the logging activities mainly in the 1970's, it was possible to preserve intact forests free from any primary harvesting. In the past, other stands were influenced by logging to various extent. Some of those stands are managed presently; others were left to natural development. This study deals with the influence of harvesting activities on the root system in forest stands. In primary stands and in stands with known harvest intensity, samples of root systems were collected. The total weight of dry basis and their layering within the soil profile were assessed. The data were analysed with a set of statistical methods. The collected roots were divided into three classes: class I $\leq$1.0 mm, class II 1.1–5.0 mm, class III over 5.0 mm in diameter. In the monitored plots, the total weight of dry basis of fine roots to 1.0 mm ranged from 2.34–3.24 t ha^{-1}. But the emergence of root mats typical for a vegetation of tropical rain forest, however, was not confirmed. The weight of dry basis of roots from 1.0–5.0 mm ranged from 6.57–9.69 t ha^{-1}. The majority of roots of class I is presented in the top 10.0 cm of the soil and their share drops with increasing depth. The roots of class II are distributed more equally. It was impossible to prove the influence of the logging on the root system.

Keywords: Root layering, root mat, selective logging, tropical rain forest

Contact Address: Zdenekk Cermák, Mendel University in Brno, Zemedelska 3, 61300 Brno, Czech Republic, e-mail: zdenek.cermak@mendelu.cz

Soil Respiration in Rubber Plantation and Rainforest Indicate Different Processes During the Rainy Season

RONG LANG[1], SERGEY BLAGODATSKIY[1], GEORG CADISCH[1], XU JIANCHU[2]

[1] *University of Hohenheim, Inst. of Plant Production and Agroecology in the Tropics and Subtropics, Germany*

[2] *World Agroforestry Centre, China & East Asia Office c.o. Kunming Inst. of Botany, Chinese Academy of Sciences, China*

Rubber plantations expand rapidly in the upper Mekong leading to remarkable land use change in the region. As part of evaluation of the land use change impact on carbon stock and sequestration, we measured the soil CO_2 flux in secondary rainforest, 22 and 9 years old rubber monoculture and a rubber-tea intercropping in Xishuangbanna, Southwest China. Soil respiration was measured with monthly interval from November 2012 to December 2013, using an open chamber soil respiration system-ADC LCi-SD. We placed 12 collars at different positions of each plot to cover the spatial variation. Soil moisture and temperature were measured with corresponding probes in the mean time. Soil respiration showed distinct difference in temporal pattern between secondary rainforest and rubber plantations during rainy season (May to October). Respiration rate increased gradually in all plots from February to June. From July to October, secondary rainforest had higher respiration rates and peaked during this period, while respiration rates of 3 plots in rubber plantations dropped and showed low emission in August. The moisture data indicated that the soil under rubber plantations was periodically waterlogged and saturated with water. On the contrary, the loose soil in rainforest was not saturated even during very wet period. Soil temperature played a major role in dry season (November to April). Soil respiration was lowest in February when rubber shed leaves, winter chill in December 2013 also contributed to low respiration rate in all plots. The soil moisture dynamics in rainforest and rubber plantations during the rainy season indicates that land use change could affect the diffusivity and gaseous transport in the soil, which further change the CO_2 emission. Soil respiration might be suppressed because of limited available oxygen during certain wet periods; this anaerobic condition could also change the methane consumption to production. Therefore, planned estimation of soil methane flux during wet period will help to verify the contribution of the both processes to the gaseous carbon losses from soil. Our study shows the importance of consideration of soil properties and moisture monitoring for the reliable assessment of land use change effect on carbon emission from the soil.

Keywords: Carbon losses, rubber plantation, soil moisture, soil respiration

Contact Address: Rong Lang, University of Hohenheim, Institute for Plant Production and Agroecology in the Tropics and Subtropics
current address: 132 Lanhei Road Heilongtan, 650201 Kunming, China, e-mail: langrong@mail.kib.ac.cn

Carbon Storage Potential of Rubber Plantations of Different Age and Elevation in Xishuangbanna

XUEQING YANG[1], SERGEY BLAGODATSKIY[1], GEORG CADISCH[1], JIAN CHU XU[2]

[1] *University of Hohenheim, Inst. of Plant Production and Agroecology in the Tropics and Subtropics, Germany*

[2] *Kunming Inst. of Botany, The Chinese Acadamy of Sciences, Center for Mountain Ecosystem Studies, China*

Forest transition by economic-orientated rubber plantations is considered as one dominant land use change in Xishuangbanna. In order to conduct sustainable land use management, as well as to meet the international political and economic interests, the public calls for reliable assessment of carbon sequestration potential by rubber tree based systems. However, the evaluation of rubber plantation's carbon stock is difficult due to variations in stand age, clone type, planting density and growth habitats. Different ownership of rubber plantations also influences various management activities, which further affect carbon stock assessments.

This study aims to assess carbon stocks at the tree level and at the plantation level. At tree level, the main locally used clone types were selected and felled with a range of stand ages and elevation gradients. To avoid the influence of plantation ownership, those trees were all selected within smallholders' plantations and with similar management activities. Destructive sampling method was used to separate trees into stems, branches (large, medium and fine), leaves, flowers/seeds, taproot and lateral roots (large, medium and fine). Log-transformed power functions were applied to build allometric relationships between diameter at breast height (DBH) and aboveground, below ground and total carbon stocks (kg C/tree). At plot level (20*25 m), sampling covering different stand ages and elevation gradients were selected. The total tree carbon stock was calculated by allometric equations built at the tree level; moreover, understory vegetation, litter, deadwood and soil organic carbon (0–30 cm) was counted together as plot carbon stock. Linear mixed models were used to evaluate the influence of clone, site, stand age, planting density, and soil conditions on carbon stocks. Adequate assessments of C stocks at plot level were made using experimentally found parameters for rubber tree specific allometric relationships. For same stand age (<20 years), C stock decreased by 13 % and 49 % from low elevation (<750 m) to mid (750–950 m) and high elevation (>950 m) respectively. We showed that expansion of rubber plantation to higher elevation reduces the C sequestration potential in the long run; an important information to design sustainable and climate friendly land use decisions on sloping land.

Keywords: Allometric equation, carbon sequestration, elevation, land use management, rubber, tree age

Contact Address: Sergey Blagodatskiy, University of Hohenheim, Inst. of Plant Production and Agroecology in the Tropics and Subtropics, Garbenstrasse 13, Stuttgart, Germany, e-mail: sergey.blagodatskiy@uni-hohenheim.de

Carbon Storage on Unmanaged Bamboo Plantations in Costa Rica

DANIEL ORTIZ[1], WILLIAM FONSECA[2], MARILYN ROJAS[2], MANUEL EDUARDO CHAVARRÍA[2], JOSÉ MANUEL ALVARADO[2]

[1]*Agtrain - Agricultural Transformation by Innovation. University of Copenhagen, Plant and Environmental Sciences, Denmark*
[2]*National University of Costa Rica, Fac. of Environmental Sciences, Costa Rica*

Perennial systems have a strong interest as contributors to climate change mitigation through carbon storage. This study evaluated the carbon removals of unmanaged bamboo plantations which were established in 1993 on the perimeter of the Arenal's reservoir (Costa Rica). We analysed the above and below-ground carbon fixing capacity by harvesting 95 culms of *Dendrocalamus latiflorus*, *Guadua angustifolia* and *Guadua aculeata* and sampling herbaceous vegetation, necromass and soils at 30 cm depth. Using the basal area as independent variable, allometric models were fitted by the ordinary method of least squares, obtaining a R^2 value of 0.815 for total carbon. In *Dendrocalamus latiflorus* plots we estimated a density of 10793 culms ha^{-1} with 186.6 tons ha^{-1} of carbon stored. Culm components accumulated approximately 59 % (111.2 tons ha^{-1}), whereas soil represented 38 % (70.11 tons ha^{-1}) and necromass/herbaceous vegetation accounted 3 % (5.28 tons ha^{-1}). In the case of mixed plantations of *Guadua angustifolia* and *Guadua acuelata*, the density was 6146 culms ha^{-1} with 118.61 tons ha^{-1} of carbon in the system. Soil represented 60 % (71 tons ha^{-1}) while culms components and necromass/herbaceous vegetation contributed to 35 % (41.94 tons ha^{-1}) and 5 % (5.67 tons ha^{-1}) respectively. The carbon fraction ranged from 43.2 % to 47.2 % among the different components on the same axle (leaves, branches, stems, roots and rhizomes), from 36.4 % to 46.7 % in the necromass/ herbaceous vegetation, and had a value of 2.45 % in soil. We observed high rates of death culms in both systems, 17 % in *Dendrocalamus latiflorus* and 25 % in *Guadua angustifolia*/*Guadua* aculeata, which could be due to internal competition. By interpreting the results of carbon content in each pool, the study suggests that high rates of death culms may be reducing the potential of bamboo plots as a carbon sink. In this sense, could some interventions (e.g. thinning) increment the carbon storage of bamboo plantations?

Keywords: Above/below-ground carbon, allometric models, basal area, carbon sink, carbon storage, culm components, unmanaged bamboo plantations

Contact Address: Daniel Ortiz, Agtrain - Agricultural Transformation by Innovation. University of Copenhagen, Plant and Environmental Sciences, Copenhagen, Denmark, e-mail: ortizdaniel86@gmail.com

Aboveground Stand Biomass Dynamics in a Chinese Fir [(*Cunninghamia lanceolata* (Lamb.) Hook] Plantation in Shitai County, China

XIAOLU TANG[1], YUANGCHANG LU[2], LUTZ FEHRMANN[1], DAVID FORRESTER[3], RUBÉN GUISASOLA RODRÍGUEZ[3], CHRISTOPH KLEINN[1]

[1]*Georg-August-Universität Göttingen, Chair of Forest Inventory and Remote Sensing, Germany*

[2]*Inst. of Forest Resource Information Techniques, Chinese Academy of Forestry, Dept. of Forest Management and Statistics, China*

[3]*Freiburg University, Chair of Silviculture, Germany*

China has the worldwide largest area of plantations, and Chinese fir [(*Cunninghamia lanceolata* (Lamb.) Hook] is among the most common plantation tree species in subtropical China, covering an estimated area of 8.54 million ha and amounting to about 21% of total plantation area. Several studies have been conducted in Chinese fir plantations, but still there are uncertainties regarding its potential and dynamics to sequester carbon in biomass as a function of stand type. Tree ring analysis is an appropriate tool to study growth dynamics, but the application of tree ring analysis to evaluate aboveground biomass (AGB) dynamics of Chinese fir stands is rare.

In this study, tree ring analysis was applied to exam AGB dynamics in a 17-year old Chinese fir plantation in Shitai County, Anhui Province, China. A total of 12 plots were established, and 18 trees were felled for stem analyses: 6 dominant, 6 co-dominant and 6 suppressed trees. 24.6 %, 47.4 % and 28.0 % of all trees in the fir plantation were considered as dominant, co-dominant and suppressed trees, respectively.

Annual DBH and biomass increment of dominant trees were significant higher than that of co-dominant and suppressed trees, but no significant difference was observed between co-dominant and suppressed trees. Stand biomass increased from 1.85 t ha^{-1} at age 3 to 108.12 t ha^{-1} at age 17, which was similar to comparable studies of Chinese fir. AGB of dominant, co-dominant and suppressed trees contributed 50.1 %, 36.4 % and 13.5 % to total stand AGB, respectively, and remained stable after age 10. Tree ring analysis offered a powerful methodology for a quick estimation of annual AGB, and potentially linked AGB dynamics of Chinese fir plantation in view of carbon market and alleviating climate change.

Keywords: Biomass increment, DBH increment, sigmoidal model, tree ring analysis

Contact Address: Xiaolu Tang, Georg-August-Universität Göttingen, Chair of Forest Inventory and Remote Sensing, Büsgenweg 5, 37077 Göttingen, Germany, e-mail: xtang@gwdg.de

Tree Species Composition, Diversity and Structure in Tunas Logging Concession Area of Papua, Indonesia

YOSIAS GANDHI[1,2], RALPH MITLÖHNER[2]

[1]*The State University of Papua, Fac. of Forestry, Indonesia*

[2]*Georg-August-Universität Göttingen, Burckhardt-Inst., Tropical Silviculture and Forest Ecology, Germany*

Tree species composition, diversity and structure of pre-logging (ULG), 4-year post-logged (LG4) and 8-year post logged (LG8) plots in Tunas Timber Harvesting Area of Papuan tropical lowland forest were studied in July 2013. Composition of families and number of species identified in unlogged forest were mostly dominated by tree families, dipterocarpaceae, lauraceae and myrtaceae among 30 families and 71 species found in the plot. However, the occurrences of the three families were at middle places in 4-year logged forest. Whereas in 8 years logged forest, dipterocarpaceae appeared as most populated families. Interestingly, this dominant species was not followed by lauraceae and myrtaceae but moraceae which mainly consist of pioneer species. There was a slightly dissimilarity floristic composition between plots found in all tree size classes as indicated by Sorensen similarity index ranging from 59.65 to 77.78 %. Shannon-Wiener index (H') showed a high heterogeneity of rare species in all plots while Simpson's index performed a high diversity of common species found in different forest disturbances. Species richness and evenness were also the best indices for presenting diversity changes between unlogged and logged forest. In addition, they showed an increase in species diversity from plot ULG (71 species) to plot LG4 (85 species) and a slightly decrease in LG8 (80 species). In the case of size class distributions, the negative exponential function showed nearly continuously inverse J-shaped curves for all forest plots. However, there was a slight disruption in the number of tree classes of logged plots which more likely explained that alteration in tree basal area and density have occurred. Shifts in species composition were apparent following logging, however the alter mechanisms behind is expected to be short-lived during first few years after logging. At last, the potential of the forest area as ecosystem services including provision of timber, carbon storage and sequestration, conservation value and biodiversity value is considerably affected by this successional pattern.

Keywords: Logging area, Papuan forest, species alteration

Contact Address: Yosias Gandhi, The State University of Papua, Fac. of Forestry
current address: Georg-August-Universität Göttingen, Burckhardt-Institute, Tropical Silviculture and Forest Ecology, Büsgenweg 1, Göttingen, Germany, e-mail: yosias.gandhi@stud.uni-goettingen.de

Population Structure and Genetic Diversity of *Populus laurifolia* Stands in the Altay Mountains of Mongolia

MARTIN WIEHLE[1], KARSTEN WESCHE[2], SVEN GOENSTER[1], BARBARA VORNAM[3], ANDREAS BUERKERT[1]

[1] *University of Kassel, Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, Germany*

[2] *Senckenberg Museum for Natural History, Germany*

[3] *Georg-August-Universität Göttingen, Büsgen-Institute: Forest Genetics and Forest Tree Breeding, Germany*

Riparian forest ecosystems belong to the most vulnerable ecosystems on our planet, and at the same time deliver important ecosystem services such as habitat provision, carbon sequestration, watershed stabilisation, erosion prevention and in-stream processing of pollutants. Over the last decades, however, human impacts such as logging of trees and over-grazing by livestock have profoundly altered these ecosystems, whose effects are still poorly understand. Since population structures, species' dynamics and viability mainly depend on the spatial heterogeneity of habitats, a reduction in stand density is usually equivalent to a reduction in the effective population size. The latter may be low because fragmentation may result in inefficient gene flows.

The Laurel Poplar (*Populus laurifolia*) appears to be ideal to study such effects of human intervention under harsh climatic environments. Therefore, a study was conducted under semi-arid conditions along the Bulgan River catchment area, western Mongolia, where tree growth is strongly restricted to watercourses, harmed by logging and subjected to browsing and grazing of livestock.

A total of 600 individuals, grouped into 40 sub-populations (comprising one Bulgan River population and five populations of 2nd order tributaries) were geographically recorded, dendrometric variables measured, and leaves sampled. Extracted DNA was analysed by nuclear encoded microsatellite markers, and genetic diversity and differentiation were subsequently calculated.

Statistically significant differences and large variations were found for tree and stand characteristics within the six surveyed populations. Size classes indicated that Bulgan River populations were younger compared to the tributaries, while stand density was highest along the Bulgan River. However, a strong variation in stand densities as well as the total absence of trees in upstream areas was even more striking. Genetic measures revealed a downstream accumulation of diversity and a moderate genetic differentiation among populations.

In conclusion, strong spatial fragmentation and clear genetic variations indicated substantial impacts of human intervention even in this remote region, which is of concern regarding the viability of populations and the ecosystem's services in future.

Keywords: Ecosystem differentiation, habitat fragmentation, poplar, riparian forest, stand density

Contact Address: Andreas Buerkert, University of Kassel, Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, Steinstraße 19, 37213 Witzenhausen, Germany, e-mail: tropcrops@uni-kassel.de

Comparison of Leaf Area Index Measurements in Rubber Plantations and Secondary Forest in Xishuangbanna, China

ARISOA RAJAONA[1], ALEXANDRA SCHAPPERT[1], SABINE STÜRZ[1], KUNFANG CAO[2], FOLKARD ASCH[1]

[1] *University of Hohenheim, Inst. of Plant Production and Agroecology in the Tropics and Subtropics, Germany*

[2] *Chinese Academy of Sciences, Xishuangbanna Tropical Botanical Garden, China*

Rubber trees (*Hevea brasiliensis*), which are considered as huge water consumers, have replaced most of the forests in Xishuangbanna, Yunnan, China. Leaf area index (LAI) is the total one-sided area of leaf tissue per unit ground area, and it is a key parameter in ecophysiology for up-scaling gas exchange from leaf to canopy level, for quantifying water loss by evapotranspiration, and for describing canopy dynamics and its microclimate.

In order to assess the impact of the land-use change in Xishuangbanna on the local and regional water balance, precise LAI measurement in forests and rubber plantations are needed. First results of experiments conducted in Menglun, Xishuangbanna, in a young (13 years old) and a mature (22 years old) rubber plantation, and in a secondary rain forest indicated that canopy dynamics differ widely between rubber plantations and forests, resulting in different water use patterns and altered heat fluxes.

Many methods have been developed to quantify LAI, and it is crucial to select the most appropriate technique according to a specific situation, object of interest, required accuracy, the time of measurement, the research scale, and the available budget. Nevertheless, LAI is not easily to quantify, and comparative measurements in plantations and forests need to consider the different canopy structures. In order to improve the precision of these measurements, different methods have been compared. LAI measurements were conducted in different distances from the individual trees and across the plots, during different times of the day (morning, midday, afternoon) according to the recommended requirements, and under different sky conditions. Measurements were carried out using light absorption method (SunScan, Delta-T Devices Ltd, Cambridge, UK), gap fraction method (LAI-2000, LI-COR, Nebraska USA; and hemispherical photography: Hemiview, Delta-T Devices Ltd, Cambridge, UK), and a destructive method. Pros and cons of each of the used instruments when measuring uniform and heterogeneous high canopy trees will be discussed and recommendations for comparative LAI studies in heterogeneous stands will be presented.

Keywords: Forest, Hemiview, LAI-2000, leaf area index, rubber, SunScan

Contact Address: Arisoa Rajaona, University of Hohenheim, Inst. of Plant Production and Agroecology in the Tropics and Subtropics, Garbenstrasse 13, 70593 Stuttgart, Germany, e-mail: arajaona@uni-hohenheim.de

Effect of Indole-3-Butyric Acid on Rhizogenezis of Juvenile Leafy Cuttings of *Swietenia macrophylla* King

JIRI LIPENSKY[1], BOHDAN LOJKA[1], MANUEL SOUDRE ZAMBRANO[2]

[1]*Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Dept. of Crop Sciences and Agroforestry, Czech Republic*

[2]*Peruvian Amazon Research Institute, Forest Tree Nursery, Peru*

Swietenia macrophylla King. (Meliaceae) commonly known as big-leaf mahogany, is neotropical heliophytic slow growing forest tree species, valued for its excellent wood quality. Because of unsustainable commercial exploitation, many populations of mahogany have been depleted and this species become rare in parts of its natural area of distribution. Despite its ecological, economical, and social importance, *S. macrophylla* remains essentially wild and hence vulnerable. One of domestication research priority of this species is development of optimal methods for successful vegetative propagation. These methods may serve as appropriate tool for elite trees genotype conservation, or for propagation of selected Hypsipyla resistant, faster-growing trees with acceptable wood quality. It is also an alternative to propagation by seeds, which is often constrained by environmental, ecological, genetic or economic factors. This study is focused on effects of six different concentrations (0, 1000, 2000, 3000, 4000, and 8000 ppm) of Indole-3-butyric acid (IBA) on rooting parameters of juvenile leafy stem semihardwood cuttings of *S. macrophylla*. After 61 days in sub-irrigated polyethylene polypropagator, the parameters of propagules were measured. The number and percentage of rooting, callus formation, number of roots, total root length, and length of the longest root was significantly higher in group treated with 4000 ppm of IBA than in control group with untreated cuttings. No significant differences were recorded in mortality, leaf abscission, and number of calli per cutting between the six groups tested. These results shows that for successive vegetative propagation of juvenile leafy cuttings of *S. macrophylla* was best application of concentration 4000 ppm of IBA.

Keywords: Domestication of forest trees, Indole-3-butyric acid (IBA), juvenile leafy cutting, subirigated polyethylene polypropagator

Contact Address: Jiri Lipensky, Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Dept. of Crop Sciences and Agroforestry, Kamýcká, 165 21 Prague, Czech Republic, e-mail: lipensky@ftz.czu.cz

Assessment of Social, Economic and Environmental Implication of Short Rotation Coppice

AZEEM TARIQ[1], ANDREAS DE NEERGAARD[2]

[1]*Georg-August-Universität Göttingen, Soil Science of Temperate Ecosystems, Germany*

[2]*University of Copenhagen, Dept. of Plant and Environmental Sciences, Denmark*

Short rotation coppice (SRC) is the system of biomass production in a short period of time by using the bio-energy plant species that resprout from base after harvest. Globally, there is a demand of developing an environmental friendly and cost effective system of power generation. In view of current climate scenario, there is an increasing concern on environmental impact of SRC plantation. Poplar and willow (*Salix* and *Populus* spp.) are more common short rotation plant species that are planted as a renewable source of energy in many European countries. The woodchips obtained from SRC can be used as a substitute for fossil fuel and can be used as a potential source for power generation. Plantation of SRC on arable agriculture land plays an important role as a carbon sink because of minimum tillage, low fertiliser requirements, annual leaf litter store in the soil and more biomass production as compared to arable crop land. The most mysterious aspect of SRC is the availability of litter that has prominent impacts on soil quality and microbial activities. If properly managed SRC system has a potential to increase the biodiversity of farmland ecosystem as a provisional habitat for many species. SRC system is only profitable under the certain political and economic scenarios, for instance availability of incentives, costs and prices of wood chip. There are assumptions that SRCs are an economically sound and environmental friendly choice that have potential to play a significant role in climate change mitigation. In spite of social, ecological and environmental benefits of short rotation coppice, there is a big challenge to convince the conventional farmers to cultivate the SRC on agricultural field because of low economic return compared to agricultural crops. Thus, it is essential to analysise the potential of SRC under different social, economic and environmental perspectives.

Keywords: Bio-energy crops, climate, economic, soil quality

Contact Address: Azeem Tariq, Georg-August-Universität Göttingen, Soil Science of Temperate Ecosystems, Göttingen, Germany, e-mail: azeem_uni@yahoo.com

Water management

Subsurface Irrigation as a Promising Approach to Reduce Pathogenic Impact When Using Wastewater

ANDREA DÜHRKOOP[1], PERIHAN TARI AKAP[2], SINAN ARAS[2], DILEK KAHRAMAN[2], EDWARD MUCHIRI[3], OLIVER HENSEL[1]

[1] *University of Kassel, Agricultural Engineering, Germany*

[2] *International Agricultural Research and Training Center, Turkey*

[3] *Egerton University, Civil Engineering, Kenya*

In developing countries irrigated agriculture consumes up to 90 % of available water. Increasing pressures on the scarce resource force farmers and stakeholders to manage their water in an efficient way in order to sustain their livelihood. The ComASI project - A Comprehensive Analysis of Subsurface Irrigation in SSA for an optimisation and adaption of an environmental friendly irrigation practice - bundles results of different research projects dealing with subsurface irrigation techniques. Subsurface irrigation (SSI) means water supply beneath the soil surface directly in the plant rooting zone with dry plant foliage (preventing plant diseases) and dry soil surface (minimising evaporation). The project comprises 4 existing subsurface irrigation techniques in 5 different countries: subsurface drip irrigation (SDI - Côte d'Ivoire, Turkey), porous hose (porous pipe/ Namibia) and auto regulative subsurface irrigation technology (ARSIT/ Algeria, Kenya). Within the framework each project is conducting analysis of SSI methods in field trials under local conditions with respect to water productivity, use of low quality water, salinity effects, and socio economic aspects. Results from Kenya and Turkey where wastewater was applied show an adequate use of wastewater in irrigated agriculture. In Turkey the research was conducted at the International Agricultural Research and Training Centre Menemen-Izmir (IARTC) in 2013. In this research, lettuce was irrigated by 3 different irrigation methods, drip irrigation, subsurface drip irrigation and furrow irrigation, with treated domestic waste water. In Kenya the research was conducted at the Egerton University. In this experiment ARSIT and drip irrigation irrigated french beans with wastewater effluent from the University pond. Anion-cation, pollution analyses and fecal coliform tests were run. Further soil samples were taken and analysed in order to monitor the status of the pathogens in soil. To investigate the impact on the crops, parameters like height, yield, and leaf area index were checked. As a conclusion with higher yields and reduced pathogenic contamination, subsurface irrigation is an optimum technique to substitute scarce natural water resources. Furthermore there is a reduced risk for farmers as they don't get in contact with waste/-water due to the water application directly in the plant rooting zone.

Keywords: Irrigation, subsurface irrigation, wastewater, water saving

Contact Address: Andrea Dührkoop, University of Kassel, Agricultural Engineering, Nordbahnhofstr.1 a, 37213 Witzenhausen, Germany, e-mail: andrea.duehrkoop@uni-kassel.de

Mitigation of Methane Emissions from Paddy Fields by Alternate Water Management

SYED FAIZ-UL ISLAM[1], ANDREAS DE NEERGAARD[1], JAN WILLEM VAN GROENIGEN[2]

[1] *University of Copenhagen, Dept. of Plant and Environmental Sciences, Denmark*

[2] *Wageningen University and Research Center (WUR), Dept. of Soil Quality, The Netherlands*

Rice paddies are a major source of anthropogenic methane (CH_4); they are responsible for about 15–20 % of the annual global efflux. It is produced in anoxic environments, including the submerged soils of wetlands and paddy fields, by methanogenic archaea during the anaerobic degradation of organic matter. Therefore water management is one of the most important tools for methane mitigation in rice production systems. The effect of mid-season drainage and intermittent irrigation on CH_4 emission is well established. However, the effect of length and timing of drainage on CH_4 emissions is still poorly understood. We studied this effect in an experiment with six different water management systems (continuous flooding, alternate wetting and drying, varied midseason drainage and varied early stage drainage with mid-season drainage). The experiment was conducted in climate chamber resembling tropical conditions and all the five drainage systems except for continuous flooding, irrigation water from the paddy was drained out at the different stages of the crop cycle. Gas sampling was carried out using static chambers and the concentration of CH_4 and N_2O was simultaneously measured using a gas chromatograph. Among all the six different water management systems applied, highest efflux of the methane was recorded from continuously flooded plot which was significantly higher than all other treatments and mid-season drainage with early stage drainage was found to be highly effective in mitigating methane efflux. It was also found that the redox potential of the soil of the drainage system was inversely proportional to the methane efflux from all the treatments. The detailed results will be presented during the conference. These results will provide important insides regarding water management for attenuation of CH_4 emission from rice fields.

Keywords: Methane emission, rice, water management

Contact Address: Syed Faiz-Ul Islam, University of Copenhagen, Dept. of Plant and Environmental Sciences, Thorvaldsensvej 40, 1871 Frederiksberg C, Denmark, e-mail: faiz@plen.ku.dk

Governmental Policies and Ground-Water Exploitation: The Case of Darab Central Valley, Iran

SUDEH DEHNAVI[1], BEATRICE KNERR[1], HOUMAN LIAGHATI[2]

[1] *University of Kassel, Department of Development Economics, Migration and Agricultural Policy, Germany*

[2] *Shahid Beheshti University, Environmental Sciences Research Institute, Iran*

Ground-water scarcity is a global problem for farmers, particularly in arid and semi-arid regions. At the same time, governments of these countries play a key role in ground-water management. Considering the case of Darab central valley, this paper intends to find out the effect of different policies aiming at wheat self-sufficiency on ground-water extraction.

In Iran, the government follows an explicit strategy of attaining national food autarky focus on wheat. Wheat minimum guaranteed price, crop insurance and credits with subsidised interest rate are the main policies implemented for that purpose. This paper investigates five policy scenarios with regard to their impact on water extraction: a) presence of subsidised credits together with minimum guaranteed price; b) presence of subsidised credit; c) presence of minimum guaranteed price; d) presence of crop insurance policy e) reference situation without policy interventions. The methods applied for data analysis are multiple regression analysis and profitability analysis. The results are calculated with regard to four village groups, differentiated according to their level of ground-water availability. Primary data used were collected in a field survey among 362 farmers from nine villages, which had been selected by multiple two-stage sampling.

It turned out that wheat minimum guaranteed price created higher profit margins than reference situation e), even in villages with low water availability. Under scenario e) only the farmers from one village could cover their wheat production cost while the rest would face loss. Crop insurance policy encouraged farmers, especially those from villages with less water availability, to expand their wheat area instead of adopting it to the available water. Credits with low interest rate led to underrating of water extraction costs and enhanced ground-water extraction. This paper concludes that credits with low interest rate, crop insurance policy and minimum guaranteed price policy run counter to sustainable use of ground-water resources, pointing to an obvious conflict between Iran's food self-sufficiency strategies and the country's long-term food security which is seriously challenged by increasing water stress.

Keywords: Ground-water availability, ground-water exploitation, policy intervention, self-sufficiency policy

Contact Address: Sudeh Dehnavi, University of Kassel, Department of Development Economics, Migration and Agricultural Policy, Steinstrasse 19, 37213 Witzenhausen, Germany, e-mail: sudeh_d@yahoo.com

Effects of Rules in Irrigation Systems: Evidence from Experiments in China, India and Vietnam

THANH LAN PHAM[1], ILONA OTTO[2], DIMITRIOS ZIKOS[1]

[1]*Humboldt-Universität zu Berlin, Dept. of Agricultural Economics, Germany*

[2]*Potsdam Institute for Climate Impact Research, Climate Impacts and Vulnerabilities, Germany*

Irrigation systems are typically classified as common pool resources which often face the problems of under-investment and over-use. A solution to those collective action problems is to create and implement suitable rules. In China, India and Vietnam irrigation systems are strongly managed by governmental organisations with top-down policy and a largely objectively institutional design process. Moreover, irrigation governance is currently challenged by multi-pressures such as social, economic, environmental, and climatic that may require institutional changes. In this context, we question the possibility for irrigation users to craft their own rules and the influence of these self-crafted rules on irrigation governance. We employed laboratory and field experiments with famers and students from China, India and Vietnam in order to compare behaviours of different decision-makers: students under laboratory conditions and farmers under field conditions across different socio-economic settings; 180 people participated in our experiments. Each experiment included three stages: no rule, externally imposed rules, and self-crafted rules by irrigation users. Each stage had 10 rounds. In total, we had 5400 observations of investment and extraction decisions. Four multilevel mixed-effect linear regression models were applied to investigate factors influencing investment and extraction behaviours of irrigation users. Our results show that physically asymmetric access to water resource created asymmetric distribution of investment and water extraction that favours upstream users. Compared to the situation of no rule, externally imposed rules were able to bring in more equal distribution of benefits among upstream-downstream users but were likely to reduce the volume of average investment and benefits. Self-crafted rules with strong enforcement worked the best in terms of giving more equal distribution among users and generating higher average benefits in comparison to situations of no rule and external imposed rules. Farmers tended to break the rules more frequently than students. Vietnamese players achieved the highest benefits. Individual characteristics of players including age and gender had only weak effects on players' behaviours. Our research confirmed two important policy conditions for equal and efficient distribution of resources that are the strong enforcement of rules and the participation of resource users in the process of designing rules.

Keywords: Asymmetric access, common-pool resource, self-crafted rules

Contact Address: Thanh Lan Pham, Humboldt-Universität zu Berlin, Dept. of Agricultural Economics, Berlin, Germany, e-mail: pham_thanh_lan@yahoo.com

Is Devolution Sufficient for Effective Institutional Performance of Participatory Irrigation Management? A Closer Look at Water Users' Groups in Tanks Irrigation in South India

RANGANATH LAKSHMAIAH[1], BRUHAN KONDA[2], YASHODA YASHODA[3]

[1] *Justus Liebig University Giessen, Institute for Agricultural Policy and Market Research, India*

[2] *University of Ghent, Fac. of Bioscience Engineering, Belgium*

[3] *University of Gothenburg, Department of Economics, Sweden*

Tanks are earthen dams that were built centuries ago to cater the water requirement of a village community i.e. for irrigation and domestic requirement. Their management is deeply ingrained in the social structure and traditions of village life even today. The institutions shaping the management have been influenced by power structure at village level and policies at state level from colonial India to contemporary India. In recent decades, with more studies emphasising participatory irrigation management, state government lead the management of these tanks to water user groups, created among the beneficiaries. The existing physical infrastructure was restored e.g., feeder-canal, tank-bund, sluice, catchment treatment, de-silting and a democratically elected governing body was established with institutional support and legal recognition to take up their responsibilities. The question is how far these de jure democratic governing bodies function democratically in reality? So a comparative study between formal community-based tank management institution and informal community-based tank management institution was conducted to find out effectiveness of institutional performance in participatory tank irrigation management. This was evaluated by eliciting stakeholders rating on modified Likert's scale for participation in 'collective action' and 'decision making' for operation and maintenance of the tank system. Similarly, 'equity in sharing', 'well defined water rights', 'monitoring and enforcement' and 'conflict resolution' as measure for perception about performance of the tank management institutions was looked at. All six parameters were selected based on Ostrom's design principle illustrated by long enduring common property resources. It is quite surprising to know even though stakeholders' rating for participation in collective action and decision making is higher in formal tank management institution, their perception on institutional performance is low with respect to the parameters equity, water rights, monitoring and enforcement and conflict resolution. This indicates that the devolution of responsibilities by the state itself is not the end, policies should also stress on processes of democratic developmental in institutions so that they can come over traditional power structures to endure in future.

Keywords: Devolution, institutional performance, tank irrigation

Contact Address: Ranganath Lakshmaiah, Justus Liebig University Giessen, Institute for Agricultural Policy and Market Research, Senckenbergstr. 3, 35390 Giessen, India, e-mail: ranga.laki@gmail.com

Water Footprint of Cotton Production in China

TIL FEIKE[1,2], JUDITH HUMMEL[2], NAN HA[2], YUSUYUNJIANG MAMITIMIN[2], REINER DOLUSCHITZ[2]

[1]*Julius Kühn-Institut (JKI), Federal Research Centre for Cultivated Plants, Inst. for Strategies and Technology Assessment, Germany*

[2]*University of Hohenheim, Inst. of Farm Management, Germany*

Cotton is globally the most important agricultural trade commodity, with China being the number one producer and consumer of cotton fiber. Cotton plays a strategic role for China's current economic development. Apart from being the essence for its textile industry, cotton production also offers high income possibilities for farmers in rural China, however often at the expense of severe natural resource degradation. The Tarim Basin (TB) in north-western China is one of the country's most important cotton production regions, accounting for about one fourth of national cotton production. In this extremely arid region overexploitation of water resources has led to severe degradation of natural riparian ecosystems in the last decades. The present study therefore aims to assess the field gate water footprint of cotton under current and improved production conditions. The analysis builds on a primary farm data set of detailed crop management data from the region. Applying a partial life cycle analysis (LCA) approach the study distinguishes between three types of consumptive water use; 1) green water: evaporated rainwater for cotton growth, 2) blue water: withdrawal of ground- or river water for irrigation purposes, and 3) grey water: water polluted through application of agricultural chemicals during growth. Four representative farm types were identified; i) flood irrigation – low yield, ii) flood irrigation – high yield, iii) drip irrigation – low yield, and iv) drip irrigation – high yield. It is shown that the choice of irrigation technology actually has a lower impact on product water footprint compared to yield level. It is therefore recommended to also focus on improving overall crop management instead of the sole promotion of drip irrigation technology.

Keywords: Cotton, water footprint, Xinjiang, China

Contact Address: Til Feike, Julius Kühn-Institut (JKI), Federal Research Centre for Cultivated Plants, Inst. for Strategies and Technology Assessment, Stahnsdorfer Damm 81, 14532 Kleinmachnow, Germany, e-mail: Til.Feike@jki.bund.de

Origin, Anthropogenic and Climate Influences on the Occurrences of Saline Groundwater at the City of Cairo, Egypt Deduced by Chemical Parameters of Water Composition

WERNER BALDERER[1], FANNY LEUENBERGER[2]

[1]*ETH Zurich, Earth Sciences, Swiss Geotechnical Commission, Switzerland*

[2]*ETH Zurich, Earth Sciences, Geological Institute, Switzerland*

In the 16th to 18th century canals and ponds outgoing from the Nile were systematically built in the growing city Cairo, for irrigation purposes and as transport ways for ships. This network of canals and ponds was able to store temporarily the incoming flood water and in this way prevent the general flooding of Cairo City. After the construction of the Aswan High dam in the 20th century (1970) these canals were not needed anymore for irrigation and as storage capacity of the flood water. Most of the canals and ponds were filled up and used for road network extensions. However the ponds of Ain Al Sira, Khayalat Al Shorta and Abo El Soud which were now no longer connected to a canal system showed the following behaviour: As these ponds were filled up with dumping materials and one of them removed even completely from the landscape (Abo El Soud), the water was invading the basements of the constructed buildings as well as outflowing in other places. The water surface rise of the two remaining ponds is still continuing and is actually even flooding nearby roads and cemeteries.

The origin of the groundwater is from outflows of the outcropping Tertiary rocks according to the main chemical composition of Pond Nr. I Khayalat Al Shorta, as also outflows of the water of the Eocene formation outcrop along the Eastern bank of the Nile valley according to the main chemical composition of Pond Nr. 2 Ain Al Sira. A remediation of the present situation would most probably only be possible by restoring the pools to their original extent and maintaining the water level constant by controlled drainage of the groundwater overflow by installing a drainage system for lowering the groundwater level with small pumping stations scattered throughout the area of high groundwater levels along the main streets in the direction of the Nile (which would possibly replace the disappcared historical channel system)

Keywords: Cairo ponds, origin and chemical composition of waters, remediation of groundwater level, water logging

Contact Address: Werner Balderer, ETH Zurich, Earth Sciences, Swiss Geotechnical Commission, Sonneggstrasse 5, 8092 Zurich, Switzerland, e-mail: balderer@erdw.ethz.ch

Low Pressure Sub-Surface Irrigation Technology for an Optimal Irrigation Management - An Auto-regulative Membrane Pipe

ANDREA DÜHRKOOP[1], ABDELAALI BENCHEIKH[2], TAREK ABDELMONEIM OUAMANE[2], AHMED MADJED DJOUDI[2], OLIVER HENSEL[1]

[1]*University of Kassel, Agricultural Engineering, Germany*

[2]*Scientific and Technical Research Center for Arid Regions (CRSTRA), Algeria*

This paper presents analysis and results of a joint research project between the Technical and Scientific Research Center on Arid Regions (CRSTRA) in Biskra (Algeria) and the Institute for Agricultural Engineering of the Kassel University (Germany). An auto-regulative membrane pipe buried beneath the soil surface was tested in greenhouse trials at the experimental station El Outaya near Biskra (Algeria) where water is scarce, with annual rainfall varying between 70 and 120 mm. The new membrane irrigation system works at low pressure to allow an auto-regulative functioning of the pipe based on the close interaction between the pipe, the soil and the plant. When the soil is dry the water supply by the pipes is high because of the high soil water tension, when the soil humidity rises the soil water tension will decrease, subsequently water flow will decrease. To sustain a constant system head a mechanical float valve has to be installed in the water supply tank. This design ensures a continuous water filling of the pipe. The irrigation method works automatically and independent of energy supply.

To compare the new membrane system with the drip irrigation technique two greenhouses were equipped with drip irrigation and the membrane pipes respectively. The greenhouses were divided into different plots and planted with tomatoes. Two types of irrigation water were tested, surface water from a local dam and groundwater with higher salinity. Results for the membrane irrigation show a water saving potential of 70 %. In this experiment the groundwater use had no impact on the soil structure, tomato crops indicate better parameter (plant height, fruit diameter and weight) compared to the drip plots. Further less diseases and weeds appeared.

For analysing the longevity and suitability of the membrane pipe material the experiment was running for two years. Results show that the pipes where groundwater was applied can be used for several years and the pipes where dam water was used showed clogging after each year. This clogging could be eliminated with a mix of detergent and water. After that procedure the pipe can be installed again.

Keywords: Auto-regulative, irrigation, subsurface irrigation, water saving

Contact Address: Andrea Dührkoop, University of Kassel, Agricultural Engineering, Nordbahnhofstr.1 a, 37213 Witzenhausen, Germany, e-mail: andrea.duehrkoop@uni-kassel.de

Water Use by Rubber and Oil Palm Plantations in the Lowlands of Jambi, Indonesia

AFIK HARDANTO[1], ALEXANDER RÖLL[1], FURONG NIU[1], ANDREA HANF[1], HERI JUNEDI[2], HENDRA YANTO[3], DIRK HÖLSCHER[1]

[1]*Georg-August-Universität Göttingen, Tropical Silviculture and Forest Ecology, Germany*

[2]*Jambi University, Agriculture, Indonesia*

[3]*Institut Pertanian Bogor, Forestry, Indonesia*

In Asia oil palm as well as rubber plantations are rapidly expanding. In both plantation types there is concern about the integrity of the hydrological cycle. Our study aimed at a comparison of the transpiration rates of the two plantation types with respect to seasonality and site conditions. In the lowlands of Jambi (Indonesia), we studied eight rubber and eight oil palm plantations, which were between 7–17 years old and 9–16 years old, respectively. For the assessment of seasonality, one rubber and one oil palm plot was measured for 12 months. Additionally, three plots of each plantation type were measured pair-wise with one relatively dry and one relatively wet plot for three to four weeks. We used Granier-type thermal dissipation probes for an assessment of the tree and palm water use. For the palms, sensors were installed in the leaf petioles and four leaves per palm, and four to ten palms per site were studied. For rubber, two sensors per tree were installed in the trunk and six to ten trees per site were studied. New equations for estimating the sap flux density were derived from lab calibration experiments. Our results suggest moderate average water use rates for both plantation types. Rubber transpiration underwent a strong seasonality as due to leaf shedding in the dry season. Also when rubber trees were fully leaved, their transpiration responded more sensitively to changes in soil moisture than oil palms. In other words, oil palm transpiration seems to be more conservative than that of rubber.

Keywords: Lowlands, oil palm, rubber, seasonality, site condition, thermal dissipation probes (TDP), water use

Contact Address: Afik Hardanto, Georg-August-Universität Göttingen, Burckhardt Institute: Tropical Silviculture and Forest Ecology, Busgenweg 1, 37077 Göttingen, Germany, e-mail: afik.hardanto@stud.uni-goettingen.de

Water Resources Saving: A Possibly Contribution from a Greywater Collection, Treatment and Reuse

MARIANA CHRISPIM, MARCELO ANTUNES NOLASCO, ANDRÉ SANTOS, GABRIEL INACIO SILVA-NETO, NEILDES SOUZA SANTANA
University of São Paulo, Brazil

Greywater is the wastewater produced by showers, bath, basins, kitchen sink and laundry and comprises 50 to 80 % of total domestic wastewater. Greywater composition varies depending on many factors, such as: residents behaviour and activities, products used, income, age and others. Greywater reuse could be an important practice because contributes to reduce the wastewater production in cities and the demand for potable water. From a public health perspective raw greywater may be contaminated with pathogens, traces of heavy metals and micropollutants. Therefore the treatment is an essential step before the reuse. Currently there is a lack of scientific studies with the aim of evaluate the performance of treatment with moving bed biofilm reactor for greywater. The objective of this study was to evaluate the technical feasibility of a greywater collection and treatment system in order to locally reuse for non-potable purposes. The specific objectives were: to characterise and to monitor an experimental system of greywater treatment; to analyse the greywater quality from the different sources, and to indicate the potential uses for treated water. The greywater sources in this study were: 4 showers, 2 washbasins and 1 washing machine situated in a building at the University of Sao Paulo. Outside the building were installed a pilot system for treatment of synthetic greywater, including: tanks for segregated wastewater collection; pretreatment with fine screen; equalisation basin; pumps, aerobic bioreactor and settling tank. The Results showed a higher greywater production in washing machine (44 %), followed by showers (42 %) and washing basin (14 %). In our research the COD: N: P ratio was 100:6.77:1.02 which indicates higher nutrient concentration in greywater than in the research mentioned above. The study should be conclude in the next couple months and at this moment it´s not possible to evaluate the performance of bioreactor, but our hope is that, in the end, the final effluent quality will reach a high quality providing possibilities of water reuse locally for of non-potable purposes, such as toilet flushing.

Keywords: Pollution, resources, wastewater, water reuse

Contact Address: Marcelo Antunes Nolasco, University of São Paulo, School of Arts, Sciences and Humanities, Av. Arlindo Bettio 1.000, 05017020 São Paulo, Brazil, e-mail: mnolasco@usp.br

Egeria densa in Itaparica Reservoir, Brazil – Need for a Management Strategy

DEBORA LIMA, GÜNTER GUNKEL
Technische Universität Berlin, Department of Water Quality Control, Germany

Egeria densa is a submerged macrophyte native from South America, yet it can be found widespread in waterbodies in different parts of the globe. It has been regarded as a pest species, due to its high growth rate and good adaptability to different environmental conditions. At the Itaparica reservoir, in the São Francisco River in Northeast Brazil, this species shows a high development of biomass since the past years. It forms monospecific and dense stands in shallow and undisturbed areas, such as bays. In this reservoir *Egeria densa* occurs down to 8 m water depth, showing high tolerance to light and sediment characteristics. The low nutrient levels in the water of Itaparica reservoir also do not seem to restrain the growth of this plant.

Blooms of macrophytes such as *Egeria densa* can be considered detrimental in different ways. On a biological point of view, it leads to the reduction of macrophyte biodiversity by out competing other species, it promotes mosquito breeding in stagnant mats and it provides habitat for snails, vectors of the human parasite *Schistosoma mansoni*. Recreation and fishery activities are also hindered by this plant (rod fishing, swimming and navigation, by fouling boat motors), as well as power production, by blockage of turbines. For these reasons, it seems essential to develop a reservoir management strategy for the control of *Egeria densa*.

Itaparica reservoir is located in the semi-arid region of Brazil, where water availability is scarce and soils in the watershed are poor. Feed for animals in this region is also limited, especially in dry seasons. The use of *Egeria densa* as an extra source of nutrients for soil amendment or as feed for livestock is considered in this study, as well as the opportunity of using this plant as substrate for the production of biogas, on a local scale. The regular removal of *Egeria densa* would not only prevent the predominance of this plant in the reservoir, but also help improving life conditions in the region, in a sustainable way.

Keywords: *Egeria densa*, management, reservoir

Contact Address: Debora Lima, Technische Universität Berlin, Department of Water Quality Control, Straße des 17. Juni 135 Sekr. Kf 4, 10623 Berlin, Germany, e-mail: debora.macielbarroslima@tu-berlin.de

Local Participation in Sustainable Community Water Management in Peri-Urban Areas of Greater Accra Region

STEPHEN JOSEPH KILASI

University of Ghana, Inst. of Statistical, Social & Economic Research (ISSER), Ghana

In Africa, Ghana in particular, there is increasing demand for greater inclusion in local decision making, especially in water management. However, few countries have the appropriate institutions and mechanisms in place to ensure more effective local participation. Community water supply systems such as hand-pumps, water points and piped water points are considered as the most viable systems for peri-urban water supply. Data from Rural Water Supply Network (RWSN) shows that in a sample of 20 sub-Saharan countries the average for non-functionality rate is 36 %. In Ghana, the non-functionality rates of community managed water systems is around 30 %. It can be estimated that in peri-urban context, non-functionality and un-sustainability rate is between 30% and 40%. The study aimed at examining and determining how local community participation and water sector institutions affect sustainability of peri-urban community managed water supply systems in Greater Accra Region. The study employed both in-depth interviews and individual household surveys. In addition, non-participant observation was employed. The study took place in the three communities Abokobi, Oyarifa and Teiman of the Greater Accra Region in Ghana. Factor analysis, logit model and descriptive analysis was applied for the quantitative data. The qualitative data was analysed using thematic content networks. The results indicated that the scope of local participation is limited, since their participation is more involuntary than voluntary. The facilitating agencies seems to determine decision making of the population, especially during planning stage. There were also variations in the perception of the concept of 'participation' between local communities and stakeholders. Local community participation and water institutions have greater impact on sustainability of peri-urban community water projects. Interestingly, local community participation in water issues was remarkably more pronounced for other public social services. In conclusion, systematic participatory in community water management is recommended. Peri-urban community water supply should be given a deliberate effort because of its heterogeneity of ethnic groups, rapid population growth and complexity of the growing of unplanned constructions. Furthermore, local organisation management strategy should be strengthened and enable the operation and maintenance of the water management systems.

Keywords: Community management, participation, sustainability, peri-urban agriculture

Contact Address: Stephen Joseph Kilasi, University of Ghana, Inst. of Statistical, Social & Economic Research (ISSER), P.O. Box LG 72 Legon, Accra, Ghana, e-mail: kilasi2000@gmail.com

Irrigation Technology, Technical and Resource-Use Efficiencies in Smallholder Urban Vegetable Farming in Lagos State, Nigeria

OLUWAKEMI ADEOLA OBAYELU[1], ABIODUN ELIJAH OBAYELU[2], ZAINAB AINA USMAN[1]

[1] *University of Ibadan, Dept. of Agricultural Economics, Nigeria*

[2] *Federal University of Agriculture, Abeokuta, Dept. of Agricultural Economics and Farm Management, Nigeria*

The study assessed the level of technical efficiency and resource-use efficiency in urban vegetable production for different irrigation technologies. It employed a cluster sampling procedure to obtain information from 142 smallholder urban vegetable farmers in Lagos State. Results showed that 18.3 % and 81.7 % of the farmers were using motorized pumps and manual irrigation (watering cans) methods, respectively. Also, 61.5 % and 35.3 % of motorized pump users and manual irrigation users had continuously used their land for more than five years. The results of the stochastic frontier model showed that quantity of irrigation water ($p < 0.01$) and pesticide ($p < 0.10$) had positive effects on vegetable output while fertiliser ($p < 0.05$) had negative influence on the productivity of urban vegetable production overall. The urban vegetable farmers were also operating at decreasing returns to scale (0.5284). Also, attainment of technical education ($p < 0.10$) and years of urban vegetable farming experience ($p < 0.01$) improved technical efficiency of the farmers. Results further showed that manure, fertiliser, herbicides, hired labour and family labour were underutilised while land, pesticides and seeds were over-utilised. The inefficiency model revealed that male farmers ($p < 0.01$) were more technically efficient than their female counterparts. Thus, it is expedient for government to support the female farmers to improve their level of technical efficiency through skill acquisition e.g. in the use of motorized pumps for irrigation. The study also found that the farmers were using too much fertilisers which reduced their level of productivity. Therefore, there is the need for to channel agricultural extension services to these food producers to assist vthem with an optimum use of fertiliser and thereby enhance their productivity.

Keywords: Irrigation technology, resource-use efficiency, technical efficiency, urban agriculture, vegetable

Contact Address: Abiodun Elijah Obayelu, Federal University of Agriculture, Abeokuta, Dept. of Agricultural Economics and Farm Management, Alabata, Abeokuta, Nigeria, e-mail: obayelu@yahoo.com

Bridging Knowledge and Action: Enhancing a 'Science for Development' in Water Resources Management

ANNA SCHWACHULA

University of Bonn, Center for Development Research, Germany

In the context of "Bridging the gap between increasing knowledge and decreasing resources", research cooperation between so called 'developed' countries and 'developing' countries or 'emerging economies' plays a crucial role: They are main institutions of generating new context-specific knowledge.
However, if science shall have positive effects on development as such, or on sustainable resource management in particular, it is necessary to go beyond scientific outputs and to turn knowledge into action and impact. A beneficial design of research projects as well as surrounding science policy is crucial to achieve this.
Based on findings of my ongoing PhD research, my contribution to the Tropentag 2014 will focus on factors that positively influence the impacts of science cooperation for water resources management along the example of research projects carried out between scientists in Germany and Peru, Brazil and other countries in the global South. Qualitative data collected through semi-structured interviews and participant observation of cooperative projects and among science policy makers gives interesting insights into the process of creating research impacts. Funding institutions as well as researchers are well aware of the basic principles that enhance uptake of results, such as cooperation on eyelevel, common ownership, transdisciplinarity, involvement of non-scientific stakeholders and problem owners in the research process, etc. However, realities of cooperation on the ground are often difficult and messy. Based on these insights, in my contribution I will point out the success factors of science for development projects, but also reflect on their limitations. I will furthermore expose stumbling blocks in the policies framing the projects. The objective of my presentation thus is to contribute to making better use of the knowledge generated in research through making it applicable in real life settings, beyond publications in scientific journals.

Keywords: Cooperation, impact, innovation, knowledge, science policy, water resources management

Contact Address: Anna Schwachula, University of Bonn, Center for Development Research, Walter-Flex-Str. 3, 53113 Bonn, Germany, e-mail: anna.schwachula@gmx.net

Development of Agricultural Land and Water Use and its Driving Forces in North-Western China

TIL FEIKE[1,2], YUSUYUNJIANG MAMITIMIN[2], NAN HA[2], REINER DOLUSCHITZ[2]

[1]*Julius Kühn-Institut (JKI), Federal Research Centre for Cultivated Plants, Inst. for Strategies and Technology Assessment, Germany*

[2]*University of Hohenheim, Inst. of Farm Management, Germany*

The extremely arid Tarim Basin (TB) in north-western China is one of the country's most important cotton and fruit production bases. However, in recent years the negative ecological consequences of the intensive agricultural production become apparent. Apart from the degradation of riparian vegetation, competition for scarce water resources among farmers tightens, leading to increasing occurrence of droughts and related yield losses. To be able to develop solutions for the aggravating problems it is decisive to clearly understand the land and water use development and its driving forces in the TB. Statistical yearbook data from 1989 to 2011, comprising the four administrative regions of the TB, namely Aksu and Bayangol prefecture, as well as Division 1 and Division 2 of the Xinjiang Construction and Production Corps, and annual producer price data constitute the data base for the present study. Relevant policy documents and data obtained through a stakeholder workshop complement the analysis. It is shown that agricultural land area more than doubled during the 1989–2011 period. This is a result of the interaction of i) vast population growth and related increase in agricultural labour, ii) positive price developments for fruits and cotton, iii) strong increase in agricultural profitability, triggering further land reclamation, iv) afforestation programs pushing the establishment of orchards, and v) insufficient restriction of land expansion. It is recommended to step up the efforts to move people out of agriculture into other sectors, and significantly improve agricultural water productivity by increasing yield levels and shifting towards labour intensive high value crops.

Keywords: China, driving forces, irrigated agriculture, land use change

Contact Address: Til Feike, Julius Kühn-Institut (JKI), Federal Research Centre for Cultivated Plants, Inst. for Strategies and Technology Assessment, Stahnsdorfer Damm 81, 14532 Kleinmachnow, Germany, e-mail: Til.Feike@jki.bund.de

Looking at Food Security through the Agricultural Water Poverty Index

MASOUMEH FOROUZANI[1], EZATOLLAH KARAMI[2]

[1]*Khuzestan Ramin Agriculture and Natural Resources University, Dept. of Agricultural Extension and Education, Iran*

[2]*Shiraz University, Dept. of Agricultural Extension and Education, Iran*

Water, not land, is now the limiting factor in agricultural production systems, particularly in arid and semi arid areas. Food insecurity and the current water crisis are the most immediate challenges of countries located in these areas, which will result in threatening sustainable livelihood of farmers' household, especially poor families. Water is one of the main factors that constrain their agricultural output and income. Low precipitation, overexploitation of water resources by farmers to increase production, low irrigation efficiency, drought and increased population together contribute to worsen the water crisis. This insecure condition has prompted an increased attention for more effective ways of water management, particularly accurate assessment of the water situation in the agricultural sector. This paper offers a glimpse of the vulnerability contexts related to agricultural water in dry areas of developing countries and then introduces the Agricultural Water Poverty Index (AWPI). It also describes the components of AWPI and emphasises on its potential to address the two important dimensions of farmers' sustainable livelihood, namely the vulnerability context and capitals needed for improving livelihood with regard to agricultural water. The most fundamental function of the AWPI is to measure the level of agricultural water poverty as the most important construct that influences agricultural water management. The paper concludes that increasing water availability can no longer be the driving force beyond secure production in those countries; however, increasing capitals in order to change the agricultural practices is the real alternative for improving agricultural production as well as ensuring a more food secure future for the water scarce countries.

Keywords: Agricultural water poverty index, developing countries, food security, sustainable livelihood

Contact Address: Masoumeh Forouzani, Khuzestan Ramin Agriculture and Natural Resources University, Dept. of Agricultural Extension and Education, Ramin, Iran, e-mail: m.forouzani@yahoo.com

Challenges for Sustainable Agricultural Practices in Semi Arid Brazil: The Example of Irrigation Projects in the Itaparica Region

GUILHERME JOSÉ FERREIRA DE ARAÚJO[1], EDVÂNIA TÔRRES AGUIAR GOMES[2], MARTIN COY[3]

[1]*Federal University of Pernambuco (UFPE), Dept. of Geography, Brazil*

[2]*Federal University of Pernambuco (UFPE), Brazil*

[3]*Innsbruck University, Dept. of Geography, Germany*

The region of Itaparica, located in Northeast Brazil, was flooded in the year 1987 due the construction of the Luiz Gonzaga Hydroelectric Dam which was built by the São Francisco Hydroelectric Company (CHESF). The flooded area is about 83.400 hectares large and affected approximately 10 cities in the States Pernambuco and Bahia. Around 50.000 people were forced to move to new cities and settlements with irrigation schemes. In the region more than 10 settlements were established and three cities were reconstructed. Since the first year the resettled people have free access to water and agricultural support, guaranteed by a CHESF and Polo Sindical (Local Syndicates Organisation) agreement. Due to the free access the small farmers have used excessive amounts of water mostly for coco, banana and onion cultivation by the sprinkler irrigation system. The salinisation of soil, a result of uncontrolled water use, is a problem in all settlements since the early 1990s. In the last years the use of the agrochemical raised significantly. Some areas are also affected by erosion. Due to these reasons many areas have become unproductive. The excessive use of agrochemical products has affected the health of producers, appliers, consumers and the local population. Since 2012 farmers do not have technical support for agricultural production and consequently the abovementioned problems have increased. The aim of this research is to show the problems of agricultural production in the Itaparica region and aims to contribute to the current debate on sustainable methods in the agricultural production. The lack of control of water and the excessive use of agrochemicals is a big problem for the region. The certification process of sustainable practices is one alternative to avoid environmental impacts. Some organisations give seals for "good agricultural practices" to incentivize production without agrochemicals and to improve the water use. After a literature review various field stays with stakeholder workshops, using constellation analysis, were undertaken. The study is integrated in the INNOVATE Project – a partnership between Brazilian and German universities studying water and land use in the Itaparica region.

Keywords: Agricultural production, environmental impacts, settlements

Contact Address: Guilherme José Ferreira de Araújo, Federal University of Pernambuco (UFPE), Dept. of Geography, Rua 16 de Julho, N.72, 52120-360 Recife, Brazil, e-mail: inzoneiro7@yahoo.com.br

Cost-Benefit Analysis of Drip Irrigation in Cotton Production in China

TIL FEIKE[1,2], THOMAS LANG[2], NAN HA[2], REINER DOLUSCHITZ[2]

[1]*Julius Kühn-Institut (JKI), Federal Research Centre for Cultivated Plants, Inst. for Strategies and Technology Assessment, Germany*

[2]*University of Hohenheim, Inst. of Farm Management, Germany*

The extremely arid climate of the Tarim Basin in the Xinjiang province in Northwestern China offers ideal production conditions for cotton, making the region one of the nation's major cotton production bases. However, in the last decades the overuse of water resources for agricultural production led to severe ecological degradation and increasing competition for water among farmers. Still the majority of farmers in the region uses flood irrigation to provide water to their crops. Drip irrigation under plastic mulch constitutes a new technology that generally features increased water use efficiency, however at higher production costs. The present study assesses the costs and benefits of applying drip irrigation based on a primary household dataset of 229 cotton producing households collected in the region. Three scenarios are tested for farmers shifting from flood to drip irrigation technology: i) no effect on yield level, ii) yield gap to sampled drip irrigation farmers is closed by 50 %, iii) yield gap to sampled drip irrigation farmers is closed completely. Furthermore three levels of seed cotton sales price are examined. Finally the necessary water price level is identified at which the net present value of the investment into drip irrigation becomes zero. The results furthermore indicate, that the application of drip irrigation is only beneficial in economic terms, if farmers manage to increase their yield levels at the same time. Therefore it is recommended to improve the agricultural extension service, and cover a substantial share of the additional cost for the farmer through providing subsidy for advanced irrigation technology.

Keywords: China, cost-benefit analysis, cotton, drip irrigation

Contact Address: Til Feike, Julius Kühn-Institut (JKI), Federal Research Centre for Cultivated Plants, Inst. for Strategies and Technology Assessment, Stahnsdorfer Damm 81, 14532 Kleinmachnow, Germany, e-mail: Til.Feike@jki.bund.de

Biodiversity conservation and ecosystem services

Screening Wild Foods for Reducing the Cost of a Nutritionally Adequate Diet in Kenya

CÉLINE TERMOTE[1], JESSICA RANERI[1], AMY DEPTFORD[2], BRUCE COGILL[1]
[1]*Bioversity International, Nutrition and Marketing Diversity Programme, Italy*
[2]*Save the Children, Hunger Reduction and Livelihoods, United Kingdom*

The determinants of poor nutrition are often rooted in poverty and inequity. Meeting nutrient needs of families while keeping costs to a minimum, improving resilience and respecting cultural traditions remains a challenge. For many populations, local and traditional foods, including wild foods can play an important role as safety net during difficult periods or to complement diets with essential nutrients. However, wild foods and their actual and potential contributions to nutrition security have rarely been studied nor considered in nutrition and conservation programmes.
This study innovatively combined ethnobiological methods with Save the Children's Cost of Diet (CoD) linear programming tool to study the role of wild food biodiversity in achieving a cost reduction of a nutritionally adequate diet for women and young children (6–23 months) in eastern Baringo District, Kenya.
Available wild and cultivated food biodiversity was documented through focus group discussions and five wild foods selected for modelling. Market surveys assessed prices of all foods by season. Diets were modeled to minimise cost and maximise nutrient adequacy using the CoD tool. Modelling was done without and with wild foods for the dry and the wet season.
Modeled diets without wild species were deficient in iron for all age groups during the dry season; vitamin B6 and calcium deficient during dry season, iron and zinc deficient during all seasons for infants aged 6–8 months. Adding wild foods, especially Berchemia discolour, in the modeled diets resulted in a lower cost diet, while meeting recommended iron intakes for women and children between 12 and 23 months.
An application of linear programming to screen available wild food biodiversity for meeting recommended nutrient intakes at a minimal cost was illustrated. The analysis should be repeated in different agro-ecological zones to increase our understanding of the multiple links between biodiversity, nutrition and health. Scalable projects that aim to link the identified foods to both consumer and producer decisions to improve production systems with local and nutritious products should be developed and the impact on various livelihood, food security and nutrition outcomes measured.

Keywords: Cost of diet, food biodiversity, linear programming, nutrition security, wild foods

Contact Address: Céline Termote, Bioversity International, Nutrition and Marketing Diversity Programme, Via dei Tre Denari 472/a, Maccarese/Rome, Italy, e-mail: c.termote@cgiar.org

Role of Local Knowledge in the Use of Medicinal Plants in SW-Madagascar

JESSICA ANDRIAMPARANY, KATJA BRINKMANN, ANDREAS BUERKERT, VOLOLONIAINA JEANNODA

University of Kassel, Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, Germany

Utilisation of medicinal plants (MPs) is the main source of health care for the local population on the Mahafaly plateau in SW-Madagascar, but little is known about the species involved. This study therefore aimed at determining the MPs used, recording the traditional knowledge on MPs uses and comparing MPs utilisation across the surveyed villages in this semi-arid region.

Semi-structured and households socioeconomic interviews were conducted in five village surrounding the Tsimanampetsotsa National Park. The usage and knowledge of MPs were compared based on the number of plants used, the number of medicinal uses and ethnobotanical indices that expressed the knowledge on plants. One way ANOVA was performed to determine knowledge and use differences among villages. The Generalized Linear Model (GLM) approach was applied to determine which variables most influenced the use and knowledge on medicinal plants.

A total of 214 identified plant species, belonging to 68 plant families and 162 genera, are used by the local people on the Mahafaly plateau to treat 46 ailments of human and livestock. The majority of the recorded medicinal plants was found on the calcareous Mahafaly plateau (95.4 %) itself and mostly collected from forest areas (81.8 %). The number of species used and the uses per plant differed significantly ($p < 0.01$) among villages. Knowledge about MPs was particularly large in people living near forests. Results of the GLM analysis indicated that the socio-cultural variables had a stronger influence on the use of MPs than socio-economic ones. We conclude that there is specific knowledge about MPs and their multiple uses merits preservation among the community groups on the Mahafaly Plateau. It may also be exploited in eco-tourism projects as part of local development efforts.

Keywords: Local knowledge, Mahafaly plateau, medicinal plants, use of traditional resources

Contact Address: Katja Brinkmann, University of Kassel, Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, Steinstraße 19, 37213 Witzenhausen, Germany, e-mail: tropcrops@uni-kassel.de

Traditional Medicinal Knowledge in Goa, India

ISABEL MADALENO
Portuguese Tropical Research Institute, Portugal

India possesses great biodiversity. In addition to the abundant native species, plants drifted from other parts of the world carried by the winds and the ocean currents. In the beginning of 2014, the Portuguese Tropical Research Institute (IICT) conducted research in the state of Goa, a former Portuguese colony. The main objective was to explore the level of reliance on traditional medicinal plants. Previous archival research provided a rich supply of spices and medicinal plants required from Goa from the 16th century onwards. Using that secondary information the IICT prepared another scientific mission to India. The survey included three types of informants: 1) the urban gardeners; 2) the spice, herb and fruit traders; 3) the Ayurvedic medicine healers. Results display a vast array of plants with medicinal applications totalling 150 different taxa. The sacred Hindu species Krishna tulsi is preferred, followed by the mango tree bark and fruit, the papaya, the aloe, the coconut, the curry tree, and ginger root. This study also confirms the results obtained in Kochi, as to the significance of urban agriculture (UA) in coastal cities of tropical countries favouring resilience to climate change. The research hypothesis is that gardening contributes to generate environmentally sustainable agglomerations, and provides income and health for the poor, meaning, UA promotes the socio-economic sustainability of cities. Urban gardens are spaces able to regulate water cycles and to produce oxygen. When they offer medicinal plant species they become landscapes of health. The paper argues that traditional medicinal knowledge is vital in India and hopes to cross-examine the cultural, religious and historical aspects of Portuguese colonisation.

Keywords: Fruits, Goa, India, medicinal, spices

Contact Address: Isabel Madaleno, Portuguese Tropical Research Institute, Rua António Galvão, 2-1ºB, 2780-047 Oeiras, Portugal, e-mail: isabel-madaleno@clix.pt

Management of Homegardens in Indonesian Agricultural Landscapes and its Impact on Invertebrate Diversity and Herbivore Predation

MANUEL TOLEDO-HERNÁNDEZ[1], YANN CLOUGH[2], LISA DENMEAD[1], TEJA TSCHARNTKE[1]

[1]*Georg-August-Universität Göttingen, Agroecology, Germany*

[2]*Lund University, Centre for Environmental and Climate Research, Sweden*

Over the last three decades Indonesia has experienced an accelerated expansion of monocultures at the cost of forest and traditional cash-crop agriculture and food production. This landscape transformation can have serious impacts on biodiversity and associated ecosystem services, as well as on the livelihood of the local people. Due to their generally high plant biodiversity and low intensity management, traditional small scale agricultural systems such as homegardens could play an important role in the preservation of biodiversity in modified landscapes. Moreover, homegardening in the tropics can ensure food security of low income households. Here, in agricultural landscapes of Sumatra, we (1) investigate the impact of homegarden size, crop diversity and management-intensity on the invertebrate community composition, and more specifically, diversity of bees and wasps, (2) estimate the impact of homegarden type on predation pressure on insect herbivores using dummy caterpillar exposure. Finally, we (3) contrast insect communities in homegardens with those found in the main agricultural systems observed in the region (oil palm, intensive rubber, and extensive rubber plantations). To determine the social and ecological factors as well as management practices driving invertebrate community composition in homegardens (e.g. crop diversity, home garden size, ethnic origin of owner, weeding, application of fertilisers, herbicides and pesticides) we completed crop inventories, and interviewed the owners in 24 homegardens. Vane traps, pitfall traps and sweep netting were used to survey the invertebrate communities in 24 homegardens and four oil palm, intensive rubber and extensive rubber plantations for comparisons between the systems. We expect higher species richness and enhanced herbivore predation rates associated with higher crop diversity and reduced intensity of management practices. The results will allow us to estimate the importance of small scale agricultural systems to maintain invertebrate communities in modified landscapes and to suggest management practices oriented to enhance crop beneficial invertebrate communities, such as hymenopteran, in home gardens.

Keywords: Bees and wasps, crop diversity, ecosystem services, herbivore predation, homegardens, invertebrate-community composition, landscape transformation, management-intensity

Contact Address: Manuel Toledo-Hernández, Georg-August-Universität Göttingen, Agroecology, Rastenburger Weg 2, 37083 Goettingen, Germany, e-mail: m1toledo@hotmail.com

Trade-Off Analysis between Single Ecosystem Services – State of the Art

INGA HÄUSER, REZA GOLBON, MARC COTTER, JOACHIM SAUERBORN
University of Hohenheim, Institute of Plant Production and Agroecology in the Tropics and Subtropics, Germany

There is a broad consensus that feeding the predicted nine billion people in 2050 remains a major global challenge for the next decades. Increasing agricultural production is therefore essential. Irrespective of how this increase is realised, whether by taking new areas under production or by increasing productivity of existing farmland, sustainability aspects should always be considered.
Studying ecosystem services (ESS) for different land use scenarios and analysing resulting trade-offs is one of the possibilities to gain a holistic view of how agroecosystems perform. The ESS approach comprises several thematic fields, ranging from provisioning services (not only agricultural production but also provision of clean water for drinking and irrigation) over regulating and maintaining services (erosion control, regulating green-house gases) to cultural services (sense of place, recreation opportunities). By analysing these services the aspects of economic, environmental and social sustainability are taken into account.
The next step is to analyse trade-offs between single ESS for different land use scenarios. Converting forests into rubber plantations increases the income of local farmers, but negatively affects the water cycle, water quality, might impact pollination services and so forth. Methods exist to analyse and visualise these trade-offs. For a detailed picture, results for single ESS can be displayed using different visualisation techniques like green (increase) and red (decrease) arrows or sustainability polygons. Another method is to analyse biophysical values relatively. Two (or more) land use scenarios are compared for each single ESS separately. After normalising the results of each service it is possible to aggregate them into a single value indicating areas of the landscape that provide the highest or lowest percentage of combined ESS. Absolute values for ESS also allow a monetary trade-off analysis if prices are available for the assessed ESS. Thereby it is possible to calculate the net gain or loss of a land use change in monetary terms and to include discount rates for future scenarios.
The aim of this paper is to demonstrate these methods using the example of rubber production in the Greater Mekong Subregion and to discuss the pros and cons of the different approaches.

Keywords: Conflict of goals, integrated valuation, environmental performance, *Hevea brasiliensis*, plantation, SE-Asia

Contact Address: Inga Häuser, University of Hohenheim, Institute of Plant Production and Agroecology in the Tropics and Subtropics, Garbenstrasse 13, 70599 Stuttgart, Germany, e-mail: haeuser@uni-hohenheim.de

The Role of Advanced Technique in Natural Resources Assessment

MUSTAFA MAHMOUD EL ABBAS, ELMAR CSAPLOVICS, TAISSER H. H. DEAFALLA

Technische Universität Dresden, Dept. of Geosciences, Germany

Despite the several series of world summits, transnational advocacy, and scholarly studies, we haven't sufficiently investigated negative environmental and social outcomes as explicated by the deadlock of natural resources extinction crisis. There are several challenges faces the natural resources management in developing countries, which imposes the need for well-designed information systems and management plans. To cope with this issue, spatiotemporal earth observation (EO) data were used to update LU/LC information with needed precision and in cost-effective manner. Time series Object-Based (OB) image analysis approach was applied to generate accurate LU/LC maps during the period 1990 to 2010. The method adopted in this research involves cross operation of classified maps to precisely delineate the change areas with semi-automation process. Aggregated to the community-level, the study utilised a well-designed questionnaire to address the driving forces associated with the change dynamics. The present study exhibits a great potential for accurate LU/LC change detection with OB post-classification technique. Additionally, it reveals strong capability of the adopted method for gaining knowledge about the change dynamics and its drivers. At the community level, the study indicates the disregarding of customary laws led the local community no more look at the forests as their own, and thus have commenced to practice all their activities as illegal, causing a rise in the rate of deforestation. Furthermore, the results of the combined analysis revealed that the mechanised agriculture was the major force of deforestation. In sum, creating enabling strategies based on innovative approaches is essential component to advance the natural resources management and planning in the area that seriously looking for better economic opportunities than were available.

Keywords: Natural resources management and planning, semi-arid region, time series analysis

Contact Address: Mustafa Mahmoud El Abbas, Technische Universität Dresden, Dept. of Geosciences, St. Petersburger Straße 12, 01069 Dresden, Germany, e-mail: mmelabbas@hotmail.com

Bridges Between Knowledge and Practice in Neotropical Mires Conservation: The Case of Iberá Wetlands, Argentina

ANA CAROLINA RODRIGUEZ[1], MICHAEL SUCCOW[2], CECILIA ACCATTOLI[3]

[1]*Humboldt Universität zu Berlin, Division of Soil Science and Site Science, Germany*

[2]*Michael Succow Foundation, Directory, Germany*

[3]*Iberá Project, Iberá Centre for Education and Training in Restoration of Large Natural Ecosystems, Argentina*

The Esteros del Iberá in the Province Corrientes-Argentina are part of one of the largest neo-tropical wetland ecosystems of South America. For a long time the area was used for extensive livestock and hunting. During the last ten years the territory has been restored by the Argentinean foundation "Conservation Land Trust", getting the status of National Natural Reserve. One key to the success was the involvement of local communities and stakeholders, especially under the creation of the "Iberá Centre for Education and Training in Restoration of Large Natural Ecosystems". The Iberá wetlands are characteristically formed by floating mires, which due to their high saturated conditions remained mainly isolated, pristine and safe from the earlier land use practices. Knowledge about pedological and ecological aspects of these particular ecosystems are crucial to design conservation strategies dealing with them, but until now it has been scarcely produced. Through a cooperation project between the German Foundations Michael Succow, Manfred Hemsen and the Argentinean Foundation Conservation Land Trust, a first ecological-hydrological characterisation of the Iberá Wetlands with emphasis on mire ecosystems was realised. The main goal of the project was to outline ecological information about the mires existing in the region: evidences about their formation, their hydrogenetic types, their carbon storage capacity, their water retention capacity and the current main threats to the health of these ecosystems. This presentation exposes the first results and produced knowledge, which shall be included in education tools for restoration and conservation of mires in the Iberá Wetlands at the Iberá Centre.

Keywords: Argentina, Iberá wetlands, mires conservation, mires ecology, neo-tropical mires, South America

Contact Address: Ana Carolina Rodriguez, Humboldt Universität zu Berlin, Division of Soil Science and Site Science, Albrecht Thaer Weg 2, 14195 Berlin, Germany, e-mail: carolina.rodriguez@agrar.hu-berlin.de

Linking Agrobiodiversity and Conservation in Man and the Biosphere (MaB) Reserves in Guantanamo, Cuba

MADELEINE KAUFMANN[1], ALEJANDRO GONZALEZ ALVAREZ[2], ALESSANDRA GIULIANI[1]

[1]*Bern University of Applied Sciences, School of Agricultural, Forest and Food Sciences (HAFL), Switzerland*

[2]*National Institute for Fundamental Research on Tropical Agriculture, Phytogenetics, Cuba*

The recent shift towards the inclusion of communities in nature conservation signals a broadening perspective among conservationists. Earlier practices of fencing off pieces of nature to "mitigate" human impact proved to be unsustainable. The UNESCO's Man and the Biosphere (MaB) concept defines no separation of people from nature to support the reconciliation of conservation of biodiversity with its sustainable use. In the Cuchillas del Toa MaB reserve, located in Cuba's Province Guantanamo where about 4000 subsistence farmers live, the interface between natural ecosystems and agricultural landscapes has not yet been investigated. This study aims at assessing farming systems and agricultural practices in the Cuchillas del Toa reserve to understand how bio-cultural production landscapes in protected areas can be synergistic with conservation of ecosystems to improve community livelihoods and agrobiodiversity maintenance. A household-level survey was conducted in two different agro-ecological zones (coastal and mountain area), on 38 households, along with transects and mapping landscape patches with GPS-points. A participatory farmer workshop was organised to identify opportunities, synergies and trade-offs for considering the use of agrobiodiversity as an option to improve the conservation of protected areas. The results show that diversity of cultivated and wild species in small family farms in this reserve has decreased over the last decades. Inadequate livelihood options – long distances to schools, hospitals – forced the younger generation to migrate to urban areas. Missing work forces, limited transportation infrastructure and bad roads lead to missing possibilities to commercialise farm products, concentrating only on a couple of cash crops. Increasingly simplified eating habits even accelerated this reduction of diversity. Additional negative impacts are given by unsustainable management practices of natural resources due to missing succession and families' short-term thinking, along with decreasing soil fertility and increasing use of chemicals. Traditional agricultural biodiversity management practices that contribute to the unique mosaic landscapes of the Cuchillas del Toa MaB reserve are in danger. As the main drivers of agrobiodiversity loss in the reserve are socio-economic aspects, there is an urging need to demonstrate the economic value and potential of agrobiodiversity, to convince government to invest in infrastructure development in the future.

Keywords: Agricultural practices, agro-ecological zones, agrobiodiversity, Cuba, family farmers , farming systems, livelihoods options, Man and the Biosphere, natural reserves

Contact Address: Madeleine Kaufmann, Bern University of Applied Sciences, School of Agricultural, Forest and Food Sciences (HAFL), Laenggasse 85, 3052 Zollikofen, Switzerland, e-mail: madeleine.kaufmann@bfh.ch

Contribution of Earth Observation to Emerging Environmental Challenges in Africa

TOBIAS LANDMANN[1], OLENA DUBOVYK[2]

[1]*International Centre of Insect Physiology and Ecology (ICIPE), Earth Observation Unit, Kenya*

[2]*University of Bonn, Inst. Crop Sci. and Res. Conserv. (INRES), Germany*

The effects of emerging environmental problems associated with climate change and human-induced land cover change often directly impede livelihoods of the rural population in Africa. Erratic rainfalls, flooding, forest cover loss, and land degradation are causing unstable agricultural yields and incomes. Earth Observation (EO) has the potential to monitor landscape dynamics in relation to climate or human-induced environmental effects. Moreover, EO can provide seamless and integrative, that is multi-data and multi-scale, geo-spatial monitoring solutions that are of particular use within data scarce environments.

This paper illustrates examples, possibilities and future perspectives from current EO research to address emerging environmental issues in Africa. Two experimental EO examples from eastern Africa are presented; (1) a multi-sensor approach to map vegetation productivity decline over eastern Africa, and (2) an integrative (multi-data) approach to map the spatial distribution of flowering plants at a local to landscape scale. In the first example, vegetation productivity decline, mapped at a regional scale using time-series of 250-meter MODIS NDVI imagery (from 2001 to 2012), is related to very high resolution (VHR) imagery in Google Earth. The MODIS-based productivity data could be effectively linked to land transformation processes (i.e. "deforestation") using the multi-date VHR imagery. Climate-induced change could be largely disentangled from the human-induced change using rainfall trends derived from passive radar satellite observations. In the second example, the spatial distribution and abundance of flowering plants are mapped for a local site in Kenya using 0.6-meter hyperspectral data. The locations of flowering plants were verified in the field using a Smartphone geo-tagging. The up-scaling potential of the hyperspectral derived flowering map to a multi-spectral Worldview-2 image was probed. The results are instigated for the quantification of pollination effects in Africa and to sustain healthy honey bee colonies.

Multi-sensor and multi-scale monitoring of environmental effects in Africa is effectively possible given that adaptable and 'intelligent' data integration models or techniques are used.

Keywords: Africa, data assimilation, earth observation, integrative monitoring

Contact Address: Tobias Landmann, International Centre of Insect Physiology and Ecology (ICIPE), Earth Observation Unit, P.O. Box 30772, 00100 Nairobi, Kenya, e-mail: tlandmann@icipe.org

Use of Daily Rainfall Data in Reliable Rainfall Risk Assessment for Rain-Fed Farming in the Nuba Mountains of Sudan

SVEN GOENSTER[1], MARTIN WIEHLE[1], JENS GEBAUER[2], ABDALLA MOHAMED ALI[3], ROGER D. STERN[4], ANDREAS BUERKERT[1]

[1] *University of Kassel, Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, Germany*

[2] *Rhine-Waal University of Applied Sciences, Sustainable Agricultural Production Systems with Special Focus on Horticulture, Germany*

[3] *University of Khartoum, Dept. of Horticulture, Sudan*

[4] *University of Reading, Statistical Services Centre, United Kingdom*

Rain-fed farming in the Nuba Mountains of the Sudan contributes substantially to the country's agricultural crop production and constitutes a cornerstone of food security for the local population. However, widely variable inter- and intra-seasonal rainfall makes rain-fed farming risky in this region. To mitigate these risks, this study provides risk statements for the rain-fed sector by calculating the probability of rainfall-induced events of agricultural importance. Additionally, the reliability of these events was assessed by determining changes of rainfall amount and the events themselves over time.

Long-term daily rainfall records (60 years) from two weather stations, Kadugli and Rashad, were provided by the Sudan Meteorological Authority. The daily data were summarised into annual rainfall amounts by the INSTAT+ software. The same software was applied to calculate rainfall-induced events such as the date of start and end of growing season for each year. Subsequently, daily and annual rainfall amounts as well as events were checked for possible monotonic trends from 1950 to 2009 and 1970 to 2009 by Mann-Kendall tests.

In Kadugli, there was no evidence for any change in rainfall amount over time. In contrast, annual rainfall data for Rashad indicated a negative trend ($p < 0.001$) of about $^{-3}$ mm per year over the 60 year period. However, a statistically significant trend could not be observed for this station between 1970 and 2009. For Rashad, an increase of low rainfall events ($>$0.85 mm to $\leq$3 mm) by 15 days coincided with a decline in the number of medium daily rainfall classes ($>$10 mm to $\leq$20 mm) by 4 days over the period from 1970 to 2009. This increase may be of concern since low rainfall events do not contribute to the crop water balance and therefore may hamper rainfed farmers' crop production. Calculations of the lengths of the growing season based on specific starting dates did not indicate statistically significant changes at either site suggesting that these results could be used as the basis for planning purposes for the next years. The results of our study are designed to contribute to a better assessment of crop management risks under rainfed farming.

Keywords: East Africa, food security, growing season, Mann-Kendall tests, rainfall-induced events

Contact Address: Andreas Buerkert, University of Kassel, Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, Steinstraße 19, 37213 Witzenhausen, Germany, e-mail: tropcrops@uni-kassel.de

Dynamics and Drivers of Land Use Changes in Southwestern Madagascar During the Past 60 Years

NOROMIARILANTO FANAMBINANTSOA[1], MIADANA H. FARAMALALA[1], ANDREAS BUERKERT[2], KATJA BRINKMANN[2]

[1] *University of Antananarivo, Dept. of Biology and Vegetation Ecology, Madagascar*
[2] *University of Kassel, Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, Germany*

Southwestern Madagascar is dominated by dry spiny forests representing a unique and highly diverse ecosystem with an exceptionally high number of endemic species. However, land cover changes and deforestation processes rapidly changed the natural environment during the past decades, especially on the semi-arid Mahafaly plateau, where the local population depends on the exploitation of local forest resources and slash and burn agriculture to meet their basic needs.
Historical aerial photographs of the national map service from 1949 and 1966, Google Earth satellite images from 2004 and Pléiades satellite images from 2012 were used to detect land use and land cover changes (LULCC) based on a supervised classification using the Sequential Maximum A Posteriori Classifier (SMAPC) and additional visual image interpretation. To understand the settlement and migration history of the villages and the historical changes in the use of ecosystem services, focus group discussions (2 per village) and semi-structured interviews with elder members of the village were conducted (10 per village). The resulting land-use history narratives were compared with the remote sensing results.
Main drivers of deforestation processes in the studied villages were slash and burn 'maize' agriculture and bushfires combined with an extension of permanent agricultural fields. From 1949 to 1966 the cropland increased up to 40 % in the villages. Since then pressure on available land resources and ecosystem services increased drastically with highest deforestation rates on the plateau site, where most woodlands were transformed to savannah. To improve people's livelihood and sustain ecosystem services, alternative land management strategies such as the cultivation of drought resistant crop varieties or measures to enhance soil fertility are needed.

Keywords: Ecosystem services, Mahafaly plateau, satellite image classification, slash and burn agriculture, SMAPC

Contact Address: Katja Brinkmann, University of Kassel, Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, Steinstraße 19, 37213 Witzenhausen, Germany, e-mail: tropcrops@uni-kassel.de

Assessment of On-Farm, Market, and Wild Food Diversity in Three Agro-Ecological Zones of Western Kenya

ASPASIA WERNER[1], ANTHONY WHITBREAD[2], KATJA KEHLENBECK[3], STEPHA MCMULLIN[3], GUDRUN B. KEDING[4]

[1]*Georg-August-Universität Göttingen, Dept. for Crop Sciences: Tropical Agronomy, Germany*

[2]*International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India*

[3]*World Agroforestry Centre (ICRAF), Tree Diversity, Domestication and Delivery, Kenya*

[4]*Bioversity International, Nutrition and Marketing of Diversity Programme, Kenya*

Assessing food diversity can help to gain deeper knowledge on issues of conservation and use of agrobiodiversity (ABD) for food and nutrition security. Therefore, the objectives of this case study were to assess on-farm, market, and wild food diversity and to collect relevant information about its availability, accessibility and usage. The diversity of food species produced on-farm and collected in nearby wild habitats was recorded for 30 households in six villages. Two villages each were located in the humid upper midlands (UM1), sub-humid lower midlands (LM2), and transitional lower midlands (LM4) of the Western and Nyanza Provinces of Kenya. Additionally, ten surveys on key local markets were carried out during the short rainy season and at the end of the dry season. Tools for data collection included focus-group discussions (two per village; six with women and men each), individual household questionnaires including farm inventories in five households per village, transect walks for documenting wild food species, and market surveys. The highest on-farm mean food species richness was found in UM1 (17.4 species/farm) the lowest in LM4 (8.6) and an intermediate diversity in LM2 (10.2). The total food species number per zone was almost the same for LM2 (34 species in total) and LM4 (35) and was highest in UM1 (49). Although situated close to forest habitats, none of the respondents in UM1 reported collection of wild foods, whereas the majority of respondents in LM4 and LM2 collected fruits and insects from the wild (60 and 90 %, respectively). Initial analyses of the market survey indicate that the number of food items was lower in the dry season but such variations across season had a minor impact on food prices. However, prices as well as number of food items per market differed widely between the different agro-ecological zones for some products (e.g. sweet banana, potato, and fish). Further analysis will be performed to draw seasonal calendars and relate ABD to functional and dietary diversity. The data gathered will provide useful information for combined agricultural and nutritional approaches to promote and inform action for improving ABD levels, community livelihoods and family nutrition.

Keywords: Agro-biodiversity, food diversity, seasonal calendar, species richness

Contact Address: Aspasia Werner, Georg-August-Universität Göttingen, Dept. for Crop Sciences: Tropical Agronomy, Göttingen, Germany, e-mail: aspasia.werner@stud.uni-goettingen.de

Geographical Indications of Handicrafts: A Tool to Improve Livelihood and Protect Biodiversity in Remote Communities?

JOHANA PATRICIA MELGAREJO ARZUZA, ALESSANDRA GIULIANI
Bern University of Applied Sciences, School of Agricultural, Forest and Food Sciences (HAFL), Switzerland

As home of a great diversity of climates and cultures, Colombia has a high potential to protect geographical indication (GI) handicrafts linked to their origin through a combination of natural and human factors, attributing uniqueness to the product. Natural factors are derived from the variety of local ecosystems, such as the Amazon Basin or the high mountains of the Andean region. Human factors are derived from the traditional knowledge, local knowhow and cultural practices of the inhabitants, concerning the production and processing of handicraft products.
The promotion of GI certifications brings an important market differentiation value to the artisanal products, in order to be able to compete with industrial products. Further GI certifications allow to preserve traditional knowledge of handicraft products and can be used as a tool to protect the biodiversity trough a sustainable use of natural raw materials and production system to elaborate the handicrafts.
The field study carried out in 2013 and 2014 aims to analyse the production system of potential GI handicrafts and the current situation of their producing communities in rural areas, with the target to assess the possible benefits of an individual GI approach. The study involved direct interviews and surveys with key stakeholders, group discussions with associations of artisans as well as government officials and visits of the workshops and the raw material producers.
The research findings show a lack of structure and weaknesses of the national legal framework in Colombia. The producers are not benefiting from an added value of a GI certification due to missing management of the certification, limited collective action among associations and producers as well as an unsustainable use of natural resources for the production.
To reach an improvement of the livelihood of the artisans and protect the biodiversity, a strengthening of the national legal framework as well as an inclusion of environmental sustainability criteria for a sustainable utilisation of raw materials is strongly recommended. Further a rigorous management of the certification and a raise of the awareness among the producers on the certification guidelines are required.

Keywords: Biodiversity, *Brosimum rubescens*, *Calamagrostis effusa*, *Carloduvica palmata*, Colombia, geographical indication (GI), handicraft, human factor, natural factor, rural development

Contact Address: Johana Patricia Melgarejo Arzuza, Bern University of Applied Sciences, School of Agricultural, Forest and Food Sciences (HAFL), Laengasse 85, 3052 Zollikofen, Switzerland, e-mail: johana.melgarejoarzuza@students.bfh.ch

Farmers' Organisations in Nnindye, Uganda: Building Social Capital for the Conservation of Natural Resources

ANNA SNIDER[1], VINCENT CANWAT[2], NASHON MOGONCHI[3], NAWA MALUMO[4], ANDREAS DE NEERGAARD[2], NICOLE SIBELET[5]

[1]*Montpellier - SupAgro, France*

[2]*University of Copenhagen, Dept. of Plant and Environmental Sciences, Denmark*

[3]*Edgerton University, Kenya*

[4]*Makerere University, Uganda*

[5]*CIRAD, Innovation, France*

Farmers' organisations can influence members to effectively manage natural resources. Social capital built in these collective organisations has been identified as an important component of development. The aim of this research was to explore the link between social capital, density of collective organisations and effectiveness of these organisations on the effective management of community natural resources. In this study we analysed farmers' organisations in Nnindye, Uganda, which consist of Savings and Internal Lending Communities (SILCs) in conjunction with an agricultural development component. Members of these organisations tend a common banana plantation and sell the produce to partially finance a micro-credit scheme.

We found a high density of farmers' organisations in the area including a SILC/agricultural development scheme in every village. These farmers' organisations were formed and supported by international NGOs in the area with the goals of developing agriculture, alleviating poverty and empowering women. We found lack of trust to be an inhibiting factor to participation in farmers' groups as well as a threat to the sustainable management of common resources. Several non-group members cited corruption among group leaders as a reason for not joining farmers' organisations and some farmers had left corrupt groups because of exploitation of common biological resources by group leaders. This paradox of high densities of collective organisations with low levels of trust seems to contradict Putnam's Instrument which uses density of voluntary organisations as a proxy for social capital in a society. However we maintain that the density of voluntary farmers' organisations in the area was artificially high due to external support and not an accurate proxy for the social capital in this area. These farmers' organisations showed some potential for creating social capital among the group members, but we found some evidence that bonding rather than bridging social capital was being created in these groups with discrimination against out-group members. Despite these challenges, many of these farmers' organisations manage to provide incentives for farmers to conserve common resources and increase agricultural production through access to improved varieties and training in good agricultural practices.

Keywords: Farmers' organisations, resource conservation, social capital

Contact Address: Anna Snider, Montpellier - SupAgro, 34000 Montpellier, France, e-mail: anna.snider@cirad.fr

The Domination of Community-Based Decision-Making by Village Level Elites in Oil Palm Conversion in Borneo

MILJA FENGER, VICTOR SUAREZ VILLANUEVA

University of Copenhagen, Faculty of Science, Denmark

The forests of Southeast Asia are tremendously rich reservoirs of biodiversity, store large amounts of carbon and are home to a number of indigenous tribes. The oil palm, *Elaeis guineensis*, is grown in humid tropical regions and has recently begun to play a key role in the transformation of these forests. While some present this development as a way for poor farmers to escape poverty, others warn of extreme harm to local and global environments and human rights violations associated with the crop. In Sarawak, Malaysian Borneo, much of the land currently targeted for oil palm expansion is communally managed forest land and subject to 'native customary rights' (NCR). There is a lack of detailed information on the roles played by different stakeholders within communities with NCR land in decisions regarding land use.

We conducted a two-week field study in a village in Sarawak of 32 households which has recently leased several thousand hectares of their forested communal land for conversion to oil palm plantation. An interdisciplinary approach was applied using both natural and social science methods such as semi-structured interviews, questionnaires, PRAs, soil and water analysis. Our study sought to understand how social structures within the village impacted on the decision-making process regarding the plantation and what the consequences of this were on social relations and on aspects of the natural environment.

A key finding is that the access to information in the decision-making process appears to be connected to the distribution of both formal political power and informal power related to factors such as wealth, education level, and social status. Leasing the communal land has cemented already existing unequal wealth and power distributions and has caused a socially disruptive conflict within the village, involving a court case between family members and former friends. Furthermore the conversion to oil palm has resulted in degrading soil fertility and pollution of local rivers. Concern for the availability of natural resources for future generations was present among villagers, but opaque dissemination of information, government pressure and financial incentives for community leaders prevented these concerns from impacting on the final decision.

Keywords: Communal land, decision-making, deforestation, native customary rights, oil palm, Sarawak

Contact Address: Milja Fenger, University of Copenhagen, Faculty of Science, Copenhagen, Denmark, e-mail: miljafe@googlemail.com

Traditional Agroecosystems (SHAGRA) and New Approaches in Agriculture: The Case of an Indigenous Community in Pastos-Cumbal, Colombia

DEISY ROSERO

Indigenous Organization for Research ORII-Tierra y Vida, Crop Production Program, Colombia

Indigenous communities have been preserving traditional crops as a perpetuity element, thus their cropping method is the base of natural resources conservation in a productive systems according to their perception and worldview. The Indigenous Reserve of Gran Cumbal is located in southwestern Colombia – Nariño. The purpose of this study was to determine the influence of "Shagra" system in sustainable agriculture, food security and *in situ* conservation of agrodiversity. The "Shagra" systems from two territories, Boyera and Cuaical, were characterised using system's view. Species and varieties were identified taxonomically and their role in the agrosystem was recognised according to the use (cultivated or wild). It was observed that the traditional knowledge is used in the Shagra system by drawing an plant interaction and organisation that create a resilent system against negative effects of intensive agriculture. In this study, 79 species were found and clasified in two groups: group A- 44 cultivated species and group B,35 companion or wild species. In the cultivated species, we found that 58.7%were used as food, 28.3 % were medicinal and 13 % were magic-ritual. Of the companion or wild species, 42.2 % were used as forage, 28.9 % were medicinal, 20 % were tolerable and 8.9 % with other uses.Potato (*Solanum tuberosum* L.) had most of the diversity observed in several varieties, followed by oca (*Oxalis tuberosa* Mol.), quinoa (*Chenopodium quinoa* Wild.), olloco (*Ullucus tuberosus* Caldas) and maize (*Zea mays* L.). The Shagra system allows an appropiate interaction between technological intensity and receptivity; although food production is its main role, the presence of wild species confirms its role in biodiversity conservation.

Keywords: Agroecosystem, diversity, indígenous, shagra, traditional system

Contact Address: Deisy Rosero, Indigenous Organization for Research ORII-Tierra y Vida, Crop Production Program, Colombia, Colombia, e-mail: daroseroa@unal.edu.co

Species Diversity and Post-Harvest Practices on the Forest Edge Homegardens in Southwestern Uganda

CORY WHITNEY, JENS GEBAUER

Rhine-Waal University of Applied Sciences, Fac. of Life Sciences, Germany

Post-harvest losses (PHL) destroy between 20 and 60 % of the East-African food production, thus heavily contributing to the devastating nutritional situation. Homegarden species and their varieties are an important genetic pool for selecting species with high post-harvest performance. To screen for plant diversity and post-harvest handling, 34 forest edge homegardens in three villages of southwestern Uganda's Greater Bushenyi region were inventoried in 2014.

An initial assessment of garden diversity found that homegardens in Kinoko-A had a total of 54 plant species with 20 indigenous, Kinoko-B had 61 plants with 28 indigenous, and Remitagu 76 plants with 29 indigenous. Of the total 48 indigenous species found, 7, 10, and 10 plants were unique to Kinoko-A, Kinoko-B, and Remitagu, respectively. The most prominent species in Kinoko-A was amaranth (*Amaranthus dubius* Mart. ex. Thell), with an average of 493 individual plants per garden. Amaranth has a year-round harvest and is not stored. The most common plant in Kinoko-B was banana (*Musa accuminata* Colla (AAA Group)), with an average of 152 individuals per garden. Farmers had no post-harvest practices for bananas, which rot soon after maturity. In Remitagu the most common species was cassava (*Manihot esculenta* Crantz) with an average of 191 individuals per garden. Cassava is stored longer term and/or dried and made into a powder to mix in the common local dishes *Kalo* and *Posho*.

Gardeners indicated post-harvest practices for some plants in the homegardens (32, 37, and 44 of the plant species in the respective villages). The local Robusta variety of coffee (*Coffea canephora* P. var.) was cited for the most post-harvest practices; it is commonly dried in the sun before sale. Next most important were cassava and string bean (*Phaseolus vulgaris* L.) in Kinoko-A, chili (*Capsicum frutescens* L.) and cassava in Kinoko-B, and chili, and taro (*Colocasia esculenta* (L.) Schott) in Remitagu. Sun drying was the main practice employed by gardeners to preserve these plants, while some roots were also stored longer term.

Keywords: Agrobiodiversity, homegardens, post-harvest, Uganda

Contact Address: Cory Whitney, Rhine-Waal University of Applied Sciences, Fac. of Life Sciences, Marie-Curie-Straße 1, 47533 Kleve, Germany, e-mail: cory.whitney@hsrw.eu

Home Gardens and Nutrition Knowledge among Households in the Urban Areas of Morogoro, Tanzania

AARATI PILLAI[1], JOYCE KINABO[2], JOHANNES HERMANN[1], MICHAEL KRAWINKEL[1]

[1]*Justus-Liebig University Giessen, Inst. of Nutrition Sciences, International Nutrition, Germany*

[2]*Sokoine University of Agriculture, Dept. of Food Science and Technology, Tanzania*

Home Gardens (HG) are an ancient agricultural practice found in many countries worldwide. In the African household (HH), the HG is an important part of the unit since it contributes to the HH food security. Nutrition education is a tool which can be used to help the HH improve their diet quality. This study aimed at improving the diet quality through nutrition education.

A nutrition survey was undertaken in Oct. 2013 targeting 40 HH having HG in an urban area in Morogoro, Tanzania. HH and HG data were collected using a semi structured questionnaire. A vegetable frequency questionnaire was used to gather information on the HH vegetable consumption. A HH 24-h recall was collected for 3 consecutive days. Focus group discussions (FGD), participatory rural appraisal (PRA) and observations were used to collect qualitative data. Nutrition education sessions were also conducted for the participants.

The results show that the major motivation for cultivating HG was the need to provide vegetables for the HH (55 %) and as an income generation activity (22.5 %). Vegetable and fruit consumption were considered very important by 90 % and 85 % of the respondents respectively. Knowledge on vitamin A and iron was scored on a scale from 0 to 8. For vitamin A, 30 % of the respondents scored 8 and 25 % scored 1. For iron, 2.5 % scored 8 and 2.5 % scored 0. A significant correlation was observed between the education level of the respondent and the knowledge score for iron ($p = 0.004$), but not for vitamin A.

Preliminary FGD analysis shows that the commonly cultivated vegetables were sweet potato leaves, pumpkin leaves, okra and cassava leaves. The main reasons for cultivating these were the ease of cultivation, HH preference and a good yield through the year. Further data analysis is underway to determine associations between the variables and FGD data is being analysed using MaxQDA.

HG provides easy access to and helps increase vegetable consumption. Providing nutrition education to these families can help to improve the choice and combination of vegetables grown and consumed. This will help in improving the diet quality of the HH.

Keywords: Home gardens, nutrition education, vegetable consumption.

Contact Address: Aarati Pillai, Justus-Liebig University Giessen, Inst. of Nutrition Sciences, International Nutrition, Wilhelmstrasse 20, 35392 Giessen, Germany, e-mail: aaratipillai@gmail.com

Can Local Foods Improve Dietary Diversity? The Biodiversity for Food and Nutrition Initiative in Kenya

VICTOR WASIKE[1], TERESA BORELLI[2], DANNY HUNTER[2]

[1]*Kenya Agricultural Research Institute (KARI), Horticulture and Industrial Crops Division, Kenya*

[2]*Bioversity International, Nutrition and Marketing for Diversity Programme, Italy*

Kenya is rich in plant diversity. It is home to 7,500 plant species of which 475 are endemic. Despite this richness, most Kenyans rely on a handful of food crops for their sustenance. Kenyans consume very small amounts of fruits and vegetables at 40g per day, way below the WHO recommended intake of 400g per day. Maize, beans, banana, rice and potatoes make up the bulk of the daily energy requirements of a typical Kenyan household, yet many indigenous species have been shown to be nutritionally equivalent or superior than more commonly used crops, both in terms of energy and of the micronutrients they provide. Knowledge and policy gaps exist, however, in the occurrence and use of this biodiversity as well as in food composition data to demonstrate the nutritional importance of many of these underutilised species, which are more affordable and better adapted to the environments in which they grow. To close this gap, the Kenya Agricultural Research Institute (KARI) – executing agency of the Biodiversity for Food and Nutrition (BFN) initiative in Kenya, in collaboration with Bioversity International and relevant country partners – is documenting the current status of agricultural biodiversity in Busia County in Western Kenya. So far, surveys have shown the existence of rich biodiversity in the area – cultivated and wild staples, vegetables, fruits, small livestock and fish – but the effective reliance on very few species. Low dietary diversity is mostly due to changing eating habits/preferences and lack of access to good quality seed. A socio-economic survey identified the lack of organised market channels coupled with poor agronomic practices and limited knowledge surrounding the production, consumption and marketing of traditional crops as the main causes of food insecurity in Busia County. Results of socio-economic surveys and situational analysis will be presented.

Keywords: Agricultural biodiversity, BFN project, Kenya, local foods

Contact Address: Danny Hunter, Bioversity International, Nutrition and Marketing of Diversity Programme, Via Dei Tre Denari 472/a, 00057 Maccarese, Italy, e-mail: d.hunter@cgiar.org

Valuation of Environmental Role of *Acacia senegal* Tree in Gum Belt of Kordofan and Blue Nile Sectors, Sudan

MOHAMED EL NOUR TAHA[1], HATIM MOHAMED AHMED ELAMIN[2], MUNEER ELYAS SIDDIG[2], TAISSER H. H. DEAFALLA[3]

[1] *University of Kordofan, Forestry and Range Sciences, Sudan*

[2] *University of Kordofan, Gum Arabic Research Center, Sudan*

[3] *Technische Universität Dresden, Inst. of Photogrammetry and Remote Sensing, Germany*

Cultivation of *Acacia senegal* is a key component of sedentary farming systems across the gum belt in Sudan, which comprise in addition to the forestry component, crop farming and livestock raising. Gum arabic from *Acacia senegal* tree is major product of the rainfed agricultural sector; it is well perceived for its significant contribution to household income of gum farmers and to foreign exchange earnings of the country. Gum trees provide in addition, a wide range of valuable environmental benefits in form of anti-desertification insurance. They provide also fodder and fuelwood and contribute to increase in crop yield through nitrogen fixation. The study focused on environmental benefits of gum trees within most important producing areas of gum belt in Kordofan and Blue Nile Sectors aiming mainly to finding out values for non marketable goods and services provided by such a tree in terms of soil protection and restoration of soil fertility. Contingent valuation method, hedonic price and replacement cost technique using market-oriented prices were chosen to value environmental effects of gum trees on land quality and to determine share of the tree in carbon sequestration. The valuation process was based on estimating cost of the fertiliser equivalent to the amount of nitrogen provided by gum stands. The internal rate of return (IRR) for a 16-year rotation gum stand was calculated to be approximately 15.2 percent. It was found that gum stands can save considerable cost of supplying ammonia nitrate fertiliser equals to approximately US$ 78 per hectare annually. When ecological benefits and social values associated with gum tree cultivation were considered, the recalculated IRR for 16-year rotation gum stands jumped from 15.2 % to approximately 61 percent.

Keywords: Anti-desertification insurance, contingent valuation method, environmental benefits, gum arabic, gum belt, nitrogen fixation, replacement cost technique

Contact Address: Mohamed El Nour Taha, University of Kordofan, Forestry and Range Sciences, Algamaa Street, 00249 P. O. Box 160 Elobeid, Sudan, e-mail: nour54321@yahoo.com

Regeneration and Biomass Production of *Euphorbia stenoclada* in the Coastal Plains of Southwestern Madagascar

ONONAMANDIMBY ANTSONANTENAINARIVONY[1], HERINAVALONA RABEMIRINDRA[1], VONJISON RAKOTOARIMANANA[1], ROGER EDMOND[1], KATJA BRINKMANN[2], EVA SCHLECHT[3]

[1] *University of Antananarivo, Dept. of Biology and Plant Ecology, Madagascar*

[2] *University of Kassel, Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, Germany*

[3] *University of Kassel / Georg-August-Universität Göttingen, Animal Husbandry in the Tropics and Subtropics, Germany*

In the coastal part of southwestern Madagascar, herbaceous forage is scarce during the dry season. Despite this, transhumant herds of cattle and, to a lesser extent, small ruminants, from the even drier and politically insecure Mahafaly plateau populate the coastal plains during this period. Livestock keepers partly compensated the lack of herbaceous forage by harvesting branches of the succulent evergreen shrub *Euphorbia stenoclada* Baill. to feed the herds. In consequence, this endemic and protected (CITES Appendix II) plant is under very strong pressure.

To quantify the potential threat, shrub density and biomass yield of the succulent branches, shrub mortality due to harvesting, and rate of natural regeneration were determined in February 2014 in four villages of the western coastal plains. Along seven 2.5 km west to east transect lines established with a range of 2 km, 10 plots (30 m × 30 m) each were installed at 250 m distance to determine those variables.

The average density of *Euphorbia stenoclada* was 422 individuals per hectare with a dry biomass yield of potentially harvestable branches of 1 ton per hectare. Due to severe harvesting, a shrub mortality rate of 10 % was determined. After harvesting, however, in some stands a strong vegetative reproduction of the normally sexually reproducing species was observed, reaching up to 17 % of the newly growing individuals.

Keywords: Coastal bushland, dry season forage, *Euphorbia stenoclada*, regeneration

Contact Address: Eva Schlecht, University of Kassel / Georg-August-Universität Göttingen, Animal Husbandry in the Tropics and Subtropics, Steinstraße 19, 37213 Witzenhausen, Germany, e-mail: tropanimals@uni-kassel.de

Eradication of the Introduced and Potentially Invasive Species of *Calotropis procera* from Socotra

HANA HABROVÁ, PETR NEMEC, GABRIELA STEFLOVA
Mendel University in Brno, Dept. of Forest Botany, Dendrology and Geobiocoenology, Czech Republic

Calotropis procera, a shrub native in northern Africa and western and southern Asia, was introduced to Socotra for more than a century ago and is one of 87 non-native species of the local flora. Although in some places of the planet the species has an invasive character, on Socotra it is not considered as dangerous. Especially in the north of the island near the capital Hadibo it is however abundantly represented in home gardens and could have an impact on the local vegetation. Therefore, it was decided to develop a proposal for its eradication.

During the field investigation, it has been found that as long as the vegetation of the island is under intensive pressure of livestock, especially goats, *Calotropis procera* will not have an invasive character outside fenced gardens. After rainfall in areas with adult fruiting trees, a large number of seedlings germinate, but they are rapidly disappearing under the pressure of grazing. Although the species is considered as not very suitable for grazing, on Socotra in the vicinity of larger towns where there is such enormous pressure on food sources, animals feed on seedlings and achievable leaves of *Calotropis procera*.

Mature individuals from the wild would be appropriately reduced mechanically using common tools, mainly by cutting them because potential shoots would be rapidly be eliminated by grazing. Another way is the ringing of the tree, i.e. mechanical interruption of the phloem, which leads to exhausting and finally the dead of the tree naturally. To eradicate the species in home gardens, workshops and trainings of local people would be the first step. They will be informed about nature conservation and possibilities of removal of Calotropis trees, while motivation for such activities would be e.g. offering other useful species of native trees for cultivation.

Keywords: *Calotropis procera*, eradication, invasive species

Contact Address: Hana Habrová, Mendel University in Brno, Dept. of Forest Botany, Dendrology and Geobiocoenology, Zemedelska 3, 61300 Brno, Czech Republic, e-mail: habrova@mendelu.cz

Morphological and Physiological Leaf Traits in Ten Native Shrubs, Northeastern Mexico

HUMBERTO GONZALEZ RODRIGUEZ[1], ISRAEL CANTU SILVA[1], ROQUE G. RAMIREZ LOZANO[2], MARCO V. GÓMEZ MEZA[3], JUAN M. LÓPEZ HERNÁNDEZ[1]

[1]*Universidad Autónoma de Nuevo León, Fac. of Forest Sciences, Mexico*

[2]*Universidad Autónoma de Nuevo León, Fac. of Biological Sciences, Mexico*

[3]*Universidad Autónoma de Nuevo León, Fac. of Economy, Mexico*

Leaf morphological and physiological traits have key implications in the growth and development of plants in specific habitats. In this regard, the aim of this study was to assess the morphological and physiological leaf traits of ten native shrubs growing in the shrubland plant community known as Tamaulipan thornscrub, northeastern Mexico. Studied plant species were *Leucophyllum frutescens* (Scrophulariaceae), *Acacia rigidula* (Fabaceae), *Bumelia celastrina* (Sapotaceae), *Acacia berlandieri* (Fabaceae), *Cordia boissieri* (Boraginaceae), *Celtis pallida* (Ulmaceae), *Forestiera angustifolia* (Oleaceae), *Amyris texana* (Rutaceae), *Bernardia myricaefolia* (*Euphorbiaceae*), and *Lantana macropoda* (Verbenaceae). Morphological leaf traits such as leaf length (mm), leaf width (mm), leaf area (cm^2), leaf dry mass (g), and specific leaf area (cm^2/g) were measured. In each plant species, 5 randomly shrubs were selected and from each shrub 10 leaves were sampled. Physiological leaf traits such as predwan (Ypd) and midday (Ymd) leaf water potential (MPa) were measured in five different shrubs per species. Data were analysed using the Kruskal-Wallis non parametric test since they did not show a normal distribution and the assumptions of equal variance. Leaf trait differences among shrub species were validated using the Mann-Whitney U test with the Bonferroni correction method. The results of this study have shown that the morphological and physiological leaf trait values in this study are in agreement with documented figures. Besides, results have revealed that there were highly significant differences among shrub species for studied traits. Highly significant and positive relationships were detected among leaf traits according to the Spearman´s rank correlation analysis. Studied leaf traits play important roles in plant productivity and functioning responses to changes in soil resource availability and adaptation to abiotic stresses such as drought, heat and nutrient limitation.

Keywords: Environment, functional traits, leaf area, specific leaf area, Tamaulipan thornscrub, water potential

Contact Address: Humberto Gonzalez Rodriguez, Universidad Autónoma de Nuevo León, Fac. of Forest Sciences, Carr. Nac. No 85 km 145, 67700 Linares, Mexico, e-mail: humberto.gonzalezrd@uanl.edu.mx

Stem and Root Anatomy of Monocot Woody Plant *Dracaena cinnabari* Balf.f

IRENA HUBALKOVA[1], JINDRICH PAVLIS[1], GABRIELA VICHROVA[2]

[1]*Mendel University in Brno, Dept. of Forest Botany, Dendrology and Geobiocoenology, Czech Republic*

[2]*Sumava National Park and Protected Landscape Area, Dept. of Monitoring, Research Coordination and Documentation, Czech Republic*

The endemic plant *Dracaena cinnabari* (Dragon Blood Tree) on the Socotra Island, Yemen, is a spectacular relict of the Tethys tropical forest. It is a secondary thickening monocot with a special tree habitus and an umbrella-shaped crown. In spite of the high importance and vulnerability of the species, its anatomy has been poorly investigated. Therefore, research focused on the anatomy of secondary thickening parts has been carried out. The samples were collected from fresh wind-throw on the highland plateau Firmihin. Seventy permanent slides showing the cellular and vascular structure of stem and root in transverse, tangential and radial cuts were created in the dendrochronological laboratory of the Department of Wood Science at Mendel University in Brno, Czech Republic. The results prove uniqueness of the anatomical structure. Atypical secondary thickening is caused by lateral meristems and extra-fascicular cambium, which are generated in a zone that separates epidermis and parenchyma of the central cylinder. Stem and root mainly consist of lignifying parenchyma tissue. Concentric vascular bundles without sclerenchyma sheaths and line arrangement of parenchyma cells (visible on transversal cut) characterise stem parts created by cambial activity. Later growth pattern termed "diffuse secondary growth" can be described as a rapid multiplying of parenchyma cells and concentration of vascular bundles in the peripheral part of a stem. This results in forming a cavity in the central part of a stem. The anatomy of secondary thickening roots is very unusual, due to the absence of radial vascular bundles that typically occur in roots. Root anatomy show concentric vascular bundles and line arrangement of parenchyma cells surprisingly similar to stem structure. Knowledge of species anatomy leads to understanding the unexplored eco-physiological processes in the plant body. Such research of endangered *Dracaena cinnabari* deserves further study.

Keywords: Dragon Blood Tree, monocot, secondary thickening parts

Contact Address: Irena Hubalkova, Mendel University in Brno, Dept. of Forest Botany, Dendrology and Geobiocoenology, Zemedelská 3, 613 00 Brno, Czech Republic, e-mail: irena.hubalkova@mendelu.cz

Feeding Habits and Reproduction of the Corvine (*Cynoscion phoxocephalus*) in the Gulf of Tortugas

OLGA ROSERO, GIOVANI GÓMEZ
University of the Pacific, Aquaculture Program, Colombia

Colombian Pacific coastal waters have varied marine resources, making it privileged in terms of availability of aquatic resources. The feeding habits and reproductive biology were studied in corvine (*Cynoscion phoxocephalus*), between September 2013 and April 2014, in the Golf de Tortugas (Colombian Pacific).

Feeding habits according to the analysis of the feeding items in the stomachs of the fish were determined as follows: vacuity index (14 %), weight of the stomach content (2.5 g). The diet included fish, (86 %) and crustaceans (10 %). The morphological characters related to the feeding habits were: length of the gut (33 cm) and the mouth area, this was not significantly different between females and males. The dietary preference in the studied species was diverse, with a generalist feeding strategy that corresponds to carnivorous fish.

There were no significant differences between adult females (n= 281) and males (n=115) in body length, but body weight differed significantly between sexes. Maturity state was 71 % and the reproductive analysis showed high values from October to February, with a maximum in December (period of major spawns). The relative fecundity ranged between 3,093 to 10,820 eggs per gram of gonad. The histology analysis showed an asynchronous development, with a dominant gonad somatic stage. The parameters of growth obtained from 792 couples of data show that corvine present an isometric growth (b=3,2392) and the relationship between the total length (TI) and the total weight (Tw) is: Tw = 0.0046*TI 3.2392. The values of Von Bertalanffy´s equation were estimated as Lα (=74.49 cm; K= 0.359 cm year^{-1} and t_o= 0.806 year s.

Keywords: Colombian Pacific, corvine fish, diet, reproduction

Contact Address: Olga Rosero, University of the Pacific, Aquaculture Program, Street 1 # 66-79, 057 Buenaventura, Colombia, e-mail: lucia.rosero@yahoo.com

Climate change (mitigation and adaptation)

Analysis of Climate Change Related Challenges Experienced by Smallholder Potato Producers in Kenya

RAEL TAIY[1], KIBET NGETICH[2], CHRISTOPHER ONYANGO[3], RHODA BIRECH[4], BERNHARD FREYER[5], FOLKARD ASCH[6], PATRICK AWUOR OORO[7]

[1]*Ministry of Agriculture, Agricultural Sector Development Support Programme, Uasin Gishu County, Kenya*

[2]*Egerton University, Sociology and Anthropology, Kenya*

[3]*Egerton University, Agricultural Education and Extension, Kenya*

[4]*Egerton University, Crops, Horticulture and Soil Chemistry, Kenya*

[5]*University of Natural Resources and Life Sciences (BOKU), Division of Organic Farming, Austria*

[6]*University of Hohenheim, Inst. of Plant Production and Agroecology in the Tropics and Subtropics, Germany*

[7]*Kenya Agricultural Research Institute (KARI), Kari-Njoro, Kenya*

This paper discusses climate change related challenges experienced by smallholder potato producers in Kenya. The analysis is based on a review of scientific and grey literature from various sources and knowledge from national and international research and advisory organisations visited. To triangulate the findings, 30 smallholder potato farmers and 76 potato value chain stakeholders in Njoro Sub-County were engaged through participatory forums including a problem and objective tree analysis, qualitative interviews, focus group discussions and brainstorming in a Collective Learning Community. The study shows that although potato is a food security crop for many smallholders in Kenya and Njoro Sub-County in particular, the yields remain quite low due to limited access to clean planting material, increased post-harvest losses, moisture extremes and pressure from invasive pests and diseases. This may be attributable to variability in drought and rainfall patterns which typify failures in present adaptation practices under rain fed systems which are highly vulnerable to the effects of climate change. Potato pests and diseases are further complicated by failure to follow the correct crop rotation regime. This results in low incomes from potato and food insecurity. Rotation of potato with maize is common and this renders the soil more vulnerable as both crops reduce the humus content. Any efforts to address climate change challenges in smallholder potato production must be complemented by investments in rural transportation infrastructure and storage facilities. Despite the climate change mitigation and adaptation initiatives by the diverse actors and organisations in Kenya, awareness is still low especially in Njoro where there is high dependency on rain fed agriculture and climate sensitive natural resources. We conclude that there is a need for coordinated effort to enhance climate change awareness and improve farmers' capacities to reduce risk or make optimal use of climate variability by applying soil and water management adaptation strategies developed collaboratively by actors in collective learning processes.

Keywords: Climate change adaptation, collective learning community, potato, smallholder

Contact Address: Rael Taiy, Ministry of Agriculture, Agricultural Sector Development Support Programme, Uasin Gishu County, P.O. Box 9361, 30100 Eldoret, Kenya, e-mail: raeltaiy@gmail.com

Can *in-situ* Rainwater Harvesting or Conservation Tillage Practices Reduce Climate-Related Risk for Maize Based Systems in the Limpopo Province, RSA?

GABRIEL LEKALAKALA[1], MUNIR HOFFMANN[1], JUDE J.O. ODHIAMBO[2], KINGSLEY K. AYISI[3], ANTHONY WHITBREAD[4]

[1]*Georg-August-Universität Göttingen, Dept. of Crop Sciences - Trop. Agronomy, Germany*
[2]*University of Venda, Dept. of Soil Science, South Africa*
[3]*University of Limpopo, Risk and Vulnerability Science Center, South Africa*
[4]*International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India*

In Limpopo Province, small-scale farmers (SSF) are predominantly located in marginal areas and reliant on rainfall. Constraints related to SSF, dry-spells, erratic rainfall with high evaporative demand, limited possibilities for expanding irrigation, scarcity of prime farmland are amongst the reasons for low productivity and hence food insecurity. To mitigate inter-seasonal climate-related risk, SSF water productivity under rain-fed agriculture needs to be enhanced, and one way is through adoption of technologies for improving soil-water storage and usage such as *in-situ* rainwater harvesting (WHi). Numerous studies across southern Africa suggest that this technology has the potential to increase rainwater productivity and thereby increase yields and reduce risk of crop failure.

In this study, strategies for improving water-use-efficiency (WUE) and hence reduction of climate-induced risk on crop production were evaluated. Based on preliminary field data and literature, a series of tillage practice scenarios were developed to compare maize performance under WHi and conservation (Con) tillage practices with a conventional (Baseline) tillage practice as control. These practices were identified for their adaptive capacity to reduce climate-related risk. The scenarios were evaluated using APSIM model for a 49 year (1960–2009) daily climate record and linked with GIS to analyse the spatial-temporal interactions of climate, soil and management on crop performance.

Preliminary simulations of on-station (Polokwane -23.8700 S, 29.4500 E) field trials (basal N application 50 kg ha^{-1}) showed that on average, there was a small difference in grain yield (Con 1.69 and WHi 1.73 t ha^{-1}) between the two practices, whereas the Baseline treatment had a grain yield of only 0.96 t ha^{-1}. This difference between the two practices was largely due to differences in management (i.e. fallow-phase weeds control, residues and N-fertiliser application) rather than the effect of tillage. Con and WHi have a positive effect on the WUE, with a WUE of about 25 kg grain/ha/mm compared to the Baseline WUE of 17 kg grain/ha/mm. Further analysis of driest (Baseline 0.0, Con 0.9 and WHi 1.0 t ha^{-1}) and wettest (Baseline 1.9, Con 2.4 and WHi 2.6 kg ha^{-1}) year in 5 suggests that the use of WHi is likely to result in slightly higher yields compared to other practices.

Keywords: APSIM model, climate-related risk, conservation tillage, *in-situ* rainwater harvesting

Contact Address: Gabriel Lekalakala, Georg-August-Universität Göttingen, Dept. of Crop Sciences - Trop. Agronomy, Grisebachstrasse 6, 37077 Göttingen, Germany, e-mail: lekalakala@gmail.com

Determinants of Land Use Allocation in Rural Areas of Vietnam and Thailand

NGUYEN LOC DUC, RATTIYA S. LIPPE, ULRIKE GROTE

Leibniz Universität Hannover, Institute for Environmental Economics and World Trade, Germany

Land use allocation is an important driver of poverty alleviation, food security and environmental change in rural areas of developing countries. This paper aims at exploring potential determinants of land use allocation taking Vietnam and Thailand as case studies. The analyses build on data obtained from a comprehensive survey of 1,806 households in Dak Lak, Hue and Ha Tinh provinces, Vietnam, and 1,760 households from Buriram, Ubon Ratchathani and Nakhon Phanom provinces, Thailand, in 2013. By using Seemingly Unrelated Regressions (SUR), underlying factors were identified that drive land use choices in the selected regions. The perception of respondents to risks related to climate change (RRCC) has a significant impact in case of Vietnam reflected by a declining share of field crops and an increasing share in perennial crops. This pattern could be associated with a higher vulnerability of field crops to climate variability suggesting that perennial crops were considered as an alternative coping strategy to climate change related risks. In the case of Thailand, RRCC shows a positive impact on the share of forest areas indicating the regional awareness of forest conservation. Moreover, holding a land title provided further incentives for households to increase agricultural land areas. However, Vietnamese households favour perennial crops at the expense of field crops once land titles are secure. This could be explained by the excess supply of rice production leading to lower market prices, hence providing numerous incentives to invest into perennial cropping systems in the long-run. In contrast, Thai households holding a land title rather allocated their land parcels to field crops, especially paddy rice. This could be attributed to a national rice policy subsidy programme offering financial incentives to farmers, and also the fact that rice production is still a major income source of rural households in the study region. As a common phenomenon in both countries, poor infrastructure (e.g. dirt road, far distance to the district town, unavailability of public water supply) fostered a land allocation towards perennial crops especially in the upland areas.

Keywords: Climate change, land title, land use allocation, Thailand, Vietnam

Contact Address: Nguyen Loc Duc, Leibniz Universität Hannover, Institute for Environmental Economics and World Trade, Koenigsworther Platz 1, 30167 Hannover, Germany, e-mail: nguyen@iuw.uni-hannover.de

How Perceptions and Knowledge Can Lead the Process of Climate Adaptation Using Local Resources: Two Study Cases of Southern Brazil

MICHELLE BONATTI[1,2], MARCOS ALBERTO LANA[2], SANDRO LUIS SCHLINDWEIN[1], STEFAN SIEBER[3], ANA CAROLINA FEITOSA DE VASCONCELOS[1], ALFREDO FANTINI[1], FRIEDER GRAEF[2]

[1]*Federal University of Santa Catarina State, Brazil*

[2]*Leibniz-Centre for Agricultural Landscape Research (ZALF e.V.), Land Use Systems, Germany*

[3]*Leibniz-Centre for Agricultural Landscape Research (ZALF e.V.), Inst. of Socioeconomics, Germany*

In Southern Brazil, rural communities present a particular process of resources management to climate adaptation and to ensure food security. The objectives of this work are i) to determine the stakeholders perception of climate change and their social organisation, ii) to assess the impacts of climate scenarios and adaptation strategies on maize yield and iii) to identify the key elements responsible for driving the development and implementation of adaptation strategies considering local resources. The analysis of socio-economic aspects from the study sites Anchieta and Guaraciaba was based on strong participative stakeholder involvement, so as using data from official sources. Perception studies carried out involved the use of semi-structured interviews (n=25) and mapping of the social organisation of the rural population. Besides that, on-farm field experiments were done to run a crop model and assess the impact of climate change scenarios on maize yield (region main crop), so as to test adaptation strategies such as crop cultivar and planting date. The results i) indicate that all interviewed farmers perceived climate variation (and also the perceived change in climatic patterns) affecting significantly agricultural production during last twenty years, impacting directly on family income. The observation of changes and variation of climatic patterns (droughts, floods, frost) leaded to the development of local knowledge about how is possible to improve their live conditions despite climate adversities (using different strategies to reduce the susceptibility of agricultural systems). Also, regarding objective ii), depending on the climate scenario yields can be drastically reduced under the present management. When adaptation strategies such as locally adapted cultivars (landraces) and adjustment of planting date are used, losses can be reduced and even compensated. The main aspect to emphasise in terms of adaptation process iii) is the higher resilience of the crop landraces – developed and maintained as part of community's commitment to improve local resources efficiency. Finally, it was identified that the community's social organisation and social support network are the key elements responsible for the development and employment of local adaptation strategies. This autonomous and autochthonous decision making process ensured conditions that fostered the resilience of local agricultural systems.

Keywords: Climate change and variation, community based, local resources, participatory, resilience of agricultural systems

Contact Address: Michelle Bonatti, Federal University of Santa Catarina State, Florianopolis, Brazil, e-mail: michebonatti@gmail.com

Global Warming and the New Geography of Brazilian Coffee Production

HILTON PINTO, JURANDIR ZULLO JUNIOR, ANA MARIA AVILA

State University of Campinas - Unicamp, Center for Research in Meteorology and Climatology Applied to Agriulture - Cepagri, Brazil

Coffee culture in Brazil is characterised by plant species Arabica (*Coffea arabica* L.), prevalent in areas with mean annual temperatures between 18°C and 22°C and plants species Robusta (*Coffea canephora* Pierre) grown in areas with annual mean temperatures between 22°C and 26°C. Temperatures outside these limits, normally caused by heat waves, cause damage to the coffee crop due to floral abortion — temperature equal or higher than 33°C - or tissue death due to frost, when leaf temperature reaches $^{-3}$.5°C or 1.5°C in the meteorological shelter. The total rainfall varies from 1200 to 1400 millimeters with a dry interval in the winter, when the harvester occurs. A dry period of four or five month with water deficiency before flowering is favourably to better quality beans.

According to the five reports of the Intergovernmental Panel of Climatic Change (1990, 1995, 2001, 2007 and 2014) in the near future the global mean temperature is supposed to increase at least 2°C in the actual Brazilian cultivated areas and the total rainfall can increase about 15 % in the tropical area. Using the IPCC parameters, a new geography of coffee plantation in Brazil was simulated for the years 2030 and 2050, based on eco-physiological behaviour of plants and climatic adaptability of both species of coffee to new climate conditions that may prevail in the country, especially in the Southeast and South regions. The results showed a migration of coffee Arabica from Southeast to South of the country and a possibility of Robusta coffee cultivation in the Southeast. Nevertheless, to the year 2020 Brazil can lose about 10 % of the potential area for Arabica coffee.

Keywords: Arabica coffee, climate and coffee, coffee, coffee and global warming, coffee in Brazil, Conilon coffee

Contact Address: Hilton Pinto, State University of Campinas - Unicamp, Center for Research in Meteorology and Climatology Applied to Agriulture - Cepagri, Rua Andre Toselli 209 - University Campus Unicamp, 13083-886 Campinas, Brazil, e-mail: hilton@cpa.unicamp.br

The Effects of Management Practices on Soil Organic Carbon Stocks in Oil Palm Plantation

NIHARIKA RAHMAN[1], JAKOB MAGID[2], ANDREAS DE NEERGAARD[2], KEN GILLER[3], THILDE BECH BRUUN[1]

[1] *University of Copenhagen, Dept. of Plant and Environmental Sciences, Denmark*

[2] *University of Copenhagen, Dept. of Agriculture and Ecology, Denmark*

[3] *Wageningen University (WUR), Dept. of Plant Sciences, Plant Production Systems, The Netherlands*

Today about 20–25 % of anthropogenic CO_2 emissions are derived from land use changes and 90 % of these changes are taking place in the tropics, with Indonesia and Malaysia as hotspots. The dominant land use transition in these countries is the transition of different forest types to large scale oil palm plantations. It is hypothesised that soil organic carbon (SOC) stocks are significantly affected by management practices and more intensive oil palm plantation management systems like Best Management Practice (BMP) have faster C accumulation rates than smallholder oil palm production practices because of the faster growth and establishment of the oil palms and applying more organic residues like empty fruit bunches (EFB), decanter cake (DC), palm oil mill effluent (POME) and front stuck back to the fields. Therefore, the aim of this study was to investigate the soil organic carbon in the different management practice (BMP, Commercial practice and Smallholder practice) in palm plantation. Soil samples were collected from 0–5, 5–10 and 10–20 cm layer by 100 cm^3 soil core from BMP practice fields, commercial practice fields and small holder practice fields in Central Kalimantan and North Sumatra in Indonesia with three replicate profiles beneath the palm circle, harvesting path and inter-row position (where they apply most of the organic residues). SOC stocks in the soils were calculated according to the fixed-depth approach as well as according to the equivalent soil mass approach. The result showed that soil organic carbon (SOC) stocks are significantly affected by management practices. SOC from BMP fields are significantly higher than commercial practice fields and small holder practice fields. The result also showed that the amount of organic carbon is significantly higher in the inter-row position of the plantation than the palm circle and harvesting path of the plantation.

Keywords: Management practices, oil palm plantation, soil organic carbon

Contact Address: Niharika Rahman, University of Copenhagen, Dept. of Plant and Environmental Sciences, Thorvaldsensvej 40, 1871 Frederiksberg C, Denmark, e-mail: nira@plen.ku.dk

Effect of Water Erosion and Land Management on the Soil Carbon Stock of Intensive Rubber Plantation in Xishuangbanna, South-West China

HONGXI LIU, SERGEY BLAGODATSKIY, GEORG CADISCH
University of Hohenheim, Institute for Plant Production and Agroecology in the Tropics and Subtropics, Germany

Xishuangbanna, SW China, as the typical tropical rain forest region, has been dramatically changed in land use over the past 30 years. Rubber plantation combined with tea cultivation boosted from 1.3 % to 11.8 %, while deforestation decreased the forest cover from 69 % to 45 %. Land use transformation from forest to rubber leads to less litter layer and higher water repellency which both contributed to higher runoff revealing higher soil loss potential. Top soil loss due to water erosion is a major concern as it means losses of most fertile soil layers reach in carbon and nutrients determining soil quality and being an important factor in agricultural productivity. This study focuses on evaluating impact of water erosion on rubber plantations of different ages and identifying major factors affecting this process. The study was performed for three rubber plantations of different age: young with open canopy (2–3 years old), mid-age with almost closed canopy (8 years old) and old rubber with close and dense canopy (36 years old). Universal soil loss erosion (USLE) plots (3m*17 m) were built in each case to collect eroded soil and runoff. The collected sediments were analysed for its carbon content and texture. Components of local water balance such as throughfall, stemflow, total precipitation, rainfall intensity as well as ground cover were measured periodically to analyse the impact of different factors: canopy closure, rain and ground cover on soil and carbon loss in rubber plantation. Ground cover was measured every month. Carbon content, texture, bulk density and hydraulic conductivity of top soil of each site were analysed with core method sample collection. The trends of total precipitation and rainfall intensity of three sites were similar. Rubber plantation presented lower soil loss than local annual crop like maize but higher than rainforest. Mid-age rubber showed highest soil loss (2.69 t ha^{-1} a^{-1}) while old rubber showed lowest (0.54 t ha^{-1} a^{-1}). We conclude that soil loss during rubber plantation development is determined by canopy closure and ground cover which were closely related to land management. Based on this, better management and soil conservation can be proposed to improve ecosystem functions of rubber plantations.

Keywords: Intensive rubber plantation, land management, soil loss, water erosion

Contact Address: Hongxi Liu, University of Hohenheim, Institute for Plant Production and Agroecology in the Tropics and Subtropics, Stuttgart, Germany, e-mail: halcyon.lhx@gmail.com

Impact of Human Activities on Carbon Sequestration in a Semi-Arid Ecosystem of Northeastern Mexico

ISRAEL YERENA YAMALLEL, JAVIER JIMENEZ PEREZ, OSCAR ALBERTO AGUIRRE CALDERON

Universidad Autónoma de Nuevo León, Dept. of Silviculture, Mexico

One of the main risks that could endanger the permanence of carbon stocks in forests is the risk associated with the demand: when demand for agricultural and/or livestock is the main cause of deforestation. Carbon content in the aboveground biomass was estimated in different land use systems in abandonment in a fraction of Tamaulipan thornscrub. The study was conducted in the ecological reserve of the Forest Sciences Faculty, UANL, and in three contiguous areas, with secondary vegetation; study systems were primary scrub, traditional agriculture (24 years of abandonment), clearcut (27 years of abandonment) and grasslands (30 years of abandonment). For the estimation of the carbon content a systematic sampling design was used, in each area four sampling sites of 1,600 m^2. The primary scrub has the highest carbon content with 11.70 MgC ha^{-1} in the aboveground biomass, the value is drastically reduced in the recovered systems with 8.03 MgC ha^{-1} in grasslands, 4.67 MgC ha^{-1} in clearcut and 2.98 MgC ha^{-1} in traditional agriculture. Recovering the initial state of the primary scrub take many years, as can be seen in the grasslands system 30 years reaching only 68 % of what it had in reserves of primary scrub, with the carbon sequestration potential of 0.27 MgC ha^{-1} $year^{-1}$ which equals 0.99 $MgCO_2e$ ha^{-1} $year^{-1}$. Although also shown as a risk to ecosystem conversion to other uses and therefore with a high potential to develop into sources of emissions of CO_2 and other greenhouse gases, tamaulipan thornscrub has great potential as carbon storage, presents a wide capacity of mitigation due to its important surface.

Keywords: Aboveground biomass, carbon content, land use systems in abandonment, Tamaulipan thornscrub

Contact Address: Israel Yerena Yamallel, Universidad Autónoma de Nuevo León, Dept. of Silviculture, Linares, Mexico, e-mail: yamallel@hotmail.com

Effect of Nitrate Supplemented to Diets Differing in Concentrate to Forage Ratio on Methane Production *in vitro*

ANDRESSA NATEL[1], RAFAEL CANONENCO ARAUJO[2], TIAGO PRADO PAIM[1], MARIA REGINA SANTOS RODEIRO PEÇANHA[1], CARINA NAZATO[1], ADIBE L. ABDALLA[1]

[1] *University of São Paulo, Centre for Nuclear Energy in Agriculture, Laboratory of Animal Nutrition, Brazil*

[2] *Grasp Ind. & Com. Ltda, Division of Research and Development, Brazil*

Dietary nitrate has been gaining attention due to its persistent methane mitigation and the objective of this study was to evaluate the effects of encapsulated nitrate as soybean meal replacer in diets contrasting in concentrate:forage ratio on ruminal fermentation and methane production by using the *in vitro* semi-automatic gas production technique. This study was conducted at Laboratory of Animal Nutrition, CENA/USP, in Piracicaba, São Paulo, Brazil. A randomised complete block design in a 2×4 factorial arrangement with two types of diet (20:80 and 80:20 concentrate:forage ratio) and three levels of encapsulated nitrate inclusion (0, 1.5, 3.0, and 4.5 % in dietary DM) was applied. There were four different inoculums, each inoculum considered as a block. Encapsulated nitrate replaced soybean meal to achieve isonitrogenous diets (13 % CP). After 24 h of incubation, there was a diet $\times$ nitrate interaction ($p < 0.05$) for methane production (mL/g OM degraded and mL/g NDF degraded). Diets with 20 % concentrate reduced ($p < 0.01$) the gas production and methane by 58 % and 62 %, respectively, when compared to the contrasting diets. There was a linear reduction in CH_4 production with addition of encapsulated nitrate to both diets, reaching a reduction of 60 % when comparing the contrasting diets with 4.5 % and 0 % of encapsulated nitrate. Encapsulated nitrate didn't affect degradability of organic matter, so that increasing the nitrate content did not affect the availability of the substrate for fermentation. The replacement of soybean by encapsulated nitrate in protein equivalent was able to reduce the CH_4 emission, particularly in diets with 20 % concentrate without affecting the degradability of organic matter.

Keywords: Gas production, greenhouse gas, methanogens, rumen fermentation

Contact Address: Andressa Natel, University of São Paulo, Centre for Nuclear Energy in Agriculture, Laboratory of Animal Nutrition, Regente Feijó 2166, 13460-580 Piracicaba, Brazil, e-mail: natel@cena.usp.br

Milk Fatty Acids Relationships with Methane Emissions from Dairy Cattle: A Step Beyond Predictions Models

JOAQUÍN CASTRO-MONTOYA[1], VEERLE FIEVEZ[2], NICO PEIREN[3], BERNARD DE BAETS[4], SAM DE CAMPENEERE[5]

[1]*University of Hohenheim, Animal Nutrition and Rangeland Management in the Tropics and Subtropics, Germany*

[2]*Gent University, Dept. of Animal Production (Lanupro), Belgium*

[3]*Institute for Agriculture and Fisheries Research, Belgium*

[4]*Gent University, Dept. of Applied Mathematics, Biometrics and Process Control, Belgium*

[5]*Institute for Agriculture and Fisheries Reserach, ILVO, Belgium*

Around the world, growing demand for dairy products is changing milk production towards increased intensity and its concomitant changes in greenhouse gases emissions, which should be quantified and managed accordingly. Particularly for methane (CH_4), several approaches have been used to quantify/estimate emissions from cattle. Milk fatty acids (MFA) have been previously used to develop predictive models for CH_4 from dairy cows. However, small data sets and low variability prevent these models from accurately predicting CH_4 under more general conditions. In this study, a data set containing 145 observations from 9 experiments with dairy cows was used to develop models to predict CH_4 expressed in four functional units (g/d, g/kg DMI, g/kg milk and g/kg BW0.75/d) and to explore the ability of MFA to differentiate high from low CH_4-emitter animals. A generalised linear mixed model was fitted to the data, and the variance explained by fixed (marginal R^2(m)) and random (conditional R^2(c)) effects were calculated for model evaluation. Variance explained by MFA (R^2(m)) ranged from 0.19 (g CH_4/kg BW0.75/d) to 0.55 (g CH_4/kg DMI). Standardized coefficients showed that C17:0 and cis-9 C17:1 are highly relevant for CH_4 prediction. Furthermore, the Gini coefficient and Lorenz curve, parameters normally applied in economics, were used to represent the distribution of MFA and its relationship with CH_4. Gini coefficients for daily CH_4 and CH_4 relative to DMI were calculated for subsets of the data according to their cumulative abundance (below 0.625 g/100 g MFA (Group 0.625); between 0.625 and 2.5 g/100 g MFA (Group 2.5); between 2.5 and 10 g/100 g MFA (Group 10); above 10 g/100 g MFA (Group 100)). Methane measurements were divided into HIGH, MEDIUM and LOW. For daily CH_4, Gini coefficients of MFA profiles in the category HIGH were different from the other categories for Group 10 and Group 0.625. For CH_4 relative to DMI, category HIGH had a higher Gini coefficient for every group, with greater differences than those found for daily CH_4. Milk FA hold a modest potential to predict amounts of CH_4 emitted by dairy cows, but they might have potential to identify high from low emitter animals.

Keywords: Dairy, methane, milk fatty acids, prediction

Contact Address: Joaquín Castro-Montoya, University of Hohenheim, Animal Nutrition and Rangeland Management in the Tropics and Subtropics, Fruwirthstrasse 31, 70599 Stuttgart, Germany, e-mail: jcm@uni-hohenheim.de

How to Reduce Greenhouse Gas Emissions from Crop Production in the North China Plain – A Farmer's Perspective Analysis

NAN HA[1], TIL FEIKE[2,1], ENNO BAHRS[1]

[1] *University of Hohenheim, Inst. of Farm Management, Germany*
[2] *Julius Kühn-Institut (JKI), Federal Research Centre for Cultivated Plants, Inst. for Strategies and Technology Assessment, Germany*

Input intensification has for a long time been China's strategy to increase crop production and satisfy its people's growing food demand. However, in recent years excessive input levels have been reached, resulting in an ever increasing emission of greenhouse gases (GHG) by China's agricultural sector and increasing cost of crop production for farmers. To be able to develop suitable strategies to decrease both GHG emissions and costs of crop production a life cycle assessment approach was applied on a primary farm data set of 65 wheat and maize producing households from Hebei province in northern China. On average 4107 and 3185 kg CO_2-equivalent GHG-emissions per hectare were released into the atmosphere from wheat and maize production, respectively. The life cycle cost (LCC) accounted for 1176 US$ per hectare in wheat and 1190 US$ per hectare in maize production. Distinct farming practices of the 65 households caused a wide range in the environmental and economic LCA results. Stepwise multiple linear regression (SMLR) was adopted to identify input factors of production systems which explain the variances on environmental and economic performance of crop production among sampled households. The two factors nitrogen (N) input and electricity used for irrigation explained 78 % and 80 % of the difference in GHG emission in wheat and maize production, respectively. Electricity for irrigation and labour were the most significant factors explaining the differences on LCC. To improve crop production with regard to GWP and economic costs it is therefore recommended focusing on N input, electricity for irrigation and labour as key target areas.

Keywords: China, crop production, greenhouse gas emission, life cycle assessment, regression analysis

Contact Address: Nan Ha, University of Hohenheim, Inst. of Farm Management, Stuttgart, Germany, e-mail: nan_ha@uni-hohenheim.de

Changed Weather Pattern and the Impact on Feed Security for Livestock

AMELIE FRITZ[1], REGINA BIRNER[1], THANAMMAL RAVICHANDRAN[2]

[1] *University of Hohenheim, Inst. of Agricultural Economics and Social Sciences in the Tropics and Subtropics, Germany*

[2] *International Livestock Research Institute (ILRI), India*

India is the leading milk producer in the world with regard to smallholder farmers. Especially for women, milk production is an important way to earn an additional regular income and improve household food security. As India's milk production is subject to climate change, smallholder dairy farmers will have to find strategies to cope with this change to secure their livelihoods.

This study aimed to identify and analyse the coping strategies of smallholder dairy farmers in Uttarakhand, Northern India. Available climate data was analysed to establish the change pattern of rainfall and temperature for past 3 decades. To analyse farmers' perceptions regarding climate change and their coping strategies, qualitative research methods, in particular participatory rural appraisal (PRA), were combined with a quantitative survey with 120 households. The data analysis includes a comparison of farmers' perception and available climate data and an assessment of the farmers' coping strategies.

Results of this study show that farmers in the study area consider climate changes as a main factor which affects the availability of fodder. 90 % of the questioned households think that there is an impact of weather on the feeding pattern. The recorded variations in weather pattern include insufficient and untimely rains along with high temperature. The variations in this climate reduced the availability of fodder and deteriorated its quality; and also there is a decreased biodiversity of fodder species. This effect is same for all the Land holding categories and also same for both the regions studied. The workload mainly for women is rising because more time is needed for fodder collection as the collected fodder is contributing more than 50 % of feed. Some of the coping strategies were buying fodder from others, renting additional land or introduction of new grass species in their private grass land or cultivated land. Since land is a limiting factor in these hilly areas, other ways are explored by the farmers to prevent wastage of fodder. In this respect the use of feed troughs and chaffing fodder are seem to be promising approaches.

Keywords: Climate change, feed security, livestock

Contact Address: Amelie Fritz, University of Hohenheim, Inst. of Agricultural Economics and Social Sciences in the Tropics and Subtropics, Stuttgart, Germany, e-mail: amelie.fritz@gmail.com

It's a Matter of Strategic Knowledge: Adaptation Measures Increase Agricultural Systems Resiliency Against Climate Change

MARCOS ALBERTO LANA[1], FRANK EULENSTEIN[1], ANGELIKA WURBS[1], MICHELLE BONATTI[2], STEFAN SIEBER[3], SANDRO LUIS SCHLINDWEIN[2]

[1]*Leibniz-Centre for Agricultural Landscape Research (ZALF e.V.), Land Use Systems, Germany*

[2]*Federal University of Santa Catarina State, Brazil*

[3]*Leibniz-Centre for Agricultural Landscape Research (ZALF e.V.), Inst. of Socioeconomics, Germany*

Agricultural production is of major interest in a world that will require doubling the food production in the next 40 years without significantly increasing the area dedicated for crops. Besides this, climate change and variation are considered major threats to the long-term resilience of agricultural systems. Studies related to climate change are usually done for individual sites and cultivars. Although the information generated is significant, it cannot be extrapolated to large and complex regions. To obtain more precise assessments about the impact of climate change and respective adaptation strategies, field experiments and simulations – using DSSAT (CERES-Maize model) – were done for maize in the Santa Catarina State (>580000 ha cultivated, 3,69 million tons), Southern Brazil. The objectives are to assess, at field and regional level, i) the impact of climate scenarios on maize production and ii) to quantify the buffer effect of strategies such as planting date and cultivar. The fields identification was done using satellite imagery coupled with in-field assessments and census data, allowing satisfactory spatial refinement. This information was attached to soil maps (1:250000 scale) and weather information for running simulations and validating CERES-Maize. Several regional circulation models (RCM) were tested in order to identify the ones that best represent past yields in target regions. An ensemble of four RCMs (LMDZ+IPSL+RCA2+RCA3) was selected based on the ability to mimic the 1990–2010 yields. After validation of the crop model, RCMs and regionalisation, simulations for 2012–2040 were run using i) actual agronomic management and ii) combinations of cultivar and planting date as adaptation strategies. Depending on the field location, the impact on maize yields ranged from -60 % to +20 %. The overall impact without adaptation strategies resulted in a reduction of the 13,49 % in maize production (from 3,69 to 3,19 million tons). When adaptation measures are employed, local yields changes ranged from -12 % to +40 %, and overall production increases by 15 % (to 3,87 million tons). The results indicate that coupling best cultivar and planting date at local level are a strategic knowledge that not only buffers the eventual deleterious impacts of climate scenarios, but also increases overall maize production.

Keywords: Adaptation strategies, adapted cultivar, landraces, local knowledge, maize production, planting date

Contact Address: Marcos Alberto Lana, Leibniz-Centre for Agricultural Landscape Research (ZALF e.V.), Land Use Systems, Eberswalder Str. 84, 15374 Müncheberg, Germany, e-mail: lana@zalf.de

The Economic Contribution of Agricultural No Cost Adaptation Strategies to Cope with Climate Change

MOHAMMADREZA NAZARI[1], SAYYED SAFDAR HOSSEINI[2], HOUMAN LIAGHATI[1]

[1]*Shahid Beheshti University, Institute of Environmental Science, Iran*
[2]*Tehran University, Dept. of Agricultural Economics, Iran*

Although the nature and size of climate change effects on the physical variables of water resources and agriculture have been well studied, its economic perspectives and the role of adaptation strategies has been less studied empirically. In this study modeling is done of the real economic behavior of stakeholders in agriculture and its integration with socio-economic and climate change scenarios in Zayendeh-Rud river basin of Iran. Achievement of these was pursued through implementation and linkage of weather generator models, hydrology neural networks, crop-water response functions and economic optimisation models of positive mathematical programming (PMP). In this modeling framework, the role of two no cost adaptation strategies in agriculture including optimal schemes of crop irrigation and cropping pattern decisions in mitigation with climate change impacts were investigated. Results showed that by mid-century, climate change will result to reduce precipitation and increase temperature parameters in the Zayendeh-Rud water basin. The direct result of these changes will be reduction of basin water resources by 4.3 and 8.1 percent compared to the base scenario up to 2040 and 2070, respectively. On the other hand, temperature increases will cause higher crop evapotranspiration and water demand. With no adaptation policy, the consequences of this change will be reduction of cultivation area, production and farmers income. However, the results of economic model showed that through implementation of an optimal cropping pattern and by choosing optimal water irrigation schemes good opportunities can be provided to deal with increasing water scarcity and higher temperature due to climate change. Hence, this methodology can also be used to design strategic plans for regional cropping patterns and crop irrigation schemes in other watersheds.

Keywords: Adaptation strategies, agriculture sector, climate change, Zayandehrud river basin

Contact Address: Mohammadreza Nazari, Shahid Beheshti University, Institute of Environmental Science, Daneshjoo Streeteivn, Tehran, Iran, e-mail: nazari_eco@yahoo.com

Climate Change in Agro-Forestry Systems: Farmers Perception and Adaptation Strategies Efficiency in the Northern Shea-Parks, Benin, West-Africa

FREDDY NOMA[1,2], AFOUDA JACOB YABI[2], PAUL CESAIRE GNANGLE[3], PROSPER HOUESSIONON[4], SIEGFRIED BAUER[1]

[1]*Justus-Liebig University Giessen, Inst. of Farm and Agribusiness Management, Germany*

[2]*University of Parakou, Dept. of Agricultural Economics and Rural Sociology, Benin*

[3]*National Institute of Agricultural Research (INRAB), Benin*

[4]*Program of Agricultural Policy Analysis (PAPA), Benin*

Shea trees (*Vitellaria paradoxa*) grow throughout West-Africa. This vegetative formation has been used for centuries by African farmers to plant crops and benefit from the land caring properties of the Shea trees. In this system, farmer perception refers to climate events, climate related damages on Shea trees and farming systems. Therefore, climate change perception is split into perceived (1) climate change events; (2) environment damages including damages on Shea trees and farming systems. Likert-type three points scale; unequal weighting and linear aggregation methods computed the corresponding indexes. The study was conducted in the Shea-parks of the northern part of Benin. The quantification of perception intensity gives the indexes: climate change events 1.32($\pm$0.23) out of 1.47 and environment damages 3.34 ($\pm$0.58) out of 4.12. These results indicate that farmers know that their livelihoods are at stake. Moreover, the sense of threat is greater for perceived environment damages through bad quality of Shea-nuts, Shea trees delay maturation; and smaller size of tubers, ears or capsules, modification of crops vegetative cycle, etc. Understanding the risk they encounter, 69.91 % of the surveyed farmers adapt using re-sowing (69.91 %), re-ploughing (57.36 %), prayers (21.43 %), traditional rituals (39.39 %), off-farm activities diversification (45.24 %) and reforestation (35.50 %). The adaptation strategies identified, was regressed on the Total Productivity Factors (TPF) index to capture their effects on agroforestry systems economic efficiency. The system is economically efficient with a TPF index 1.53 ($\pm$1.27) on average. The index is significantly affected by re-sowing, re-ploughing, traditional rituals and off-farm activities diversification. Among these strategies, only increases in the re-ploughing frequency and off-farm activities diversification have a positive effect, respectively, on Shea-parks economic efficiency. Moreover, the Logit model reveals that only Shea trees density affected negatively both strategies; and farmer gender affects negatively off-farm activities diversification. Therefore male household head, having more than 20 Shea trees per hectare is likely not to apply these two adaptation strategies. Indeed, Shea nuts trade net revenue 18287.87 ($\pm$16869.45) Fcfa per month in harvest times, may compensate farmers that do not practice re-ploughing and off-farm activities diversification as climate change adaptation strategies.

Keywords: Adaptation strategies, climate change, economic efficiency, perceptions, Shea-parks

Contact Address: Freddy Noma, Justus-Liebig University Giessen, Inst. of Farm and Agribusiness Management, Giessen, Germany, e-mail: orounoma@yahoo.fr

A Sustainability Analysis of Observed Climate Change Adaptation Strategies in Maize Farming in Northern Benin (West Africa)

ROSAINE NERICE YEGBEMEY[1], AFOUDA JACOB YABI[2], SIEGFRIED BAUER[1]

[1] *Justus-Liebig University Giessen, Inst. of Farm and Agribusiness Management, Germany*

[2] *University of Parakou, Dept. of Agricultural Economics and Rural Sociology, Benin*

The issue of sustainable adaptation to climate change is viewed like a window towards a long-term future for agriculture. However, little is known on the extent to which observed climate change adaptations could ensure a sustainable agriculture. In this context, the main objective of the study was to analyse relationships between observed climate change adaptations as developed by farmers and the sustainability of their production systems. Accordingly, a Participatory-Indicators-Based (PIB) approach was used to measure agricultural sustainability at the farm level. Then, a Tri-variate Tobit regression model was used to analyse the main drivers of the measured sustainability levels, including the observed climate change adaptations as explanatory variables. The data collection was conducted by survey methods on 336 maize producers randomly sampled and interviewed based on a questionnaire. The results highlighted that maize farming in the study area presented weaknesses in the economic and social spheres but positively scored in the environmental area. Furthermore, a positive and strong correlation was found between economic and social dimensions of sustainability and weak negative correlations between environmental and economic dimensions of sustainability on the one hand, and environmental and social dimension of sustainability on the other hand. Farmers' socio-economic characteristics such as contact with extension services, organisation membership, access to credit, farm size, and observed climate change adaptations such as on-farm diversification, land use changes, and other adaptations were found to be the major driving forces underlying the sustainability level of maize farming systems. Among the observed climate change adaptations, on-farm diversification and land use changes strategies were found to be sustainable options whereas the group of other adaptations appeared to be an unsustainable option.

Keywords: Adaptation strategies, Benin, climate change, maize farming, sustainability

Contact Address: Rosaine Nerice Yegbemey, Justus-Liebig University Giessen, Inst. of Farm and Agribusiness Management, Senckenbergstrasse 3, 35390 Giessen, Germany, e-mail: yrosaine@hotmail.fr

Knowledge Management on Climate Change Adaptation: Communication and Learning Structures in Ethiopia

MAXI DOMKE, JÜRGEN PRETZSCH

Technische Universität Dresden, Inst. of International Forestry and Forest Products: Tropical Forestry, Germany

Knowledge management is a challenge for climate change adaptation. Abundant knowledge is available within scientific and traditional knowledge systems. But this expertise is not interlinked and communicated effectively for a successful implementation of local adaptation strategies.

This study contributes to the understanding and assessing of knowledge management on climate change adaptation at the local level particularly in Ethiopia. The research's objectives are (1) the identification of stakeholders and their strategies, (2) the analysis and comparison of prevailing knowledge systems and their compatibility, and (3) the investigation of endogenous perspectives on social, cultural and socio-economic components influencing the effectiveness of knowledge processes.

In the initial baseline study that was carried out in 2013 three instruments were used: a situation, stakeholder and basic social network analysis. Data were collected by reviewing national documents, conducting 15 key informant interviews at the national and regional level as well as 54 semi-structured questionnaires with governmental, non-governmental stakeholders and communities in two districts. Open questions allowed capturing *in situ* aspects that serve to complement indicators analysing knowledge transfer and exchange in detail.

Preliminary findings show idle potentials that can contribute to the enhancement of the knowledge flow. The collaboration of the public and private actors on environmental and livelihood issues is mainly focused on administrative aspects. Main sources for climate related information on the district and village level are governmental authorities and broadcasting whereby especially research institutions are marginalised. Due to gender-related cultural patterns women have limited access to information even though they play an important role in the knowledge transfer within the community.

By shifting the focus to more conceptual and participatory methods the learning effect is likely to increase. Development Agents (governmental extension worker) play a crucial role in the communication and information network of community and local government that can influence local decision making. Their working approaches need attention. For the accomplishment of comprehensive activities at the local level a functioning infrastructure as well as necessary skills and capacity have to be built to ensure an enduring knowledge flow and the sustainability of long-term strategies.

Keywords: Adaptive capacity, extension, knowledge systems, social capital

Contact Address: Maxi Domke, Technische Universität Dresden, Inst. of International Forestry and Forest Products: Tropical Forestry, Pienner Straße 7, 01737 Tharandt, Germany, e-mail: maxi.domke@tu-dresden.de

Supporting the Global Implementation of REDD and FLEGT

PREM RAJ NEUPANE, MICHAEL KÖHL, DANIEL PLUGGE

University of Hamburg, Inst. for World Forestry, Germany

Despite the numerous forest policy and forest management initiatives on local, regional and global level, deforestation, forest degradation and illegal logging have been continuing at an alarming rate. To address this, an initiative of the EU called "Forest Law Enforcement, Governance and Trade" (FLEGT) and United Nations' "Reducing Emissions from Deforestation and forest Degradation in developing countries" (REDD) are currently designed and put into action. These two initiatives comprised of overlapping objectives, closely linked working issues, identical stakeholders and share a common ultimate target. Together with numerous other initiatives, such as certification schemes (FSC, PEFC) or guidelines for sustainable tropical forest management (ITTO, CBD), this situation calls for the harmonisation of their aims and objectives and the elaboration of their synergies. Therefore, research is needed to analyse the interactions between the international regimes at national and international level.

In response, the European Forest Institute (EFI) established a Project Centre- Supporting the Global Implementation of REDD and FLEGT (SURF). The initiative aims at research, development, demonstration and dissemination (RDD&D) in contemporary forestry issues (such as sustainable forest management, prevention of illegal logging and trade in illegal timber) and climate change issues, as well as foresight and knowledge transfer. These researches contribute to develop science based approaches of measurement, reporting and validation, design of REDD and FLEGT mechanisms, and certification in a multi-disciplinary environment. The Center provides an information platform for its partners, EFI Member Countries, and member organisations; and provides an interface between the SURF user and research communities.

In the next five years (2014–2018), SURF activities are envisaged to contribute significantly to an improved conceptual and methodological integration of REDD and FLEGT in the broader context of sustainable development, and place forests high on the international research and policy agendas, especially in relation to environment, economy, agriculture, energy and sustainable landscapes.

The proposed presentation is intended to give an overview of the Project Center. We believe, such a presentation will be of high value to the Tropentag 2014 audience as the Center directly responses to the overall conference theme of "Bridging the gap between increasing knowledge and decreasing resources".

Keywords: Climate change, FLEGT, project centre, REDD, SURF, sustainable forest management

Contact Address: Prem Raj Neupane, University of Hamburg, Institute for World Forestry, EFI - Project Center SURF, Leuschner Str. 91, 21031 Hamburg, Germany, e-mail: neuprem@gmail.com

The Power Dynamics among Indonesian State Agencies: Examples from the REDD+ Program and the One Map Initiative

AGUNG WIBOWO, LUKAS GIESSEN

Georg-August-Universität Göttingen, Chair Group of Forest and Nature Conservation Policy, Germany

The Indonesian Ministry of Forestry, a state agency traditionally responsible to manage around 130 million hectare or two-thirds of the country's land, is challenged to accommodate upcoming claims from both domestic and international levels, especially including political tasks relating to global climate change and REDD+ policy. These new forest-related tasks result in additional competition for competencies, staff and resources between the Ministry of Forestry and other established or newly created state agencies. We hypothesise that there has been a decrease in power of the Ministry of Forestry due to national and international influences. The theory of power and the theory of bureaucratic politics are used to study these processes and to reveal the power dynamics among the Ministry of Forestry and other state bureaucracies in two selected cases, viz. the REDD+ Program and One Map Initiative. The results show, first, the power of the Ministry of Forestry has been declining and must now be shared with other agencies. Agencies gaining power at the cost of the Ministry of Forestry in both cases are the Presidential Delivery Unit for Development Monitoring and Oversight (UKP4), REDD+ Agency, the Ministry of Agriculture, and the Ministry of Environment. The National Council on Climate Change (DNPI) and the National Planning Agency (BAPPENAS) slightly gain power through the REDD+ Program, while Geospatial Information Agency (BIG) and the Ministry of Energy and Natural Resource gain through the One Map Initiative. Second, the REDD+ Program seems to be a symbolic policy since the goals are too ambitious and hard to be implemented on the ground, no leading agency responsible to succeed them, and the policy is constructed on a weak legal base. Third, the aim of the One Map Initiative is technically achievable, but facing severe conflicts of interests from local governments and sectorial state agencies involved. Production oriented state agencies will gain much benefit whereas conservation interest will be defeated. Fourth, implementation of both policies is facing heavy challenges since the Ministry of Forestry who embraces long-term information on forests and has experienced staff on the ground is not involved in agenda-setting and formulation of both policies.

Keywords: Coercion, incentives, information, one map initiative, power dynamics, REDD+ program, state agencies

Contact Address: Agung Wibowo, Georg-August-Universität Göttingen, Chair Group of Forest and Nature Conservation Policy, Büsgenweg 3, 37077 Göttingen, Germany, e-mail: agung.wibowo@stud.uni-goettingen.de

Linking REDD+ with SFM – A Case Study from the Fiji Islands

MICHAEL MUSSONG[1], SETAREKI QALIDUADUA[2]

[1]*Eberswalde University for Sustainable Development, Fac. of Forest and Environment, Germany*

[2]*Fiji Forestry Department, Forestry Research Division, Fiji*

REDD+ (Reducing Emissions from Deforestation and Forest Degradation) is an emerging mechanism, designed to offer incentives to conserve and enhance forest carbon stocks in developing countries. Sustainable forest management (SFM) is one out of five eligible activities under the REDD+ scheme. Regarding a community orientated SFM-development Fiji is a leading country in the South Pacific. To develop a SFM-system a research area was established already in 1989. Between 1992 and 1994 three different SFM-orientated treatments (removing approx. 1/6, 1/3 and 1/2 of the standing volume of all trees $\geq$35 cm dbh) where applied in seven compartments. For control purposes another three compartments kept untouched and two compartments where harvested according to the "conventional" logging procedure removing approx. 80 % of the standing volume.

Twenty year after the first harvest a carbon inventory was carried out in the same area. Systematically distributed circular sample plots were established covering the carbon pools of litter, small debris ($<$10 cm diameter), ground vegetation as well as shrubs and trees from seedlings up to 34 cm dbh. The trees $\geq$35 cm dbh where recorded in a full enumeration. For lying deadwood $\geq$10 cm diameter a line intersect method was chosen. The conversion into dry biomass was carried out by using oven dried samples (for litter etc.), the conversion model for trees after Chave et al. (2005), and a common shoot to root ratio of 1:0.24 for below ground biomass. Soil carbon was not yet investigated.

The results show that during a 20 year felling cycle the average carbon stock for a medium SFM-treatment is only 3 % less than in the untouched stand while the conventional logging leads to 23 % less carbon. Further investigations indicate that there will be no net emission of carbon dioxide through the applied SFM-treatment if $\geq$33 % of the removed wood is still existing 20 years after harvesting (e.g. as furniture) or was used to replace fossil energy.

Keywords: Carbon dioxide emission, carbon stock, Fiji, REDD+, SFM, sustainable forest management

Contact Address: Michael Mussong, Eberswalde University for Sustainable Development, Fac. of Forest and Environment, Alfred-Möller-Str. 1, 16225 Eberswalde, Germany, e-mail: mmussong@hnee.de

Forest management and agroforestry II

Forest management and agroforestry III

Technologies and socioeconomics

Technology, engineering and food

Comparative Study of Energy Productions from Selected Crop Residues through Anaerobic Digestion at Mesophilic Temperature

ADEMOLA OYEJIDE ADEBAYO[1], SIMEON OLATAYO JEKAYINFA[1], BERND LINKE[2]

[1]*Ladoke Akintola University of Technology, Dept. of Agricultural Engineering, Nigeria*

[2]*Leibniz-Institute for Agricultural Engineering (ATB), Dept. of Bioengineering, Germany*

The conventional energy sources in the world are rapidly reducing due to industrial and urban development. In the same way, demand on the world's fossil fuels increases, their prices rise and their environmental effects are becoming more obvious. This has led to rising interest in the development of alternative energy sources. One of these alternative energy sources is biogas. This work evaluated and compared the biogas yields of maize stalk (MS), maize cobs (MC) and rice straw (RS) by batch experiment at mesophilic temperature (37C). The study was carried out in a laboratory scale batch digester. The digestion bottles were fed with 9.95, 11.70 and 7.53 g, respectively, which were calculated. The digestion took place for a period of 34 days after which the gas production was noticed to be below 1 % of the total gas produced till that time. The biogas yields from organic dry matter (ODM) of MS, MC and RS were found to be 357.10 lN kg^{-1} ODM, 514.31 L kg^{-1} ODM and 324.54 L kg^{-1} ODM respectively after 34 days digestion time. Methane yields (ODM) of MS, MC and RS were also found to be 222.39 L CH_4 kg^{-1} ODM, 298.39 L CH_4kg^{-1} ODM and 211.30 L CH_4kg^{-1} ODM respectively. The biogas/methane yields from fresh mass (FM) of MS, MC and RS were found to be 147.59 L kg^{-1} FM / 91.91 L kg^{-1} FM, 180.65 L kg^{-1} FM / 104.81 L CH_4kg^{-1} FM and 177.29 L kg^{-1} FM / 115.43 L CH_4kg^{-1} FM. MS, MC and RS maize stalk was found to have methane concentrations of 61.9, 58.0 and 65.1 %, respectively. This study has established that among MS, MC and RS, MC has the highest biogas and methane yields.

Keywords: Batch experiment, biogas potential, energy, maize cob, maize stalk, mesophilic, rice straw

Contact Address: Ademola Oyejide Adebayo, Ladoke Akintola University of Technology, Dept. of Agricultural Engineering, P.M.B. 4000, H021001 Ogbomoso, Nigeria, e-mail: ademolaadebayo1@yahoo.com

Hydrothermal Carbonisation of *Acrocomia aculeata* for the Production of Hydrochar and Activated Carbon

CATALINA RODRIGUEZ CORREA[1], ARIANE VOGLHUBER[1], DIETER OBERLAENDER[1], DANIELA HAUPENTHAL[2], ANDREA KRUSE[1]

[1] *University of Hohenheim, Inst. of Agricultural Engineering, Germany*

[2] *Universidad Católica del Paraguay, Campus Itapúa, Paraguay*

Macaúba palm (*Acrocomia aculeata* (Jacq.) Loddiges ex Mart) is a South American palm species used mainly as food and oil crop. The oil is extracted from the seed and the pulp, leaving the epicarp, endocarp and pressed cakes as residues. The aim of this study was to explore possible applications for these residues after a carbonisation process in a closed system and with high pressures. For achieving this, the different parts of the macaúba fruit as well as the pressed cakes were submitted to a 2-step hydrothermal carbonisation process to obtain a carbon-rich product (hydrochar HC), and study its potential as fuel and as feedstock for activated carbon. The HC obtained from all raw materials showed a high carbon content ranging between 25–120 % due to a strong oxygen loss. This was reflected in a calorific value increase ranging from 30 % for the hard inner shell to up to 50 % for the biomasses with high oil content and pressed cakes. The H, N and S concentrations slightly varied during the carbonisation process. Based on the H/C and O/C ratios, the obtained HCs have a close resemblance to brown coal, however the ash content was lower and the energy content higher. The surface area increased by a factor of 5 compared to its parent material. Besides its value as a possible energetic source, the possibility of making activated charcoal using HC as precursor was also explored. To achieve this, the HC were submitted to a chemical activation. The activated carbons were characterised by means of BET analysis for measuring the surface area and SEM images.

Keywords: *Acrocomia aculeata*, activated carbon, hydrothermal carbonisation

Contact Address: Andrea Kruse, University of Hohenheim, Inst. of Agricultural Engineering, Stuttgart, Germany, e-mail: andrea_kruse@uni-hohenheim.de

Sedimentation of Mechanical Extracted *Jatropha curcas* L. Oil Applying Multiphase Flow Fundamentals

SHKELQIM KARAJ, SEBASTIAN ROMULI, JOACHIM MÜLLER
University of Hohenheim, Inst. of Agricultural Engineering, Tropics and Subtropics Group, Germany

Jatropha curcas L. is an attractive crop which has the ability to provide plant oil as an income source for rural communities inducing economic growth, welfare and securing fuel for cooking, lightning and heating. Mechanical extraction is the most common method to produce plant oil in a decentralised system. Raw *J. curcas* oil includes up to 35 % impurities originating from organic pressed material which should be removed in order to improve the chemical properties. For any technical use those impurities must be removed in order to prevent clogging of technical components and to de-accelerate oxidation and hydrolysis. The oil temperature is an important factor to be considered for an efficient clarification process. When the temperature decreases, the rate of sedimentation becomes slower because it is influenced by the density of the particles, as well as by the density and kinematic viscosity of the fluid. In this study, a multiphase sedimentation unit was constructed at University of Hohenheim based on "Weihenstephan–Standard" and assimilated with pressing machine type Komet D85–1G. The multiphase sedimentation unit was tested for its performance regarding total contamination reduction efficiency and sedimentation time. Furthermore characteristic and variable chemical properties were analysed and compared with DIN-norm (DIN 51 605). The multiphase sedimentation unit showed a high reduction of total contamination demonstrating a considerable potential for improving *J. curcas* oil properties for use in rural communities. It is expected that this sedimentation principle can be established in developing countries to assist local communities in producing high quality oil at low costs.

Keywords: Clarification, Jatropha oil, multiphase flow, sedimentation, total contamination

Contact Address: Shkelqim Karaj, University of Hohenheim, Inst. of Agricultural Engineering, Tropics and Subtropics Group, Garbenstr. 9, 70599 Stuttgart, Germany, e-mail: shkelqim_karaj@uni-hohenheim.de

An Actor-Oriented Analysis to Identify Postharvest-Losses in Small-Scale Milk Production Systems in Nakuru, Kenya

EVA HILT[1], MARIA JOSE RESTREPO RODRIGUEZ[2], MARGARETA AMY LELEA[2], BRIGITTE KAUFMANN[2]

[1]*Georg-August-Universität Göttingen, Germany*

[2]*German Institute for Tropical and Subtropical Agriculture (DITSL), Germany*

Various reasons for postharvest-losses (PHL) along the milk value chain have been identified in scientific studies, whereby some, such as spillage and spoilage occur on farm and are described as resulting from "poor handling practices". In order to support smallholder dairy farmers to reduce such losses, we use an actor-oriented approach, based on the concept that production systems are purposive human activity systems, in which production is not merely a function of material flow but rather of farmer management determined by their knowledge of the complex socio-ecological system. Especially in small-scale production systems, farmers act under conditions of constraint which highlight the importance of understanding why farmers do what they do. By conducting an activity and knowledge analysis the current study aimed to identify reasons for PHL and derive improvement strategies that are reasonable from the smallholder dairy farmer's perspective. Field data collection was conducted in two distinct study sites of Nakuru County, Kenya. The study used a multi-method approach, combining semi-structured interviews with 47 farmers, focus group discussions (n=3) and participatory observation of the milk handling practices. Furthermore, quantitative data on milk production and marketing were collected monthly with >70 farmers. Qualitative data were structured using content analysis. In order to access the knowledge guiding farmers' practices such as the rules that underlie their routine and problem solving actions, a cybernetic knowledge analysis was conducted. The results show that with regard to milk spoilage, producers describe specific cause-effect relations. They differentiate traits of milking equipment and parlours, assess their activities of milk gaining and storage process, and for all observe related sources of contamination. Underlying problems described by the producers are e.g. lack of means to construct cemented cowsheds and parlours, which would promote animal cleanliness and health, as well as safe milking. Despite this awareness, current low gains from milk production hinder and disincentivize investment in improving milking practices. Hence, training on milk handling will not yield enhancements. Co-developing improvement options that combine farmers' knowledge with technical innovations will offer most opportunities for reducing milk losses and improving quality.

Keywords: Knowledge analysis, post-harvest losses, small-scale dairy production, systems approach

Contact Address: Eva Hilt, Georg-August-Universität Göttingen, Göttingen, Germany, e-mail: eva.hilt@stud.uni-goettingen.de

Prediction of Water Content in Indonesian Green Coffee Beans Using near Infrared Spectroscopy

ADNAN[1], DIETER VON HÖRSTEN[2], DANIEL MÖRLEIN[3], ELKE PAWELZIK[1]

[1]*Georg-August-Universität-Göttingen, Dept. of Crop Sciences: Inst. Quality of Plant Products, Germany*

[2]*Julius-Kühn-Institute, Institute for Application Techniques in Plant Protection, Germany*

[3]*Georg-August-Universität-Göttingen, Dept. of Animal Sciences, Germany*

Water content in green coffee bean is one of the most important factors with direct influence on its quality. Usually, water content is analysed using a gravimetric method including 16–24 h oven drying. The aim of this study is to evaluate the feasibility of near infrared spectroscopy (NIR) for non-destructive and fast prediction of water content in Indonesian green coffee beans using multivariate analysis. Green coffee beans were obtained from different origins in Indonesia, n=5 for Arabica and n=7 for Robusta. Coffee beans were placed in a climacteric chamber at 25°C and relative humidity (RH) of 30–85 % in order to obtain a wide range of water content. NIR spectra were collected using a bench top Fourier transform (FT) NIR instrument in the wavelength range of 1000–2500 nm in diffuse reflectance (log 1/R) mode. Water content was analysed according to ISO 6673 as reference. NIR spectra were collected from 108 samples, n=64 for calibration and n=44 for prediction. Partial least squares regression (PLSR) using raw data with 3 latent variables factors yielded the best prediction with coefficients of determination (R^2) for calibration, cross validation, and prediction of 98.3 %, 97.9 %, and 96.4 %, respectively. Weighted regression coefficients from PLSR revealed that the wavelengths 1409, 1724, 1908 and 2249 nm are highly correlated with the water content. Using these selected wavelengths for multiple linear regression (MLR) yielded R^2 for calibration, cross validation, and prediction of 97.6 %, 96.9 %, and 97.3 %, respectively. To conclude, NIR combined with chemometrics is a promising method for rapid and reliable water content prediction in green coffee beans.

Keywords: Coffee bean, MLR, near infrared, PLSR, water content

Contact Address: Adnan, Georg-August-Universität-Göttingen, Dept. of Crop Sciences: Inst. Quality of Plant Products, Carl-Sprengel-Weg 1, 37075 Göttingen, Germany, e-mail: adnan.adnan@stud.uni-goettingen.de

Microwave PRE-Treatment for Improving Oil Recovery of Mechanical Extraction of *Jatropha curcas* L

SEBASTIAN ROMULI, SHKELQIM KARAJ, JOACHIM MÜLLER
University of Hohenheim, Inst. of Agricultural Engineering, Tropics and Subtropics Group, Germany

Jatropha kernel contains up to 60 % of oil. Mechanical pressing of Jatropha kernel is an attractive technique to extract the oil. However, the process still has the drawback of low oil recovery efficiency caused by the high tenderness of the material. Thermal pre-treatment of kernel before pressing is seen as a relevant solution, because it increases the temperature of the material, that leads to higher temperature of press head and thus stimulates more oil to be mechanically extracted from the kernel. Among the existing treatments, microwave pre-treatment has received great interest because the heat generated from the electromagnetic field develops in the inner of the kernels and simultaneously inhibits hydrolysis triggered by the enzymes during pressing.
The objective of this study was to investigate the optimum condition of pre-treatment to achieve the highest oil recovery efficiency of *J. curcas* kernels. The mechanical screw press Komet D85–1G was used to conduct the experiments. Nozzle with 6 mm diameter, press cylinder with 1 mm bore size, screw press with choke worm shaft ring size 16 mm, and rotational speed at 19 rpm were set. To support the process, each screw head was constantly heated using a heating device, which was set at 100, 120, and 140C. The microwave power from 160 to 800 Watt, and the heating time of kernel from 1 to 4 minutes were determined as the process variables.
Oil recovery, capacity, torque, and temperature were monitored and the performance of the process was described. The important physicochemical properties to evaluate the oil quality such as acid value, and carbon residue were also evaluated and compared with oil extracted without using any pre-treatment. The optimum condition of pre-treatment significantly improved the oil recovery and quality.

Keywords: Heat, Jatropha kernel, microwave pretreatment, oil recovery efficiency

Contact Address: Sebastian Romuli, University of Hohenheim, Inst. of Agricultural Engineering, Tropics and Subtropics Group, Garbenstraße 9, 70599 Stuttgart, Germany, e-mail: sebastian_romuli@uni-hohenheim.de

Performance of Pellets from Jatropha Hulls and Shells in a Prototype Small Scale Stove

SHKELQIM KARAJ, SEBASTIAN ROMULI, SEBASTIAN AWISZUS, JOACHIM MÜLLER

University of Hohenheim, Inst. of Agricultural Engineering, Tropics and Subtropics Group, Germany

Jatropha curcas L. fruits and its byproducts can be used for diverse applications. During processing of Jatropha fruits, hulls and shells come up as byproduct in significant quantities. Hulls and shells can be used as energy carriers in combustion facilities for producing energy from renewable resources.

In the present study pelleting experiments with hulls and shells of Jatropha and combustion tests with a prototype small scale pellet stove were carried out. The physico-mechanical and chemical properties of produced pellets were analysed for different pellet production quality. Emissions gasses were monitored and controlled by altering combustion properties such as air flow rate and fuel feeding rate. To improve pelleting properties different moisture contents (0, 5, 10 and 15 % w.b.) were induced during pellet production.

Pellets were optimised by finding the best mixture in terms of successful pelleting and effective combustion. Moisture content and pellet temperature during production were identified to have a strong influence on the physico-mechanical properties. Combustion experiments showed that pellets without additional water had significant higher burning temperatures than pellets produced with additional water.

The flame temperature was around 700°C, burning chamber temperature was between 600 and 700°C and the flue gas was around 200°C. The CO_2 emissions ranged from 3 to 5 Vol. % for all experiments. With increasing air mass flow, the CO_2 values were slightly increasing. The CO emissions were below 2 g m^3 for all experiments. Increasing the feeding rate from 5 to 10 kg h^{-1} the CO value also increased, but for higher rates there was no further influence on CO emissions.

In general, increasing moisture content of pellet leads to decreasing thermal efficiency. The study shows that there is a good opportunity to substitute traditional biomass like wood by *J. curcas* hulls and shells pellet for cooking and heating.

Keywords: Combustion, emission control, *Jatropha curcas*, mechanical properties, pellet production

Contact Address: Sebastian Romuli, University of Hohenheim, Inst. of Agricultural Engineering, Tropics and Subtropics Group, Garbenstraße 9, 70599 Stuttgart, Germany, e-mail: sebastian_romuli@uni-hohenheim.de

Potential of Livestock Dung Based Biogas in Rural Households in Nepalese Context

NARAYAN PRASAD ADHIKARI, MANFRED DENICH
University of Bonn, Center for Development Research (ZEF), Germany

In Nepal, biogas as an energy source for cooking and heating has been considered to be an appropriate technology to cope with both destruction of forests and unhealthy indoor air pollution. The capacity for producing biogas is usually estimated based on the number of livestock at household or regional level. The results might be misleading due to the large variation of dung yield depending on livestock species and age. Fodder availability is another reason for the spatial and temporal variation of dung yields.

The study evaluates the potential of biogas production based on cattle and buffalo dung in three topographical zones of Nepal: mountainous, hilly, and lowland (Terai). The survey was carried out in 240 livestock holding households. Data of fresh dung yield were obtained from 210 livestock individuals classified into 4 categories: mature buffalo ($>$ 3 yrs), young buffalo ($\leq$ 3 yrs), mature cattle ($>$ 3 yrs) and young cattle ($\leq$ 3 yrs). The annual net availability of dung for biogas production is evaluated by considering an accessibility factor, the collection efficiency and the utilization ratio. Calculations are based on surveys in which the fuelwood equivalent of 1 m^3 biogas is observed to be 4.57 kg by assuming the production of 0.036 m^3 biogas from 1 kg of fresh dung.

Analyses reveal that through dung-based biogas production, the fuelwood consumption per household can be reduced by 14 %, 37 % and 60 % in mountainous, hilly and lowland areas, respectively. As expected, the average daily dung yield per buffalo is higher than that of cattle, and mature animals produce more dung than young ones. Despite the highest livestock number per household in mountainous (5.2) as compared to hilly (2.7) and lowland areas (2.6), the net availability of dung at household level is the lowest in mountainous areas due to lower availability of fodder.

Keywords: Biogas, buffalo, cattle, dung, energy, topography

Contact Address: Narayan Prasad Adhikari, University of Bonn, Center for Development Research (ZEF), Ecology and Natural Resources Management, Walter-Flex-Straße 3, 53113 Bonn, Germany, e-mail: narayan.aepc@gmail.com

Determining Technical Efficiency of Farm Households in Vietnam

HUYNH NHU PHAN, DUC LOC NGUYEN, RATTIYA S. LIPPE, ULRIKE GROTE
Leibniz Universität Hannover, Institute for Environmental Economics and World Trade, Germany

Improving agricultural efficiency is important in enhancing economic growth as well as promoting poverty reduction in developing countries. This approach has become very relevant in the context of Vietnam where the livelihoods of two thirds of the population mainly rely on farming activities. However, the recent decrease in agriculture growth severely impacts on small farm households, making them more vulnerable to poverty. Appropriate schemes to improve agriculture production, therefore, should be taken into account for enhancing the efficiency of this sector. This study aims at determining the technical efficiency of rice, coffee and maize sectors, which are the main crops in three provinces Daklak, Thua Thien Hue and Hatinh of Vietnam. The analysis is based on the comprehensive household data set from 2013 of the German Research Foundation project "Impact of shocks on the vulnerability to poverty: consequences for development in emerging Southeast Asian economies". The estimated results of the Stochastic Frontier Approach firstly revealed that the average technical efficiency of rice, corn and coffee are not very high as compared to other studies. They range at around 50 %, 49 % and 59 %, respectively. The differences of the crops' technical efficiency scores between the three provinces were examined by using the t-test. Secondly, the determinants of the technical efficiency were obtained by applying a tobit model to identify reasonable solutions to improve technical efficiency for specific province and different geographic regions. These were the age, education, amount of remittance which they receive from friends or relatives, the share of non-farm income, social organisation of the member and topographical zone.

Keywords: Stochastic frontier approach, technical efficiency, Vietnam

Contact Address: Huynh Nhu Phan, Leibniz Universität Hannover, Institute for Environmental Economics and World Trade, Lodyweg1, 30167 Hannover, Germany, e-mail: huynhnhu2901@gmail.com

Potential of Large-Scale Biogas Production in Urban Areas: A Case Study in Moshi, Tanzania

NATALI BÖTTCHER, ANDREAS LEMMER

University of Hohenheim, State Institute for Agricultural Engineering and Bioenergy, Germany

Moshi is the capital of the Kilimanjaro Region of Tanzania. Moshi's economy is strongly dependent on tits natural resources, especially Mount Kilimanjaro and the surrounding area. Solid waste management is a serious problem in Moshi. The landfill will soon reach its capacity and yet there is no solution for a new system.

The aim of this case study was to research the potential biogas production from organic waste, on a municipal scale. Contrary to conventional biogas production in Tanzania on a small-scale household level, a novel approach for urban biogas production was developed. The goal is to decrease the amount of solid waste dumped at the landfill while simultaneously introducing a clean bioenergy system.

In this study it was determined that 13,658 t a^{-1} solid waste with an organic share of 66.5%, and 3,754 t a^{-1} residues would be available in Moshi. The chemical composition of several samples and their specific biogas and methane yields were later measured in the laboratory at the University of Hohenheim, Germany.

Depending on which substrates are used, a daily maximum energy production of 11,654 kWh^{-1} to 16,051 kWh^{-1} would be possible. Based on a hydraulic retention time of 40 days, the digesters would need a dimension of 1,978 m^3 or 1,614 m^3. The results show that the respective digester volume is 164 times bigger compared to a state of the art household digester with a size of 12 m^3, mostly used in rural areas. Yet such technology is not standard in Tanzania. This implies that process technology and process biology need to be addressed in further studies.

Interviews of potential biogas users showed that the energy demand is even higher than the maximum potential biogas production.

A separation of the organic waste would significantly decrease the waste volume, as well as emissions and ignitions at the landfill, and offer a valuable resource that could be recycled. An important next step for the project is to establish a pilot plant to review the concept.

Keywords: Bioenergy, biogas, recycling, solid waste management, Tanzania, urban area

Contact Address: Natali Böttcher, University of Hohenheim, State Institute for Agricultural Engineering and Bioenergy, Garbenstr. 9, 70599 Stuttgart, Germany, e-mail: natali.boettcher@uni-hohenheim.de

Effects of a Prototype Solar Dryer on the Quality of Solar Dried Fish: Reducing Post-Harvest Losses at the Artisanal Fisheries Sector of Ghana

EMMANUEL SAKA, LAWRENCE ABBEY, CHARLES TORTOE
CSIR-Food Research Institute, Food Processing and Engineering, Ghana

Artisanal fisheries has provided Ghana both food and feed fish for years. The main problem of this sector is post-harvest losses. Earlier studies identified some causes of these losses to include weak local regulations and monitoring, lack or inadequate fishing, processing, storage and sales support systems. Research targeted at solving these problems has not been exhaustive, as issues such as high cost of processing, reduction in value of processed fish due to poor processing methods and absence or negligence of quality standards still exist. Although freezing has been recommended and used for fish, it is not suitable for all fish species. The texture of Anchovy (*Engraulis encrasicolus*) for example is negatively affected by freezing, hence they are smoked or open air dried immediately on landing. Smoke drying increases processing cost and impact on the climate by way of carbon emissions coupled with reduction in the number of trees that help clean the atmosphere of the carbon gases. Traditional open air drying though cheaper has over the years yielded low value fish due to contamination and bad weather. The current study tested performance of a prototype solar dryer, on the improvement of the quality of anchovy. Fresh anchovies obtained from the James Town Accra Ghana Landing Beach, were washed in sea water and transported on ice to the laboratory. The fishes were transferred into a perforated cold chest containing flaked ice (ratio of flaked ice to fish being 1:1) for use the next day. Drying was carried out for 36 hours. Water activity (aW) using a capacitor type aW metre and colour by the L* a* b* method were used to assess the quality of solar dried fish. The L* a* b* values obtained were 52.77± 1.18, 0.87± 0.13 and 3.23±0.60 respectively, and aW of 0.62±0.01. Drying in the prototype solar dryer also reduced the drying time from 48 hours to 36 hours and produced products with quality close to those produced by the open air drying method.

Keywords: Anchovies, pelagic fish, prototype solar dryer

Contact Address: Emmanuel Saka, CSIR-Food Research Institute, Food Processing and Engineering, Shiashi, 233 Accra, Ghana, e-mail: emmanuelsaka@yahoo.co.uk

Using a Hybrid Solar Drier for Fish Processing

ANNA HUBÁČKOVÁ[1], JAN BANOUT[1], IVA KUČEROVÁ[1], RITHY CHRUN[2], MILOSLAV PETRTÝL[3], LUKAS KALOUS[3], PETRA CHALOUPKOVA[1]

[1]*Czech University of Life Sciences Prague, Faculty of Tropical AgriSciences, Czech Republic*

[2]*Royal University of Agriculture (RUA), Fac. of Agro-Industry, Cambodia*

[3]*Czech University of Life Sciences Prague, Fac. of Agrobiology, Food and Natural Resources, Czech Republic*

More than 74 % of the population in Cambodia is dependent on agriculture and fishing. Basic nutrition of local people consists of rice and fish, and people receive more than 80 % of animal protein from fish and other aquatic animals. Preservation of foods by drying is one of the most advanced methods of fish processing in this country.
The aim of this work is to evaluate drying as an alternative method of fish preservation in Phnom Penh, Cambodia with respect to acceptability of the resulting fish products to Cambodian, consumers.
Drying experiments were done with five fish species chopped into pieces of approximate dimensions 5×2 cm^2 in a hybrid solar dryer. The drying unit uses solar energy during the day and energy from burning wood during the night; the wood consumption was 17 kg per night. Following factors were monitored during the drying process: weight of the tested fish product, temperature and relative humidity, drying air velocity and air flow, solar radiation. Water content of the samples was determined gravimetrically.
Drying processes always started in the evening of one day and finished the next day, each running for 20 hours. The average time needed for achieving a moisture content (wb) of 18–21 % - needed for product stability - was 7, 9, 9, 8 and 7 hours for swamp eel (*Monopterus albus*), Nile tilapia (*Oreochromis niloticus*), walking catfish (*Clarias batrachus*), channa (*Channa lucius*) and climbing perch (*Anabas testudineus*), respectively. All of the fish species were found to provide an acceptable final product. It was also found that tilapia was the most positively evaluated species of the fish tested.

Keywords: Aquaculture, fisheries, food processing

Contact Address: Anna Hubáčková, Czech University of Life Sciences Prague, Faculty of Tropical AgriSciences, Kamýcká 129, Prague, Czech Republic, e-mail: hubackovaa@ftz.czu.cz

Using of Natural Preservatives for Meat Drying and Storage

HELGA JOHANA HERNÁNDEZ HERNÁNDEZ[1], JAN BANOUT[1], ADELA FRANKOVA[2], PAVEL KLOUCEK[2]

[1]*Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Dept. of Sustainable Technologies, Czech Republic*

[2]*Czech University of Life Sciences Prague, Fac. of Agrobiology, Food and Natural Resources, Dept. of Crop Production, Czech Republic*

Drying is a traditional processing that has been used over many centuries to preserve foods. Drying is used for making a variety of specialty processed meats, for example, country ham which is dried at ambient temperatures and beef jerky, dried at elevated temperatures. Drying procedures vary in terms of temperature, relative humidity, rate of air movement, and final product characteristics. The drying process has been shown to be an efficient method of conservation, but using high temperature during drying can increase microbial and chemical reactions and leads to deterioration of food quality. Processed meat is a main source and route of infection by food-borne pathogens, such as, bacteria which is one of the principal types of microorganisms that cause food spoilage and food-borne illnesses. There are some foodborne illnesses attributed to dried meat such as salmonellosis or infestation by *Escherichia coli*. The microbial and chemical deterioration can be controlled using either synthetic or natural preservatives. Nowadays, meat industry uses chemical additives in several meat processes like curing to prevent growth of food-borne pathogens and extend the shelf life of refrigerated storage. Since concern over the safety of chemical additives has arisen in recent years, consumers increasingly demand use of natural products as alternative preservatives in foods. Particular interest has been focused on the potential application of plant essential oils as safer additives for meat, to prevent the microbial and chemical deterioration when added to food. Whereas, the use of natural preservatives during drying and further storage in rural areas of developing countries can replace chemicals compounds with negative impacts on human health. This project investigates the effect of oregano essential oil on meat drying by controlling the microbial load and water activity during the process of drying in a conventional oven and the storage. The results will show the influence of using essential oils in beef drying and during the storage against *Escherichia coli* ATCC 25922.

Keywords: Drying, food-borne pathogens, meat drying

Contact Address: Jan Banout, Czech University of Life Sciences Prague, Faculty of Tropical AgriSciences, Kamýcká 129, 16521 Prague, Czech Republic, e-mail: banout@ftz.czu.cz

Quality Evaluation of Set Yoghurt Supplemented with Turmeric Powder (*Curcoma longa*.L) During Storage Period

SIHAM RAHMATALLA, LINA ABD AAZEEM, MOHAMED OSMAN MOHAMED ABDALLAH

University of Khartoum, Dept. of Dairy Production, Sudan

Curcumin is the main active ingredient in turmeric responsible for turmeric's numerous activities. Known by its anti-oxidative, anti- microbial and anti-inflammatory properties and as a cancer and chemo preventive agent. This study was carried out to assess the effect of supplementing set yoghurt made from cow's milk with different levels of turmeric powder 0 % (plain yoghurt), 0.25 % (T1), 0.5 % (T2) and 0.75 % (T3) on some physico-chemical properties, microbiological quality and organoleptic characteristics at 1, 5, 8 and 12 days of refrigerated storage (5Co). The results revealed that the effect of addition of turmeric powder was significant on all physico-chemical properties ($p < 0.05$), except for the lactose content. In general the pH value of the set yoghurt was relatively higher in turmeric yoghurt compared with plain yoghurt and decreased with the increased level of turmeric powder with concomitant decrease in titratable acidity in turmeric yoghurt. The turmeric yoghurt with 0.5 % and 0.75 % had increased significantly ($p < 0.05$) the fat content of yoghurt in comparison with plain and 0.25 % samples during the storage period. Furthermore, the higher level of turmeric concentrations (0.75 %) increased the ash content significantly ($p < 0.05$) compared with the control samples and yoghurt with low and medium turmeric concentrations (0.25 % and 0.5 %). On the other hand, the increase of turmeric powder level was associated with decrease in protein content during the storage period.

The yoghurt samples supplemented with 0.75 % turmeric powder secured the best microbial profile with resultant lowest total viable bacteria count (TVBC) log10 (5.42), Lactobacillus count (LBC) log10 (5.11) cfu ml^{-1} and complete absence of coliform bacteria. The sensory analysis revealed that the yoghurt with 0.25 % turmeric powder recorded the best acceptance among panelist compared to plain yoghurt and other concentrations of turmeric yoghurt.

The study concluded that addition of turmeric powder to set yoghurt improved chemical, organoleptic and microbiological qualities of the product resulting in high consumption acceptance.

Keywords: Chemical characteristics, curcumin, microbiological aspects, sensory evaluation, Set yoghurt

Contact Address: Siham Rahmatalla, University of Khartoum, Dept. of Dairy Production, Khartoum, Sudan, e-mail: sihamerwa76@yahoo.com

Milk Protein Genetic Variation in Butana Cattle and Characterisation of a New α-Lactalbumin Gene Variant

AMMAR SAID AHMED[1], SIHAM RAHMATALLA[2], MONIKA REISSMANN[1], RALF BORTFELDT[1], GUDRUN A. BROCKMANN[1]

[1]*Humboldt-Universität zu Berlin, Dept. of Crop and Animal Sciences, Germany*

[2]*University of Khartoum, Dept. of Dairy Production, Sudan*

Butana, a dairy cattle breed of Sudan, has been gradually declining in numbers over the last years due to the breed substitution, and indiscriminate crossbreeding. Breeding and conservation strategies for this breed should be based on a combination of genetic and phenotypic characteristics. Therefore, milk protein genetic variants are of interest for breeding in terms of milk yield and composition. The present study aimed at assessing allelic variations of milk protein genes that are characteristic for Butana cattle.

Five Butana cattle were sequenced for all exons and flanking intronic sequences of the bovine milk protein genes CSN1S1, CSN2, CSN1S2, CSN3, LALBA and LGB. The obtained sequences were compared with the *Bos taurus* reference sequence for cattle at Ensembl (*Bos taurus*:UMD3.1.69). 50 unrelated individuals were genotyped to determine allele frequency of indentified non-synonymous SNPs.

We identified 98 SNPs in Butana cattle compared to the reference sequence at Ensembl: nine non-synonymous, seven synonymous, four 5' UTR, 14 3' UTR and 64 intronic SNPs. Fifty-eight SNPs were novel. Among them a non-synonymous SNP (BTA5:31348386G>A) was identified in exon 2 of *LALBA* causing the amino acid substitution Ile60Val in the protein. According to the alphabetical order of already described variants, the corresponding protein variant was named *LALBA*E*. The most frequent allele encoded the *LALBA*B* protein variant (0.46). For the other genes, the most frequent variants encoded the proteins *LGB*A* (0.88), *CSN3*B* (0.74), *CSN1S1*C* (0.66) and *CSN1S2*A* (0.61). The Sudanese Butana cattle are highly polymorphic in the milk protein genes. High genetic variability for milk proteins provides a resource for breeding, utilisation and conservation of the local breeds.

Keywords: *Bos indicus*, Butana cattle, genetic variants, milk protein genes

Contact Address: Ammar Said Ahmed, Humboldt-Universität zu Berlin, Dept. of Crop and Animal Sciences, Invalidenstrasse 42, 10115 Berlin, Germany, e-mail: saidahma@hu-berlin.de

Implications of Introducing a New Dairy Technology for Small-Dairy Production in the Peruvian Andes

EDUARDO FUENTES[1], JOE BOGUE[2], PIERRE-YVES LE GAL[3]

[1]*Montpellier Supagro, UMR Innovation, France*

[2]*University College Cork, Food Business and Development, Ireland*

[3]*CIRAD, UMR Innovation, France*

Developing countries face a need for higher quantities of food and food of improved quality. Improving milk quality, especially milk composition, in parallel with increased milk production may benefit local supply chains and enhance their sustainability. One of the main difficulties associated with improving milk quality is to count with an adequate control, i.e. to have the necessary measuring equipment and to have sufficient knowledge to interpret the results. This paper investigates the effects of the in-field introduction of ultrasonic milk analyser equipment (UMA) on the perception of milk quality of small-scale dairy farmers and processors in a Peruvian Andean context, characterised by scarce resources, a dual market and high milk demand. For this analysis, an UMA was used to investigate milk quality on 20 dairy farms and 3 dairies over a 12-months period. Milk samples were analysed *in situ* to obtain measurements that could be immediately discussed with stakeholders. Concurrently, 10 dairies who bought an UMA after the researchers' intervention, were interviewed about their use of the device. Farmers showed a lack of knowledge of milk quality but were interested and desired to learn more about it. They reflected on possible variations in cow diets or the milking process to explain milk composition fluctuations. However, no main changes were observed during the 12-month monitoring period, since processors were not ready to pay more for better milk quality. From the processors' perspective, although the UMA provided a range of variables that described the chemical quality, dairies were mainly focused on density, as a quality indicator, as milk adulteration was their main concern and because of a lack of training on the other variables. Moreover, since milk demand is higher than supply in the area, most of dairies did not use the equipment periodically because they feared that farmers, unhappy with quality control, would move to processors with less interest in quality aspects of milk. It was concluded that the successful implementation of new technologies like UMA required the establishment of a more coordinated quality improvement scheme between stakeholders along dairy supply chains, including public authorities in charge of national regulations.

Keywords: Farmers, logistics, milk quality, processors

Contact Address: Eduardo Fuentes, Montpellier Supagro, UMR Innovation, 2 Place Pierre Viala, 34060 Montpellier, France, e-mail: eduardo.fuentes_navarro@cirad.fr

Escherichia coli O157 Serotype in Beef Carcasses Post Slaughterhouse in Nairobi and Eldoret, Kenya

JOHN KAGO[1], ERASTUS KANG'ETHE[2], JOHN WANGOH[1], KOHEI MAKITA[3]
[1]*University of Nairobi, Dept. of Food Science, Nutrition and Technology, Kenya*
[2]*University of Nairobi, Dept. of Public Health, Pharmacology and Toxicology, Kenya*
[3]*Rakuno Gakuen University, Veterinary Epidemilogy, Japan*

The research covered three slaughterhouses in Nairobi and Eldoret. The objectives were to assess the prevalence of *E. coli* O157 serotype contaminated carcasses at dispatch, the possible cross-contamination during transportation, and knowledge, attitude and handling practices that led to increased contamination or bacterial growth. Randomly selected 250 beef carcasses were sampled. Swab samples from a single carcass were obtained from three sites during loading and offloading of meat to carriers. A total of 1500 samples were obtained. *E. coli* O157 serotype was isolated, and purified using sorbital MacConkey, MacConkey and nutrient agar. Serotyping was by card agglutination test. Oxoid verotoxin test kit was used to test for verotoxin (VT1 and VT2) production. Carrier environment was monitored. Knowledge, attitude and practices of meat transporters were assessed through a semi structured questionnaire and observations. Probability of contamination was modeled and run through Monte Carlo simulation using winBUGS®. Prevalence and data from the questionnaire were analysed using SPSS Ver.17.

The contamination prevalence at offloading was significantly higher compared to loading ($p = 0.05$). The probability of obtaining an *E. coli* O157 serotype contaminated carcass at Dagoretti, Limuru and Eldoret, respectively, was 14, 16 and 19 at loading and 31, 39 and 66 at offloading per 1000 carcasses handled. The temperature in the meat carrier significantly increased ($p = 0.004$) during transportation between loading and offloading. The average time taken to transport the meat from the slaughterhouses to the butchery was 65 minutes.

About 14 (43.8 %) of the meat transporters had worked in the meat industry for at least 5 years and almost an equal number 13 (40.4%) had had formal training on meat hygiene. About 53 % of meat transporters claimed to wash hands regularly with cold water and soap. Meat carriers were cleaned at the river or in a car wash with cold water and soap only. Carcasses were loaded on the shoulders of the transportation personnel and placed on the floor of the carriers or heaped on top of other carcasses. Offloading at the butchery was done by the same person with no change over of clothes that could be soiled with blood.

Keywords: Beef carcasses, *Escherichia coli* O157 serotype, transportation chain

Contact Address: John Kago, University of Nairobi, Dept. of Food Science, Nutrition and Technology, 29053-00625 Kangemi, Nairobi, Kenya, e-mail: jkago73@yahoo.com

Image Fusion System for Non-Destructive Colour Evaluation of Papaya During Drying

PATCHIMAPORN UDOMKUN[1], MARCUS NAGLE[1], DIMITRIOS ARGYROPOULOS[1], BUSARAKORN MAHAYOTHEE[2], JOACHIM MÜLLER[1]

[1] *University of Hohenheim, Inst. of Agricultural Engineering, Tropics and Subtropics Group, Germany*

[2] *Silpakorn University, Dept. of Food Technology, Thailand*

Colour changes are common physical phenomenon observed during drying which need to be controlled, as it directly affects consumer acceptance of the dried products. This study aimed to investigate the effects of drying temperatures (50, 60, 70, 80 °C) on colour kinetics of papaya during drying. In addition, it monitored the feasibility of a computer vision system (CVS) combined with laser light backscattering analysis at 650 nm for predicting colour changes. The results showed that the lightness (L*) and redness (a*) values decreased, whereas yellowness (b*), hue (h*), chroma (C*) and total colour difference (ΔE) values increased as drying proceeded. The zero-order kinetic model was found to generate the great fit for L*, a* and ΔE values, whereas b*, h* and C* values were adequately explained by the fractional conversion model. The activation energy (Ea) was manifested that the h* value was more sensitive to temperature than other parameters.

For non-invasive colour evaluation, the results also revealed that each image processing factor obtained can potentially be used to describe each colour attribute change, except for C* value. The multivariate correlations of measured backscattering parameters and digital image properties were found to yield the best fit for colour validations. As a result of this study, it is possible to estimate the optimum process conditions for achieving desired dried papayas through the parameters of the derived models. Moreover, the use of CVS technique coupled with laser backscattering methods provides a useful tool for quality control based on a rapid, consistent, non-intrusive, and objective method for in-line measurement of product quality in fruit drying processes.

Keywords: Colour, drying, image analysis, laser backscattering, papaya

Contact Address: Patchimaporn Udomkun, University of Hohenheim, Inst. of Agricultural Engineering, Tropics and Subtropics Group, Garbenstrasse 9, 70599 Stuttgart, Germany, e-mail: Patchimaporn.Udomkun@uni-hohenheim.de

Essential Oils: New Preservative for Mushroom Packaging

FATANEH YARI

Iranian Research Organization for Science and Technology (IROST), Agricultural Research Institute, Iran

The effect of various essential oils, viz. lime, cumin, tarragon, thyme and anise on the shelf life of mushrooms was studied during storage period. Mushrooms treated indirectly with pieces of filter paper consist of essential oils which disperse the volatiles oil vapour in the package. The mushrooms were stored under modified atmosphere packaging (MAP) conditions with 4±0.5°C and 80±5 % relative humidity (RH). Morphological and physiological changes were estimated every 2 days. All treatments significantly affected the quality of packaged mushrooms ($p < 0.01$). Applications of volatiles oil delayed discolouration associated with reduced phenolic compounds. Higher contents of total soluble solids (TSS), total acidity and TSS/T acid ratio of fresh-cut mushroom was observed in treated packaging. The best result for the quality criteria were obtained from the lime and tarragon treatment whereas cumin was found more effective to controls decay compared with the other treatments in MAP. The result showed that essential oils inhibited the growth of total bacteria,yeasts and moulds counts. Thyme and cumin extract was more effective to control decay. Although cumin extract exhibited off odor after opening the pack. Moreover it was determined that the mushrooms could be stored successfully for 4 weeks in MAP. Control had a greater incidence of discolouration and minimum storage life. Results from the present work suggest that Passive MAP with indirect essential oils treatment and storage at 4°C can be used successfully for extending the shelf-life of the mushrooms for more than 25 days. Shelf life of mushrooms through the application of tarragon under passive MAP condition was improved about 30 days.

Keywords: Decay, essential oil, MAP, mushroom

Contact Address: Fataneh Yari, Iranian Research Organization for Science and Technology (IROST), Agricultural Research Institute, P.O. Box 3353-5111, 3353136846 Tehran, Iran, e-mail: fataneh.yari@gmail.com

Optimising Ensilability of Sorghum-Soybean Mixture Using Epiphytic Lactic Acid Bacteria Inocula

LAILA BERNAL[1], MARIO CUCHILLO HILARIO[2], PATRICIA AVILA[2], ALEJANDRA ZAMBRANO[2], JOHANNA MAZABEL[2], SIRIWAN MARTENS[2]

[1]*La Salle University, Fac. of Agricultural Sciences, Colombia*

[2]*Intern. Center for Tropical Agriculture (CIAT), Tropical Forages Program, Colombia*

Lactic acid fermentation is a desirable trait for silage making. However, legumes own a high buffer capacity, which might lead to pitfalls when ensiling. In contrast, graminaceous forages may favour ensilability. The objective was to investigate the optimal sorghum/soybean proportion to optimise acidification. Secondly, we assessed epiphytic lactic acid bacteria (LAB) of sorghum (*Sorghum bicolor* L. var. H70) and soybean (*Glycine max* var. Panorama 29) to facilitate lactic acid fermentation in a rapid *in-vitro* test (Rostock Fermentation Test-RFT). Forage was harvested at pre-flowering stage in December 2013 at CIAT Palmira, Colombia. LAB from sorghum and soybean were cultivated on Rogosa agar for 5 days at 35 °C and a single LAB from each material were isolated. Inoculates were evaluated for their acidification ability: LAB-epiphytic S738 (from sorghum), LAB-epiphytic S739 (from soybean), LAB from CIAT bacteria collection (S66.7), commercial silage inoculant (SilAll4 $\times$ 4™-Brazil) and a control. Sorghum and soybean and their combination (100/0, 33/67, 67/33, 0/100) were also tested for ensilability. 50 g of minced forage were introduced into an autoclaved 200 ml water in triplicate. The treatments were incubated at 37°C to determine the pH at 0 (before inoculation), 20, 28, 44 and 48 hours. We used a completely randomised design with factorial arrangement, where the first factor was the inclusion level of sorghum in the mixture and the second factor was the inoculant used. Yij=μ+Si+Ij+SixIij+eij; where Y= is the target variable, μ= is the overall mean, S= proportion of sorghum in the silage (100/0, 33/67, 67/33, 0/100)i, I= inoculant (S738, S739, S66.7 and control)j and e= random experimental error. At higher amounts of sorghum in the mixture, the pH registered lower averages. e.g. at 20h sorghum/soybean (100/0) the pH was 3.8, followed by 4.4 and 5.4 for sorghum/soybean mixture (63/37 and 37/63, respectively). The worst pH value (6.1) was for soybean alone (0/100). S738 (4.85) and S66.7 (4.86) showed the best acidifying potential at 20 hours ($p = 0.0196$), whereas control had the worst pH value (5.05). Larger inclusion of sorghum assured better lactic acid fermentation. Epiphytic lactic acid bacteria are a feasible option to be used as inoculants to promote lactic acid fermentation.

Keywords: Epiphytic lactic acid bateria, rostock fermentation test, tropical forage

Contact Address: Mario Cuchillo Hilario, Intern. Center for Tropical Agriculture (CIAT), Tropical Forages Program, Recta Cali-Palmira km. 17, A.A. 6713 Cali, Colombia, e-mail: m.cuchillo@cgiar.org

Value chains and markets

Changes Induced by Certification Practices in the Cocoa Value Chain

ENRIQUE URIBE LEITZ[1,2], KEES BURGER[1], FRANCOIS RUF[2]

[1]*Wageningen University, Development Economics, The Netherlands*

[2]*CIRAD, UMR Innovation, France*

This paper focuses on the changes that certification has brought to the cocoa value chain in recent years. Certification has been a common tool for all stakeholders in the cocoa sector. Not only, major chocolate companies committed to source 100 % certified products in the years to come, but also action has been taken by governments, retailers and NGOs to support the introduction of certification to the cocoa value chain. As a result, the increased number of certified cocoa producers and the higher demand for certified cocoa, have led to a restructuration of how cocoa is being traded. One change at the producer level is that village traders tend to disappear while large exporters build direct relations with farmer groups. This shortening of the supply chain is led by certification of cocoa producers and the creation of cooperatives, induced by exporters. We propose a theoretical model of value chain organisation and provide an analysis of the forces involved in shaping the value chain. Our model is supported by primary data collected in Côte d'Ivoire and Indonesia. Results confirm that a shortening of the value chain through certification is by eliminating village traders while the farm gate prices increase only in form of premiums received. Since premiums are projected to disappear or at least decrease in the years to come as a result of mass certification, we expect that farmer groups will see the cost of certification outweighing the benefits. This paper ends by discussing how institutional changes can secure a more positive outcome of certification in the cocoa value chain.

Keywords: Certification, cocoa, value chains

Contact Address: Enrique Uribe Leitz, Wageningen University, Development Economics
current address: Erkratherstr. 182, 40233 Düsseldorf, Germany, e-mail: enrique.uribeleitz@wur.nl

Socio-Ecological Significance of Collection and Marketing of Ancient Forest Commodities: The Case of Myrrh and Opoponax in the Dryland Areas of Southeastern Ethiopia

ADEFIRES WORKU GIZAW[1], JÜRGEN PRETZSCH[1], HABTEMARIAM KASSA[2], DEMEL TEKETAY[3]

[1]*Technische Universität Dresden, Inst. of International Forestry and Forest Products: Tropical Forestry, Germany*

[2]*Center for International Forestry Research (CIFOR), Ethiopia*

[3]*Botswana College of Agriculture, Dept. of Crop Science and Production, Botswana*

The objective of this study was to investigate the role of collection and marketing of age-old but still high value gum and resin products, in enhancing livelihoods and ecosystem resilience in the Somali National Regional State, southeastern Ethiopia. Based on the principles of "socio-ecological co-evolution theory" mixed quantitative and qualitative methods were employed to collect the data. Various descriptive and test statistics were used to analyze participation in gums and resins income activities and factors affecting it, and level of income and its distribution, among actors. Six types of gums and resins, namely myrrh, opoponax, frankincense, gum arabic, gum talha and hagar are collected from the dry forests and traded through nine major marketing channels. Some of the channels are considered as illegal since they involve unauthorized cross border trade. Triggered by complex price and non-price related factors, the illegal channels account for up to 40 % of the annual marketed volume of all gums and resins and 60 % of myrrh. Fourteen major actors engaged in the production and marketing chain of the study products. Producer households reported the growing importance of income from gums and resins in their risk management and livelihood diversification strategies. Income from these products constituted 62.4 and 21.6 % of the total forest and overall annual household incomes, respectively. Upward and skewed income distribution patterns were found among actors, indicating unfavourable condition for producer households. Producer households received only 32.2 and 13.1% of the price margin of myrrh and opoponax, respectively, whereas urban merchants got 67.8 and 86.9 %, respectively. Despite the age-old gum and resin production and marketing practices and their historical contribution to promote sustainable use of dry forests, product management remains traditional, and the marketing system is disorganised, characterised by weak financial capacity, thin representation of specialised actors and under-developed customary practices that, in turn, led to high rate of smuggling. Policy measures and extension messages that may facilitate the development of pro-poor and inclusive gums and resins value chain and sustainable management of dry forests are discussed in the context of the pastoral and agro-pastoral production systems.

Keywords: Agro-pastoral and pastoral communities, Ethiopia, household income, myrrh, opoponax, Somali region, sustainable forest management, value chain

Contact Address: Adefires Worku Gizaw, Technische Universität Dresden, Intitute of International Forestry and Forest Products -tropical Forestry, Pinner Str 7, Tharandt, Germany, e-mail: adefires@yahoo.com

Using Dairy Hubs to Improve Farmers' Access to Milk Markets in Kenya: Gender Implications

IMMACULATE OMONDI[1,3], KERSTIN ZANDER[2], SIEGFRIED BAUER[1], ISABELLE BALTENWECK[3]

[1]*Justus-Liebig University Giessen, Inst. of Farm and Agribusiness Management - Project and Regional Planning, Germany*
[2]*Charles Darwin University, School for Environmental Research, Australia*
[3]*International Livestock Research Institute (ILRI), Kenya*

Women make crucial contributions in agriculture and rural enterprises in all developing country regions yet they face more severe constraints in accessing productive resources markets and services compared to their male counterparts. In dairy sector, which is a major pillar in the socio-economic standing of sub-Saharan Africa, with Kenya having one of the largest dairy industries in the region, women contribute substantial labour to all of the activities associated with the dairy enterprise. It is therefore imperative that adequate attention is given to understanding the challenges facing women in dairying. This is important, especially in designing pro-poor development efforts. This study uses logit and tobit model to analyse factors that affect participation in dairy marketing hubs- collective farmer-owned milk bulking and/ or chilling plants from which farmers also access other services deemed necessary for their dairy enterprises - in Kenya. Primary data was collected from 300 dairy farmers in Western Kenya milk shed. The results of the study indicate relatively low participation of women in high value dairy markets i.e. the dairy hubs. In addition to having lower annual per capita cash income, producing less milk, and relatively higher dependence on dairy compared to their male counterparts, female-headed households were found to be significantly worse off in terms of education and number of income sources. While the results of the study support the premise that participation in dairy hubs would be important in improving households' dairy incomes, it also provides strong the evidence of women's apparent reluctance to participate in dairy hubs, arguably, due to loss of control of income from milk sales. This implies the need for careful, evidence-based interventions and change in structures that can encourage participation of women, ensure equitable intra-household distribution of the proceeds from dairy enterprise, and/ or compensate women's loss of income, without negative impacts on the stability of gender relations within the households.

Keywords: Collective milk marketing, dairy hubs, intra-household income distribution, logit, probit, women

Contact Address: Immaculate Omondi, Justus-Liebig University Giessen, Inst. of Farm and Agribusiness Management - Project and Regional Planning, Giessen, Germany, e-mail: Immaculate.Omondi@agrar.uni-giessen.de

Choice of Marketing Channels by Rubber Small Traders in the Jambi Province, Indonesia

RAKHMA MELATI SUJARWO[1,2], THOMAS KOPP[1], RITA NURMALINA[2], RATNA WINANDI ASMARANTAKA[2], BERNHARD BRÜMMER[1]

[1]*Georg-August-Universität Göttingen, Dept. of Agricultural Economics and Rural Development, Germany*

[2]*Bogor Agricultural University, Dept. of Agribusiness, Indonesia*

Rubber remains an important commodity in international trade, and is the main raw material for many industries. World rubber production is dominated by Asian countries, with Indonesia being the second largest producer after Thailand. With the third largest plantation area, the Jambi province is one of the largest contributors to Indonesia's rubber production (10.66 %).

In order to develop the Indonesian rubber industry further, the efficiency of the rubber marketing system needs to be taken into account which is strongly impacted by the choice of the marketing channel. Hence, considering choice in marketing channels will lead to the enhancement the efficiency of the rubber value chain.

Many researchers have focused their study on the choice of marketing channels of different commodities. However, most of these studies focused on farmers, while the study of marketing channels on the traders' level is rare. Nevertheless, rubber traders are important stakeholders in the distribution of rubber from farmers to processors. This study of marketing channel choice on traders' level is able to fill the gap and to contribute to the diversity of research.

Factories are expected to be the most beneficial buyers from the traders' perspective in order to optimise their trading business. However, there are many traders who select other channels. The questions addressed in this study are which factors determine the choice of marketing channels by rubber traders and why the village traders tend to sell the rubber to other channels than a factory.

A multinomial logistic regression model is employed to determine the factors affecting the channel choice. Results show that factors significantly affecting the decision of channel choice include location, credit access, information access, profitability aspects, and traders' characteristics. Traders tend to sell to other channels instead of factories if their location is far from the factory, if they have a relatively low quantity to sell, if there is better information access and if other channels have a more accessible bureaucratic procedure.

Keywords: Channel choice, multinomial logistic regression, rubber, small trader

Contact Address: Rakhma Melati Sujarwo, Georg-August-Universität Göttingen, Dept. of Agricultural Economics and Rural Development, Platz der Göttinger Sieben 3, Göttingen, Germany, e-mail: rakhmasujarwo@ymail.com

Rice Price Volatility Measurement in Indonesia Using GARCH and GARCH-X Method

DESSY ANGGRAENI[1,2], TINOUSH JAMALI JAGHDANI[1], ANDRIYONO KILAT ADHI[2], AMZUL RIFIN[2], BERNHARD BRÜMMER[1]

[1]*Georg-August-Universität Göttingen, Dept. of Agricultural Economics and Rural Development, Germany*

[2]*Bogor Agricultural University, Dept. of Agribusiness, Indonesia*

Typical agricultural price series may seem to follow a typical pattern, such that price increases in accelerating pace in one year followed by a sharp drop in the following year, yet their movements are unpredictable. In case of rice in Indonesia, this broad price movement within a short period is highly undesirable since it is a staple food and it is also a source of income for the majority of people, especially those living in the rural areas. Due to its strategic significance, rice price stabilisation plays a key role in the long term policy making process of Indonesian agriculture. This study aims to understand the volatility trend of rice price in Indonesia, by exploring some possible drivers and test the significance impact those drivers to overall volatility measurement. The methodology follows GARCH and GARCH-X technique to model volatility. Some of the drivers that we tested are the impact of national rice reserve level, harvest season, international rice price, and other macroeconomic variable. Our study on rice price volatility shows that the volatility of rice price was driven more by its own-variance rather than external shocks. Introduction of relevant external regressors such as stock level estimations or dummy vector for other macroeconomic variable to GARCH-X were found to be able to overall volatility estimation. Parameters of these external regressors were statistically significant to better describe price observations in GARCH-X model. However, the impacts of these external regressors are very small compare to the impacts of own-variance or external shocks. Maintaining sufficient level of rice stock at government reserve is important to keep rice market's social-psychology stable, but it is not enough to give meaningful impact in reducing price volatility. Obviously, good price stabilisation policy should be able to combine reasons for price volatility and cost of stabilisation at balance proportion.

Keywords: GARCH model, GARCH-X model, price volatility, rice

Contact Address: Dessy Anggraeni, Georg-August-Universität Göttingen, Dept. of Agricultural Economics and Rural Development, Platz der Göttinger Sieben 5, Göttingen, Germany, e-mail: dessy.anggraeni@gmail.com

Participation in Integrated Aquaculture-Agriculture Value Chain: Dynamics and its Determinants

ABU HAYAT MD. SAIFUL ISLAM

University of Bonn and Bangladesh Agricultural University, Center for Develoment Research (ZEF) and Department of Agricultural Economics, Germany

Since long time integrated aquaculture with agriculture (IAA) technologies have been promoted by different national and international organisation in many parts of Asia and Africa as a potential sustainable intensified technique. However, little rigorous empirical research exists, but for widespread diffusion and targeted policy intervention it is necessary for such technologies. The objective of this article is to investigate the determinants of dynamics of participation in IAA value chain by indigenous people in Bangladesh. It utilises a large, three wave panel dataset collected from value chain participator and non-participator (control) households from 2007 to 2012. The data enables us to identify the distinguishing features of continuing participants in the IAA value chain as well as non-participators and leavers (dis-participators), groups which were very often overlook from most of the technology adoption studies. We employ different panel estimation strategies to control for omitted variables and endogenous regressors that very often are not investigated or questionable in cross-section studies. The results, however, confirm previous findings that larger farms with better access to complementary inputs are more likely to participate in IAA-related value chain activities, non-participators appear quite unlikely to become participators, and landless, off-farm and non-farm income dependent households are more likely to participate in IAA backward and forward related value chain activities. Despite its immense promise, we find that IAA value chain participation is difficult for most of the smallholder farmers because the method requires a significant amount of complementary inputs which is often very difficult to access by the marginalised extreme poor households. This article highlightes how panel data can improve our understanding of adoption of technology in general and sustainable farming system technology in particular.

Keywords: Bangladesh, discrete choices panel data methods, integrated aquaculture with agriculture, marginalised extreme poor indigenous households, participation dynamics, value chain

Contact Address: Abu Hayat Md. Saiful Islam, University of Bonn and Bangladesh Agricultural University, Center for Develoment Research (ZEF) and Department of Agricultural Economics, Walter Flex strasse 3, 53113 Bonn, Germany, e-mail: saiful_bau_econ@yahoo.com

Finnish Citizens' Concerns about Global Food Security and Agri-Environmental Issues

HANNA PARTIO[1], EIJA POUTA[2], TUOMAS KUHMONEN[1]

[1] *University of Helsinki, Dept. of Economics and Management, Finland*

[2] *Mtt Agrifood Research, Economic Research, Finland*

The global population growth and economic growth of large developing nations increase the global demand for food. Since the global arable land and water resources are limited, it is crucial that agricultural production is sustainable and takes environment into account. The climate change will also affect greatly on farming conditions worldwide. Sufficiency of food is a challenge especially in developing countries. Their food production is often insufficient and unstable or serves developed countries. Different countries have different concerns, but citizens are important indicators of the state of food security. Therefore it is important to examine citizens' views related to sustainability and food security not only in developing countries but also in developed ones.

Based on quantitative survey data set (n=1,623), this research examines Finnish citizens concerns about various dimensions of global food security and agri-environmental issues. The research data was collected via nationwide mail survey in 2007 by the National Consumer Research Center of Finland. To determine the citizens' concern about different policy dimensions, a four-point Likert scale from no cause for concern (1) to extremely worrying (4) was used.

Principal component analysis exposed two components of concern. The components may be called food security and agri-environmental dimension and risk dimension. These components explain 59,4 % of the total variance. A cluster analysis of the respondents, based on the two components, produced four clusters: risk-concerned, generally concerned, concerned about food security and biodiversity and not concerned respondents. The clusters differed by their demographic, economic, attitudinal and consumption profiles. It seems that citizen's concerns focus on specific aspects of sustainability and various social groups have specific profiles in their concerns.

Keywords: Agriculture, citizens, food security, public concern, sustainability

Contact Address: Hanna Partio, University of Helsinki, Dept. of Economics and Management, Latokartanonkaari 9 (P.O.Box 27), 00790 Helsinki, Finland, e-mail: hanna.partio@helsinki.fi

Do Consumers Care about Ethics? Influence of DEAR and GDI on Buying Preferences

HYNEK ROUBIK, JANA MAZANCOVA, SANDRA KRUPICKOVA
Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Czech Republic

These days consumers can express their concern about the ethical behaviour of companies by means of ethical buying and consumer behaviour. The purpose of this study was to investigate how DEAR (Development Education Awareness Rising) and GDI (Global Development Issues) knowledge affects consumers preferences in the environment of the Czech University of Life Sciences Prague (CULS Prague). The pilot survey was conducted in Prague, Czech Republic from February to March 2014 at the level of students of the Faculty of Tropical AgriSciences. Data collection was done through online survey. Our survey involved 106 respondents out of total 636. Collected data were categorised, coded and analysed in a statistical programme Statistica 10. In the study we examined DEAR impacts and its effects on consumer's care, consumer's habits and attitude, and influence of DEAR on buying preferences. Some of the most recent studies tend to assume that some ethical intentions are authentic; however, internal and external factors affect actual purchase decisions. This is why we also aimed at finding a relationship between DEAR and ethical consumption behaviour. Our results revealed a positive correlation ($\rho = 0.664$, $\alpha = 0.005$) between examined factors - knowledge of specific terms (effects of GDI and DEAR) with socially responsible consumers behaviour. This result indicates connection between knowledge about specific issues and consumers habits. If consumers are well informed, positively influenced and have access to willed products they act as socially responsible consumers. Therefore, there is proven importance of education and access to information as a key component for conscious behaviour. It confirms the importance of knowledge about GDI and proper DEAR as a main linkage between knowledge and consumers habits and their socially responsible behaviour in connection with shopping preferences. These days Global Development Education and Development Education Awareness Rising should be considered not only alternatively in education, but it should become more common part of educational process. Attention should be paid to these issues at the international and global levels.

Keywords: DEAR, ethically created products, global development issues

Contact Address: Hynek Roubik, Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Dept. of Sustainable Technologies, Kamycka 129, 16521 Prague, Czech Republic, e-mail: hynek.roubik@seznam.cz

Consumer Preferences Regarding Quality Rice in Thailand

LARA BEISIEGEL, NINA LANGEN
University of Bonn, Dept. of Agricultural and Food Market Research, Germany

Rice is the primary staple crop for more than half of the world´s population. Thus, quantity has long been the main focus of research in order to alleviate poverty and malnutrition. But with increasing prosperity across Asia, rising incomes and urbanisation levels a diversification of the diet composition and of consumption habits can be observed. In particular rice consumption is reported to begin to decrease among affluent consumers due to a westernisation of their diets. For Southeast Asia this holds especially true for Thailand. The transition towards western habits includes the shopping behaviour in terms of quality awareness as well as market channels. A shift away from wet markets to supermarkets can be observed. The growing share of supermarkets has a high sensitivity for high income consumer demands and is able to translate those desires into standardised requirements which have to be met by the downward supply chain. This creates challenges but also opportunities for a market orientation throughout the value chain which can be met if the preferences of the respective consumer segments are understood. Hence, knowing and meeting the preferences of the growing middle and upper class in terms of quality becomes a crucial factor in ensuring long term economic viability in the production and domestic marketing of the country´s main agricultural commodity.
Against this background the paper describes a consumer study investigating Thai consumers preferences for rice. The current decisive attributes when selecting rice for at-home consumption among the urbanised population of Thailand are investigated. Trends like convenience, sustainability, safety and health concerns are taken into consideration to assess the extent to which these quality criteria influence consumers' purchase decision. The question which rice quality attributes play a major/minor role is answered by means of a survey based on "Best Worst Scaling".

Keywords: Consumer research, food choice trends, rice quality, urbanisation

Contact Address: Lara Beisiegel, University of Bonn, Dept. of Agricultural and Food Market Research, Nussallee 21, 53115 Bonn, Germany, e-mail: larabeisiegel@googlemail.com

Factors Affecting Profit Efficiency among Smallholder Beef Producers in Botswana

SIRAK BAHTA, ALEC MAKGEKGENENE
International Livestock Research Institute (ILRI), Botswana

The livestock sector is an important component of Botswana's economy, contributing about two thirds of total agricultural value added. Climate constrains intensive arable farming in most of the country. Within the livestock sector, beef production remains an important sub sector in the rural economy as a source of income and employment, and it represents a significant investment opportunity. In addition, beef is the major agricultural generator of foreign exchange and provides about 80 % of agriculture's contribution to GDP.

Beef productivity has recently been stagnant, however, and there are concerns that its competitiveness has been eroded over the last decade. This is vital to the generation of benefits from preferential access to the EU market. Causal factors are likely to include many supply side constraints manifest as low off take rates and high mortality. There is significant overcapacity in processing, with consequent low profitability in processing operations. Moreover the reduction of EU beef support prices and the high cost of Sanitary and Phyto-sanitary (SPS) compliance have had adverse demand-side effects on competitiveness.

Farm level cross sectional data of 556 from randomly selected livestock producers were used to investigate the competitiveness of small holder livestock farmers in Botswana. A translog stochastic frontier production function is estimated, in which profit inefficiency effects are modeled in terms of household specific characteristics and transaction costs. The Log likelihood test showed strong rejection of the OLS, indicating presence of inefficiency.

The mean profit efficiency level of 0.56 suggests that with in the current production technology there is still a substantial room for beef profitability improvement in Botswana. Significant profit efficiency drivers include, among others, age, access to information, proximity to market and access to income from crop production. Considering the importance of livestock sector for wealth creation and poverty eradication in the rural areas where poverty is more pronounced, there is a need for appropriate development strategies and policies directed towards addressing these factors.

Keywords: Botswana, competitiveness, inefficiency, profit efficiency, Stochastic frontier function

Contact Address: Sirak Bahta, International Livestock Research Institute (ILRI), Private Bag 0033, Gaborone, Botswana, e-mail: s.bahta@cgiar.org

Do Thai Cut Orchid Producers Benefit from Q-GAP Certification?

HENNING KRAUSE, RATTIYA S. LIPPE, ULRIKE GROTE
Leibniz Universität Hannover, Institute for Environmental Economics and World Trade, Germany

Standards and certification schemes have become increasingly important in the global floricultural trade as a result of social and environmental concerns in the entire value chain. This is also true for Thailand which is one of the major exporters of cut orchids in the world with an annual trade volume of 50 million € in 2012. To further increase the competitiveness of its orchid sector in the world market, the Thai government introduced the Q-GAP programme where production follows the standard for Good Agricultural Practices (GAP). However, the number of certified orchid producers has declined over time raising important questions about the costs and benefits of the Q-GAP program. This paper therefore aims to evaluate the impact of the Q-GAP scheme on Thai cut orchid producers: The analysis is based on survey data of 256 certified and non-certified orchid producers in the major production areas. To circumvent selection bias, Propensity Score Matching was applied. A binary choice model determining the adoption of Q-GAP certification served as balancing score. Results show no significant impact of Q-GAP certification on the income of cut orchid producers. This can be explained by the fact that certified and non-certified products follow the same value chains so that certified producers do not receive any price premium and that Q-GAP certification does not improve the access to upgraded markets. Also pesticide expenditure and quantities could not be reduced by the scheme, which goes along with evidence from prior studies on Q-GAP's impact on Thai vegetable production. However, tendencies of indirect benefits such as improved farm management leading to higher performance (e.g. expanding production areas and invest in agricultural assets) as well as increased participation in cooperative activities and better worker's protection are visible. Conclusively the public Q-GAP scheme does not seem to fulfil its expectations to reduce pesticide usage and increase income from orchids. Due to limited perceived benefits, Thai cut orchid producers have few incentives to participate. Better monitoring could reduce the pesticide usage and increase credibility of the scheme.

Keywords: Cut orchids, household welfare, impact, pesticide reduction, public GAP standard, Q-GAP, Thailand

Contact Address: Henning Krause, Leibniz Universität Hannover, Institute for Environmental Economics and World Trade, Noltestr. 4, 30451 Hannover, Germany, e-mail: hkrause87@gmx.de

Leveraging Sustainability: How Do Producer Cooperatives Use Coffee Certifications to Promote Sustainable Agricultural Practices?

ANNA SNIDER[1], GUY FAURE[2], NICOLE SIBELET[2], EVA KRAUS[3], ASKE SKOVMAND BOSSELMANN[3], ANDREAS DE NEERGAARD[3]

[1]*Montpellier - SupAgro, France*

[2]*CIRAD, Innovation, France*

[3]*University of Copenhagen, Fac. of Life Sciences, Denmark*

Coffee production in Costa Rica has traditionally been input-intensive and ecologically unsustainable. Sustainable coffee certifications may offer farmers in developing countries an incentive to produce coffee in an environmentally, socially and financially sustainable manner. Small farmers, who would otherwise not have access to the resources need to access certifications, particularly to the training needed to incorporate these new requirements, can access certifications and training through farmer cooperatives. The certifications, in turn, help the cooperatives penetrate new markets, access outside resources and form partnerships with external knowledge brokers.

While financial aspects are very important factors in the cooperatives' decision to pursue certifications, certifications are more than just a way for farmers to earn a premium price for their product. Sustainable coffee certifications, such as fair trade, CAFE Practices of Starbucks, Rainforest Alliance certified and certified organic have a set of standards which focus on environmental, and in some cases, social and financial sustainability. These certifications have the potential to influence the way the cooperatives serve their members. Certifications incite innovations at the cooperative level and the collaboration of new actors to better provide services, training and advice to member producers and thus leverage an ideology of sustainability among members.

This research consisted of case studies of four Costa Rican coffee cooperatives which participate in a variety of sustainable coffee certifications. The certifications can induce changes at the cooperative level which are needed to develop a new discourse about sustainable farming systems, provide new services to support farmers to comply with certification and influence farmers' perceptions about sustainable farming systems. Farmers in certified cooperatives often have more access to training in sustainable practices such as soil and water protection and personal protection against pesticides.

Certifications have also encouraged innovations on the institutional level in the form of consortia and public-private partnerships. These associations strengthen the capacities of small cooperatives with low levels of human capital and increase their access to training in sustainable management and farming practices. The potential for certifications to influence farmers' perceptions about sustainability is, however, dependent on perceptions and motivations of the cooperative administration.

Keywords: Certifications, coffee, cooperatives, sustainable agriculture

Contact Address: Anna Snider, Montpellier - SupAgro, 34000 Montpellier, France, e-mail: anna.snider@cirad.fr

Agri-Information on Mobile Platforms as a Tool to Bridge Rural-Urban Markets for Hill Farmers in Uttarakhand

SANJAY BAHTI

GIZ, develoPPP.de, India

Inadequate information, in terms of relevance and timeliness, is a key hindrance in the decision making of small holder farmers. Access to information is even more critical in a hill state like Uttarakhand, India where 75 % population depends on agriculture despite small land holding. Modern agriculture is knowledge intensive which requires timely and reliable information on different aspects and stages of crop cycle including post harvest and market information. Timely information can help in efficient decision making leading to improved returns to the small holder farmers. Multiple initiatives using various media including television, radio, magazines, bulletins, call centres etc have been used by various agencies however the access to these services are found to be still inadequate in Uttarakhand Hills. With high penetration of mobiles phones (82 %) in rural households. Mobile platform presents an opportunity to use it for efficient dissemination of agricultural information. GIZ, in partnership with various stakeholders and Reuters Market Light as service provider, facilitated the agriculture information dissemination through SMS in Uttarakhand on a pilot scale, with an overall aim of addressing the information gaps of small and marginal hill farmers as a part of its Regional Economic Development (RED) Programme. This paper discusses the impacts of this pilot initiative, from the results of a study conducted for impact assessment after one year of intervention. The methodology included FGD, structured and semi structured interviews. Study sample consisted of 10 % of the beneficiaries and non beneficiaries from 5 districts of Kumaon & Garhwal. The information requirements of farmers (both subscribers and non-subscribers) were found to be the weather forecast, market price, seeds, Government schemes and crop advisory, respectively in the order of priority. Mobile SMS was rated as the best source of information, helping farmers gain timely market information from and adopting better agricultural practices. Few cases reported 5–10 % increase in the market value of their produce. The preference for this service was found to be aligned with specific crop cycles. Further customisation of content, improvement in customer care services and training for farmers are few recommendations

Keywords: Agri-information, decisions making, distress sale , SMS service, Uttarakhand

Contact Address: Sanjay Bahti, GIZ, develoPPP.de, 533 Indira Nagar, P.O New Forest , 248001 Dehradun, India, e-mail: sanjay.bahti@giz.de

Smallholder Oil Palm Value Chain in Cameroon: A Case Study from the Department of Sanaga-Maritime

IYABANO ABOUBAKAR HAYATOU[1,3], FEINTRENIE LAURÈNE[1], MIARO III LUDOVIC[2], ABDELHAKIM TAHANI[3]

[1]*CIRAD - Central African Regional Office, Cameroon*

[2]*WWF, Central Africa Regional Office, Yaoundé, Cameroon, Cameroon*

[3]*Mediterranean Agronomic Institute of Montpellier, France*

Cameroon has been producing palm oil for centuries but industrial scale production started around 1907 under the German colonisation with the development of estates and mills around the Littoral region (Sanaga-Maritime). The country's production of palm oil can be grouped into traditional (artisanal) and industrial milling. The production is stratified in three groups: an agro-industrial sector, smallholders in contract with agro-industries and traditional independent smallholders also called artisanal sector. Smallholders with less than 5 ha of oil palm represent more than 75 % of oil palm growers but provide only half of the production due to very low yields. Despite the presence of these three groups, the national production is not sufficient to cover the domestic consumption. The government considers the oil palm sector (both artisanal and industrial) as an important tool to alleviate poverty and to generate national revenues.

This paper analyses the operation of smallholding oil palm value chain in the Department of Sanaga-Maritime. Data were collected trough field survey that involved distribution of pre-structured questionnaires to a sample of 60 actors purposively selected. The data collected through these questionnaires were analysed using Olympe software. The study reveals that, oil palm smallholding value chain is made up of three categories of farmers: family farms, rural and urban investors. The average margins of farmers are higher for the plantation of urban investors, followed by those of the rural investor and the family farms. Family farmers are the actors who process all their produce into red palm oil, whereas, the rural investor and urban elites do not process their produce. They rather sell their nuts, either to local artisanal millers or to the local agro industry. Two types of artisanal millers have been identified: manual vertical press users and combined motorized horizontal press users. In general, the motorized horizontal presses have a higher production capacity (tons/day) than the manuals presses. The study also reveals that the extraction rate slightly differs according to the type of press used.

Keywords: Artisanal millers, Cameroon, oil palm, olympe, value chain

Contact Address: Iyabano Aboubakar Hayatou, CIRAD - Central African Regional Office, s/c Laurène Feitrenie CIRAD - Forest Ecosystems Goods and Services Direction Régionale D'afrique Centrale, 2572 Yaoundé, Cameroon, e-mail: iyabano1aboubakar@yahoo.fr

Transaction Costs Between Dry Bean Producer Markets in Brazil

PAULO ETERNO VENANCIO ASSUNCAO[1], ALCIDO ELENOR WANDER[2]
[1]*Federal University of Goias (UFG), School of Agronomy, Brazil*
[2]*Brazilian Agricultural Research Corporation (EMBRAPA), National Rice and Beans Research Center (CNPAF), Brazil*

Brazil is one of the main dry bean producing and consuming countries worldwide. Each year between 3 and 3.5 million tons are supplied to the Brazilian domestic market. With an average consumption of 17/kg/capita/year, dry beans represent staple crops in Brazil. Cropping systems are heterogeneous, varying from small-scale extensive mixed cropping to large-scale monoculture with central pivot irrigation systems. Brazilian dry bean production comprises common beans (*Phaseolus vulgaris* L.) and cowpeas (*Vigna unguiculata* (Walp.)). Both species are grown in three different seasons, resulting in supply over the whole year. This paper aimed to assess the presence of transaction costs in bean markets in Brazil. Therefore, threshold autoregressive (TAR) models were used to check co-integration and the existence of transaction costs in the Brazilian dry bean market. The threshold model is presented as alternatives and at least appear as a complement to traditional models of co-integration, and the model takes into account the possibility of discontinuities in the process of price transmission between markets, therefore, are usually assigned transaction costs. The results confirmed the presence of transaction costs in the bean market. The transaction costs are mainly related to freight component of production, since markets are often far away from producing regions. The higher the market transaction costs and distance between considered markets, the longer price schocks take to dissipate. Actions like improvements in transportation and communication infrastructure and reduction of fees and cash expenses as well as removing technical trade barriers may contribute to increase market integrations. Therewith, transaction costs may be reduced and markets can become more competitive.

Keywords: Cointegration, common bean, threshold autoregressive model

Contact Address: Alcido Elenor Wander, Brazilian Agricultural Research Corporation (EMBRAPA), National Rice and Beans Research Center (CNPAF), Rodovia GO-462, km 12, 75375-000 Santo Antonio de Goias, Brazil, e-mail: alcido.wander@embrapa.br

Factors Influencing Coffee Marketing Strategies among Coffee Farmers in Ggolo Parish, Uganda

ANDNET ABTEW[1], ENRIQUE URIBE LEITZ[2], IRENE TAMUBULA[3], MILLICENT OYUGI[4]

[1]*International Center for Insect Physiology and Ecology (ICIPE), Plant Health Division, Kenya*

[2]*Wageningen University, Development Economics, The Netherlands*

[3]*Makerere University, Uganda,*

[4]*Egerton University, Kenya*

This study aims to understand the factors leading small coffee farmers to choose between selling their coffee to the rural traders (farm gate) or to the regional dehusking factory available in the Ggolo parish, Nkozy Sub-County, Mpigi District in Uganda. Prices obtained at the producer level vary according the marketing strategy. Therefore, this study was conducted to: i) analyse the relationship between factors influencing the choice in the marketing strategies, and ii) compare the revenue from the different marketing strategies. Data for the survey was generated through semi-structured interviews, cross sectional surveys, participant observation, personal interviews and one focus group discussion. Results show that 58 % of the farmers combine both strategies, while 25 % sales to rural traders and 16 % only sale to the regional factory respectively. Most influential factors driving the marketing choice were found to be, the quantity of coffee produced, the quality level of the harvest, the different income generating activities and the cash availability of the households. From the regional factory, the coffee is traded through middlemen to the exporting companies, who take the product to the international market which indicates that the small scale coffee farmers are distant from the international markets. Here we notice that to benefit resource poor farmers, shortening the coffee supply chain is needed. One possibility could include building trust among farmers and establish farmers associations to market the coffee more efficiently and access higher value markets and avoid selling to the rural traders at the farm level. This and other similar strategies would help farmers to get a better income. In Uganda, this will benefit over two-thirds of the country households which depend on coffee production as a source of income. Hence, this reflects the urge for a better marketing strategy which addresses the underlying factors behind the choices of coffee marketing at the production level.

Keywords: Coffee, marketing strategies, supply chain

Contact Address: Enrique Uribe Leitz, Wageningen University, Development Economics
current address: Erkratherstr. 182, 40233 Düsseldorf, Germany, e-mail: enrique.uribeleitz@wur.nl

Reasons of Prices for Wild Chili (*Capsicum annuum* L. var. *glabriusculum* Heiser & Pickersgill) in North-East Mexico

HORACIO VILLALON-MENDOZA[1], SANDRA ELIZABETH SOLIS-URBINA[1], MOISES RAMIREZ-MERÁZ[2], TEODORO MEDINA-MARTÍNEZ[3], FORTUNATO GARZA OCAÑAS[4]

[1]*Universidad Autónoma de Nuevo León, Dept. of Agroforestry, Mexico*

[2]*INIFAP, Forest Management, Mexico*

[3]*University Autonom Tamaulipas, Ecology Institute, Mexico*

[4]*Universidad Autónoma de Nuevo León, Dept. of Silviculture, Mexico*

The "Chile piquin", a wild chili (*Capsicum annuum* L. var. *glabriusculum* Heiser & Pickersgill) represents a natural resource and typical culture of North-East Mexico. This plant species is a component of the piedmont shrubs of this region and is perennial. It grows in the semi-arid and tropical region of Mexico. In order to understand the factors influencing the great demand and also the high cost of piquin pepper in north-eastern Mexico, surveys were undertaken in the study area. This was done to determine the factors that make people to pay a high price for piquin pepper. The present study has been undertaken specifically in the representative municipalities where chile piquin is mainly marketed: in Ciudad Victoria (Tamaulipas state) and Linares and Monterrey (both located in Nuevo Leon). On these markets interviews were held. The results showed with 95 % confidence, that its desirable flavor compared to that of other chilis like serrano and jalapeno, was the main reason for the consumer to pay more for the piquin pepper. The consumers offer a higher price for piquin chilli not only because it is considered a product of better taste, but also of better they esteem quality, and the hard work required for its production, besides it is considered a regional resource. Hence piquin pepper is considered a premium product for which people pay on average US$ 6.25$\pm$3.75 per pound.

Keywords: Flavor, North-East Mexico, piquin pepper, price factors, quality

Contact Address: Horacio Villalon-Mendoza, Universidad Autónoma de Nuevo León, Dept. of Agroforestry, Carr. Nal km 145, 67700 Linares, Mexico, e-mail: horacio.villalon@gmail.com

Factors for Success and Failure of Pig Production Marketing Groups in Vietnam

KERSTIN SCHÖLL, ANDRÉ MARKEMANN, ANNE VALLE ZÁRATE
University of Hohenheim, Inst. of Animal Production in the Tropics and Subtropics, Germany

Pig production is an essential source of livelihood for small-scale farmers in Vietnam. Small-scale farming with an average of one to two sows per farm dominates the pig production sector. Pork is mostly produced for the domestic market.
Still, small-scale farmers often have limited opportunities to sell their marketable surplus in an efficient and profitable manner. In recent years, several intervention projects have focused on linking farmers to markets in order to improve their livelihoods. Establishing farmer groups or cooperatives is one way to improve access of farmers to markets and empower them in marketing interventions. Yet, not all farmer groups or cooperatives are working successfully. This paper evaluates the sustainability of farmer groups devoted to pig production and marketing in Vietnam.
Pig production groups can be grouped into common interest groups (CIG), cooperative groups (CG) or cooperatives. CIGs are the simplest form of farmer organisations, while CGs require a cooperative contract, and cooperatives are established formally under the Vietnamese Law of Cooperatives.
A survey of 286 members from 15 CIGs, one CG and two cooperatives, and 479 non-members was conducted from September to December 2013 in three provinces in Northern and Central Vietnam, and in Hanoi. The chosen provinces (Cao Bang, Lao Cai and Ha Tinh) are among the poorest provinces of Vietnam.
The farmers were asked to give reasons for potential successes and failures of their farmer group and to subsequently rank their answers. Farmer group members were also asked about their satisfaction with the management of the group and their membership based on a 4-point Likert scale (very satisfied to very unsatisfied).
Preliminary results suggest that members ranked training as the most important success factor, followed by external support. As major causes for failure member commitment was ranked first, followed by leader board commitment. Most of the members were satisfied with the leaderboard and their commitment. However, a small number was very unsatisfied due to inequalities in treatment towards the members. Members' satisfaction with the organisational set-up can be closely correlated with the duration and the sustainability of active farmer groups.

Keywords: Farmer cooperative groups, smallholder pig production, sustainability, Vietnam

Contact Address: Kerstin Schöll, University of Hohenheim, Inst. of Animal Production in the Tropics and Subtropics, Garbenstrasse 17, 70599 Stuttgart, Germany, e-mail: kerstin.schoell@uni-hohenheim.de

An Exploratory Analysis of the Effectiveness of Milk Market in Odisha, India

BRAJA SWAIN[1], NILS TEUFEL[2]

[1]*International Livestock Research Institute (ILRI), India*

[2]*International Livestock Research Institute (ILRI), Kenya*

The dairy sector plays an important role for Odisha, an Eastern Indian state, contributing a large share of the agricultural gross domestic product (GDP) and supporting the socioeconomic development of millions of rural households. In Odisha, 80 percent of rural households depend on dairy and draw 30 per cent of their annual income from it. Also, dairy constitutes a major share of the value of output from the livestock sector – the share has increased from less than 50 percent in 1950–51 to about 65 percent in the 2000s. Nevertheless, the dominating small, resource constrained farmers have not been able to extract the potential benefits from the growing demand as they have failed to improve their linkages with markets and consumers. Improving the efficiency of the value-chain system is seen as a major opportunity for the development of the dairy sector.

To explore the effectiveness of milk markets in Odisha 130 villages were randomly selected from two districts (Puri and Bhadrak), based on their milk production and marketing systems. The data were collected with a focus group questionnaire covering the following topics: village characteristics, cattle population, milk production, market channels, feed markets and female participation. The results show that 70 percent of the produced milk was consumed as liquid while 30 percent was processed – into curd, ghee and cheese. Where dairy co-operatives are not very strong, farmers process most of the milk themselves and sell the products to middlemen and sweetshops. 55 percent of milk and cheese are sold while only 20 percent of ghee is sold. Among the different market channels, middlemen play an important role, while co-operatives have only a limited role. Farmers are selling 55 percent of their milk through middle-men while 38 percent are sold to co-operatives and 5 percent to household consumers. Finally, farmers benefit more from dairy in terms of high milk price, input subsidies and health care support where co-operatives are strong compared to the weak region. The results give an indication for appropriate policy structures to be created for improving the integration of milk producers and consumers.

Keywords: Milk market, Odisha, smallholder

Contact Address: Braja Swain, International Livestock Research Institute (ILRI), 9th floor, Aggarwal Corporate Tower, 23 Rajendra Place, 110008 New Delhi, India, e-mail: brajacds@gmail.com

Mapping Urban Foodsheds – A Comparison of Tamale and Ouagadougou

HANNA KARG[1], EDMUND KYEI AKOTO-DANSO[2], PAY DRECHSEL[3]

[1] *University of Freiburg, Department of Environmental Social Sciences and Geography; Physical Geography, Germany*

[2] *University of Kassel, Organic Plant Production & Agroecosystems Research in the Tropics and Subtropics, Germany*

[3] *International Water Management Institute (IWMI), Water Quality, Health and Environment, Sri Lanka*

Cities as major hubs of consumption induce an inflow of food from the rural to the urban areas. To meet the growing urban demand cities increasingly have to rely on large-scale, long distance transportation of food. On the other hand, in many cities, urban and periurban farming contributes noticeably to certain niche food markets. Analysing food flowing through a city's foodshed reflects the integration in international and national markets, and the importance of local, i.e. urban and periurban agricultural production.

This study was carried out by the UrbanFoodPlus project in Tamale, Ghana and Ouagadougou in Burkina Faso, two of the fastest growing cities in West Africa. It is part of ongoing PhD projects and will answer the following research questions:

1. What are the major food flows entering the cities of Ouagadougou and Tamale, and how did they change over the years?
2. What is the extent of the urban foodshed of both cities and hence, what is the relative contribution of urban and periurban production (locally produced food) vs. imports (from regional, national and international sources)?
3. How do size and shape of the foodshed change across seasons?

Food flows were recorded at roads entering the cities and at major markets during the peak and lean season. First results indicate that flows vary considerably across seasons in both cities with the major staple crop supply covered by local and regional production during the peak season. In the dry season, both cities provide the urban population with fresh vegetables from urban irrigated production. Ouagadougou's status as national capital is reflected in the larger diversity of food items in the markets and the relatively longer distances food travels.

Keywords: Food flow analysis, foodshed, urban and periurban agriculture, West Africa

Contact Address: Hanna Karg, University of Freiburg, Department of Environmental Social Sciences and Geography; Physical Geography, Freiburg, Germany, e-mail: hanna.karg@geographie.uni-freiburg.de

Commercialisation of Plant-Based Farm Products and its Impact on Living Standard of Rural Households in Fergana Valley, South-Western Kyrgyzstan

LINDA POREBSKA[1], MARTINA VLKOVÁ[1], VLADIMIR VERNER[1], ALEXANDER KANDAKOV[1], ZBYNEK POLESNY[1], LUKAS PAWERA[1], NURUDIN KARABAIEV[2], JAN BANOUT[1]

[1]*Czech University of Life Sciences Prague, Fac. of Trop. AgriSciences, Czech Republic*

[2]*Kyrgyz National Agrarian University, Fac. of Agronomy, Kyrgyzstan*

Traditional agricultural markets are an integral part of both rural and urban areas worldwide, particularly to supply local households with basic food. Recent studies point out, however, that to the number of products sold depends on the socio-economic characteristics of both vendors and buyers. Further the commercial potential of the markets differ according to the natural, cultural and economic situation of a particular region. Thus, the aim of our study was to (i) describe the historical and recent development of rural markets in the target area, (ii) document main kinds of food and snacks sold and the main categories of use, and, (iii) identify how commercialisation of these products influences the living standard of the vendors. The study was carried out in Kulundu commune, south-western Kyrgyzstan, where Fergana valley interferes into the country. Data were collected during July 2012 on two rural markets. Products sold on markets were documented and sixteen vendors were interviewed using pre-prepared questionnaires. Results showed that markets offered twenty kinds of local species of vegetables and fruits. All species were of local origin and serve particularly as a food supplements or garnitures for local cuisine. Furthermore, vendors stated that selling their production at local markets is important for ensuring economic security. The target area had several specific socio-economic factors that influenced market situation. Firstly, markets focused on selling agricultural products were closed during the time of communism and they were re-established in mid-1980s during the transformation of Soviet Union's economy. Their importance further increased after the collapse of USSR a few years later. Till the mid-1980s, all food supplies were distributed through a network of small shops and there was no need for specialised rural markets. Additionally, a relatively small amount of crop species were sold regularly on focused markets, which could be explained through the existence of a cross-boundary trade with neighbouring Tajikistan. Actually, traditional rural markets in Kulundu are prosperous, offering food supplements for daily life of local people and contribute significantly to the improvement of livelihood generation of the vendors.

Keywords: Agro-biodiversity, ethnobotany, household economy, market survey

Contact Address: Vladimir Verner, Czech University of Life Sciences Prague, Faculty of Tropical AgriSciences, Department of Economics and Development, 129 Kamycka Str., 16521 Prague 6 - Suchdol, Czech Republic, e-mail: vernerv@ftz.czu.cz

Promoting the Use of Baobab (*Adansonia digitata* L.) in Rural Communities in Eastern Africa

MAHMOUD FADL EL MULA AHMED[1], YAHIA OMAR ADAM[2], MUNTHALI CHIMULEKE[3], DIETRICH DARR[4], ELWASILA MUKHTAR MOHAMED ELWASILA[1], JENS GEBAUER[4], TSIGE-YOHANNES HABTE[5], HENRY JOHNSON[6], KATJA KEHLENBECK[7], MICHAEL KRAWINKEL[5], TARIG ELSHEIKH MAHMOUD[8], ANTHONY MAINA[9], NYORI JEREMIAH MBUGUA[10], DAGMAR MITHÖFER[4], KAVOI MUTUKU MUENDO[10], RABEA NORTH[4], WILLIS OMONDI OWINO[10], FREDAH KARAMBU RIMBERIA[10], EL AMIN SANJAK[1], MARTIN SCHÜRING[11], MUNEER ELYAS SIDDIG[8], MOHAMED EL NOUR TAHA[12], ANDREAS TRIEBEL[13]

[1] *University of Khartoum, Fac. of Agriculture, Sudan*
[2] *University of Khartoum, Fac. of Forestry, Sudan*
[3] *Mzuzu University, Fac. of Environmental Sciences, Malawi*
[4] *Rhine-Waal University of Applied Sciences, Fac. of Life Sciences, Germany*
[5] *Justus-Liebig University Giessen, Inst. of Nutritional Sciences, Germany*
[6] *PhytoTrade Africa, United Kingdom*
[7] *World Agroforestry Centre (ICRAF), Tree Diversity, Domestication and Delivery, Kenya*
[8] *University of Kordofan, Gum Ararbic Research Center, Sudan*
[9] *Wild Living Resources , Kenya*
[10] *Jomo Kenyatta University of Agriculture and Technology, Kenya*
[11] *ttz Bremerhaven, Germany*
[12] *University of Kordofan, Forestry and Range Sciences, Sudan*
[13] *Baobab Social Business gGmbH, Germany*

Baobab (*Adansonia digitata* L.) is a majestic tree that occurs naturally throughout the drier parts of sub-Saharan Africa. This multipurpose species with an exceptionally nutritious fruit has the potential to play an important role in family nutrition and food security in marginalised rural communities. Following initiatives by PhytoTrade Africa that led to the acceptance of baobab dried fruit pulp as a novel food ingredient in the EU and the US in 2008, further opportunities for cash income generation potentially arise from growing international demand for baobab.

The vast majority of recent research activities on baobab have mainly focused on Southern and Western Africa, but little is known about East Africa, particularly Kenya and Sudan. To explore the potential of baobab to improve food security, nutritional health and rural poverty, a research consortium has been formed bringing together research institutions and the private sector in Kenya, Sudan, Malawi, UK and Germany. Stakeholder workshops and field visits were conducted in Germany and Kenya to exchange the available information and identify knowledge gaps.

The results of the workshops can be summarised as follows:

Contact Address: Dietrich Darr, Rhine-Waal University of Applied Sciences, Fac. of Life Sciences, Marie-Curie-Str. 1, 47533 Kleve, Germany, e-mail: dietrich.darr@hochschule-rhein-waal.de

• To ensure a sufficient supply of baobab products, there is the urgent need to (i) investigate the current contribution of baobab products to local diets, food security and income generation; (ii) assess the ecology, distribution and abundance of baobab and potential future changes; (iii) analyse the potential of new processing technologies for maintaining nutrients during storage; (iv) assess markets, supply chains, consumer preferences and industry requirements for baobab products; and (iv) build capacities of local communities, particularly women, on value addition and raise their awareness on the value of baobab products for family nutrition.
• Future research should address the improvement of the long-term food security and nutrition of local communities in the target regions by (i) ensuring the availability of and access to baobab products with high nutritional value, (ii) increasing the use of baobab products in daily diets, and (iii) raising incomes from selling raw and processed baobab products of high nutritional value.

Keywords: Food security, fruit tree, Kenya, neglected species, nutrition, sudan, value chain, workshop

Competitiveness in the Peruvian Asparagus Industry

JANET KARINA VALVERDE VILCARA, WOLFGANG BOKELMANN
Humboldt-Universität zu Berlin, Dept. of Agricultural Economics and Social Sciences, Germany

Peru has experienced a remarkable economic growth in the last years. Despite the global financial crisis of 2009; it is one of the fastest growing countries in Latin America. In Peru, the export is a very important economic activity that has been driving this growth. However, as the main Peruvian exports come from the extracting industries like metals and mining products, the poverty rates remain high in rural areas. Agricultural exports give a chance to Peru not only to improve their overall economic performance but also to promote the economic development of the rural regions.
Asparagus with its high international demand and prices was an astute choice. Asparagus has a history of almost 50 years in the Peruvian agriculture, and it has given Peru experience and recognition as an agricultural export country. Currently, Peru is the largest asparagus exporter worldwide, with its main commercial type being the green fresh asparagus. The asparagus industry has also offered employment in urban areas, leading to social and especially gender dynamics in these areas. The Peruvian asparagus industry is believed to be competitive. Is that really the case? And if it is, do we know the reasons for it?
This research presents an investigation into the competitiveness of the Peruvian asparagus industry and the circumstances of its international competitiveness out from the perceptions of experienced industry actors. To improve the value chain performance in an increasingly global market, Peruvian asparagus industry actors must have a clear understanding of how to assess their competitive position and how to affect their determinants.
In the first part of this research, we predominantly use different measures of competitive performance. In the second part of this research, an empirical study is performed, using expert interviews from the asparagus industry in Peru. The study assesses the importance of several factors of the value chain competitiveness. Further analysis of qualitative data is still ongoing.

Keywords: Asparagus, competitiveness, determinants of competitiveness, industry, performance competitiveness

Contact Address: Janet Karina Valverde Vilcara, Humboldt-Universität zu Berlin, Dept. of Agricultural Economics and Social Sciences, Kaiserstrasse 141, 12105 Berlin, Germany, e-mail: janetkarina@hotmail.com

Enhancing the Farm-Level Cocoa Bean Quality through Sustainable Cocoa Production Program in West-Sulawesi

PREMA DHANAVEL[1], INGRID FROMM[1], MANFRED BORER[2]

[1]*Bern University of Applied Sciences, Swiss College of Agriculture, Dept. of International Agriculture, Switzerland*

[2]*Swisscontact, Sustainable Cocoa Production Program, Indonesia*

The lack of farm-level value addition can lead to an inferior quality of the cocoa bean production in Indonesia. The Sustainable Cocoa Production Program (SCPP) in West Sulawesi province, in collaboration with the Nestlé Cocoa Plan, intends to increase the farm-level cocoa productivity and the quality of the beans.

The principle objective of this study was to identify the existing social conditions and extent of SCPP intervention influencing the quality of cocoa beans at West Sulawesi farmer-level. Secondly, the study conducted a Cost-Benefit Analysis (CBA) for producing premium quality beans by individual farmer and a sensitivity analysis of SCPP investments in the program. Stratified random sampled data from 126 cocoa farmers and data from 10 cocoa traders were used for the study. The data collected was analysed using descriptive statistics, weighted mean average, independent sample t-test, and the Fisher's test statistics using the SPSS software to identify the underlying causes for the different quality levels of the cocoa beans produced.

The results indicated that the factors which had a significant impact on premium quality cocoa production were SCPP support, wet bean cocoa production per hectare, selling market type, and source of financial capital to the farmers. The study revealed that some of the farmers were bound to an interlocked market situation, which is one of the problematic reasons for quality improvements, in spite of SCPP intervention. The cost benefit analysis indicated that the premium quality cocoa production is marginally profitable for the farmers with a nominal benefit cost ratio of 5.83, a net present value of IDR 100,371,964 (€ 6431), and an internal rate of return of 4.97 %. While the conventional quality cocoa production has a lower nominal benefit cost ratio, net present value, internal rate of return of 4.47, IDR 92,473,766 (€ 5928) and 4.48 % respectively.

The recommendations from this study are to pass a legislative act of mandatory fermentation of the cocoa beans used for domestic grinding and export, integrating village cocoa collectors into BT Cocoa supply chain and to increase the number of BT Cocoa buying units or mobile collection centers.

Keywords: Quality cocoa bean, Sulawesi, sustainable cocoa production program

Contact Address: Prema Dhanavel, Bern Universty of Applied Sciences, School of Agricultural, Forest and Food Sciences (HAFL), International Agriculture, Parkweg 9, 3510 Konolfingen, Switzerland, e-mail: dhanp2@bfh.ch

Management in Agri-Food Chains: What Do We Know about Contracts and How to Move Forward?

LANA REPAR, STEPHEN ONAKUSE, JOE BOGUE
University College Cork, Food Business and Development, Ireland

Today's increase in number of people consuming food and expecting its timely and quality supply urges to introduce new ways of coping with scarce resources. From the available knowledge bases, the emerging interdisciplinary approaches combine practical agricultural, economic, business, social and legal principles in order to assist sustainable development. This is particularly the case in supply chain management of agri-food systems in developing countries where different stakeholders engage in activities that secure delivery to the markets. The research focuses on one aspect of chain management - the contracts between company and farmers - and the role they play in Sub-Saharan African context. The main problem explored by the study is the status of contracting; namely under which conditions it works and what it brings to involved parties. In addition, the following question leads the research: how can we move further in understanding the contracts to make them work better for the poor and concurrently support economic progress? The gap in the literature involves lack of systematic review and exposure of evidence from Sub-Saharan Africa that could enable comparison of topics such as (i) benefits for farmers, (ii) benefits for companies, (iii) motivation for participation, (iv) contract preferences, (v) risk sharing, (vi) political surrounding and does it support contracting, (vii) market characteristics, and (viii) other external factors influencing contract implementation. The aim of the research is to analyse and synthesize the data on contracts from selected African countries and discuss the findings in the light of multidisciplinary lens. This will secure drawing more informed and in-depth conclusions, since connecting various disciplines and testing the evidences against their paradigms helps to indicate where the contracting does (not) work. In reviewing the literature, research employs adjusted systematic review method that tracks 9 steps: writing the protocol, literature searching, screening, obtaining sources, selection, quality assessment, data extraction, analysis and synthesis, and discussion. The study included 25 published scientific studies from 2000 to date. It finds similarities in reported benefits and problems, and differences in policy and market characteristics that enable contracting in studied countries. Further research should explore and develop tools for assessing the contract efficiency.

Keywords: Analysis, contracts, supply chain management, systematic review

Contact Address: Lana Repar, University College Cork, Food Business and Development, Cork, Ireland, e-mail: lana.repar@gmail.com

Problems and Development Potential of Hop Production in Russia

OLGA AMURINA[1], RALF SCHLAUDERER[1], KLAUS KAMMHUBER[2]
[1]*University of Applied Sciences Weihenstephan, Dept. of Agriculture, Germany*
[2]*Bavarian State Research Center for Agriculture, Hop Research Centre, Germany*

In the last twelve years the hops area in Russia declined by approximately 1,400 ha, although the beer production developed more and more. In 2012 Russia had a beer output of around 97.4 million hectoliters and occupied the fourth place among the beer producing countries. Each year about nine thousand tons of hops are used for the beer production.
The aim of this work is presenting the status and development options of hop production in Russia on the basis of the Chuvash Republic. Chuvashia is climatically very suitable for the cultivation of hop (*Humulus*).
Research data were used from the Chuvash State Agricultural Research Institute as well as market reports of the company Barth-Haas Group. Descriptive analysis of hop price, beer production and hop-growing areas in Russia and around the world were used as evaluation method. The quality analysis of seven hops clones from Chuvashia was conducted in the laboratory according to EBC-methods in Hull Hop Research Centre in Bavaria.
The market analyses showed that Russia has the highest beer output in Europe. However, the main hop-growing region Chuvashia has lost a large market share of hops. The reason is the importation of hops with better quality and larger diversity. The results of hop price analysis showed that the hop market has large fluctuations.
For the economic evaluation of contribution margin calculations were made for baby hops and hops in full yield. From the perspective of the production costs of hop production is profitable in Chuvashia. The analysis of hops clones showed that the Russian hop in terms of alpha acid content is competitive except for the hop oil content with other hop providers. It would be advisable to breed new varieties with higher hop oil content.
Consequently the hop providers must care more about the hop quality and the processing of different hop products, because this is the crucial point, whether the Russian breweries will buy domestic hop.

Keywords: Beer production, hop market, hop products, hop quality, investment

Contact Address: Ralf Schlauderer, University of Applied Sciences Weihenstephan, Dept. of Agriculture, Steingruberstraße 1a, 91746 Weidenbach, Germany, e-mail: ralf.schlauderer@hswt.de

Livelihood strategies and farm-household systems

Transformative Change Towards Sustainable Livelihoods - Too Big for Development-oriented Research?

MICHAEL HAUSER

University of Natural Resources and Life Sciences (BOKU), Centre for Development Research (CDR), Austria

The gap between expanding scientific knowledge and decreasing availability of natural resources is also an expression of rising global inequalities. This paradox, however, should not tempt researchers to promote transformative change as a solution without rethinking the epistemological foundation of science and technology development. Transformative change with the ability to bridge science and practice and eventually contribute to sustainable livelihoods is complex, dynamic and multi-dimensional. It confronts inequalities in access to food, shelter, wealth, and health. Therefore, transformative change is also about values, policies, politics, and power. To understand livelihood challenges in agriculture, forestry, fisheries and food, monodisciplinary research will remain important. But such research is not applicable to address the intertwined psychological, cultural, economical and technical dimensions that underpin transformative change towards sustainable livelihoods. This has implications for researchers who engage in transformative change. Researchers must know the essence of development history rather than repeating it. Clarity of roles and labour sharing across disciplines and stakeholders are as important as sound methodologies and scientific rigor. Researchers must accept their limitations in prescribing and controlling the direction and pace of transformation change. Scientific "hit and run" operations are doomed to fail. Instead, transformative leaders must mindfully reconcile academic traditions and underlying paradigms. Doing so is easier said than done, but critical for bridging the pervasive gaps between what people know and what they do.

Keywords: Leadership, research, transformative change

Contact Address: Michael Hauser, University of Natural Resources and Life Sciences (BOKU), Centre for Development Research (CDR), Gregor Mendel Straße 33, 1180 Wien, Austria, e-mail: michael.hauser@boku.ac.at

Bridging the Gap Between Formal and Informal Research in Agriculture and Natural Resource Management

ANN WATERS-BAYER[1], CHESHA WETTASINHA[2], LAURENS VAN VELDHUIZEN[2], GABRIELA QUIROGA[2], KEES SWAANS[2]

[1]*ETC Foundation, Prolinnova International Secretariat, Germany*

[2]*ETC Foundation, Prolinnova International Secretariat, The Netherlands*

The many efforts to transform scientific knowledge into sustainable agriculture and natural resource management (NRM) have brought limited benefits to smallholder farmers, including fishers, livestock-keepers and other resource users. Donors, policymakers and civil-society organisations (CSOs) are exerting pressure on the formal agricultural research and development (ARD) sector to make its research more useful to smallholders. Many formal ARD institutions are now seeking ways to engage more closely with smallholders in order to conduct research that is more relevant for and accessible to them, and are seeking examples and good practices as sources of learning.

Some examples of ARD that is focused on smallholders and in which the research process is co-managed and driven by smallholders can be found in "informal" ARD that is facilitated by CSOs. Information on the process and outcomes of these initiatives rarely appears in double-refereed scientific journals; most of the documentation is scattered in reports, websites and publications for development practitioners.

The CGIAR Research Program Aquatic Agricultural Systems (AAS) pursues an approach to ARD that involves embedding research in development processes and strengthening stakeholders' capacities to innovate and adapt. AAS, together with CCAFS (Climate Change, Agriculture and Food Security), asked prolinnova – an NGO-led multistakeholder international network that promotes local innovation processes in agriculture and NRM – to explore the approaches, outcomes and impacts of "informal" ARD facilitated by CSOs. Based on eleven case studies from Africa, Asia and Latin America drawn from over 100 cases that were identified and vetted, we assessed the extent to which farmer-led processes of research and innovation in agriculture and NRM led to improvements in rural livelihoods. These built on local knowledge and generated more intensive ways of using available resources with low levels of external inputs.

This paper presents the main findings of this study. It analyses available evidence on the impact of farmer-led approaches in terms of food security, ecological sustainability, economic empowerment, gender relations, local capacity to innovate and adapt, and influence on ARD institutions. It then draws lessons for future partnerships between formal and informal ARD actors who are seeking common goals in serving smallholder communities.

Keywords: Adaptive capacity, endogenous development, farmer experimentation, impact assessment, innovation processes, local knowledge, participatory research, smallholder farmers

Contact Address: Ann Waters-Bayer, ETC Foundation, Prolinnova International Secretariat, Rohnsweg 56, 37085 Göttingen, Germany, e-mail: waters-bayer@web.de

Assessing Innovation Needs in Tanzanian Mixed Smallholder Farming Systems: A Participatory Situation Analysis

MARIA HÖHNE, MARGARETA AMY LELEA, BRIGITTE KAUFMANN

German Institute for Tropical and Subtropical Agriculture (DITSL), Germany

Tanzanian smallholder farmers are increasingly confronted with production system problems due to volatilities in the environment and market that necessitate innovations in farming practices. Innovations need to fit both the context and the capabilities of people involved in order to be effective, as there is no "one size fits all" solution.
This study aims to identify potential points of entry for innovations by analysing constraints and opportunities while recognising available capitals (natural, physical, economic, human, social) and responding to commonly held livelihood problems and shared challenges in agricultural production processes.
Field data collection was carried out from January until April 2014 in four representative case study sites (CSS) in the Morogoro (semi-humid) and Dodoma (semi-arid) regions of Tanzania. Methods combine a participatory livelihood analysis with a participatory assessment of agricultural activities. Per village approximately 100 people participated in 14 group sessions using livelihood illustration and charting, net maps and problem trees as tools in groups segregated by gender. Resource maps and seasonal calendars were developed with mixed groups.
Results show that livelihood in all CSS is centreed on agricultural activities on smallholder farms, followed by casual labour. This lack of diversification leads to increased vulnerability as the agricultural sector becomes increasingly erratic from both climate and market. Available capitals differ the most at regional scale. For example, farmers in Dodoma have been in the midst of drought scenarios for many years, while in the semi-arid Morogoro, this situation is relatively new to farmers. Important is also the difference of multi-ethnic, multi-religious communities in Morogoro where farming schedules and livestock kept vary within households. In the mono-ethnic traditional Mgogo communities in Dodoma crop farming and livestock keeping is integrated much stronger.
During the assessment of agricultural activities participants reported problems due to lack of rainfall, soil fertility, pest and diseases, lack of input and market availability and accessibility as well as low prices. In Morogoro additionally the conflict between crop farmers and pastoralist was named as a dominant problem. Farmers expressed an interest in gaining more information to assist them as they make decisions to adapt to changing conditions.

Keywords: Innovation needs, livelihood, local knowledge, participation, smallholder, Tanzania

Contact Address: Maria Höhne, German Institute for Tropical and Subtropical Agriculture (DITSL), Steinstraße 19, Witzenhausen, Germany, e-mail: maria.hoehne@stud.uni-goettingen.de

Under a Changing Climate: Livelihood Strategies in Forest-Adjacent Communities. A Socio-Economic Analysis from Lowland Bolivia

TINA BAUER, ANDRÉ LINDNER, JÜRGEN PRETZSCH
Technische Universität Dresden, Inst. of International Forestry and Forest Products: Tropical Forestry, Germany

Agriculture, forestry activities and cattle ranching interact with climatic extreme events like floodings and droughts in tropical lowland Bolivia. The study area comprises of indigenous communities with subsistence rainfed agriculture located in in the North Bolivian Amazon. The site raises concerns about the effects of changing weather conditions on livelihoods of rural forest-adjacent communities.
This ongoing Ph.D. research is part of the International Network on Climate Change (INCA) and is expected to increase understanding on the impact of changing weather conditions on livelihood activities and forest dependency. Furthermore, the study analyzes if farmers shift from climate affected income activities to a more intense forest use and the role of forest products in climate change adaptation and coping strategies.
The socio-ecological system is investigated in a holistic way, applying a case study approach on household level. The study used participative tools such as field laboratories and 50 household interviews have been conducted to gain mainly quantitative data using CIFOR Poverty Environmental Network investigation tools. A photo-elicitation method is planned for end 2014 and will show rural people´s perspective. Preliminary findings show that changing environmental frame conditions (irregular seasons, more frequent extreme weather events) influence agricultural calendars, crop yields, timber harvest and tend to change land-use systems. In 2013, a large part of Amazonian Tacana families were unable to prepare shifting cultivation fields for subsistence income due to unpredictable and long-lasting rain periods. A tendency towards an increased harvest of forest products in extreme years as compensation for affected income activities is evident. Alternative income activities and thus climate change adaptation opportunities have been recognized as the bee-keeping of stingless bees (Meliponini).

Keywords: Bolivia, climate change, community forestry, socio-ecological system, sustainable livelihoods

Contact Address: Tina Bauer, Technische Universität Dresden, Inst. of International Forestry and Forest Products: Tropical Forestry, Pienner Straße 7, 01737 Tharandt, Germany, e-mail: tina.n.bauer@gmail.com

Sustainability Criteria of Smallholders' Oil Palm Farming in Indonesia: A Stakeholder View

ERNAH ERNAH, HERMANN WAIBEL

Leibniz Universität Hannover, Institute of Development and Agricultural Economics, Germany

Indonesia has become a major supplier of palm oil in the world market which is reflected in the significant expansion in the country's area planted to oil palm. This expansion has largely been at the expense of forest and peat lands mainly in Sumatra. In response to actual and potential environmental and social problems the Government of Indonesia (GoI) has been promoting the concept of sustainable oil palm production (ISPO). ISPO is a combination of regulatory measures and voluntary standards.

In this paper we analyse the views of different stakeholder along the oil palm value chain in the oil palm industry including those small holders in the province of Jambi, Sumatra. Our source of data is Focus Group Discussions in four villages and a stakeholder survey that included large scale oil palm producers, government agencies, farmers association, researchers and NGOs. The objectives of the study are twofold: (1) to compare stakeholders views on the ISPO criteria and (2) to explore perceptions of oil palm farmers to implement ISPO criteria in the reality of small holder oil palm production.

In the analysis keywords from Focus Group Discussions were analysed using qualitative methods and non-parametric statistical tests are used to compare stakeholder views on ISPO criteria. Results show that some sustainability criteria such as not planting peat land had not been followed from the start as 70 % of oil palm production in the four villages takes place on peat land.

Results show that while stakeholders tend to agree on the principles large differences exist in views regarding the practicality and economics of implementation of standards. Focus Group Discussions revealed that ISPO criteria do not only have benefits but also have costs which in many cases are beyond household's financial capacity. The policy recommendation emerging from these findings is that governments on the one hand should more strictly enforce standards and on the other hand should provide more effective guidance on contractual arrangements between small holders and oil palm companies.

Keywords: Indonesia, oil palm industry, smallholders, sustainability criteria

Contact Address: Ernah Ernah, Leibniz Universität Hannover, Institute of Development and Agricultural Economics, Koenigsworther Platz 1, 30167 Hannover, Germany, e-mail: ernah@ifgb.uni-hannover.de

Socio-Economic Characterisation of Date Palm (*Phoenix dactylifera* L.) Growers in Pakistan

GHAYOOR FATIMA[1], ANDREAS BUERKERT[1], IQRAR AHMAD KHAN[2]

[1] *University of Kassel, Organic Plant Production & Agroecosystems Research in the Tropics and Subtropics, Germany*

[2] *University of Agriculture Faisalabad, Institute of Horticultural Sciences, Pakistan*

Further increases in food production for a rapidly growing population is a major policy goal in Pakistan where traditional staples such as rice and wheat have experienced intensification in many but remote drought-ridden areas. Date palm (*Phoenix dactylifera* L.) fruit and its by products may be an option to complement staples due to its nutritional composition: 44–88 % total sugars, 0.2–0.5 % fat, 2.3–5.6 % protein, 0.5–3.9 % pectin, 6.4–11.5 % dietary fibre, salts, minerals and vitamins. Additionally, date palms are well adapted to harsh climatic and soil conditions, provide protection to under crops and may also help to reduce desertification. To full knowledge gaps about the role of date palm in rural communities, this project aimed at studying the socio-economic impact and conditions of date palm growers across four provinces of Pakistan. To this end during 2012–2013 a total of 170 households (HH) were selected and interviewed with a structured questionnaire using a snowball sampling technique. Most of the HH were headed by male (99.4 %) who were married (74 %) and often illiterate (40 %). Agriculture was the main occupation (56 %) of date palm growers while a few were coupling agriculture with business (17 %), labour work (10 %) and employment (government, 9%; private, 8 %). Date sale contributed $>$ 50 % to total income of 39.4 % HH or for 24 % of HH even 91–100 %. Farmers grew a total of 39 date palm cultivars and had an average of 409+559 date trees. The majority of the respondents sold date palm to commission agents (35 %), contractors (22 %), whole sellers (21 %), directly to consumers (3 %) and hawkers (1 %), whereas 28 % HH were cultivating date palms only for self consumption. Most date palm growers sowed cereals (54 %) followed by fodder (53 %), cotton (35 %), sugarcane (24 %), beans (23 %) and fruits (17 %) in the winter and summer seasons, respectively. Date palm growers had only limited knowledge about high quality date cultivars, farm management, pest and disease control, harvesting and post-harvest practices. Changes in extension and marketing efforts are needed to allow farmers better exploit value chains in date palm thereby reaping higher benefits and secure there often marginal livelihoods.

Keywords: Date palm cultivars, food security, livelihood strategies, nutrition

Contact Address: Ghayoor Fatima, University of Kassel, Organic Plant Production & Agroecosystems Research in the Tropics and Subtropics, Steinstrasse 19, 37213 Witzenhausen, Germany, e-mail: ghayoor.fatima@gmail.com

Socio-Economic Characteristics of Farmers from Iporá and Neighbourhood, Goiás State, Brazil

PAULO ALEXANDRE PERDOMO SALVIANO[1], EDUARDO RODRIGUES DE CARVALHO[1], ALCIDO ELENOR WANDER[2]

[1]*Federal Institute of Education, Science and Technology, Iporá Campus, Brazil*

[2]*Brazilian Agricultural Research Corporation (EMBRAPA), National Rice and Beans Research Center (CNPAF), Brazil*

The official data of the Brazilian government has reported that the economy of Iporá and neighbouring municipalities has been based primarily on dairy farming and secondly on beef cattle raising. The objective of the present study was to carry out the diagnosis of the socioeconomic characteristics of farmers from Iporá and neighbouring municipalities. Two hundred and forty farmers were interviewed between April 2013 through April 2014 in rural communities meetings, agro dealer stores, during the campaign of vaccination against the foot and mouth disease and in the 28th Agricultural Exhibition of Iporá. Out of total people interviewed, 146 families have lived on the farm (60.8 %), 139 farmers have used exclusively family labour (57.9 %) and 146 farms have a total area of up to 100 ha (60.9 %). The participation of family members in the daily work of the farm has been high with predominance of spouses (n=136) and sons/daughters (n=104). Dairy farming has been the agricultural activity that mostly contributes to family livelihood (n=165; 63.2 %), followed by beef cattle raising (n=109; 55.6 %). Rural retirement (n=42; 34.5 %), social programs (n=14; 30.7 %) and jobs outside the farm (n=71; 47.3 %) have had a greater contribution than fruit-growing (n=4; 22.5 %), vegetables (n=5; 34 %) and fish (n=4; 15 %) production. The association of dairy farming with the remaining agricultural activities has been low, which disagrees with the concept that family farms have a more diversified production. A small number of farmers is organised in associations (n=74; 30.8 %) or cooperatives (n=97; 40.4 %). This disarticulation has reflected in the market access, which has been reported by 81 interviewees as the second most difficulty to remain in the agricultural activity. Most of the farmers have utilised agrochemicals (n=125) and fertilisers containing nitrogen, phosphorus and potassium (n=139). We concluded that farmers from Iporá and neighbouring municipalities have mostly depended on dairy production for the livelihood of their families and have faced difficulties to access the market due to disarticulation, besides the high dependence on agricultural inputs for food production. Additional research and efficient extension services are needed to improve the socioeconomic aspects of farmers from Iporá and neighbouring municipalities.

Keywords: Dairy production, family farming, livelihood

Contact Address: Alcido Elenor Wander, Brazilian Agricultural Research Corporation (EMBRAPA), National Rice and Beans Research Center (CNPAF), Rodovia GO-462, km 12, 75375-000 Santo Antonio de Goias, Brazil, e-mail: alcido.wander@embrapa.br

Integrated Analysis of Household and Remote Sensing Data for Settlement Characterisation in Tamale, Northern Ghana

RAFAEL HOLOGA, HANNA KARG, JOHANNES SCHLESINGER

University of Freiburg, Dept. of Environmental Social Sciences and Geography; Physical Geography, Germany

Urban growth and land use change in the northern region of Ghana and especially around the region's capital, Tamale, have a severe impact on the characteristics of urban, peri-urban, and rural settlements. However, there is a lack of studies systematically analysing the relationship between urban growth, land use changes, and its manifestation in different types of settlements.

For the study, a total of 460 households distributed over 23 grids of a size of 25 hectares each were randomly selected. A stratified sampling was implemented, based on building densities and theoretical travel times. These were derived from recent satellite images and a statistical algorithm tool for geographic information systems (GIS).

A multi-method approach based on household survey and remote sensing data was chosen. Both data sources were linked in order to allow verification, triangulation and up scaling of the findings. Household data was collected using a standardised household questionnaire in March/April 2014. The questionnaire included indicator groups focussing on accessibility, supply, prosperity, migration background and other social indicators. The remote sensing data base consisted of a mix of available images with varying ground resolutions, such as LANDSAT-8, Pleiades and others. The data was analysed in order to quantify land use change and to gain a rough understanding about overall land use trends such as urban growth or conversion of agricultural land. Furthermore, an unmanned aerial vehicle (UAV) was used in selected grids to allow for a more detailed view on small-scale land use dynamics. The study showed that urban growth has a significant impact on a wide range of characteristics of urban, peri-urban, and rural settlements. Furthermore, it could be shown that household characteristics, such as market access or agricultural activities are significantly correlated to the location of the respective settlements.

A typology was developed in order to allow for a more sophisticated understanding of settlement characteristics in the western African context. This could eventually lead to a more adjusted spatial planning process in rapidly growing cities of the region.

Keywords: GIS, remote sensing, settlement typology, Tamale, UAV, urban growth

Contact Address: Rafael Hologa, University of Freiburg, Dept. of Environmental Social Sciences and Geography; Physical Geography, Werthmannstr. 4, 79085 Freiburg, Germany, e-mail: rafael.hologa@gmx.de

Cultural and Gender Differences in Assessing Upgrading Strategies (UPS) for Enhancing Food Security in Tanzania

ISA LAURA SCHNEIDER[1], JANA SCHINDLER[2], FRIEDER GRAEF[2], STEFAN SIEBER[1]

[1]*Leibniz-Centre for Agricultural Landscape Research (ZALF e.V.), Inst. for Socioeconomics, Germany*

[2]*Leibniz-Centre for Agricultural Landscape Research (ZALF e.V.), Inst. for Land Use Systems, Germany*

Developing best suitable strategies to upgrade food security in rural poor areas needs experts and stakeholders from all fields of the food value chain. Thereby, among others nationality, cultural background and gender may influence their assessment on potential and feasibility for the implementation of such strategies.

We present the outcome of an ex-ante expert assessment of upgrading strategies (UPS) for two case study regions in Tanzania (Dodoma and Morogoro). Using a questionnaire for the assessment of the potential and feasibility of UPS among different food value chain components, the expertise of German and Tanzanian scientists was collected. 29 out of 90 scientists responded to our questionnaire. These scientists are members of a larger research consortium called Trans-SEC "Innovating Strategies to safeguard Food Security using Technology and Knowledge Transfer: A people-centred approach".

Hence we gained information on UPS which were assessed as suitable for improving food security for smallholder agriculture. Expertise on obstacles regarding the implementation of the proposed UPS was evaluated as well. Among other factors we determined the influence of nationality and gender of the scientists on the assessment of the UPS.

Interestingly, results show clear differences between Tanzanian and German, and between male and female researchers. They were found throughout all food value chain components and most UPS between both regions. However, only a few of these differences were statistically significant. According to their nationality and cultural background, assessments by German and Tanzanian scientists varied strongly, especially regarding Dodoma region, but in all components of the food value chain. The main differences between assessments of male and female scientists were found for the food value chain components of food processing, consumption and waste management components. However, gender related differences in responses were not as strong as those between scientists' nationalities.

Keywords: Food value chains, gender, nationality, upgrading strategies

Contact Address: Isa Laura Schneider, Leibniz-Centre for Agricultural Landscape Research (ZALF e.V.), Inst. for Socioeconomics, Tuerrschmidtstraße 34b, 10317 Berlin, Germany, e-mail: isalaura.schneider@gmail.com

Do Organisations Believe in Poverty Traps? An Empirical Study of Poverty Reduction Strategies

ZOLTÁN M. FERENCZI

Humboldt-Universität zu Berlin, Faculty of Life Sciences, Dept. of Agricultural Economics and Social Sciences, Germany

Poverty traps, framed as trap like situations in which initial income as a threshold variable determines future income, have been increasingly called into question by scholars in recent years. One group of authors explain the increasingly wide income gap between OECD countries and developing countries (DCs) by arguing that a poverty trap prevents countries with large pockets of extreme poverty in their populations from development. If a household has to invest all or most of its current income to maintain life in the present, there will be no margin of income for savings, investments in education and health, healthier food choices, etc., leading to a vicious circle of poverty, they argue. The resulting low level of tax revenues, in turn, leads to the government's inability to provide the necessary market infrastructure for growth, thereby scaling up the poverty trap to the macro level. On the other hand, several other scholars reject the existence of poverty traps, presenting cross-country empirical and, increasingly, household level panel data that do not support the theory. As an alternative to threshold like poverty dynamics, they argue in support of a non-linear achievement model of income determination.

In light of the apparent contradiction in the scientific discourse, the question of whether or not organisations charged with poverty reduction believe in poverty traps emerges as a relevant empirical question. Anecdotal evidence suggests that organisations do embrace the theory of poverty traps and design interventions that presuppose the existence of a threshold like poverty trap dynamic. However, systematic empirical research studying organisations' beliefs regarding poverty dynamics is very sparse. A differentiated analysis according to fields (education, health, environment, etc.) seems relevant as poverty traps may be context specific rather than all-pervasive phenomena. This contribution offers to address this gap by studying the beliefs of a select group of international organisations and DC states through analysing key strategic documents using qualitative research and content analysis.

Keywords: Growth models, organisations, poverty reduction, poverty traps

Contact Address: Zoltán M. Ferenczi, Humboldt-Universität zu Berlin, Faculty of Life Sciences, Dept. of Agricultural Economics and Social Sciences, Robert Koch Platz 4, 10115 Berlin, Germany, e-mail: z.ferenczi@hu-berlin.de

The Role of Backyard Gardening in West African Cities – Evidence from Ghana and Burkina Faso

MARTINA SHAKYA[1], IMOGEN BELLWOOD-HOWARD[2], HANNA KARG[3], JOHANNES SCHLESINGER[3]

[1]*Ruhr University Bochum, Institute of Development Research and Development Policy, Germany*

[2]*Georg-August-Universität Göttingen, Institute for Social and Cultural Anthropology, Germany*

[3]*University of Freiburg, Department of Environmental Social Sciences and Geography; Physical Geography, Germany*

Urban backyard gardening is commonly characterised as mainly subsistence-oriented 'niche farming', whereas open space farming tends to be perceived as market-focused. However, few studies have systematically analysed the role of backyard gardening in urban and periurban food supply and income generation in West African cities.

This paper is based on a standardised survey conducted in Tamale, northern Ghana and Ouagadougou, Burkina Faso in September/October 2013. A total of 516 farmers were randomly sampled using a remote sensing-based approach. High resolution satellite images were used to classify built-up areas. In a second step, thirty areas were randomly selected in and around each city, stratified into urban (i.e. open space cultivation and backyard gardening) and periurban production. Those for backyard gardening had shares of built-up area between 50 and 80 percent. Within each cell, ten households were sampled using spatial random selection. Questionnaire data were triangulated with focus group discussions and interviews.

As expected, urban backyard gardens, open space farming sites and periurban villages differ in terms of plot sizes and cultivated crops. In contrast to common perceptions, the survey data show that backyard gardening contributes consistently to urban food markets despite the small-scale character of the production areas. On average, backyard farms produce about a third of their crops for commercial purposes.

Backyard farmers in Tamale most commonly cultivate green leafy vegetables and tomatoes for the market. In Ouagadougou, the thirsty crop lettuce is most commonly cultivated in backyards. In general, irrigation availability appears as a key production constraint. Many backyard farmers thus use the drought-tolerant okra to circumvent reliance on irrigation. This is the second most commonly cultivated subsistence and commercial crop year-round in both cities. Okra is frequently planted at the end of the rains as it could survive into the dry season on residual soil moisture, then dried and stored for year-round consumption and sale.

Innovative backyard farming thus contributes towards subsistence and commercial production in these West African cities. These farms should therefore not be forgotten in further research on food security and agricultural commercialisation strategies.

Keywords: Agricultural commercialisation, backyard gardening, land-use classification, spatial random sampling, urban agriculture, West Africa

Contact Address: Martina Shakya, Ruhr University Bochum, Institute of Development Research and Development Policy, Universitätsstr. 150, 44801 Bochum, Germany, e-mail: martina.shakya@rub.de

The Influence of Rearing of Ruminant Animals on Livelihood Security in Witima Village, Kenya

MARGOT ROUX[1], NORMAN MARTIN CASAS[2], PETER WORM[3], LAERKE ISABEL NORUP NIELSEN[3], NEGAR LATIFI[3]

[1]*Agris Mundus, Sustainable Agriculture, Denmark*
[2]*University of Copenhagen, Agricultural Development, Denmark*
[3]*Roskilde University, Denmark*

This study seeks to contribute to the unclear role that ruminant rearing plays in rural smallholder livelihood security. It is based on data collected during a two-week fieldwork in Witima village, Nyeri South district, in the Central Highlands of Kenya. It is becoming increasingly important to examine the role that ruminants play in livelihood security in this setup, as the main economic activity, coffee, has suffered from years of poor performance, making farmers venturing into other farm enterprises such as dairy. The study uses the Sustainable Livelihoods Framework, which helps to provide an understanding of important assets and access modifiers relevant to the rearing of ruminants as part of smallholders' livelihood strategies.

This study finds that decreasing land sizes are limiting the possibilities of rearing large quantities of animals, however it also impels farmers to keep ruminants as the manure is needed for other farm enterprises kept alongside the animals. Furthermore, ruminants are kept as storage of wealth, which can then provide financial protection in times of crises. The study also finds that ruminant production is constrained by a lack of knowledge and the limited access to financial capital. This, together with a lack of farmers groups, limits the productivity of the ruminants kept, which consequently lowers the livelihood security gained. Therefore this report concludes that ruminants play an important role in the livelihood security of villagers, but there is a need to improve management and collective action to benefit from the animals full potential. Some suggestions of development of this sector in Witima village were discussed with local producers. The formation of farmer groups is an option that the producers decided to implement. Other options are considered, such as improving the feeding rations of the ruminant animals, using better feeding techniques, along with improved facilities and hygiene.

Overall, this study identifies that knowledge sharing amongst the ruminant producers in Witima village, where natural resources are limited, is a potential development strategy.

Keywords: Central Highlands, Kenya, livelihood security, Ruminant rearing, Smallholder

Contact Address: Margot Roux, Agris Mundus, Sustainable Agriculture, Tranehavegard 39, 2450 Copenhagen, Denmark, e-mail: bdf864@alumni.ku.dk

Living on the Margins: Indigenous Peoples' Food Systems, Biodiversity and Food Security

HARRIET KUHNLEIN[1], PHRANG ROY[2], CÉLINE TERMOTE[2], DANNY HUNTER[2]

[1]*McGill University, Centre for Indigenous Peoples' Nutrition and Environment (CINE), Canada*

[2]*Bioversity International, Italy*

For millennia, communities of Indigenous Peoples have been the custodians of the vast majority of the planet's food and genetic resources and stewards of the diverse ecosystems and cultures which have shaped these resources. Indigenous Peoples' food systems are remarkably diverse and represent important repositories of knowledge from long-evolved cultures and patterns of living. Local ecosystems have provided healthy and resilient diets which have had minimal impact on the environment and ensured food and nutritional security. This has dramatically changed in recent times and food insecurity now presents a serious and growing challenge among indigenous communities. The nutrition transition - the process by which development, globalisation, poverty and subsequent changes in lifestyle have led to excessive calorific intake, poor quality diets and low physical activity - is particularly prevalent among many communities of Indigenous People. These influences have also placed much traditional knowledge under threat. As a consequence, alarming dietary shifts from traditional foods and healthy diets towards consumption of poor quality processed foods and diets have taken place, manifesting in the dramatic emergence of obesity and associated non-communicable diseases (NCD) among indigenous compared to non-indigenous groups. Regardless of geographic location, Indigenous Peoples suffer higher rates of health disparities and lower life expectancy compared with non-indigenous Peoples. The irony is that Indigenous Peoples' food systems often contain foods that are nutritionally rich and provide ample levels of both macro- and micronutrients. While no single response can solve the problem of food insecurity, strengthening and leveraging Indigenous Peoples' food systems is one important strategy in a multidisciplinary approach to improve diets and reverse negative food-related health outcomes. Not only do these food-based approaches potentially improve nutrition and health in a sustainable manner, they also revive biocultural knowledge and heritage, strengthen food sovereignty and food system sustainability and contribute to the conservation of biological diversity. There is potential to learn a great deal from Indigenous Peoples, and for indigenous leaders to steer the future course of food sovereignty and food system sustainability. In this context, the paper will present case studies of Indigenous Peoples' food systems from across the world.

Keywords: Agrobiodiversity, food security, indigenous peoples

Contact Address: Danny Hunter, Bioversity International, Nutrition and Marketing of Diversity Programme, Via Dei Tre Denari 472/a, 00057 Maccarese, Italy, e-mail: d.hunter@cgiar.org

Impact of Crop Production Strategies on Household Food Security and Welfare in Malawi's Central Region

GRETTA FITZGERALD[1], LANA REPAR[1], NICHOLAS CHISHOLM[1], MIKE FITZGIBBON[1], HOWARD DALZELL[2]

[1] *University College Cork, Dept. of Food Business and Development, Ireland*

[2] *Valid Nutrition, Ireland*

Policy, its transition and various stakeholders' interests shape agriculture in Malawi. More recently, these influences are directed towards diversification, resulting in a shift away from tobacco and cotton production for export and towards production of food crops for consumption and local sale (such as groundnut and soya bean). Despite the external incentives, resources available to farmers largely influence production strategies - this is especially the case for the majority of resource poor farming households in Malawi, which are below the poverty line. For these households resource management plays a key role in securing their food supply and welfare. However, limited land access, soil fertility, agro-inputs, market channels, technology and information act as barriers to increased productivity. The paper explores the importance of land allocation for export and food crop production, and its impact on food security. The household data were selected from a cross-sectional longitudinal survey (n=195) conducted in three districts in Malawi's Central Region - Lilongwe, Michinji and Salima from 2010–2013. The study finds evidence of positive relationship between production strategies, food security (measured through household diet diversity score — HDDS) and welfare (measured through wealth groups). Households that cultivate export cash crops have higher HDDS, and have higher welfare levels as opposed to households growing food crops. Further research needs to comprehensively examine strategies' efficiency by addressing the differences between production and market risks (e.g. price and transaction costs) that both strategies face, and explore how those risks influence income levels and expenditure allocation of rural households.

Keywords: Food security, households, Malawi, production strategies, welfare

Contact Address: Gretta Fitzgerald, University College Cork, Dept. of Food Business and Development, College Road, Co. Cork Crok, Ireland, e-mail: 107439326@umail.ucc.ie

Household Food Security and Dietary Diversity in Different Agro-Ecological Zones of Western Kenya

LYDIAH WASWA[1], IRMGARD JORDAN[1], JOHANNES HERRMANN[1], MICHAEL KRAWINKEL[1], GUDRUN B. KEDING[2]

[1]*Justus-Liebig University Giessen, Institute of Nutritional Sciences, Germany*

[2]*Bioversity International, Nutrition and Marketing of Diversity Programme, Kenya*

Household food security is associated with improved overall dietary quality that promotes good health. The objective of this study was to assess the differences in household food security between different agro-ecological zones (AEZs) in Bondo and Teso districts in rural western Kenya.

The cross sectional nutrition survey was conducted in July/August 2012 targeting 293 randomly selected households with mothers/caregivers with children aged 6–23 months. The agro-ecological zones were all lower midland (LM) zones: humid LM1 (n=69), sub-humid LM2 (n=79), semi-humid LM3 (n=50), and transitional LM4 and semi-arid LM5 taken together (n=95) as only few participants from LM5 were integrated in the study. The AEZs were grouped into two zones: the dry zone included LM3 and LM4+LM5 (n=148) while the humid zone consisted of LM1 and LM2 (n=145). Semi-structured interviews assessed household socio-demographic characteristics. The household hunger scale was used to assess household hunger. The 24-hour recalls were used to document the household dietary intakes. A household wealth indicator (WI) and household hunger score (HHS) were compiled for the households. Household dietary diversity score (HDDS) were computed according to the FAO guidelines.

Overall 35 % and 3.4 % of the households experienced moderate and severe hunger respectively. Mann-Whitney test showed that the dry zones experienced less hunger compared to the humid zones ($p < 0.001$). Further HDDS values were higher in the dry zones compared to the humid zones ($p < 0.001$).

These findings show that food access was better in the drier semi-humid/transitional arid zones than the humid/sub-humid zones. This contradicts the common pattern of low food availability in the drier semi/transitional zones. There is need for further investigations taking into consideration other variables to understand why the HHS and HDDS were significantly higher in the drier zones compared to the more humid zones.

Keywords: Agro-ecological zones, dietary diversity score, food security, household hunger score, wealth index

Contact Address: Lydiah Waswa, Justus-Liebig University Giessen, Institute of Nutritional Sciences, Wilhemstr. 20, 35392 Giessen, Germany, e-mail: marutilydiah@googlemail.com

Comparison of Farmers' Decision Making Between two Different Scenarios of Shifting Cultivation in Northern Thailand

KRITTIYA TONGKOOM, CARSTEN MAROHN, GEORG CADISCH
University of Hohenheim, Institute of Plant Production and Agroecology in the Tropics and Subtropics, Germany

Agriculture in the highlands of northern Thailand has been dominated by rotational shifting cultivation for centuries. Each village has its own traditional knowledge for doing this cropping system. And this knowledge is transferred from generation to generation.
This study aims to define farmers' decision making criteria for choosing the area to establish the plot, and criteria for changing from fallow to cropping in subsistence (Nong Khao village) and more market oriented systems (Bor Krai village). Information on cropping calendar, cropping history, fallow period, type of crop, plot preparation, crop productivity, fertiliser and pesticide application and criteria for farmers' decision and management were collected by using semi-structured interviews (n = 30) and group discussions in both villages.
The results showed that farmers in both villages used different criteria for making decisions. Farmers in Nong Khao village plant upland rice one year, then left the plot fallow for ten years. No pesticides, no herbicides, no synthetic fertilisers were applied. Their rice production is mainly for household consumption. On the other hand, farmers in Bor Krai do cultivate for 2 years: upland rice in the first year and maize for feeding pig for the second year, followed by 6 years of fallow and application of herbicide. Distance from the village and soil texture are the criteria for choosing the plot in both villages. Whereas farmers from Nong Khao use trees as indicators of good soil, farmers from Bor Krai use soil colour as indicator. Trees' canopy shedding, weed suppression and diameter of the tree are the criteria for changing from fallow to cropping of both villages. As a next step, the correlation between farmers' decision criteria and crop productivity should be analyzed. This information might help to support decisions towards reducing fallow periods and choosing suitable plots for cultivation.

Keywords: Fallow period, maize, traditional knowledge, upland rice

Contact Address: Krittiya Tongkoom, University of Hohenheim, Institute of Plant Production and Agroecology in the Tropics and Subtropics, Garbenstr. 13, 70599 Stuttgart, Germany, e-mail: kt005may@gmail.com

Soil Science Meets Economics: An Interdisciplinary Study on Urban and Periurban Agricultural Production Systems in Ghana and Burkina Faso

VOLKER HÄRING[1], IMOGEN BELLWOOD-HOWARD[2], MARC HANSEN[3], HANNA KARG[4], JOHANNES SCHLESINGER[4], MARTINA SHAKYA[3], BERND MARSCHNER[1]

[1]*Ruhr University Bochum, Inst. of Geography, Soil Science and Soil Ecology, Germany*

[2]*Georg-August-Universität Göttingen, Institute for Social and Cultural Anthropology, Germany*

[3]*Ruhr University Bochum, Institute for Development Research and Development Policy, Germany*

[4]*University of Freiburg, Department of Environmental Social Sciences and Geography; Physical Geography, Germany*

In sub-Saharan Africa urban and periurban agriculture plays an important role in people's livelihood strategies, supplying staple and vegetable crops to local markets. High urbanisation rates put pressure on urban and periurban production sites, but also create new market opportunities for local farmers. This is associated not only with socioeconomic changes in the lives of urban and periurban farmers, but also environmental changes in cultivated soils. The aims of the present study were to demonstrate the links between crop production, economic input and soil fertility of single backyard and open-space fields in urban and periurban agricultural areas. Using a remote sensing-based approach, 247 fields in Tamale (Ghana) and 246 fields in Ouagadougou (Burkina Faso) were randomly selected for the study. Farmers were interviewed via structured questionnaires on field inputs, outputs, soil management and household socioeconomic information. Three soil sample replicates were taken from each field. A preliminary evaluation of the data showed that backyards had a higher pH than open spaces in both cities. For organic C and total N stocks ambivalent trends were found. In Tamale organic C stocks were higher (by 10 %) in backyards than in open space fields whereas N stocks were equal. In Ouagadougou, organic C stocks and total N were higher (by 25 % and 15 %, respectively) in open space fields than in backyards. Backyard farms in Tamale, generally unfenced in the dry season, received more C rich inputs than open space fields. Conversely, in Ouagadougou's enclosed backyards the limited application of C and N rich inputs led to lower C and N stocks compared to the open space. More arid conditions in Ouagadougou also led to less available organic inputs and shorter growing periods. This study presents the interaction of economic inputs and soil fertility on the economic outcome of urban and periurban farmers in sub-Saharan Africa.

Keywords: Backyard, carbon, nitrogen, pH, urban farming

Contact Address: Volker Häring, Ruhr University Bochum, Inst. of Geography, Soil Science and Soil Ecology, Universitätsstr. 150, 44780 Bochum, Germany, e-mail: volker.haering@rub.de

Impact of Organic Farming on Rural Households' Welfare: Evidence from Benin (West Africa)

LAURENT C. GLIN[1], EPIPHANE SODJINOU[2], DANSINOU SILVERE TOVIGNAN[3], GIAN LINARD NICOLAY[4], JONAS HINVI[2]

[1]*Research Institute of Organic Agriculture (FiBL), West Africa, Mali*

[2]*Institut National des Recherches Agricoles du Bénin (INRAB), Benin*

[3]*University of Parakou, Benin*

[4]*Research Institute of Organic Agriculture (FiBL), International Cooperation, Switzerland*

Although introduced in West Africa for almost two decades, no comprehensive assessment of the impact of organic cotton on rural household wellbeing has been carried out. This research aims to contribute to fill this gap by addressing particularly the question whether and how the adoption of organic cotton farming affects farmer households' welfare. For this purpose, we used both qualitative and quantitative methods and collected data on a sample of 191 households in three agro-ecological zones of Republic of Benin. We used new development of impact assessment approach, by combining the nonparametric propensity score matching and qualitative methods. Our qualitative account based on participatory wealth ranking, helped get insights into how farmers perceive and construct their living standard and what they value as criteria according to their specific social, economic, and cultural contexts. A set of criteria ranging from social, economic and cultural aspects has been considered with relatively different weighs in each farmer community. It came out that around 40 % of organic farmers seem confident to have reduced poverty over the last 3 years. Moreover, we found that the adoption of organic cotton has a positive impact on rather poorer farmer households' wellbeing including gender empowerment, poverty reduction and vulnerability. However, most of the organic households encounter problems in food security during the year. The conventional farming with its higher risk taking requirement is more attractive for the middle class of rural society and the higher labour requirement of organic farming might reduce their willingness to convert. The middle social strata of rural society could as well benefit from the organic principles, if the challenges of mechanisation, research-advice performance, credit and infrastructure are addressed.

Keywords: Benin, gender empowerment, organic cotton, poverty, propensity score matching, vulnerability, West Africa

Contact Address: Laurent C. Glin, Research Institute of Organic Agriculture (FiBL), West Africa, Bamako, Mali, e-mail: glinlaurent@yahoo.fr

Smallholder Organic Farmers' Attitudes, Objectives and Barriers Towards Production of Organic Fruits and Vegetables in India: A Multivariate Analysis

RAVI NANDI, WOLFGANG BOKELMANN, NITHYA VISHWANATH GOWDRU, GUSTAVO HENRIQUE DE SOUZA DÍAS

Humboldt-Universität zu Berlin, Dept. of Agricultural Economics and Social Sciences, Germany

The Indian organic food sector has experienced important growth during recent years. Despite growth potential, the area under organic farming is meager. Indian smallholders (<2 ha) are facing challenges to enter and stay in the organic food sector and benefit from this growth in a sustainable way. In this context, the aim of this paper was to analyse smallholder farmer's attitudes, objectives and barriers towards production of organic fruits and vegetables (F&V) in Karnataka State, South India, as well as to identify farmers' profiles based on attitudes and objectives. The source of information used was based on a field survey carried out during early 2014. Purposive random sampling technique was used to draw the sample (n=127) and the mode of data collection was face-to-face interviews; collected data were analysed by using descriptive, factor and two-step cluster analysis (SPSS 16.0). The results of factor analysis based on attitudes revealed that five factors including "Market", "Environmental", "Support", Benefit & Cost" and "Community" explained 70.9 % of the variance. Further, factor analysis based on objectives acknowledged presence of three latent factors including "Economic", "Environmental" and "Socio-cultural" explaining 77.1 % of the total variance. Similarly, four latent factors were identified based on factor analysis of sixteen barrier variables, representing "Production", "Marketing", Techno-managerial" and "Economic & Financial" barriers, which explained 68.5 % of the variance. Further, three clusters emerged on these attitudes and objective factor scores representing, 45.0 %, 23.6 % and 31.5 % of the sample size. All three clusters have different levels of orientation to produce organically on the basis of each factor. The "Market" and "Economic" factors are most important in two clusters followed by "Support" and "Environmental" factors; a third cluster was fairly indifferent towards the organic F&V production. Farmer's age, gender, education, family size, years of experience in organic farming, farm size and cattle population enable the three clusters to be differentiated. Results of this research have implications for policy makers and marketing professionals towards organic agriculture development by calibrating appropriate strategies to promote organic farming and enabling supporting environment in Karnataka State.

Keywords: Attitudes, barriers, India, multivariate analysis, organic farming

Contact Address: Ravi Nandi, Humboldt-Universität zu Berlin, Dept. of Agricultural Economics and Social Sciences, Robert Koch Platz 4, 10115 Berlin, Germany, e-mail: nandi999hu@gmail.com

Investigating Relationship Between Farmers' Water Conservation Behaviour and Social Capital

FATEMEH RAHIMI, MASOUD YAZDANPANAH, MASOUMEH FOROUZANI
Khuzestan Ramin Agricultural and Natural Resources University, Dept. of Agricultural Extension and Education, Iran

There is a high risk of serious water shortages in Middle-East and North African countries. To decrease this threat water conservation strategies are gaining overall importance and one main focus is now on farmer's behaviour. In this regard, Iran faces a serious and worsening water crisis, and water conservation by its farmers is rightly seen as crucial to any resolution. Despite increasing acknowledgement that social capital is an important determinant of natural resource management, empirical evidence regarding the direction and strength of these linkages in the developing world is limited and inconclusive. Furthermore In order to improve the effectiveness of the sustainable management of natural resources it is essential to explore their social implications. The aim of this article is investigate relationships between social capital and farmers' water management behaviour in western Iran. To measure social capital, we adopt a structural/cognitive distinction from previous study, whereby structural social capital is measured by organisational membership and cognitive social capital is measured by a composite index of trust, reciprocity, and mutual help. A face-to-face survey of farmers (n = 360) was undertaken in western Iran. The reliability and validity of the instruments were examined and approved. IAs a first step we used a confirmatory factor analysis to aggregated indicators of social capital. In a second step we used a multiple linear regression to investigate different aspects of social capital on farmers' water conservation behaviour. It is evident that significant connections exist between aspects of social capital and behaviour of farmers towards water conservation.

Keywords: Agriculture, Iran, social capital, water conservation

Contact Address: Masoud Yazdanpanah, Khuzestan Ramin Agricultural and Natural Resources University, Dept. of Agricultural Extension and Education, Ahwaz, Iran, e-mail: masoudyazdan@gmail.com

When Nature Frowns: The Impacts of Floods on Livelihoods in Rural Cameroon

BALGAH ROLAND AZIBO[1], GERTRUD BUCHENRIEDER[2]

[1]*Bamenda University of Science and Technology and Pan African Institute for Development in West Africa (PAID WA), Social Sciences, Cameroon*

[2]*Martin-Luther-University Halle-Wittenberg, Inst. of Agricultural and Nutrition Sciences, Halle (Saale); associated research fellow at IAMO, Germany*

Natural disasters such as floods, famines and earthquakes have strong negative impacts on livelihoods especially for poorer households in developing countries, where risk markets and states are missing, dysfunctional or only function partially. While much of the existing literature has concentrated on economic impact assessment, a gap exists in understanding the impacts of shocks in a comprehensive manner, and their combined effects on livelihoods. This article assesses the impacts of the September 2012 floods households rural Cameroon, adopting a comprehensive asset portfolio approach based on the sustainable livelihoods framework. A standardised questionnaire was used to collect data from victimized and a matching sample of non-victimized matching households, using recall method, allowing for a before – after comparison in order to disentangle the specific impacts of the floods. An analysis of the role of formal and informal risk management strategies amongst victims in the research area after the floods is also undertaken. The results reveal that victims were essentially not different from non-victims before the floods, suggesting that this shock was not selectively biased towards the poor as assumed in the theoretical literature. However, the floods had serious impacts on the asset portfolios of victims, as indicated by significant losses in livestock, household assets and limited food security. Social impacts included low recovery rates and reluctance to relocate to safer areas. The article concludes with the need for comprehensive approaches to better apprehend the impacts of floods on victims. The need for combining formal (government) and informal instruments in dealing with flood impacts in rural areas in developing countries is discussed.

Keywords: Floods, impacts, livelihoods, rural Cameroon

Contact Address: Balgah Roland Azibo, Bamenda University of Science and Technology and Pan African Institute for Development in West Africa (PAID WA), Social Sciences, TP.O Box 5044 Nkwen, Bamenda, Cameroon, e-mail: balgazib@yahoo.com

The Role of Social Safety Nets in Risk Management: Evidence from Syrian Rural Areas

KINDAH IBRAHIM[1], RAID HAMZA[2], SAMIRA SOUBH[2], JANA MAZANCOVA[1]

[1]*Czech Univeristy of Life Sciences Prague, Fac. of Tropical AgriSciences: Sustainable Technologies, Czech Republic*

[2]*National Agricultural Policy Center, Rural Development Department, Syria*

The objective of this study was to investigate the role played by safety nets in helping rural population to mitigate risks that affect their livelihoods. Safety nets are now considered as an important component of poverty reduction strategies adopted by governments in developing countries in order to support the poor through specific interventions. The research was carried in 2009 in five farming systems in Syria, depending on the Sustainable Livelihoods Approach (SLA) in order to identify the strategies used by rural households to confront agricultural, environmental and economic risks, as well as to explore the role and the impact of social safety nets in overcoming those risks. Accordingly, primary data were collected through a field survey covering 444 households. Qualitative and quantitative methods of analysis were used to obtain the main results. Our main findings suggest that the elimination of direct governmental subsidy (i.e. food subsidy, fuel subsidy and public education subsidy) would contribute to lower the ability of households to manage risks, and this would affect their livelihoods and might lead to their dropping below the expenditure-based poverty line. Moreover, results reveal that among risk coping strategies adopted by the households, borrowing ranked first followed by consumption reduction and assets selling strategies. Additionally, poverty status proved to have an important role in determining the strategy adopted, poor households do not adopt constructive strategies such as saving while they increasingly adopt less effective strategies like consumption reduction and selling assets. Finally, we employed the PROBIT regression to address the main factors that affect farmers' choice of certain coping strategies; we found that "safety nets" factor would have a positive impact on rural households; the larger the number of safety nets a household benefits from, the higher their capability to adopt efficient risk management strategies. We suggest that microfinance could play an important role as safety nets as it helps creating more work opportunities and thus helps households diversifying their livelihoods. Another possibility is to raise the awareness about the role of "saving" as coping strategy as it enable farmers to invest in their resources more effectively.

Keywords: Coping strategies, livelihoods, poverty, risk management, Syria

Contact Address: Kindah Ibrahim, Czech Univeristy of Life Sciences Prague, Fac. of Tropical AgriSciences: Sustainable Technologies, Kamýcká 129 165 21 Praha 6 - Suchdol, Prague, Czech Republic, e-mail: kindah.ibrahim@gmail.com

The Impact of Multiple Shocks on Household Asset and Poverty in Kenya

MARTHER NGIGI[1], ULRIKE MUELLER[2], REGINA BIRNER[2]

[1] *University of Bonn, Center for Development Research (ZEF), Germany*

[2] *University of Hohenheim, Inst. of Agricultural Economics and Social Sciences in the Tropics and Subtropics, Germany*

This study evaluates the impact of singular and multiple shocks on households' asset and its implications for poverty, using two waves of panel data of 360 rural households in three agro-ecological zones in Kenya. The study considers a wider range of household assets and a number of covariate and idiosyncratic shocks. To control for unobserved heterogeneity across households, we applied household fixed effects model. The results show that covariate shocks negatively affects poultry, cattle and draft livestock, through physical death or as a coping strategy to smooth consumption and other expenditures. Further, drought affects financial capital, consumer durables and social capital. Political shocks negatively affect financial and social capital. Health shocks adversely affect poultry and draft livestock, which trigger the demand for credit to meet the sudden medical bill. The joint significant tests of multiple shocks show that covariate and idiosyncratic shocks jointly affect livestock holdings, consumer durables, financial and social capital. The differential impacts of shock on asset depend on the liquidity of asset, the nature of the shock and the coping behaviour of the household. The exposure to multiple shocks also worsen the level of poverty because productive assets partly determine the income levels of the households. These findings suggest the need to consider shocks as a major driving force of development outcomes. The study suggests the need to design policies for social protection intervention and affordable rural insurance mechanism. Enhancing security and political stability in the rural setting could also safeguard assets as well as enhancing social capital.

Keywords: Asset-based approach, fixed effects, Kenya, multiple shocks, poverty

Contact Address: Marther Ngigi, University of Bonn, Center for Development Research (ZEF), Walter-Flex Str. 3 53113, Bonn, Germany, e-mail: martherngigi@gmail.com

Shocks and their Implications on Food Security of Vulnerable Households in Indonesia

DEWI NUR ASIH, STEPHAN KLASEN
Georg-August-Universität Göttingen, Development Economics, Germany

Growing evidence shows that the world is facing a threat of climate change with the increase of temperature, intense rainfall and sea level rise.The intergovernmental Panel on Climate Change (IPPC) projected that these extreme climatic events, along with climate change will have adverse effects on agricultural production and food security in the coming decade and will be particularly pronounced in rural households of developing countries. Indonesia is an agrarian country where most of the households are engaged in agricultural activities for their income and livelihood. Thus, any irregularities in climate and weather patterns may threaten the small farmers' crop production, income, and human capital investment. These multiplier effects then have substantial negative effects for food security and poverty alleviation. In the present study we analyse the impact of expected temperature and rainfall changes on farm level productivity and subsequently on household welfare condition. Time series data on temperature and rainfall changes are combining with survey data from rural farming households to compute household vulnerability of food security. Using panel data this study aims to identify the effects of weather shocks and the key factors affecting food security during 2001 – 2006, and to provide some recommendations for improving food security in rural areas in Indonesia. We idevelop a household food security index from principal component analysis. The food security index is used as the dependent variable and an econometric approach applied is to identify the significance of the primary factors influencing a household's food security throughout the years. It shows that the increase of temperature and the variability of rainfall tend to alleviate food security. Moreover, a household's assets endowment is an important determinant of persistent food insecurity and vulnerability over the time. The result shows the importance of infrastructure construction in agricultural areas to be strengthened, and the need for efficient risk reduction and mitigation programs to improve risk exposure and coping ability of rural households under climate change.

Keywords: Agricultural production, food security, weather shocks

Contact Address: Dewi Nur Asih, Georg-August-Universität Göttingen, Development Economics, Platz der Göttinger Sieben 3, 37075 Göttingen, Germany, e-mail: dewinurasih@yahoo.com

Livelihood and Economic Activities as Adaptation Strategies to Climate Change in the Bolivian Andes

MAROLYN VIDAURRE DE LA RIVA, ANDRÉ LINDNER, JÜRGEN PRETZSCH
Technische Universität Dresden, Inst. of International Forestry and Forest Products - Tropical Forestry, Germany

This research explores the livelihood of rural communities and the potential of different economic activities as adaptation strategies to climate change in two regions of the Bolivian Andes: highlands and inter-Andean valley. Following an exploratory design, two communities were selected as case studies. Information was collected using a participatory rural appraisal approach, complemented by a household survey. The results are summarised in the following three main aspects:
1) The assessment of climate conditions reveals the occurrence of intensive rain, drought, hailstorm and frost as the main climatic threats. The incidence of these events results in increasing economic losses and causes negative impacts on the livelihoods of both communities.
2) Using principal component and cluster analysis, three wealth groups which significantly differ in their livelihood portfolios were identified. The poorest group is characterised by households with lower income, less education, older people, and with the higher percentage of women as a household head, resulting overall in higher vulnerability.
3) The assessment of the economic activities revealed seven categories of income sources: crop production, livestock production, natural resource related activities, out-farm activities, wage, remittance and others. Crop production and wage were the main income source in the communities with significant differences between the wealth groups. Additionally, the findings showed that crop production was positively correlated with three aspects: (i) participation in social networks, (ii) available labour and (iii) access to land.
The findings suggest that in both regions, when the climatic threat results in crop production losses, the wealthiest group relied on the income from wage work to cope with their losses. Consequently, as the livelihood of the poorest group limits the implementation of wage work activities; it might be recommended to integrate this group in social networks and reinforce alternative economic activities.

Keywords: Climate change, poverty, rural communities, vulnerability

Contact Address: Marolyn Vidaurre de La Riva, Technische Universität Dresden, Inst. of International Forestry and Forest Products - Tropical Forestry, Pienner Str. 7, 01737 Tharandt, Germany, e-mail: marolynvida@gmail.com

Socio-Economic Impact of Inle Lake Shoreline Changes on Surrounding Communities in Myanmar

THIN NWE HTWE, KATJA BRINKMANN, ANDREAS BUERKERT
University of Kassel, Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, Germany

People living in water and lakeshore area of Myanmar's Inle Lake rely largely on floating garden and lakeshore farming systems. As wetland agriculture, the latter allow the year-round cultivation of a range of crops. This land use has subjected the watershed areas to excessive deforestation with subsequent serious damage to the wetland ecosystems and changes in the lakeshore area, resulting in changes of livelihood opportunities which, however, are poorly understood.

The aim of this study therefore was to assess the effects of lakeshore area changes on residents' livelihood in the floating garden, lowland and upland cultivation zone of the Inle Lake region. Based on a stratified random sampling design 300 households (HH) were interviewed using semi-structured questionnaires to collect socio-economic base data on livelihood strategies. The three agricultural zones differed in cultivated area, total household asset, agricultural income and input use (pesticide and manure) as well as livestock units and income

Annually floating gardens contributed $2108 and lakeshore $892 to total HH gross margin (GM). In floating gardens, cultivation of tomato as cash crop led to the highest potential income and average GM was $5276 $ha^{-1}yr^{-1}$. At lakeshores, rice and sugarcane were the main crops and their contributions to GM were $418 and $629 ha^{-1} yr^{-1}. Agriculture, livestock production and off-farm activities contributed 85, 1, and 14 % to annual income of floating garden households and 74, 5, and 21 % to annual income of lakeshore HH.

Highest profits came from tomato plantation on floating garden, but this also caused environmental degradation following intensive application of mineral fertilisers and pesticides.

Keywords: Floating gardens, Inle Lake, Lakeshore shrinkage, livelihoods

Contact Address: Katja Brinkmann, University of Kassel, Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, Steinstraße 19, 37213 Witzenhausen, Germany, e-mail: tropcrops@uni-kassel.de

Socio-Economic Determinants Affecting the Farm Income of Small Fruit Producers in NE-Brazil

HEINRICH HAGEL[1], CHRISTOPH REIBER[2], REINER DOLUSCHITZ[1], JOSÉ FERREIRA IRMÃO[3], CHRISTA HOFFMANN[1]

[1] *University of Hohenheim, Dept. of Computer Applications and Business Management in Agriculture, Germany*

[2] *University of Hohenheim, Inst. of Animal Production in the Tropics and Subtropics, Germany*

[3] *Federal Rural University of Pernambuco, Dept. of Literature and Human Sciences, Brazil*

Since the 1960s, Brazil's government promoted irrigated agriculture in the country's semi-arid Northeast to decrease poverty and reduce rural exodus. Especially in the last two decades, irrigated agriculture within big irrigation schemes along the lower-middle São Francisco river basin increased rapidly. Irrigated fruit production using modern irrigation techniques played an important role in the economic growth of this region. Although favourable climate conditions, constant water availability, and efficient production techniques provide the fundamentals required for prosperity and economic independence of smallholders, many smallholders are facing poverty, despite similar initial situations to prosperous farmers. An analysis of socio-economic key factors was conducted to assess their impact on farm income. Sixteen experts were interviewed to gain an overview on irrigated fruit production in the regions Petrolina and Itaparica at the lower-middle São Francisco. Additionally a random sample of 132 farmers within the main irrigation schemes in those regions was interviewed to identify driving forces of economically successful crop production. Qualitative data were analysed using content analysis and quantitative data by multiple regression analyses. Inhibiting forces affecting farm income were insufficient infrastructure and therewith bad access to markets, low market power, and low availability of credits for means of production. Lack of knowledge about the new production methods increased these negative effects. Smallholders with less available capital had fewer chances to invest in perennial fruit plantations and modern irrigation infrastructure. However, these measures are crucial to generate higher and more secure income in the long term, thereby providing an escape from the poverty gap. Prospective water shortages, due to expansion of irrigated areas and climate change will increase the importance of water efficient production methods and consequently the requirement for capital and knowledge for their implementation.

Keywords: Irrigated agriculture, Northeast Brazil, regression analysis

Contact Address: Heinrich Hagel, University of Hohenheim, Dept. of Computer Applications and Business Management in Agriculture, 70593 Stuttgart, Germany, e-mail: hagel@uni-hohenheim.de

Agricultural policies and institutions

Agricultural Incentives in Kyrgyzstan: The Impact of Domestic Policies and Changing Macroeconomic Conditions

ELIZA ZHUNUSOVA, ROLAND HERRMANN

Justus-Liebig University Giessen, Institute for Agricultural Policy and Market Research, Germany

Together with the rest of the economy, the agricultural sector in Kyrgyzstan has undergone crucial reforms during the transition period following the collapse of the Soviet Union. The policies influencing agricultural incentives, i.e. farmers' earnings, through the influence on farm-gate prices have also changed substantially. Recent macroeconomic developments, such as the booming gold mining sector and an increasing inflow of workers' remittances on the one hand, and increasing import prices on the other hand, are also likely to have an impact on agricultural incentives through the influence on the exchange rate. This paper aims at investigating the impact of both direct agricultural policies and changing macroeconomic conditions on agricultural incentives for the case of Kyrgyzstan. Nominal Rates of Assistance (NRAs) are estimated in order to quantify direct distortions to agricultural prices resulting from the policies in the agricultural sector. In the second step, True Protection Concept is employed in order to analyse relative incentives between importable, exportable and nontradable sectors in the Kyrgyz economy. Empirical results show that first, direct distortions to agricultural prices do not seem to follow a certain pattern implying that governmental policies in the agricultural sector apparently have not attempted to protect a particular branch of agriculture. The only exception are grains, NRAs for which are generally positive, but not large, pointing at a general encouragement for grain growers from the government probably following food self-sufficiency goals. Second, the true protection analysis shows that around half of the burden of the price increase for importables is shifted to the exportables sector, including agricultural exportables. This means that if prices in the importable sector increase in response to exogenous factors or certain trade policies, domestic exporters, both agricultural and non-agricultural, would be taxed implicitly. Since the Kyrgyz government seeks to promote exports, findings from the present study could serve as a useful scientific background for future trade and agricultural policy development.

Keywords: Agricultural distortions, Kyrgyz Republic, true protection

Contact Address: Eliza Zhunusova, Justus-Liebig University Giessen, Institute for Agricultural Policy and Market Research, Senckenbergstr.3 , 35390 Giessen, Germany, e-mail: Eliza.Zhunusova@zeu.uni-giessen.de

Why Are Market-Based Conservation Mechanisms Gender-Blind? Perspectives from Three Schemes in Kenya

JULIET KARIUKI, REGINA BIRNER

University of Hohenheim, Inst. of Agricultural Economics and Social Sciences in the Tropics and Subtropics, Germany

Ecosystem services are vital for human welfare and sustaining and enhancing their provision is central to the survival of humanity. Payments for Ecosystem Services (PES) and Reduced Emissions from Deforestation and Forest Degradation (REDD+) are increasingly being employed in resource-threatened environments. Such approaches compensate or reward resource-managers through financial and other means to promote resource conservation and restoration by adopting compatible land use practices. Evidence shows that such approaches can enable the enhanced and continued provision of ecosystem services and promote positive social outcomes as well as livelihood benefits. However, much of this evidence is not conceptualised from a gendered perspective despite increased knowledge of gendered roles and responsibilities which shape resource use in the rural landscapes where market-based schemes are implemented. This study starts to fill this knowledge gap by exploring the extent to which three schemes in Kenya integrate gendered concerns in design and implementation. We further consider the gendered differences in resource-use and decision-making regarding benefit-sharing. The research used a combination of in-depth intra household interviews coupled with gender disaggregated focus group discussions to gather information on scheme implementation and impacts. Results show that while costs and benefits associated with the reviewed schemes differed across gender, gender inclusion in the design and implementation occurred only under requirements from donors or international standards. The findings also show that the role of national policies creates a pathway for men and women to contest existing benefit-sharing mechanisms; however local institutions to systematically execute this are largely missing or weak. We draw from various gender environment theories to discuss the social factors influencing gender inclusion in the three schemes and propose a framework through which gendered concerns can be better integrated into PES and REDD+.

Keywords: Gender, institutions, Kenya, payments for ecosystem services

Contact Address: Juliet Kariuki, University of Hohenheim, Social and Institutional Change in Agricultural Development, Wollgrasweg 43, 70599 Stuttgart, Germany, e-mail: j.kariuki@uni-hohenheim.de

Large-Scale Irrigation Projects in Northern Peru and their Social, Economic and Environmental Effects

ZOILA MENACHO PORRAS

Humboldt Universität zu Berlin, Resources Economics, Germany

The decade of the 90´s in Peru was characterised by performing an institutional change supported by drastic neoliberal reforms at the state and economic level aiming in essence at stabilising the critical socio and economic situation. The agricultural sector faced an institutional change reflected by the end of state monopoly and the liberalisation of agricultural land. In fact, the promotion of private investment in public services and infrastructure allowed important public-private partnerships in the Peruvian coast which involved water treatment and irrigation systems like the Chavimochic project. This case has been evaluated for demonstrating the effects of the lack of awareness in respecting natural resources.

This project was supported as a panacea for drought due to the changing climatic conditions of the coastal region and its big agricultural potential. Chavimochic is structured for covering water deficit, making thousands of former inactive hectares productive and using effectively the waters of Santa River. Since then, large agro-concerns in Chavimochic could export their products to the international market and thanks to them the brand Peru for products like asparagus and avocado is now internationally well known. However, the way this project has been implemented is characterised by an income generating point of view instead of a life-supporting view. The improvement of irrigation in this area shows nowadays several economic, social and environmental consequences. An extensive investigation work has been done through field work and interviews for demonstrating basically the soil salinity risk, ground water pollution, social stress through extension of urban centres and social conflicts for water resources. Moreover, the effects are not limited to the present time but for the near future these are programmed as the agro-concerns will depend on melt waters of the Andes, social conflicts will rise due to the lack of basic management policies, soil degradation will become a problem because of lack of water management knowledge.

Keywords: Institutional change, irrigation projects management, land use

Contact Address: Christian Schleyer, Humboldt Universität zu Berlin, Resource Economics, Hannoversche Str. 27, 10115 Berlin, Germany, e-mail: zmenachop@hotmail.com

Challenges to Operationalise Agricultural Innovation Systems: A Mexican Case Study

TINA BEUCHELT[1], JOHN HELLIN[2], TANIA CAROLINA CAMACHO VILLA[2], ROBERTO RENDON MEDEL[3], RICARDO ROMERO PEREZ GROVAS[4], BRAM GOVAERTS[2], FRANCISCO GUEVARA HERNANDEZ[5]

[1] *University of Bonn - Center for Development Research (ZEF), Ecology and Natural Resources Management, Germany*

[2] *International Maize and Wheat Improvement Center (CIMMYT), Socioeconomics Program, Mexico*

[3] *Universidad Autónoma Chapingo, CIEESTAM , Mexico*

[4] *Katholieke Universiteit Leuven, Dept. of Earth and Environmental Sciences, Belgium*

[5] *Universidad Autónoma de Chiapas, Agronomic Sciences, Mexico*

Sustainable agricultural intensification is required to meet the growing demand worldwide for food, feed and energy, especially in the face of climate change. Proposed agricultural innovations include a range of technologies and management practices. However, farmer adoption rates have been low because of the i) complexity of technologies and management practices; ii) complex interplay between technologies, farming systems and local contexts; and iii) linear approaches to knowledge transfer. In response, extension approaches based on agricultural innovation systems are becoming increasingly popular. Despite this, little is known about the most effective pathways to operationalize these systems within short timeframes.

This paper uses the Mexican Sustainable Modernisation of Traditional Agriculture (MasAgro) programme as a case study to analyse the challenges to operationalising agricultural innovation systems. We outline the relationship between Mexico's extension approaches and global trends in technological change. We then analyse how MasAgro's innovation networks are operationalized. Thirdly, we identify ways to efficiently target in innovation networks, using a case-study from the state of Chiapas. Finally, we draw lessons from MasAgro´s innovation systems. This research is based on a comprehensive literature review, three years´ field observations, and 648 interviews with farmers and key stakeholders.

Mexico has continuously changed its extension approaches following global trends. To date, a variety of different extension modalities exist. MasAgro's innovation networks grew from small networks in a couple of regions to a national initiative. At that level, the innovation networks struggled to become fully institutionalized and operational, creating frictions with short evaluation timeframes of politicians. Identifying key change agents and efficient targeting became a problem with the fast network expansion; applying network analysis has proven helpful to improve this. Adjustments

Contact Address: Tina Beuchelt, University of Bonn - Center for Development Research (ZEF), Ecology and Natural Resources Management, Walter-Flex-Str. 3 , 53113 Bonn, Germany, e-mail: beuchelt@uni-bonn.de

in the operationalisation approach were necessary given the diverse agro-ecological, socio-economic and political contexts; however this reduced resources to institutionalise joint learning. The Mexican experience shows that operationalising agricultural innovation networks requires already major efforts on a small scale but to do this on a larger scale within a few years, organisational and institutional learning capacities need to develop much faster and require more support than expected by all major network actors and brokers.

Keywords: Agricultural innovation systems, extension, Mexico, social network analysis, targeting

Local Agricultural Institutions as Agents of Development - Case Study of Effectiveness of Farmer's Associations in Woreda Angacha, Southern Ethiopia

TARAS VOZNYUK, JIRI HEJKRLIK

Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Czech Republic

Ethiopian economy is highly dependent on agricultural sector which accounts for almost half of country's GDP and 80 percent of employment. Despite this fact, agriculture in the country is dominated by smallholder producers. According to statistics about 90 percent of Ethiopian households cultivate less than 2 hectares, and only 0.9 percent cultivate more than 5 hectares. That is why government of Ethiopia tries to accelerate agricultural growth through different policies and programs including support of agricultural cooperatives, which in turn help to boost smallholder commercialisation. A legislative base for cooperatives exists in Ethiopia since the 1960s, however, the new birth of cooperatives as we know it today was given in 1994 by Agricultural Cooperative Societies Proclamation (Proclamation No. 85/1994). This law gave cooperatives more freedom in marketing and reduced governmental control. As a result, the number of societies increased dramatically – from 2007 to 2012 it grew by almost 90 percent.

The aim of this paper is to contribute to the growing discussion whether membership in agricultural cooperatives really enables small scale farmers to improve their financial and social position. In this framework, it also examines if local cooperative societies function according to proclaimed democratic principles and inclusiveness of modern coops. Agricultural production cooperatives in Woreda Angacha (SNNPR) in southern Ethiopia were taken as a case in point. The survey is based on primary data collected in the field from 100 farmers-members and 6 leaders of 6 cooperatives using questionnaires and semi-structured interviews. The results of the survey show that membership in agricultural cooperatives helps small-scale farmers to reach better market access and incomes for their produce as well as it brings them other benefits, such as market information, use of cooperative's infrastructure, trainings. However, several problems of the cooperative enterprises were detected as well. Organisational and management difficulties were found in most of the surveyed organisations.

Keywords: Agricultural cooperatives, development, problems of cooperatives, small scale farmers

Contact Address: Jiri Hejkrlik, Czech University of Life Sciences Prague, Faculty of Tropical AgriSciences, Kamycka 129, 165 21 Prague, Czech Republic, e-mail: hejkrlik@ftz.czu.cz

Sustainability Analysis of PES: Case Study of Sloping Land Conversion Program in China

XIAOLING SONG

Justus-Liebig University Giessen, Inst. for Project and Regional Planning, Germany

Payment for ecosystem services (PES) has attracted considerable attention around the world recently, and arapid progress on PES research and practice has been achieved. However, PES still faces many difficulties, for example some case studies of PES show, e.g. in land use change programs, that the phenomena of reconverting often happen especially when the payments end. In this article, we chose China-Sloping land conversion programme as example, based on the dara from a farmers' survey, to analyse factors which may affect the participators' decisions of keeping the forest or reconverting from forest back to croplands.

To alleviate ecological problems such as serious soil erosion and extreme flooding, China implemented Sloping Land Conversion Program (SLCP) since 1999 firstly in western China, then this program spread quickly to other parts. Till now it led to millions of hectares of marginal croplands being converted to forests across 25 provinces involving 124 million people and costing the government 358 billion Yuan (US$51.1 billion).

Although SLCP has extensively been implemented in China, sustainability of the programme is not sure. Based on the survey data of the households in the SLCP area in Anhui province, this paper analyses the sustainability of the programme from farmers' perspective, who are the direct implementers of the program. As the compensation will end in a few years, the decisions of farmers whether to keep the forest or reconvert them back to cropland directly influence the program's sustainability. Current SLCP studies mainly focus on West of China, especially on the three pilot provinces Sichuan, Shaanxi and Gansu, but little in other provinces, therefore this study selected Anhui Province located in southeastern China as study area, in order to fill the locational gap.

A decision making model using Tobit approach was employed to analyse the data. The results showed that factors as income source, share of SLCP to cropland, labour availability, importance of subsidies for household's income, whether cropland can produce enough food for households etc. have significant influence on the decisions of participators.

Keywords: Payment for ecosystem services, sloping land conversion program, sustainability, Tobit

Contact Address: Xiaoling Song, Justus-Liebig University Giessen, Inst. for Project and Regional Planning, Senckenbergstr.3, 35390 Giessen, Germany, e-mail: lilysong@live.com

Perceived Employability of Graduates on the Asian Labour Market: Different Perspective of Employers, Graduates and Universities

PETRA BRTNÍKOVÁ, ZUZANA POLÍVKOVÁ, PETRA CHALOUPKOVA, MILAN SLAVIK

Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Czech Republic

Education is still considered as presumption for successful employment and thus it influences the socio-economic situation. Educational systems in South-East Asia went through many reforms in the last decades. This study examines how far higher education graduates in agriculture and related life sciences are capable to stand out on domestic labour market in 6 selected countries: Cambodia, China, Indonesia, Mongolia, Thailand and Vietnam. The analysis highlights the need to adopt skills and competences that graduates have to acquire during their studies at home universities or abroad to fullfill the demands of the local employers. The results should help to adjust the study programmes to the needs of the local stakeholders and to help the European universities to understand the needs of the local labour markets. To conduct this study two-dimensional approach was chosen. Quantitative questionnaires are distributed through online survey to more than 500 locals and 200 Erasmus Mundus graduates. Three different target groups are addressed and the questionnaire is adopted accordingly. The qualitative approach involved also semi-structured interviews with employers/HR managers and key informants from related NGOs, public and private institutions. Selected employers and graduates are invited to join the focus group discussions during local workshops, these should provide a platform for discussion and cooperation. To conduct the selected research activities the researchers will be present personally in the field accompanied by local consultants. Goal is also to assess whether the labour market in the six selected countries is ready and open to competitive graduate labour. All activities related to this research are coming under ongoing Erasmus Mundus project ASK Asia that is facilitated in a cooperation with four European and six Asian universities.

Keywords: Cambodia, China, competences, education, graduate destination, Indonesia, knowledge, Mongolia, skills, Thailand, Vietnam

Contact Address: Petra Chaloupkova, Czech University of Life Sciences Prague, Faculty of Tropical AgriSciences, Kamycka 129, 16521 Prague, Czech Republic, e-mail: chaloupkova@ftz.czu.cz

Manpower Development and Education System in Agriculture in Iraq after Conflict Period

VLADIMIR KREPL[1], BADIR AL-GABOORI[2], PATRICK FRANCIS KAPILA[3]

[1]*Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Dept. of Sustainable Technologies, Czech Republic*

[2]*Ministry for Climate Protection, Environment, Agriculture, Nature Conservation and Consumer Protection of the German State of North Rhine-Westphalia, Germany*

[3]*University of Venda, School of Agriculture, Department of Agricultural and Rural Engineering, South Africa*

Manpower development in agriculture in Iraq, particularly the development of the educational system in Iraq, requires a beneficial policy environment. The insufficient education system additionally suffered through thirty years of instability in the country that stigmatized manpower development in the agricultural sector. The development of agriculture in Iraq is at present inconceivable without education and training which has to correspond with the current situation in rural areas. Iraqi agriculture has gone through many changes during the last three decades. Unfortunately, these changes have had a negative impact with the lack of water, soil erosion, elimination of crop rotation, lack of agronomy intervention, non-availability of vet control and services, lack of maintenance for farm machinery, lack of power, etc. New educational programmes for vocational training, high schools or universities have to reflect the real and long-term requirements of Iraqi agriculture. During the years 2008-2012 the authors researched in the education levels in the agricultural field. The study collected data from the Iraqi Statistical Office (Ministry of Planning, 2012) using questionnaires as a research tool. A total of 620 questionnaires were received from a total of 1200 administered SWOT analyses. One of the main objectives of study was to assess the current education curricula in schools and academic bodies in the field of agriculture in Iraq. Based on the findings, a proposal for a new educational programme in form of syllabus was developed. The syllabuses are designed on the basis of particular requirements not only for the professional field but also with respect to the location and region of Iraq. The focus is mainly on the vocational and high school programmes in crop production, animal husbandry; further in postharvest technology, particularly on food processes, conservation and packaging technology. The above mentioned education curricula are set up for rural areas of Iraq with a focus on agriculture and non agricultural production, particularly for farmers, smallholders as well as for small and medium sized entrepreneurs.

Keywords: Education, entrepreneurs, Iraq, smallholders, syllabus

Contact Address: Vladimir Krepl, Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Dept. of Sustainable Technologies, Kamycka 129, 165 21 Prague, Czech Republic, e-mail: krepl@ftz.czu.cz

An Integrated Pathway of Production Systems Modelling Analysis in Sub-Saharan Africa

AMIT KUMAR SRIVASTAVA, THOMAS GAISER, FRANK EWERT
University of Bonn, Inst. Crop Sci. and Res. Conserv. (INRES), Germany

Most parts of sub-Saharan Africa are characterised by low crop productivity and large yield gaps. According to FAO (2011) a rise in food demands of about 70% is expected globally by 2050 with largest increase rates in sub-Saharan Africa. On the other hand, sub-Saharan Africa remains the region with the lowest crop productivity per hectare (highest yield gap) and lowest adaptation capacity to the expected climatic changes. A comprehensive and detailed analysis of the production systems in each country at the national level is resource and data limited. However, emerging issues like closing yield gaps or impacts of climate change could be addressed via model based, spatially explicit scenario analysis of national production system, estimating the impact of intensification/adaptation scenarios on the national food production. One major output would be the identification of potential hotspots of vulnerability to climate change or of most promising areas for investment into intensified crop production.

Due to the fact, that a national assessment of the food production systems may require a high level of generalisation, which would not be able to account for the specificity of local or regional production systems, a two-phase approach is proposed. The approach is based on a finer resolution analysis of local/regional production systems using cropping system/agroforestry system models combined with farm scale models to represent locally relevant bio-physical and bio-economic drivers. Then the results of the first phase analysis will be integrated into national food system models taking into account economic and physical equilibrium of demand and supply at the national scale. A possible pathway for such two-phase analysis will be presented.

Keywords: Production systems modelling, sub-Saharan Africa, yield gap

Contact Address: Amit Kumar Srivastava, University of Bonn, Institute of Crop Science and Resource Conservation (INRES), Katzenburgweg 5, 53115 Bonn, Germany, e-mail: amit@uni-bonn.de

The Transformation of Land Rights as an Instrument for Conservation? A Case Study from Pará, Brazil

MICHAELA MEURER

Philipps-University of Marburg, Cultural and Social Anthropology, Germany

The region around the city of Santarém at the Lower Amazon in Brazil is nowadays discussed particularly regarding mechanised soy production and governmental infrastructural projects, which are all together impulses for deforestation, both on a local and a supra-regional level. Concurrently there are two national protected areas with the aim to guarantee conservation of the rainforest by sustainable forest management and restricted land use. One of these areas is the Reserva Extrativista Tapajós-Arapiuns (Resex).

The Resex is managed by a committee (Conselho Deliberativo), consisting of governmental and public institutions, non-governmental actors as well as representatives of the local population. In 2013 the Conselho Deliberativo approved an agreement about the use of natural resources which includes a transformation of land tenure, saying that the area will stay state-owned, but dwellers will receive fixed parcels of land at their own disposal. The Conselho Deliberativo will be the responsible board for administration of allocation and control. This arrangement replaces the "traditional" local system of common land, where access to resources is managed by each community, and residents practice shifting cultivation instead of farming on defined individual sites.

The present contribution focuses on the transformation of land tenure described above, arguing that this case shows a general tendency nowadays where sustainable use of limited natural resources is to be realised by external regulation - either through the state or through privatisation and thus market mechanisms. This is caused by the assumption that local communities are unable to regulate the use of common resources. But data from fieldwork in 2013 indicate that the "traditional" system already consists of an informal community-based structure that provides a control of access to land. Following researches like Elinor Ostrom, many case studies prove that the protection of commons against over-utilisation and exploitation cannot invariably be reached by the general strategy of transformation into private property or state regulated resources, but that especially local informal structures are able to secure sustainability. This contribution aims to discuss whether and how the informal system of community-based management in the Resex is considered in the new agreement about land tenure.

Keywords: Brazil, community-based management, conservation, land tenure

Contact Address: Michaela Meurer, Philipps-University of Marburg, Cultural and Social Anthropology, Kugelgasse 10, 35037 Marburg, Germany, e-mail: michaela.meurer@uni-marburg.de

Land-Use Alternatives of Small-Scale Farmers' in Northern Bangladesh: Use of PROMOTHEE Analysis

MD. SALAUDDIN PALASH, SIEGFRIED BAUER

Justus-Liebig University Giessen, Inst. of Farm and Agribusiness Management - Project and Regional Planning, Germany

This study explores the policy variables that can influence the farmers' land use decisions. The study represents the northern part of Bangladesh where the land conversion from crop to fish farming highly exists. The study focuses on the small-scale freshwater pond fish farming. A multi-stage sampling procedure was followed to select the study area and the sample. Mymensingh district, with high existence of the land conversion, is considered as the study district. Among twelve sub-districts in Mymensingh district, four sub-districts as Mucktagachha, Trishal, Phulpur, and Bhaluka were selected. A sample size of 115 small farmers was purposively selected in four sub-districts. The farmers face difficulty to make a land use decision because, one alternative can setback other alternatives depends on some criteria, and at the same way other alternatives also can setback each other depends on other criteria. The farmers have to consider these factors while choosing an alternative. Accordingly, making land use decision considering all criteria is a challenge. A PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluations) method was used to get rid of the problem, which revealed the effects of some important variables on farmers' land use decisions. The fish farming is favorable in the base case; however, it is altered in the scenario analyses. In the scenario of increasing BCR (Benefit-cost Ratio), the small farmers prefer crop farming instead of fish farming. The same result is in the second-scenario analysis (increasing output price growth rate), but the preference index rates are different. The index rate of changing BCR value is higher than the change of output price growth. The study concludes that there is a scope for the policymakers to intervene in the parameters of price growth rate and BCR.

Keywords: Land-use alternative, MCDM, PROMETHEE, small-scale farm

Contact Address: Md. Salauddin Palash, Justus-Liebig University Giessen, Inst. of Farm and Agribusiness Management - Project and Regional Planning, Unterhof 69 Zi. 1025, 35392 Giessen, Germany, e-mail: palash80@gmail.com

Food Insecurity and Coping Strategies Along the Urban-Rural Continuum in Tamale

SOPHIE UNGER, TAKEMORE CHAGOMOKA

University of Freiburg, Deptartment of Environmental Social Sciences and Geography; Physical Geography, Germany

Food insecurity is a worrying challenge all over the world, with sub-Sahara Africa most affected. Literature reveals that in developing countries food insecurity is largely a "managed process", meaning people are not passive victims of sudden events but are active participants in responding to the risks they face in their daily lives. Our research focuses on food insecurity and coping strategies and seeks to understand the role of urban and periurban agriculture in food security, how households cope with food shortages and how these coping strategies changes along the urban - rural continuum. A transect approach was used to guide data collection along the North - South and East - West transects along the urban - rural continuum. A total of 20 focus group discussions, with each eight participants (four women, four men), has been conducted. Additionally, three qualitative interviews were conducted, one in each spatial dimension (urban, periurban and rural). Preliminary results reveals that majority of households experienced a poor harvest in the last season and they were consequently expecting to experience food insecurity this year. All interviewees explained, that the most difficult time in terms of food insecurity is June and July. This is the period when rain season has already started and people engaged in farming, but crops not yet mature. Most common coping strategies include reliance on cheaper and less preferred food, limiting portion size and reducing the number of meals a day. In periurban and rural areas, hunting and gathering of wild food is widely practised. In urban areas, people tend to be in a better position to cope with food insecurity, as they can always turn to occasional jobs to generate some monetary income, for example, carpentry or trading. While in some places borrowing and taking credit is very common, it is a social taboo in other communities. This study will further produce an index on frequency and severity of the different coping strategies used in each of the locations along the urban - rural continuum and produce a map to visualise in which parts of Tamale certain challenges and coping strategies are located.

Keywords: Food coping strategies, food insecurity, transect approach, urban and periurban agriculture

Contact Address: Takemore Chagomoka, University of Freiburg, Deptartment of Environmental Social Sciences and Geography; Physical Geography, Werthmannstr. 4, 79085 Freiburg, Germany, e-mail: takemore.chagomoka@geographie.uni-freiburg.de

Enabling Rural Innovation - An Integrated Approach for Empowering Farmers in Managing Natural Resources and Accessing Market Opportunities

THOMAS PIRCHER, AMOS OWAMANI

Horizont3000 Austrian Organisation for Development Co-operation, Regional Office East Africa - Enabling Rural Innovation East Africa Project, Uganda

Commercialisation of agriculture and the transition from subsistence into market-oriented farming is often driven by short-term benefits and result in a depletion of natural resources. This highlights the importance of an integrated approach for promoting agro-enterprise development in family farming systems.

HORIZONT3000 is implementing a project called Enabling Rural Innovation in East Africa (ERI EA) that aims at enhancing and balancing food sovereignty and increasing incomes through market oriented agriculture, while sustaining the natural resource base of farmers. The project is based on the Enabling Rural Innovation (ERI) approach, which has been developed in East Africa by the International Center for Tropical Agriculture (CIAT) to overcome the linear, top-down mode of technology development and market access in agriculture. In collaboration with various research and development partners, an interdisciplinary team developed the approach over several years.

In the ERI EA project, community development facilitators of HORIZONT3000's partner organisations in Uganda and Tanzania are carrying out trainings with farmer groups in their respective districts. The trainings are comprised of five modules: Participatory Diagnosis, Participatory Market Research, Farmer Participatory Research, Enterprise development, and Participatory Monitoring & Evaluation. The participating farmer groups identify local resources, collectively develop action plans to capitalize on available resources and continuously monitor them in the process of developing agro-enterprises. Based on a market research by farmer groups themselves, they learn how to produce according to product quality criteria from potential buyers and make trade agreements before producing. In Farmer Participatory Research, the groups experiment with different technological options of agricultural practices and evaluate those with criteria that include not only marketability and the value as food crops, but also context-specific preferences and sustainability of production practices.

Building on identified natural resources to develop profitable agro-enterprises, awareness of the importance to safeguard them is created. Hence, the ERI approach supports farmer-led development in a sustainable way and empowers farmers to manage their natural resources responsibly.

Keywords: Community-based management, farmer-led development, market oriented

Contact Address: Thomas Pircher, Horizont3000 Austrian Organisation for Development Co-operation, Regional Office East Africa - Enabling Rural Innovation East Africa Project, Plot 4775 Church Rd. Off Ggaba Road Kansanga, Kampala, Uganda, e-mail: thomas.pircher@horizont3000.org

Development of a Framework on the Communication of Biodiversity: The Case of Australian Food Companies

BAHRAM FAZLI KHOSROSHAHI, CHRISTINA BANTLE

University of Kassel, Dept. of Agricultural and Food Marketing, Germany

Ecosystems are exploited to supply the increasing global demand for food in recent century. This had a negative impact on biodiversity. Food industries can play a prominent role in biodiversity conservation by reducing their unsustainable activities and communicating it to their consumers. Australia is a biodiversity-rich country and follows the "Strategy 2010-2030" to preserve its biodiversity by engaging industries, especially food industries, to raise public awareness in this issue. There is little information in the scientific literature on the communication of biodiversity. This study had the aims of providing scientific information regarding the current communication activities of Australian food companies and proposing a conceptual framework on the communication of biodiversity.

Data was collected from the websites of 169 Australian top-ranked food companies which were listed in database of IBISWorld market research organisation. Qualitative and quantitative content analyses were used to analyse web content and company reports. A category system was defined in accordance to the research aims for analysing the messages. An innovative scoring system was developed to show the degree of which companies communicate on biodiversity. An inductive and exploratory approach with consideration of "elaboration likelihood method" and "response hierarchy models", was taken in this study to develop the conceptual framework.

Results showed that 24 % of the sampled companies had at least one message regarding biodiversity. 5 % of the sampled companies communicated on biodiversity at a high level. Agricultural and fishing companies communicated the biodiversity issue most in detail. Food companies communicated on their own projects regarding biodiversity conservation. Messages were formulated mainly by use of positive appeals and they had the theme of hope, joy, health, greenness and freshness. Companies had problems in visibility of, ease of access to and preciseness of biodiversity messages, and usage of emotional and rational appeals.

The developed framework helps companies to involve a wide range of audiences from unconcerned public reviewers to interested recipients and experts. It aims to attract low-involved recipients by emotional appeals, lead them to detailed information, increase their knowledge and motivate them to take action. It satisfies high-involved recipients by rational and informational appeals and detailed messages.

Keywords: Biodiversity communication, food companies, message analysis, qualitative content analysis, raising awareness about biodiversity

Contact Address: Bahram Fazli Khosroshahi, University of Kassel, Dept. of Agricultural and Food Marketing, Steinstraße 19, 37213 Witzenhausen, Germany, e-mail: bahramfazli@yahoo.com

Environmental Sustainability in the Era of Technological Development: Any Hope for Finite Resources Dependent States?

LERE AMUSAN

North West University, Mafikeng Campus, Politics and International Relations, South Africa

The question of development has been in the front burner of every state in the international system. This has taken various forms from the time of Industrial Revolution till date. What comes to mind is the development in technology which keeps on proffer alternatives for the development of a state, but at a cost. The use of finite energy sources such as coal, natural gas and crude oil (fossil fuel) have become important issue that preoccupy the minds of state, multinational oil companies, civil societies and private individual in the form of their negative impacts on the general development of the affected states. Attempt to bridge the gap between increasing knowledge and decreasing resources brings about what is known by some students of political economy as a resource curse that, in many cases, aggravated to civil wars, militancy, fracking and piracy. At the extreme case, it engendered implosion of many states fuelled by the military industrial complex activities. It is the intention of this paper to look into the crises inherent in the technological development and its impacts on environmental issues that is facing the global system with no solution in sight. In doing this, this study will employ critical theory because, as in other social sciences discussion, a theory (general theory) may not be able to capture the problem at hand. Special focus will be on some selected African states such as Libya, Nigeria, South Africa and Kenya. The needs to focus on these states are multifarious. Each represents a geo-political zone in the continent of Africa. They are sub-regional hegemons and mineral extraction states with all the vicissitudes of price changes at the international level. Their over-reliance on multinational corporations in their developmental approaches implies that environmental crisis on the continent cannot be resolved until holistic approaches are introduced. The same continues to affect human security because of the introduction of alien capital intensive as a mode of production.

Keywords: Africa, finite resources, resource curse, sustainability

Contact Address: Lere Amusan, North West University, Mafikeng Campus, Politics and International Relations, Albert Luthuli / University Road, 2735 Mmabatho, South Africa, e-mail: lere.amusan@nwu.ac.za

Changes of Property Right Institutions on Namibian Marula Fruits as Impacts from Biotrade

SHIGEO WATANABE, KATHARINE NORA FARRELL

Humboldt-Universität zu Berlin, Inst. of Agricultural and Horticultural Sciences, Germany

Marula (*Sclerocarya birrea*) is one of the traditionally used multipurpose fruit trees in southern Africa. In the north central region of Namibia, a traditional custom rule regulates access to marula fruits and its processing as collective actions of local women. The abolition of apartheid and expansion of urbanization were accompanied by commodification of marula fruit products and commercialization of production through biotrade contracts.

This study aims to depict mechanisms of a sequence of economic institutional changes at local level with analytical frameworks of Hagedorn's Institutions of Sustainability (IoS) and Williamson's four level analyses on economic institutions and using the concept of power from Herbert Simon, in order to evaluate changes of behaviours of resource users due to biotrade contracts. Qualitative data on institutional changes were collected by interviews and document surveys in fieldworks in Namibia in 2011. The combination of designed institutional sets of biotrade contracts and a primary producer co-operative are found to create new choices for the sales of marula products. These include the introduction of fruits processing machines, which enabled intensive use of marula fruits. However, this has brought economic incentives for local women to alter property right rules on resource allocation of fruits. Contrary to traditional rules, access rights to fruits are now allocated not only among local women but also to men. Considering a social cognitive norm that labour using a machines is male dominated, processing work has shifted from women to men. This can exacerbate power asymmetries between the rich and the poor as well as between genders. Referring to the IoS, these unintended institutional innovations can be understood as adverse transactional effects of biotrade on the income and equality of local women. Increasing unequal present patterns of resource uses may reduce the interdependencies of local women as found in social capital. This study reveals the significance of gender power asymmetries for understanding adaptation of the biotrade contracts on marula oil. It is suggested that changes in property rights on marula fruits might help to limit future damage from biotrade contracts for sustainable uses of marula fruits.

Keywords: Gender, institutions of sustainability, marula, power

Contact Address: Shigeo Watanabe, Humboldt-Universität zu Berlin, Inst. of Agricultural and Horticultural Sciences, Unter den Linden 6, 10099 Berlin, Germany, e-mail: watanash@agrar.hu-berlin.de

A Causality Analysis on the Empirical Nexus Between Export and Economic Growth in Post-Soviet Countries: Evidence from Georgia

SURAJ GHIMIRE, JIRI HEJKRLIK

Czech University of Life Sciences Prague, Faculty of Tropical AgriSciences, Czech Republic

Today foreign trade is inevitable for a country like Georgia where resources and markets are limited for the sustainable and economic growth of the country. The role of export in the economic performance of Georgia was clearly demonstrated by the experience of collapse of national economy after the independence from Soviet Union and consequent political barriers to trade with Russia. The paper tries to assess empirically the relationship between export and economic growth in Georgia using annual data over the period 1972–73 to 2010–12. The research is based on econometric time series techniques. Granger causality and cointegration test were used to test the hypothesis of economic growth led by export. The paper is based on the following research questions whether there is bi-directional causality between GDP growth and export, or whether there is unidirectional causality between the two variables or whether there is no causality between GDP and export in Georgia or whether there exists a long run relationship between GDP and export Georgia. Before conducting the causality test unit root properties of the data are examined using Augmented Dickey Fuller test. The Johansen cointegration test is done to indicate an existence of long run equilibrium relationship between the two variables. The data indicates that Georgia can expand its domestic market by exporting both manufactured item and agricultural goods and services. Exports increase contribute to GDP, and as a whole they contribute to the economic growth of the country. The result shows that there is bidirectional Granger causality between total export and GDP and in short run both variables does not cause each other. The determination of the causal pattern between export and growth has important implications for policy-makers decisions in order to implement appropriate growth and development strategies.

Keywords: Econometric modeling, economic development, Georgia, trade and development

Contact Address: Suraj Ghimire, Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Dept. of Economics and Development, Kamycka129, 165021 Suchdol, Czech Republic, e-mail: surajghimire2000@gmail.com

The Biomass-Based Value Web as a Novel Perspective on the Increasingly Complex African Agro-Food Sector

DETLEF VIRCHOW[1], MANFRED DENICH[1], ARNIM KUHN[2], TINA BEUCHELT[1]
[1] *University of Bonn, Center for Development Research (ZEF), Germany*
[2] *University of Bonn, Institute for Food and Resource Economics, Germany*

Undernourishment and micronutrient deficiency in Africa are still at high levels, while at the same time the international and domestic demand for non-food agricultural produce, like feed, energy and industrial raw materials, is continually increasing. The rising demand for more diverse biomass-based produce will transform traditional agriculture from a food-supplying to a biomass-supplying sector. Concepts are required which improve food security for the poor through increased food availability while supplying sufficient non-food, processed biomass to offer employment and income opportunities and hence improve the economic access to food. For these concepts analytic approaches are needed which are able to depict the increasingly complex ways of biomass from crop production to final consumption. Conventional value-chain approaches analysing single value chains are not sufficient anymore. We develop a biomass-based value web approach, in which the 'web perspective' is used as a multi-dimensional methodology to understand the interrelation between several value chains, to explore synergies and to identify inefficiencies in the entire biomass sector. This is instrumental to increase the sector's efficiency. The web perspective focuses on the numerous alternative uses of raw products, including recycling processes and the cascading effects during the processing phase of the biomass utilisation. A case study of a biomass-based value-web approach from Ethiopia is presented. The first step is to describe the material flows of all produced biomass from the various crops, the involved actors and interrelations from production to consumption in such a biomass-based value web. Furthermore, the information and financial flows will be described and analyzed. As a second step the local bottlenecks and opportunities of improving the system productivity and food security in the biomass-based value-web are discussed. Finally, an outlook is given of how the analytic approach of biomass-based value webs can improve the understanding and efficiency of an increasingly complex agricultural system as part of the emerging bio-economy in Africa.

Keywords: Bio-economy, biomass-based value-web, food and non-food competition, system productivity

Contact Address: Detlef Virchow, University of Bonn, Center for Development Research (ZEF), Walter-Flex-Str. 3, 53113 Bonn, Germany, e-mail: d.virchow@uni-bonn.de

Developing Food and Nutrition Security Criteria for Biomass Standards and Certifications

TINA BEUCHELT[1], RAFAËL SCHNEIDER[2], DETLEF VIRCHOW[1], ANNA MOHR[1]

[1] *University of Bonn - Center for Development Research (ZEF), Ecology and Natural Resources Management, Germany*

[2] *Deutsche Welthungerhilfe e.V., Policy and External Relations, Germany*

International biomass demand and trade is growing as governments start shifting from petroleum-based to bio-based economies. While bioeconomy strategies prioritise in principle food security over other biomass uses such as bioenergy, questions around the implementation arise. Environmental and social standards are currently developed to ensure that biomass is sustainably produced; yet while a large body of scientific literature exists food security aspects are hardly addressed. Even those standards which include food security indicators do not assess food and nutrition security in practice, usually due to measurement difficulties since practical indicators, verifiers and thresholds lack.

We aim to fill this gap by identifying suitable criteria, operational indicators and verifiers to measure local food security impacts of biomass production which can be applied to all types of biomass independent of its later use (e.g. food, feed, fibre, energy) and farm sizes. In addition, they must be relevant at global and national level, across different sectors and standards.

The research is based on a comprehensive literature review and complemented by stakeholder workshops and expert interviews with certification bodies, standard initiatives, NGOs, ministries and enterprises. Normative values are based on a broad definition of sustainability, e.g. the Brundtland-Commission and the human right to adequate food.

A respective set of indicators and verifiers are identified reflecting all dimensions of food and nutrition security (access, availability, utilisation, stability). In addition to a common set, specific indicators for family farms and large-scale farming are developed which enable family farms to participate and slowly adjust to rising standards and which encourage large-scale farms to contribute to local development. Minimum and advanced requirements are defined which are adjustable to local contexts, reliable and easy to measure.

The increased use of biomass for non-food purposes and hence the rising competition requires regulations that guarantee food security and the realisation of the right to adequate food. The developed food and nutrition security criteria provide guidance for regional and national standard setting as well as for private certification systems. A field test of the criteria is recommended to ensure practicability in developing countries.

Keywords: Bioenergy, biomass, certification, food security, nutrition, right to food, standards

Contact Address: Tina Beuchelt, University of Bonn - Center for Development Research (ZEF), Ecology and Natural Resources Management, Walter-Flex-Str. 3 , 53113 Bonn, Germany, e-mail: beuchelt@uni-bonn.de

Economics of Land Degradation in Eastern Africa: Case of Ethiopia, Tanzania and Malawi

OLIVER KIRUI, ALISHER MIRZABAEV

University of Bonn, Center for Development Research (ZEF), Germany

Land degradation remains a serious impediment to improving livelihoods in the eastern Africa region. This working paper presents a general overview of the state and extent of land degradation in East Africa, explores its proximate and underlying drivers, identifies the land degradation hot-spots in the region, and also discusses the productivity and poverty impacts of land degradation in the region. It is intended to serve as an exploratory tool for the ensuing more detailed quantitative analyses to support policy and investment programs to address land degradation in eastern Africa. We critically review the strengths and weaknesses of the previous studies on the causes of land degradation in the region. Recent assessments show that land degradation affected 51 %, 41 %, 23 % and 22 % of land area in Tanzania, Malawi, Ethiopia and Kenya respectively. The key proximate causes leading to land degradation widely cited in the literature for the region include non-sustainable agricultural practices, overgrazing and over-exploitation of forest and woodland resources, while the major underlying causes are believed to be population pressure, poverty and market and institutional failures. Water and wind erosion are the most widespread types of land degradation in the region. The economic damages from land degradation are substantial. To illustrate, this loss is estimated at about 3 % of GDP in Ethiopia and about 9.5-11 % of GDP in Malawi, annually. The available estimates indicate that yield reduction due to soil erosion may range from 2-40 % depending on the crop and location across eastern Africa. In spite of these dynamics, the adoption of sustainable land management practices in the eastern Africa region, and in sub-Saharan Africa, as a whole, is highly insufficient - just on about 3 % of total cropland, according to some estimates. To address land degradation, there is a strong need to substantially increase the investments and strengthen the policy support for sustainable land management.

Keywords: Eastern Africa, economics of land degradation, poverty, sustainable land management

Contact Address: Oliver Kirui, University of Bonn, Center for Development Research (ZEF), Walter-Flex Str. 3 53113, 53113 Bonn, Germany, e-mail: okirui@uni-bonn.de

Identifying Gainers and Losers When Land Prices Change under Large-Scale Land Acquisitions in Ghana

ELIAS DANYI KUUSAANA

University of Bonn, Center for Development Research (ZEF), Economic and Technological Change, Germany

Recent renewed investment in agriculture in sub-Saharan Africa is very welcoming since it presents opportunities to augment the comparatively lagging food supply in the region. However, large land acquisition for agro-investment globally is stirring debate about their political, social, cultural, economic and ecological implications on smallholders and host communities. Though several works are on-going in this area, empirical findings that identified and compared losers and gainers in host communities as changes in land prices occur remains limited. This study was largely qualitative - relying on household surveys, focus group discussions and key stakeholder interviews. The study found that inequalities in benefiting from land revenue were customarily anchored and existing land and agricultural policies offered very little remedies for vulnerable groups. Unequal power relations between land custodians and clustered land users dictated who could benefit more from price changes. Chiefs and family heads entrusted with allodial titles were found to be gaining most from land price changes. On the other hand, sharecroppers, women and poor community commoners were the most hit by changing land prices. Policy direction should target spreading land transaction proceeds to the entire community in the form of community infrastructure and social services. Under the current tenure regime, land custodians are not obliged to earmark land transaction proceeds for community development or compensate expropriated households. Though the proponents of large agro-investments in Africa have argued that boosting agriculture will generate foreign currency, create employment and improve agricultural modernisation and productivity, such notions have not fully manifested in host communities as the investment agreements hardly assign such obligations. These targets are however realisable if effective legal and institutional frameworks are put in place.

Keywords: Chieftaincy, gainers/losers, Ghana, land investments, land markets, land prices

Contact Address: Elias Danyi Kuusaana, University of Bonn, Center for Development Research (ZEF), Economic and Technological Change, Walter-Flex Str 3, 53113 Bonn, Germany, e-mail: ekuusaana@yahoo.com

Governance Challenges of Agricultural Recovery Programs in Regions under Stress: A Case Study of Post-Conflict in Northern Uganda

EMMY WASSAJJA

University of Hohenheim, Inst. of Agricultural Economics and Social Sciences in the Tropics and Subtropics, Germany

Twenty years of conflict in northern Uganda led to the displacement of the majority of the population who later were forced into internally displaced camps.
Programs that promote agricultural development play an important role in post-conflict areas because virtually all the population in the area depends on agriculture for their survival. Yet there are major governance challenges in the implementation of such programs geared at post-conflict recovery. The large scale programs that are being implemented in the post conflict situation of northern Uganda such as the Community Driven NUSAF Programme and the Local Government Led NAADS programme offer an important opportunity to learn about the opportunities and challenges of different implementation and targeting mechanisms. The goal of the paper is to study such programs in a comparative perspective with the goal to generate policy relevant information on promising strategies for achieving food security and agricultural development in post conflict areas. Taking post conflict northern Uganda as case study, this paper explores the various governance challenges in the implementation of the two large public programs and also to explore the various strategies that have been developed to address these challenges. The research was a qualitative and quantitative study using questionnaire, interviews and the participatory mapping tool, the net-map. The net-map which identifies the different steps involved in different implementation mechanisms, the actors involved, the influence level of the actors and entry points for corruption and local capture. The study identified a number of challenges and opportunities both on the demand side (individuals receiving the service) and supply side (the organisation providing the service). The study also identified a number of solutions to address the governance challenges. Furthermore the paper offers important insights in the management of livelihoods programs in post-conflict contexts.

Keywords: Demand and supply strategies, governance challenges, post-conflict

Contact Address: Emmy Wassajja, University of Hohenheim, Inst. of Agricultural Economics and Social Sciences in the Tropics and Subtropics, Wollgrasweg 43, 70599 Stuttgart, Germany, e-mail: emmy.wassajja@uni-hohenheim.de

Value chains and markets II

Livelihood strategies and farm-household systems II

Development cooperation

Community development and extension

Identification and Prioritisation of Farmer Innovations in Northern Ghana

JUSTICE A. TAMBO, TOBIAS WÜNSCHER
University of Bonn, Center for Development Research (ZEF), Germany

Over the years, farmers have been recognised as innovators and experimenters and not just adopters of introduced technologies. The innovations developed by farmers (which are generally referred to as farmer innovations) could complement the highly promoted externally-driven technologies in addressing the numerous challenges facing agriculture. The aim of this paper is to identify outstanding innovations developed by smallholder farmers in northern Ghana, and prioritise the high potential ones for further scientific validation or dissemination. Using an innovation contest that rewards farmers' creativity, we identified 29 promising innovations. Additionally, 19 innovations were scouted through a household survey. The innovations are largely extensive modification of existing practices or combination of different known practices in unique ways to save costs or address crop and livestock production constraints. While some of the identified innovations can be recommended or disseminated to other farmers, most of them may require further validation or research. However, validating all of these innovations will be very expensive and time-consuming. We propose the multi-criteria decision making analysis based on expert judgement as a simple and useful method to prioritise the high-potential innovations. Using this method, we find that among the most promising innovations involve the control of weeds, pests and diseases using plant residues and extracts, and the treatment of livestock diseases using ethnoveterinary medicines. We briefly explain the six most highly ranked innovations. This case study from northern Ghana provides a further proof that smallholder farmers develop diverse and spectacular innovations to address the myriads of challenges they face, and these need to be recognised and promoted.

Keywords: Farmer innovation, innovation contest, innovation scouting, multi-criteria decision making, northern Ghana, validation

Contact Address: Justice A. Tambo, University of Bonn, Center for Development Research (ZEF), Walter-Flex-Str. 3, 53113 Bonn, Germany, e-mail: jatambo@uni-bonn.de

How Innovations Survive after Researchers Leave the Research Site - Collaborative Learning Processes in Nicaraguan Smallholder Farmer Families to Increase the Sustainability of Farmer-Researcher Innovations

IRUNE PEÑAGARICANO[1], GIANNA LAZZARINI[2], BERNHARD FREYER[1], REIN VAN DER HOEK[3]

[1]*University of Natural Resources and Life Sciences (BOKU), Division of Organic Farming, Austria*

[2]*ETH Zurich, Environmental Systems Science, Switzerland*

[3]*International Center for Tropical Agriculture (CIAT), Central America, Nicaragua*

A well-known research phenomenon in developing countries is that innovations initiated by researchers often disappear after they leave their study site. Therefore our aim was to create methodological efforts towards a more enduring implementation of new farmers' practices. The project background included a three-year investigation in Nicaraguan smallholder farms in five villages at two different sites. In on farm and on site trials, Quesungual systems (QS) were developed and established by researchers from CIAT and the Universidad Nacional Autonoma de Nicaragua. QS is a combination of tree, cash crop and legume planting, to avoid erosion, to increase nitrogen, carbon fixation and biodiversity, as well as to raise yields of cash crops for income. To better understand under which circumstances this innovation takes place and maintains after researchers leave the research site, our entry point was to study more in detail the socio-cultural and socio-economic environment, by establishing a format for trust building and mutual learning processes. To do so we initiated what we name a collaborative learning community between stakeholders, researchers and local advisors, which is highly flexible and sensitive to react on stakeholder demands. We facilitated monthly workshops with men, women and youth, over a period of four months, by placing them in the centre of our communication process and focusing on their everyday experiences and challenges. Collaborative learning among all stakeholders involved farmer to farmer exchange and enabled them to observe and reflect on the Quesungual innovation in their fields, and helped researchers to better understand about the success and failure of QS also beyond the pure technical issues. This provided a double-loop learning process for the innovation and contributed to adaptations on individual farms. As trust was built, possibilities were opened for further discussions on specific research issues, raised by both farmers and researchers. Thus, we realised the relevance of improving communication between researchers and the main stakeholders that also strengthened the identification of constrains concerning the implementation and maintenance of innovations. Finally in one of the two research sites it was possible for the local advisor to take over the collaborative learning approach.

Keywords: Collaborative learning community, farm and household innovation, smallholder farms

Contact Address: Bernhard Freyer, University of Natural Resources and Life Sciences (BOKU), Division of Organic Farming, Gregor Mendel Straße 33, 1180 Wien, Austria, e-mail: Bernhard.Freyer@boku.ac.at

Innovation Platforms as a Tool for Small Holder Dairy Development: A Case from Uttarakhand, India

THANAMMAL RAVICHANDRAN[1], ALAN DUNCAN[2], NILS TEUFEL[3]

[1]*International Livestock Research Institute (ILRI), India*
[2]*International Livestock Research Institute (ILRI), Ethiopia*
[3]*International Livestock Research Institute (ILRI), Kenya*

Innovation platforms (IPs) are emerging as a new tool for agricultural development focusing on sustainable market development and technology uptake. IPs as a development approach recognise that innovation emerges from the complex interaction of multiple actors who together foster technical, social and institutional change. Interim evaluation is needed to understand the innovation process with a view to adjusting forward planning and activities. ILRI has implemented 2 dairy value chain IPs in 2 districts in the state of Uttarakhand in India. This study evaluates the process of IP functioning and conflict management through a qualitative "innovation story line". The IP meetings were regularly documented with details of issues discussed, actions planned and follow up activities.

Qualitative analysis of IP documentation over one year led to a storyline which showed that even though identified constraints were similar for both platforms, different innovations emerged according to the driving forces and the enabling environment. The first innovation to emerge was linking to the market for milk sales; linking with the state co-operative was the only option for the Sult clusters as the distance to the nearby town is large. In Bageshwar clusters marketing channels are diverse, starting with a self-help group based co-operative, followed by sharing excess milk with private traders. Feed and breed improvement innovations emerged later and were reasonably successful after market access had been improved. There were institutional conflicts (co-operative membership, breeding policy) and religious beliefs (not to sell milk) which hindered the innovations but these were handled through informal negotiations and tackled through innovative champions. Private actors were not attracted to the value chain initially, but were later motivated by marketing and feed sales.

The innovation storyline/history is a powerful tool to reflect on the innovation process and to share experiences with outsiders and it can be a qualitative first step for impact assessment. Addressing the conflicts or power dynamics in the initial stage is important in the IP to avoid stalling the innovation process.

Keywords: Conflict management, dairy development, innovation platform, innovation storyline

Contact Address: Thanammal Ravichandran, International Livestock Research Institute (ILRI), International Livestock Research Institute (ILRI) 904 Aggarwal Corporate Tower Rajendra Place, 110008 New Delhi, India, e-mail: thanamvet_bha@yahoo.com

Taboos as Informal Institution of Local Resource Management in Ghana

PAUL OSEI-TUTU

University of Freiburg, Fac. of Environment and Natural Resources, Germany

Taboos are good examples of informal institutions, where traditional local norms rather than official rules define and regulate the actions of people. They are mostly self-complied, out of fear of misfortunes that are believed to befall people who flout them. This attribute sets them apart from other informal local norms and gives them unique natural resource conservation potential. But the potential role of taboos in natural resource management and nature conservation is threatened by decline in their ability to influence local practice as local communities transform. Some taboos have lost or are losing their influence on practice in contemporary communities. The societal transformations that have been alleged to affect compliance with taboos include formal education, adoption of foreign religion and in-country migration. Nevertheless, some natural resource management taboos have survived societal transformation and continue to influence local practice. The literature on the subject does not explain why some resource management taboos have lost their influence on practice in contemporary local communities while others in the same contexts continue to influence local practice. This knowledge is vital for defining the role of taboos in contemporary natural resource management and nature conservation.

Based on study of wildlife, forest, water and land taboos in three Ghanaian communities, the paper discusses why some resource management taboos have lost their influence on practice in contemporary local communities and why others continue to influence practice. The data was collected through review of available reports, interviews, focus group discussions and personal observation. Institutions, institutional change and institutional compliance constitute the theoretical background. The findings indicate that the adoption of foreign religion (Christianity) has indeed reduced compliance with local resource management taboos. However, formal education and in-country migration have had no noticeable impact on compliance with the resource management taboos. Other reasons that explain compliance or non-compliance with the resource management taboos are local importance of the resources they protect and compliance or non-compliance by others.

Keywords: Compliance, Ghana, informal institutions, local resource management, taboos

Contact Address: Paul Osei-Tutu, University of Freiburg, Fac. of Environment and Natural Resources, Tennenbacher Str. 4,, D-79106 Freiburg, Germany, e-mail: paul.osei.tutu@ifp.uni-freiburg.de

Challenges in Applying Social Indicator Systems - The Case of Forest Communities in Guatemala

GIANNA LAZZARINI[1], IRUNE PEÑAGARICANO[2], BERNHARD FREYER[2]

[1]*ETH Zurich, Environmental Systems Science, Switzerland*

[2]*University of Natural Resources and Life Sciences (BOKU), Division of Organic Farming, Austria*

Indicator models are applicable to many different situations and cases, yet controversial as they potentially increase gaps between the outcomes in research and reality. By reducing complexity such models often simplify the real world situation. Specifically social sustainability, based on local traditions and norms, but also determined by state, provincial gobernment, politics and laws, has to be understood in a cultural context for a comprehensive assessment. Human well-being (HWB) is especially relevant in this discussion as it substantially depends on the local perception and has major influence on the success of sustainable development. On that account, a HWB indicators set was developed in the frame of a sustainability assessment tool by the Center for International Forestry Research (CIFOR). The main objective of this study was to identify the local understanding of HWB in the Maya Biosphere Reserve (MBR) of Guatemala, where social and economic issues such as land use conflicts and poverty might affect sustainable forest management.

There have been many projects supporting the community forestry approach in order to maintain or enhance ecological sustainability but so far little attention has been paid to the social perspectives of a sustainable future. Thus we examined the actual situation regarding the CIFOR human well-being indicator set compared to local perceptions of HWB. Furthermore, we analysed, whether the applied indicator model is sensitive to the local understanding of HWB. In total 37 interviews were conducted with local stakeholders including forest workers, housewives, farmers and teachers in two communities in the MBR.

It has been found that several CIFOR indicators include important issues of the local population: conflict, fairness, access to resources and benefits from the forest. Other elements, on the contrary, are not covered to the extent to which the local population describes them. Health issues are pressing and the access to medical assistance is crucial in the perspective of the local population. Further, education is an important factor; the central issue is the financial burden related to the fact that students in remote communities have to move to urban areas for higher education. Economic problems are mainly related to the lack of long-term employment opportunities. These aspects should consequently be addressed in more detail in the HWB assessment.

From a transdisciplinary point of view we concluded that such indicator models developed together with the local population could help to approximate the HWB assessment of CIFOR to local realities.

Keywords: Human well-being, local perception, sustainability assessment, transdisciplinarity

Contact Address: Gianna Lazzarini, ETH Zurich, Environmental Systems Science, Universitaetsstrasse 22, 8092 Zurich, Switzerland, e-mail: g.lazzarini@student.ethz.ch

Comparative Analysis of Gum and Resin Value Chains and their Rural Development Potentials in the Drylands of Ethiopia and Sudan

ASMAMAW ALEMU ABTEW[1], JÜRGEN PRETZSCH[1], LAURA SECCO[2], TARIG ELSHEIKH MAHMOUD[3]

[1]*Technische Universität Dresden, Inst. of International Forestry and Forest Products: Tropical Forestry, Germany*
[2]*University of Padova, Dept. of Land, Agriculture, Environment and Forest, Italy*
[3]*University of Kordofan, Gum Arabic Research Centre, Sudan*

Natural gums and resins are among the commercially viable non-timber forest products (NTFPs) extracted in the drylands of Ethiopia and Sudan with high potential for both rural livelihood improvement and the national economies. Integrating the value chain approach and the livelihood analysis, this study examine the structure and functioning, governance, and distributional outcomes in the small-scale produced natural gum and resin value chains in both countries. Research cases were carried out in 2011 and 2012 to gather primary data from all value chain actors and other relevant stakeholders. The value chains involve three major functional segments: raw material production, processing, and marketing and distribution. The direct value chain actors involved in the different segments of the value chain include smallholder producers, village traders, producers associations, wholesalers, processing and exporting companies. In addition, several organisations such as Forest National Corporation, Sudanese Standard and Metrology Organisation, Gum Arabic Board, Cooperative Promotion Agency, Ministry of Trade and Investment provide support services and regulate the value chains. Despite similarities in the nature of the products, the organisation of the value chains in the two countries show variations in terms of length of the chain, horizontal coordination and vertical integration. The analysis revealed that the gum and resin value chains benefit the actors engaged in the production, processing and trade of the products at local, regional and national levels. The value chains generated a positive value added at the different nodes along the chains. However, the analysis of the distribution of the value added and commercialisation margin in the current value chains indicates an upward skewed benefit distribution. Processing and exporting companies were the main value contributors and the first beneficiaries of the value added. The analysed value chains are commonly characterised by limited value added at producer level, lack of cooperation and coordination between the actors, and power asymmetry. Regarding the governance structure, the value chains are buyers-driven governed by large traders and exporting companies which in turn

Contact Address: Asmamaw Alemu Abtew, Technische Universität Dresden, Inst. of International Forestry and Forest Products: Tropical Forestry, Pienner Str. 7, 01735 Tharandt, Germany, e-mail: asmamawalemu@yahoo.com

have a captive relationship with major importers. In light of the prevailing opportunities and constraints in the current value chains, different upgrading strategies are recommended and their possible outcomes and policy implications discussed. Organisation and empowerment of producer associations, credit and microfinance services, infrastructure development, market information system, and training and extension services are among the intervention areas required to upgrade small-scale producers and exploit the rural development potentials of the value chains.

Keywords: Governance, gum and resins, rural development, upgrading, value added, value chain

A New Management Tool: CPM-Systems in Science

STEFAN SIEBER[1], KATHARINA LÖHR[1], JANE WAMBURA[1], CHRISTIAN HOCHMUTH[2], FELIX WENDENBURG[2], LARS KIRCHHOFF[2], DIRK SPRENGER[3], FRIEDER GRAEF[4]

[1]*Leibniz-Centre for Agricultural Landscape Research (ZALF e.V.), Inst. of Socioeconomics, Germany*

[2]*Europa-Universität Viadrina Frankfurt, Germany*

[3]*Humboldt-Universität zu Berlin, Seminar for Rural Development (SLE), Germany*

[4]*Leibniz-Centre for Agricultural Landscape Research (ZALF e.V.), Inst. for Land Use Systems, Germany*

Conflict Prevention and Management System (CPM-System) are well known in business contexts, but are new to large international and interdisciplinary projects in the field of global change and food security. Trans-SEC is the pilot project to use a CPM-System in the context of an international research consortium with more than 100 researchers of 15 world-wide institutes to stabilise in a value chain approach the situation of 4000 households in Tanzania. A team of experts implement the CPM-System in iterative steps. CPM-Systems therefore...

A. are developed to (1) support Trans-SEC members with complex challenges and conflicts in a systematic way, (2) encourage and support cooperative working relations. To strengthen awareness for complex challenges, difficult negotiations between programme members, conflicts and conflict dynamics, (3) foster an organisational culture of open communication and willingness to tackle complex challenges in a constructive manner.

B. aim at situations and individuals for complex internal challenges and conflicts (1) in the work workplace (personal and interpersonal) and (2) between and within institutes or teams. It is designed for individuals and (sub-)groups for all Trans-SEC team members.

C. can be used in situations of experiences with (1) complex personal or interpersonal challenges related to Trans-SEC, (2) difficulties regarding cooperation within Trans-SEC, (3) conflicts and misunderstandings.

D. offer continuously available services and guidance in the form of (1) individual and group coaching, (2) workshops and trainings such as teambuilding, cultural awareness, conflict analysis, (3) conflict moderation of science processes, (4) supervision and (5) mediation as well as (6) practical material for orientation (e.g. code of conduct).

E. prevent and solve internal Trans-SEC conflicts as (1) local conflict contact points (in development process) that provide an orientation about which measure to take in a conflict situation and (2) external and independent team of skilled and experienced conflict mediators.

Keywords: Conflict management, conflict prevention, land use / global change, project management

Contact Address: Stefan Sieber, Leibniz-Centre for Agricultural Landscape Research (ZALF e.V.), Inst. of Socioeconomics, Eberswalder Str. 84, 15374 Müncheberg, Germany, e-mail: sieber@zalf.de

Towards Integrated Assessment of Gender Relations in Farming Systems Analysis

KAROLINE HEMMINGER

Wageningen University, Farming Systems Ecology Group, The Netherlands

Gender sensitivity in agricultural research and development is considered to be crucial for effectively contributing to gender equity, but also for improving the effectiveness of agricultural interventions in terms of poverty alleviation and improvement of household nutrition. Yet farming systems research often neglects the analysis of gender relations even when working in the context of smallholder households. More than 30 years of research have repeatedly revealed that women hold an important role in smallholder agricultural production. In many cases, women contribute the majority of agricultural labour and are responsible for certain domains of production on which they have special local knowledge. Their responsibility for household nutrition has often been emphasized. Yet, because farming systems analysis and the modelling tools used for it often focus only on biophysical and economic data, women's special needs, preferences and constraints are not considered when innovations for the design or improvement of farming systems are developed. Therefore it is the aim of this study to show options for integrating the analysis of gender relations in farming systems research.

The study focuses on the conceptualisation, i.e. the identification of relevant gender issues and their causal relations based on literature review, expert interviews and qualitative interviews with female farmers that were performed during a two week case study in the Eastern Province of Zambia, location to the SIMLEZA project of the Africa RISING program ("Sustainable Intensification of Maize-Legume Systems for the Eastern Province of Zambia" and "Africa Research in Sustainable Intensification for the Next Generation" by CIMMYT and IITA).

The findings are presented in a conceptual framework that illustrates the complex mutual effects of agricultural intensification and gender relations. Based on this, possible extensions or changes to model based farming systems analysis were identified, such as the inclusion of sex-disaggregated labor profiles or the analysis of separate economic units within one household to capture independent female income. Furthermore it can be concluded that understanding and commitment of researchers to gender matters is a necessary precondition to reach gender sensitivity in agricultural research. The presented conceptual framework aims at facilitating this.

Keywords: Farming systems analysis, gender, conceptual framework

Contact Address: Karoline Hemminger, Wageningen University, Farming Systems Ecology Group, P.o.Box 563 AN, Wageningen, The Netherlands, e-mail: karoline.hemminger@web.de

A Model for Understanding the Economic Rationality of Agricultural Modernisation of the Mesoamerican Milpa System

HEIKE VIBRANS

Postgraduate College of Agricultural Sciences, Dept. of Botany, Mexico

Traditional (family, peasant) agriculture is often considered unproductive because of low yields of the main crop. However, many farmers, even in relatively well-communicated areas, do not adopt modern, high-input methods, despite available credits and much promotion. One explanation for non-adoption of modern methods is risk, which is ameliorated by diversity, at an efficiency cost – most traditional farming systems are mixed, either within the field or within the farm. Other explanations are cultural conservatism or lack of schooling. A different reason was suggested by several local studies on the total input and output of maize fields with other cultivated and non-crop species (milpas) in central Mexico; they included labor and energy costs, as well as interviews on decision processes. They showed that maize grain only contributed about 15–30 % of the value of the whole harvest under rain-fed conditions with low-input methods; cultivation for only this product was often not profitable. In contrast, if all inputs and outputs ("secondary" products) were considered, the system was highly profitable, as long as labour/opportunity costs were low. Based on these data, a model is presented that explains and predicts farmer's decisions on modernisation. It is based on a novel classification of agricultural crops (selfconsumption, crops that add value within the farm, locally valuable crop/speciality, regional cash crop, international cash crop) and the cost of inputs, particularly of labour opportunity costs, market access and energy (transport, agrochemicals). Modernisation occurs when opportunity costs rise and/or external energy costs sink. In order for intensive, high-external-input cropping to be an economically rational alternative, farmers would need to value their time at about the level of the salary of a recent university graduate in Mexico, in our milpa example. The model can be applied to other systems, and different scales. This contribution shows that a discussion based only on the yield and economics of the main crop is not adequate for traditional systems.

Keywords: Agricultural modernisation, economic evaluation, intercropping, Mexico, traditional agriculture

Contact Address: Heike Vibrans, Postgraduate College of Agricultural Sciences, Dept. of Botany, Carretera Mexico-Texcoco km 36.5, 56230 Montecillo, Texcoco, Mexico, e-mail: heike@colpos.mx

Identifying Potential Methods of Up-Scaling Index Based Livestock Indurance: Lessons in Extension and Outreach

PHILEMON CHELANGA, RUPSHA BANERJEE
International Livestock Research Institute (ILRI), Livelihoods Gender and Impact, Kenya

About 80 percent of Kenya are arid or semi-arid lands (ASAL) with the main livelihood being pastoral, agro-pastoral and subsistence agriculture. The populations in these areas, among the poorest in the country, suffer from a weak natural resource base in addition to weak institutions and infrastructure. In such cases droughts act as a covariate shock that erodes livestock assets making most households fall into a poverty trap. Such situations leave the poor pastoralists with few available strategies to manage and cope with livestock mortality risk. To protect livestock keepers in the ASALs from drought-related asset losses, the International Livestock Research Institute (ILRI), in collaboration with a suite of partners, developed and implemented a market-mediated index-based insurance product. The Index Based Livestock Insurance (IBLI) is calculated by using a measure of pasture availability that is recorded by satellites, called the Normalized Differenced Vegetation Index (NDVI). This index is then used to predict the livestock mortality rate in specified divisions. From its first pilot in Marsabit district in 2010, the adoption of IBLI has taken place in Isiolo and Wajir in Northern Kenya and the Borana zone in Southern Ethiopia in collaboration spearheaded by public and private partners. A market study was conducted in Wajir, Mandera and Garissa in Northern Kenya with the aim of mapping how information flows in these regions; understanding where and when pastoralists aggregate themselves; and identifying the most efficient mechanisms for spreading information about IBLI in a cost effective and efficient manner. The agent model is used in delivering the product to the pastoralist. Even though the IBLI product is commercially viable, a review of the uptake process shows that delivering it in such a complex socio-economic and institutional set-up is challenging. The implementation process was faced with constraints related to effective information dissemination and efficient service delivery mechanisms. Therefore, understanding market functioning and identifying the asymmetry between the service providers and the pastoralists is a necessary step in ensuring sustainability in service delivery to such marginalised groups.

Keywords: Extension, index based livestock insurance, Kenya, service delivery

Contact Address: Rupsha Banerjee, International Livestock Research Institute (ILRI), Livelihoods Gender and Impact, Nairobi, Kenya, e-mail: brupsha@cgiar.org

Inclusive Business Models in Peru for Sustainable Use of Agricultural Biodiversity and Income Generation

MATTHIAS JÄGER[1], KAREN AMAYA[2]

[1]*International Center for Tropical Agriculture (CIAT), Colombia*

[2]*Bioversity International, Colombia*

Agricultural biodiversity has been on a steady decline for the last century despite the potential of being a source of income especially in areas where conventional markets and value chains are underdeveloped. Peru is home to the highest diversity of cultivated chili peppers (*Capsicum*) in the world, but most of these native chilies are grown on small farms and have never been commercially used.

A BMZ funded project, coordinated by Bioversity International and implemented by public and private sector partners in Peru aimed to fill the knowledge gap by characterising useful and commercially interesting traits of chilies, mapping the value chain, identifying bottlenecks in all value chain links and developing relevant strategies to overcome these and to develop and take products to markets to meet emerging demand trends for new and unique flavours that provide new opportunities for smallholder farmers to generate higher income.

This paper shows the case of an inclusive and socially responsible business model successfully applied by project partner Agro Export Topará, an organic processing, exporting and fair trade certified Peruvian company, sourcing their unique raw material from smallholder farmer associations, also project partners. Twenty years ago, the company was stumped when clients asked about the distinctive attributes of the chili varieties they offered. This research is now providing the answers enabling the company to promote Peruvian native chilies in international markets.

Holistic approaches implemented by the project helped forge mutually beneficial institutional and commercial alliances between small farmer organisations, processing companies, retailers, service and input providers, research organisations, local governments and develpoment organisations. As a result, new and traditional products using native chili diversity have been developed and are now sold in rural and urban markets. The *Capsicum* project is a pioneer effort in trying to link the different actors of the value chain of a native Andean species with great genetic variability and great potential for the development of agribusinesses, applicable to other country contexts. Partnerships and inclusive business models are key to tackle failures in markets in order to raise incomes, enhance livelihood resiliency, and prepare farmers to face future climate change challenges.

Keywords: Corporate social responsibility, high-value differentiation, inclusive business models, neglected genetic resources, value chain development

Contact Address: Matthias Jäger, International Center for Tropical Agriculture (CIAT), Cali, Colombia, e-mail: m.jager@cgiar.org

Considering Imperfect Information in Supporting Development Decisions

EIKE LUEDELING, TODD ROSENSTOCK, JAN DE LEEUW, KEITH SHEPHERD
World Agroforestry Centre (ICRAF), Kenya

Agricultural development is constrained by limitations of data availability and quality. While research for development aims to close these knowledge gaps, most such research is never used in decision-making. On the other hand, most development decisions are not supported by robust science. Major reasons for this situation are that research is rarely sufficiently comprehensive and studies almost always omit important factors, because they are hard to measure, lack data or lie outside the researchers' area of expertise.

New approaches are needed that provide decision-makers with timely and accurate information that supports specific decisions. Business analysis methods have been developed to support decisions under imperfect information. Applied Information Economics is such an approach, in which analysts develop business-case models for decisions together with decision-makers to ensure that all benefits, costs and risks that need to be considered are included in the analysis. Such models initially do not include much mechanistic detail, but they strive to be comprehensive, in that all relevant factors are incorporated, regardless of ease of measurement. The team then proceeds to define their current state of uncertainty on all variables, as expressed by probability distributions, and to run Monte Carlo simulations to anticipate the range of plausible decision outcomes. From this analysis, variables of high information value are identified as priorities for measurement, measurements are taken where needed and the decision is optimised.

Applying the principles of Applied Information Economics, we investigated a number of decision cases in development, including irrigation projects in Africa, dam construction in the Mekong, yield improvement prospects of Conservation Agriculture in East Africa, urban water supply in Wajir, Kenya's and improved seed supply systems in West Africa.

In almost all decisions, high-value variables were different from what scientists routinely measure. Furthermore, in most cases, relatively small research efforts were necessary to reduce uncertainty about decision outcomes sufficiently for making recommendations about the decision that had a very small chance of being wrong. The wider application of this approach has potential for greatly enhancing the efficacy of development investments and to identify key priorities in research for development.

Keywords: Business analysis, decisions, expert knowledge, Monte Carlo simulation, uncertainty

Contact Address: Eike Luedeling, World Agroforestry Centre (ICRAF), Land Health Decisions, United Nations Avenue, 00100 Nairobi, Kenya, e-mail: e.luedeling@cgiar.org

Application of Scenario Planning in the Context of Rural Transformation: The Case of North West Ethiopia

KUMELA GUDETA, MICHAEL BRAITO, MARIANNE PENKER, MARIA WURZINGER, MICHAEL HAUSER

University of Natural Resources and Life Sciences (BOKU), Austria

In research for development, methods of knowledge co-production promise new modes of collaboration between science and local actors, better and more context-specific results with a higher societal impact. This paper looks into the merits of participatory scenario planning methodology in developing countries based on the experience with the method in three watersheds, Mezega, Godinge and Wujraba, in North Gondar, Ethiopia. The primary purpose of scenario planning was fostering collaboration between research organisations and the integration of knowledge and assessments from different academic disciplines on the one hand and local, implicit knowledge of stakeholders on the other hand. This was starting from identification of locally relevant thematic research problems up to integration of thematic scenarios for future intervention strategies. The project implementing research organisations involved the University of Natural Resources and Life Sciences, Gondar University, BahirDar University, and Amhara Region Agricultural Research Institute. After delineating geographical boundaries and a timeframe of ten years with the project partners, six thematic areas were selected, namely Institutions, Demography, Soil and Water, Livestock, Crop and Nonfarm Livelihoods. We started with a conceptual clarification of inter- and transdisciplinarity and adopted the methodology to the needs of the partners and the context. Scenario planning was witnessed as a helpful boundary task bridging the gaps between different research organisations, disciplines as well as between researchers and local actors. It supported the integration of knowledge from different scales and diverse disciplines with active participation of farmers and experts to better understand the social change process. Driving forces for the six thematic areas, which were identified by non-academic actors in the study areas, were integrated with those from the literature review. Although it was realised that real world problems can not only be solved by a single discipline or experts from academia alone due to their complexity and uncertainties, we have little insights so far on the actual social learning process or local empowerment for transformation processes on the local level. Finally application of the method clearly shows the method's potential for narrowing the gap between academia and practice by increasing the responsiveness of the organisations for transformation.

Keywords: Interdisciplinary, participatory scenario planning, rural transformation

Contact Address: Kumela Gudeta, University of Natural Resources and Life Sciences, Centre for Development Research, Gregor-Mendel-Straße 33 1180, Vienna, Austria, e-mail: kumela.nedessa@boku.ac.at

Capacity Building of Women Farmers through Sustainable Agricultural Practices for Rural Prosperity

PAWAN KUMAR[1], JÓSKA GERENDÁS[2], SURENDER ROPERIA[3]

[1]*S M Sehgal Foundation, Agricultural Development, India*

[2]*K+S Kali GmbH, Agricultural Advisory, Germany*

[3]*K+S Fertilizers (India) Pvt. Ltd., India*

Women farmers in India are the backbone of the rural economy. They are responsible for 60–80 % of the food production, and yet they receive only a fraction of inputs (such as improved seeds and fertilisers), land, credit, agricultural training and information, compared to men.

In May 2013, S M Sehgal Foundation and K+S Kali GmbH started a joint project – Unnat Krishi, meaning improved agriculture. The project leverages the existing self-help groups (SHGs) to disseminate improved, well-established agricultural technology. Unnat Krishi aims to strengthen the capacities of smallholding women farmers by educating them about soil testing, standard fertiliser applications and improved package of practices (seeds, nutrients and pest management). Basically, the project's objective is to make available improved technology, which is otherwise not accessible to female farmers in the region.

The programme further facilitates micro-lending through SHGs to help women procure agriculture inputs and other resources. To increase the financial capacity of SHGs, participating members have to return 70 % of the funds used for agricultural inputs to their respective SHG. To ensure ownership and participation of the local population, a female farmer from each village is nominated as a leader. She acts as local agricultural resource person and facilitator between the project coordinators and fellow farmers.

A baseline survey of 150 households was done at the beginning of the project. It was found that the family size of 54 % of the households surveyed was 7 and average landholding was between 0.5 and 0.1 acres. Around 41 % of the respondents were illiterate. The farm mechanisation was low, amounting to 21 % of the farmers having tractors and only 4 % having threshers.

In the current fiscal year 185 female farmers have benefited directly from the project over two cropping seasons. The yield assessment was done in April 2014. In demo plots, the registered yield increase in mustard and pearl millet ranged from 30-40 %. This translated into higher gross incomes by 2,574 Indian rupees in millet and 5,627 Indian rupees in mustard. Indirectly, over 1000 female farmers benefitted from information on scientific agricultural practices through trainings, field days and exposure visits. The higher crop income in the previous seasons has instilled confidence among the farmers about Unnat Krishi project techniques and resulted into better adoption rates of the techniques.

Keywords: India, rural prosperity, self help groups, smallholder women farmers, women farmers friend

Contact Address: Surender Roperia, K+S Fertilizers (India) Pvt. Ltd., German Centre 14th Floor Building 9b Dlf Cybercity Phase-III, 122002 Gurgaon, India, e-mail: surender.roperia@kali-gmbh.com

Impact of Access to Agricultural Extension Services on Tea Households' Income in the Northern Region of Vietnam

LUAN DO XUAN, HUONG KIEU THI THU, SIEGFRIED BAUER

Justus-Liebig University Giessen, Inst. of Farm and Agribusiness Management - Project and Regional Planning, Germany

The Northern Upland of Vietnam is one of the poorest regions of Vietnam where local people are highly dependent on agriculture to earn income. In the region, tea plants play an important role in generating employment and improving income for farmers. Agriculture extension services for tea production such as pest and disease control, fertiliser application, new varieties application are available to support tea farming activities and help farmers to overcome poverty. However, the impact of these extension services on improving tea productivity and farmer's income still remains questionable.

In this context, this study tested the hypothesis that accessing to agricultural extension services can improve tea household's income. Tea households which received agricultural extension services are assumed to obtain higher tea productivity and therefore better income compared to others. Data were obtained from a household survey of 120 accessed households and 180 non-accessed households in three provinces namely Thai Nguyen, Phu Tho and Tuyen Quang in the Northern Upland Region of Vietnam. To control for the problem of selection bias, we used the approach of Propensity Score Matching. This is a robust estimator because it is less sensitive to minor changes in specification of regressions and is adequate for removing the bias associated with the differences in covariates. The results showed that tea households with membership of local mass organisations (Women, Farmer and Youth Union), more experience in tea production, and cultivating a larger area of tea are more likely to receive agricultural extension services. Results also revealed that extension services have positive impact on tea farmers' income. Accessed households earn an average monthly income of 30.43 percentage points higher than that of non-accessed housholds.

Keywords: Agricultural extension, impact, northern Vietnam, propensity score matching, tea farms

Contact Address: Luan Do Xuan, Justus-Liebig University Giessen, Inst. of Farm and Agribusiness Management - Project and Regional Planning, Jl University Giessen, 35392 Giessen, Germany, e-mail: doxuanluan@gmail.com

Effectiveness of Radio and TV Agricultural Information Programs in Sudan

MOHAMED ZAKARIA YAHIA[1], DIETRICH DARR[2], ALI MOHAYAD BANNAGA[1]
[1] *University of Khartoum, Dept. of Agric. Extension and Rural Development, Sudan*
[2] *Rhine-Waal University of Applied Sciences, Fac. of Life Sciences, Germany*

Agricultural extension services in Sudan are not effective in delivering agricultural innovations to farmers, not least due to a small number of extension staff who are equipped with poor means of transportation. The purpose of this study is to assess whether radio and TV agricultural programs can compensate for the apparent shortcomings of direct extension methods.
A total of 840 farmers have been interviewed in six states of central Sudan. A purposive sampling approach and semi-structured questionnaire were used to collect primary data, which have been complemented with 40 in-depth household interviews to obtain qualitative information and triangulate the quantitative data. SPSS was used for statistical analyses.
The results revealed that 35 % of respondents followed the agricultural radio programs at least sometimes, and 27 % watched the agricultural programs on TV sometimes or more often. In comparison, 22 % of respondents are exclusively covered by direct extension methods, and 24 % of farmers had no access to any extension programs. ANOVA analysis revealed that the speed of adoption of 6 agricultural technologies by farmers is significantly increased with better access of farmers to sources of agricultural information. T-test analysis revealed that TV extension is significantly more effective than radio extension programs in changing farmers' attitudes and adoption of the investigated agricultural technologies, while both TV and radio are similar in changing the farmers' knowledge.
The study showed that radio and TV agricultural programs play an important role in compensating for the apparent shortcomings of direct extension methods. Recommendations refer to further improvement of the agricultural extension programs to achieve the aim of Sudan as one of three countries in the world which are expected to contribute effectively to global food security.

Keywords: Adoption of farm technologies, public extension, rural advisory services

Contact Address: Dietrich Darr, Rhine-Waal University of Applied Sciences, Fac. of Life Sciences, Marie-Curie-Str. 1, 47533 Kleve, Germany, e-mail: dietrich.darr@hochschule-rhein-waal.de

Traditional Agricultural Knowledge vs. Modernity. Changing Cultivation Practices and Generational Conflict in Northern Togo

BERNHARD MARTIN

Martin-Luther-University Halle-Wittenberg, Geosciences and Geography, Germany

For a long time African agricultural practices were considered by European agronomists as irrational and ecologically unfavourable. From the 1970s, a revaluation took place and African cultivation methods were recognised as agricultural knowledge. At this time the "traditional" agricultural practices, however, were increasingly replaced by new cultivation techniques as the ox plow introduced by development projects. The evaluation of these changes by agronomists oscilliated between the praise for a successful agricultural modernisation, the concern about the ecological impacts of the innovations and the incomprehension of the decline of "traditional" knowledge.

In northern Togo this agricultural change accelerated during the 1990s under the influence of the expansion of cotton cropping: Ox plows were widely disseminated, the use of chemical fertiliser rose sharply, hybrid maize replaced partially traditional millet and sorghum varieties and the wooded park land has been thinned.

This paper argues that these changes must be regarded in the context of a generational conflict and the quest of modernity of the young men: By a successful revolt against the authority of the elders many young men obtained economic independence and were now able to make their own agricultural decisions. Therefore, they aimed to distinguish themselve from the elders by the expansion of cotton and maize cropping and new cultivation practices which they regarded as modern such as the ox plow and the use of chemical fertilisers. The young men neglected the questions of the ecological impacts of the new cultivation and sustainability in favour of short term high incomes and social prestige replaced. "Traditional" local knowledge fitted no longer with their aspirations. The elders regarded the new cultivation practices as harmful but were unable to convince the young men to readjust their agricultural methods.

Keywords: Agricultural change, generational conflict, quest of modernity, Togo, traditional knowledge

Contact Address: Bernhard Martin, Martin-Luther-University Halle-Wittenberg, Geosciences and Geography, Von-Seckendorff-Platz 4, D-06099 Halle/saale, Germany, e-mail: b.martin_2011@yahoo.de

How Does the Relation of Development Agents and Farmers Influence the Adoption of Land Improvement Techniques?

LENKA PESKOVA, JANA MAZANCOVA

Czech University of Life Sciences Prague, Faculty of Tropical AgriSciences, Czech Republic

Ethiopia is a country with one of the strongest systems of agricultural extension services. Family, other farmers and development agents (DAs) all act as advisors. The trained DAs which disseminate the information about modern and improved attitudes to agriculture are the backbone of the system of agricultural extension services. In Ethiopia, there are on average 476 farmers under the supervision of one DA. Each DA is specialised in one of the three disciplines: crop production, animal production or natural resources management. This paper analyses the relation between farmers and DAs in Kembata Tembaro zone, located in SNNP region. The farmers were divided into two groups based on their adoption of land improvement techniques: more techniques adopters and less techniques adopters. Within the period spanning September – November 2012, a total of 173 questionnaires were collected. The data were evaluated by SPSS (20) using Chi-square test; adjusted residuals were computed to express the relation between variables. The results indicate that the relation between farmers and DAs is strongly influenced by their personal relation. For farmers with higher adoption rate, the DAs are the prefered advisors (Φ = 0.396, $\Phi = 0.001$), they share more information with DAs ($\Phi = 0.266$, $\Phi = 0.001$), they are more interested in the DAs specialisation, they are more frequently visited by DAs ($\Phi = 0.282$, $\alpha = 0.001$), they have less preferences regarding the DAs gender ($\Phi = 0.357$, $\Phi = 0.001$) and if they receive wrong advice, they less likely complain (Φ = 0.395, Φ = 0.01). On the other hand, farmers with lower adoption rate receiving not enough quality services from DAs do not cooperate any more with them and complain ($\Phi = 0.395$, $\alpha = 0.001$). Even though the farmers are interested in DAs qualification, they are not comfortable to complain – this leads to decreasing the quality of information dissemination. This paper can provoke other studies that focus on behaviour and relations between farmers and their advisors to improve the quality of agricultural extension services.

Keywords: Development agents, Ethiopia, extension services

Contact Address: Lenka Peskova, Czech University of Life Sciences Prague, Faculty of Tropical AgriSciences, Kamýcká 129, 16521 Prague 6, Czech Republic, e-mail: lenka.pesek@gmail.com

Rubber Intercropping Adoption of Smallholders in Xishuangbanna, China

SHI MIN[1], HERMANN WAIBEL[1], JIKUN HUANG[2]

[1]*Leibniz Universität Hannover, Inst. of Development and Agricultural Economics, Germany*

[2]*Center for Chinese Agricultural Policy, Chinese Academy of Sciences, China*

Driven by the relative high profits of rubber farming, smallholders in Xishuangbanna have experienced widespread and dramatic land use changes mainly through the conversion of the traditional crops e.g. maize, rice and rainforest areas to rubber plantations in past 30 years. The adoption of rubber cultivation has not only resulted in profound changes in the landscape but also triggered higher climatic and economic risks. Since the period before rubber can be harvested is around seven years, intercropping can be an effective strategy to generate additional income and contribute to household food security. Intercropping can also contribute to more efficient use of resources like labour, land and other natural resources. In addition, compared to monoculture, intercropping farming in mountain area normally has positive effects for soil conservation and agro-biodiversity.

In this study we examine the use of rubber intercropping by rubber farmers in Xishuangbanna. We develop an intercropping adoption model and assess the determinants of rubber smallholders' land management system. These include socio-economic factors as well as location and natural resources factors. The analysis is based on a cross section data set of 612 rubber farmers from 42 villages in Xishuangbanna prefecture. The study allows identifying the preferences of smallholders for land use management and rubber intercropping. Such information can help extension workers and local policy makers to design strategies for improving rubber farmer' income and food security and promote sustainable rural development in Xishuangbanna. The findings of this study have also implications for other rubber producing area in South East Asia.

Keywords: China, intercropping, rubber, Xishuangbanna

Contact Address: Shi Min, Leibniz Universität Hannover, Institute of Development and Agricultural Economics, Königsworther Platz 1, Hannover, Germany, e-mail: min@ifgb.uni-hannover.de

From Technology Adoption to Understanding Innovation: Lessons from Plantain Innovation Systems in Four Countries

HILDEGARD GARMING[1], JOSEFINA MARIN[2], SONJA PÜRCKHAUER[3], ALIRAH EMMANUEL WEYORI[4], CHARLES STAVER[5], GERMAN RIVERA[2], FALGUNI GUHARAY[6]

[1]*Thünen Institute of Farm Economics, Germany*
[2]*CATIE, Costa Rica*
[3]*University of Bonn, Germany*
[4]*Leibniz Universität Hannover, Germany*
[5]*Bioversity International, France*
[6]*CIAT, International Centre for Tropical Agriculture, Nicaragua*

In Latin America and West Africa plantains are an important staple food and cash crop for smallholder households, although growing market demand has also attracted medium and large-scalegrowers to the crop. In recent decades improved production technologies and new varieties have become available and were tested in major producing countries. Uptake of these technologies has been uneven between countries and across different segments of growers within countries. In a GIZ-funded project, aiming to understand and improve technological innovation for small-scale plantain production, we analysed production technology and the innovation systems for the plantain sector in Nicaragua, Panama, Dominican Republic and Ghana. Rather than focusing on individual farmers' adoption decision, an innovation system approach was applied to identify factors stimulating or blocking innovation among farmers. Farmers and different actors related to plantain such as extension, research, associations, finance, other supporting organisations, traders, processors and input dealers were interviewed. In each country a workshop was held applying RAAKS methodology (Rapid Appraisal of Agricultural Knowledge Systems), to map relationships and flows of information between the actors and to identify constraints and options for improving innovation capacity. The four countries represent unique combinations of formal research organisations, agriculture and trade policies, market chain governance and plantain information flows impacting on smallholder innovation and wellbeing. While Ghana has a consolidated plantain research programme at CRI, technology change is characterised by seasonal gluts and minimal input and market infrastructure. With plantains being a priority crop in Dominican Republic, public research has played a strong role in supporting technological innovation and dissemination of new varieties. Strong market demand has stimulated innovation in large and small-scale farmers, too. In Panama, public research and extension programs include plantains, however small-scale farmers' capacity to innovate is constrained by a perceived lack of public support. In Nicaragua, coordination of the plantain sector is provided mainly by a producer organisation. Although public support is nearly absent, farmers respond to market dynamics and have reached an intermediate level of innovation.
The studies identified major bottlenecks for innovation and propose entry points for policies to improve plantain productivity and income for small-scale producers.

Keywords: Dominican Republic, Ghana, innovation system analysis, Nicaragua, Panama

Contact Address: Hildegard Garming, Thünen Institute of Farm Economics, Braunschweig, Germany, e-mail: hildegard.garming@ti.bund.de

Adoption of Land Management Practices in Ethiopia: Which Network Types Matter Most?

TEFERI MEQUANINTE, REGINA BIRNER, ULRIKE MUELLER

University of Hohenheim, Institute of Agricultural Economics and Social Sciences in the Tropics and Subtropics, Germany

In recent years researchers have began discussing the impact of social networks on the adoption of sustainable land management practices. However, key research questions such as which types of social networks matter most and how do specific network types matter for adoption is not addressed fully. Using Farmers Innovation Fund data of the World Bank, we fill this research gap by exploring the impacts of three types of social networks (relatives, friendship and neighbourhood) on the adoption of soil conservation and tree planting. Our findings showed that relative networks have a positive impact on planting trees but its impact on soil conservation is negative. This indicates the presence of "egoistic behaviour" even in stronger ties such as relatives. Our conclusion is that farmers tend to plant trees as a means of securing land holdings. However, such "private benefit" incentive may disappear when it comes to soil conservation, which is more of a "social benefit".

Keywords: Natural resource management, neighbours, networks, relatives, soil conservation, tree planting

Contact Address: Teferi Mequanninte, University of Hohenheim, Institute of Agricultural Economics and Social Sciences in the Tropics and Subtropics, Wollgrasweg 43, 70599 Stuttgart, Germany, e-mail: Teferi.Tensay@uni-hohenheim.de

Describing Adoption of Integrated Soil Fertility Management Practices in Northern Ghana

ALEXANDER NIMO WIREDU[1,2], EDWARD MARTEY[2], MATHIAS FOSU[2]

[1] *University of Hohenheim, Inst. of Agricultural Economics in the Tropics and Subtropics, Germany*

[2] *CSIR-Savanna Agricultural Research Institute, Socioeconomics, Ghana*

As population grows the needs to increase agricultural production becomes more challenging given the finite availability of land. Integrated soil fertility management (ISFM) practices have been promoted to ensure sustainable use of soil resource. The package includes use of improved crop varieties, inorganic, and organic fertilisers. This study examined the factors that affect adoption of ISFM technological package with data from a cross section of 225 randomly selected farm households in northern Ghana. Among the components in the ISFM technological package, the use of inorganic fertilisers was most adopted by about 96 % of the sampled households. Organic fertilisers were adopted by about 60 % of the sampled households, while improved crop varieties were adopted by about 89 % of the households. In all, about 69 % of the sampled households had adopted the ISFM technology package. By implication, the promotion of the ISFM technology should emphasise the use of organic matter which appears to be lagging behind the other components. The results from a Cragg's two step model suggest that education and extension remains crucial in the promotion of ISFM. Provision of credit in the form of fertilisers, seeds of improved varieties, and payment for labour will avoid diversion of cash credit. In addition to these, the study showed that the technology was more suited for farmers with high land-labour ratio, more assets, and those engaged in agriculture as their only source of livelihood. These groups of households should be systematically targeted during the dissemination of ISFM in northern Ghana.

Keywords: Adoption, Cragg, Ghana, ISFM

Contact Address: Alexander Nimo Wiredu, University of Hohenheim, Inst. of Agricultural Economics in the Tropics and Subtropics, Stuttgart, Germany, e-mail: anwiredu@yahoo.com

Small Organic Fertiliser Factory Promotion in Rural Communities of Northeast Thailand

PHASSAKON NUNTAPANICH
Ubonratchathani Rajabhat University, Fac. of Agriculture, Thailand

The main occupation of people in the rural area of northeast Thailand is agriculture. Major cost of farming about 70 percent is the chemical fertiliser and pesticide. Reduction of chemical fertiliser use can decrease cost of agricultural production. Therefore, the promotion to farmers self-reliance in the preparation of fertiliser for use in the community is probably one of the ways to reduce costs of agricultural production in rural area. This research used Participatory Action Research (PAR) method for promoting farmer to establishment of the small factory for production of high quality organic fertiliser for services in the community and nearby to reduce the cost and expense of farmers and also help to promote and maintain the quality of the environment.

The project was operated pilot study and implemented with the farmer groups in village of Amnat Charoen province of northeast Thailand. The research found that farmers can produce fertiliser for use in the community, not less than 70 tons per year. Important knowledge desire for improve group operation as three main topics such as; 1) group management, 2) ability in business, and 3) high quality organic fertiliser production technologies. The vision of group for organic fertiliser production in next step they will setting target the production of not less than 140 tons per year for distribute sufficiency supply to household in community and nearby. The impact of the project in the past found that the distribution of organic fertilisers in the community more than the former. Resulting in the production cost of farmers are decreased. While the yield was not significantly different from the use of chemical fertiliser resulted in farmers participating are higher income than the last time. The constrain on project implementation including, lack of knowledge and raw material for organic fertiliser production. For suggestion should be the environmental impact study, which use the long-term monitoring in the next time.

Keywords: Small organic fertiliser factory, sustainable agriculture development, technology transfer and adoption

Contact Address: Phassakon Nuntapanich, Ubonratchathani Rajabhat University, Fac. of Agriculture, Ratchathani Road, 34000 Muang District, Thailand, e-mail: phassakon_n@hotmail.com

Assessing Community-Based Enterprise: A Case Survey

SOVIANA

Justus-Liebig University Giessen, Institute of Farm and Agribusiness Management, Germany

Community-based enterprise (CBE) has been increasingly acknowledged as a potential instrument for solving environmental and poverty problems. Despite the increasing implementation, however, a clear understanding about the organisation of CBE is still lacking. Focusing on a certain sector/country, some authors have given some efforts to develop the CBE concept. Nevertheless, the author argues that to create a generally applicable concept, an analyses beyond one particular sector or region ist essential. For that purpose, this paper aims to bridge the knowledge-gap in the CBE concept by founding the analyses on organizational insights and the generalizability-gap by employing a case survey. The objectives of this paper are: (1) to identify the organisational architecture and performance of the existing CBEs, and (2) to compare and analyse the current theoretical CBE concept with the practical experiences. The implication of this paper will be especially important for the advancement of conceptual knowledge of the CBE concept, which can further lead to a better implementation of CBE-scheme in practice.

The case survey comprises 34 cases from 12 different countries, covering several sectors such as tourism, agriculture, and handicraft. The desriptive staticstics show that the CBEs are typically established under socio-economic as well as political pressure. In half of the cases the community originally does not have the necessary means to establish a CBE, and in almost all casts there is at least one active NGO, which supports the community. The community participation is dominant in operation-phase and providing material/infrastructure. Meanwhile, the main financial provider are the NGOs. In all other activities, community members are generally involved, but not free from the influence of outsiders (government, NGO and private actors). Various legal forms are used. Almost all CBEs apply a membership system. The CBEs indeed bring economic, social, and environmental improvements to various degrees. Furthermore, using ordered-logistic-regression analysis (STATA 12) and partial-least-squares regression (SmartPLS 2.0), the relationships between contextual constraints, stakeholder's participation, and performance are analysed. Community and NGO's participation-level is influential in leading to good performance. Community representation positively (and significantly) influences the performance. Meanwhile, contextual constraints are not significantly influencing the community participation level.

Keywords: Case survey, community-based enterprise, organisation performance, organisational architecture

Contact Address: Soviana, Justus-Liebig University Giessen, Institute of Farm and Agribusiness Management, Senckenbergstrasse 3, 35390 Giessen, Germany, e-mail: s.soviana@yahoo.com

Adaptive Management of Inter- and Transdisciplinary R&D Projects: Case Study in Southwest China

THOMAS AENIS[1], GERHARD LANGENBERGER[2], JUE WANG[1], GEORG CADISCH[2]

[1] *Humboldt-Universität zu Berlin, Agricultural Extension and Communication Group, Germany*

[2] *University of Hohenheim, Inst. of Plant Production and Agroecology in the Tropics and Subtropics, Germany*

Large R&D projects such as the Sino-German project "SURUMER: Sustainable rubber cultivation in the Mekong region" nowadays should be more and more oriented towards implementation of its results. Funding programmes such as the "Sustainable Land Management" of the German ministry of education and research (BMBF) are usually demanding a high level of interdisciplinary integration, and transdisciplinary communication and cooperation of researchers and stakeholders from praxis and policy/administration in order to jointly solve societal problems.

What seems a simple statement is in praxis coupled with fundamental challenges: paradigmatic changes are required of researchers, who usually are confronted with a need to leave the academic "ivory tower" and conduct activities towards application of results which include the communication with practitioners. Practitioners in turn are confronted with scientists who do not tell their results but want to establish "dialogues" and "discourses". Such "strange" behaviour might cause discomfort particularly in societies which still are hierarchically structured as for example in rural China.

For project management this causes stress. It is impossible to plan a project in a linear way, from design via experiment/survey and analysis to publication. Adaptive Management is demanded which aims in general at an open problem solving process. On the basis of process monitoring and regular evaluations, strategies, structures and activities will be adjusted often in several "loops", thus enabling co-learning processes within the group of scientists and between researchers and practitioners.

In this presentation, the authors discuss the problem situation and possible solutions with respect to the experiences made in SURUMER:

• Interdisciplinary and transdisciplinary integration has been focussed on both, a concept of participatory scenario development and the LUCIA model as a focal methodology;

• The strategy to involve stakeholders has been adjusted by focussing on three main target groups, and methodologically on scenario discussions; concrete activities for stakeholder communication are planned within the discourses;

• Project organisation has been improved, too: a strategy and monitoring team and an external board of advisors have been established, internal and external communication procedures have been institutionalised such as interdisciplinary work groups, regular plenary meetings, a newsletter etc.

Keywords: Adaptive management, interdisciplinarity, stakeholder involvement, sustainable rubber cultivation, transdisciplinarity

Contact Address: Thomas Aenis, Humboldt-Universität zu Berlin, Agricultural Extension and Communication Group, Luisenstr. 53, 10099 Berlin, Germany, e-mail: thomas.aenis@agrar.hu-berlin.de

The Role of Stakeholder Analysis for Sustainable Development: Experiences from Rubber Cultivation in Southwest China

JUE WANG, THOMAS AENIS

Humboldt-Universität zu Berlin, Agricultural Extension and Communication Group, Germany

The objective is to theoretically discuss stakeholder analysis and its role in rural development projects, to present the overall approach and the methods being applied in the SURUMER project, and to discuss preliminary results. Emphasis will be laid on how the findings of the stakeholder analysis have been and will be used, particularly with respect to adaptive management. In nature resource management and regional development planning, one of the key factors is knowledge about the actors, understanding their different roles, functions, interests, and inter-linkage structures. Stakeholder analysis can provide such knowledge and may be therefore a solid base for developing actor-oriented sustainable development strategies and furthermore interaction between actors. The SURUMER project is developing strategies for sustainable rubber cultivation in Xishuangbanna prefecture, Southwest China. Stakeholder involvement is seen as axiomatic, whereby "Stakeholders" of the SURUMER project are those individuals or groups who are affected or can affect those sustainable rubber cultivation strategies. In general, the stakeholder analysis have been stepwise deepened while the groups of stakeholders involved have been widened: In the initial phase of the project, the main objective was to identify and to involve key stakeholders. On local level a baseline study has been conducted in eight villages which aimed at stakeholders' problem perceptions, their interests and their formal and informal communication networks. On regional level, representatives of stakeholders have been asked to participate in workshops and meetings, focus group discussions and etc., to discuss about their roles in rubber cultivation, their expectations for future, and the communication among them. One unforeseen result was that even farmers are aware of the problems and have ideas for improvement. In the recent phase, one of the main tasks of research-practice interaction is to jointly develop future scenarios. Stakeholder analysis emphasises, with respect to ecosystem services, on practitioners indicators, their interests and their priorities. In future, the focus of stakeholder analysis will be shifting towards improving knowledge on factors of implementation. The approach therefore again deepened and as part of in-depth analysis, attention will be laid on hidden agendas of actors, the complex power structures, and potential conflicts and synergies. Implicaions of the stakeholder analyses, which are communicated within SURUMER, are firstly the involvement of key stakeholders (innovative farmers, village heads, prefecture and provincial authorities) into a participatory process of situation analysis and scenario definition which helps to shape the strategies mentioned above: Knowing more about the framework conditions for implementation helps in turn to plan related activities more realistically.

Keywords: Natural resource management, rubber cultivation, stakeholder analysis

Contact Address: Jue Wang, Humboldt-Universität zu Berlin, Agricultural Extension and Communication Group, Luisenstr. 53, 10099 Berlin, Germany, e-mail: jue.wang.1@agrar.hu-berlin.de

Life Cycle Assessment of Municipal Wastewater Systems: Applications and Limitations

JULIANA DALIA RESENDE, MARCELO ANTUNES NOLASCO

University of São Paulo, School of Arts, Sciences and Humanities, Brazil

The preocupation with environmental dimension of sustainability has gained increasing relevance, and environmental management tools, such as, the Life Cycle Assessment (LCA) have been increasingly used by both industries and government. The LCA allows the quantification of environmental emissions and the environmental impact analysis of products, system, or process, enabling the identification of opportunities for reducing environmental burdens, for example, by minimising the use of materials. The society has demanded that processes, products or services are analysed from an environmental point of view, including those related to the processing of waste, such as sewage treatment plants. However, studies that make assessment of municipal sewage treatment process at the design stage of the treatment system still has been incipient and restricted concerning the consideration of environmental variables in decision making. Thus, the present study aimed to obtain information on key advances, gaps and limitations in LCA of sewage treatment systems, and provide suggestions for future work in this area. To meet this target, a literature review related to the topic, published in articles in the period from 2008 to 2014 was performed. It was noted that many studies have focused on environmental aspects of nutrient recycling from wastewater, to reduce the need for fertilisers chemicals. Another very much studies topic was the use of biogas for power generation. However, more research and analysis are required to identify the most significant environmental issues, and to enable the knowledge gained can be used as a resource for decision-makers in evaluating alternatives technologies used in wastewater treatment.

Keywords: Applications, LCA, life cycle assessment, limitations, review, sewage, wastewater, wastewater treatment

Contact Address: Juliana Dalia Resende, University of São Paulo, School of Arts, Sciences and Humanities, São Paulo, Brazil, e-mail: julianadr@hotmail.com

Rururbanisation – A Threat to Agricultural Intensification and Food Security?

PER HILLBUR

Malmö University, Sweden, Dept. of Science, Environment, Society, Sweden

This paper addresses the challenge of agricultural intensification to meet food security in Africa. The case study is based on the development of a high-potential area in Babati District, Manyara Region, Tanzania, over the last 20 years. The development from agricultural frontier to high-potential integrated agricultural production is now abandoned for urbanisation "by definition". Although still rural in character, the villages in focus have recently become part of the administration of the town council, which means that the process to certify individual rights of occupancy is halted. The individual household's control over the land is an important incentive for further investments and land intensification. This process has been identified in Tanzania since the 1930s (Kilimanjaro), but seems now to reach a large number of medium- to high potential areas around market towns. The results are based on extensive field research by the author in the 1990s, which has been followed up with data collection in 2013 and 2014 in the same villages. The data sets show that farmers – in spite of tripled maize yields over 20 years and significant signs of successful intensification and diversification – are forced to look for new frontiers in more distant areas with lower potential. This is a problem for overall food production levels as well as for sustainable land use in vulnerable environments. The study discloses parts of the rich heterogeneity in rural Africa, where high-potential areas with stabilising population numbers are taken out of business, therefore denying farmers their role as engines in the process of sustainable agricultural intensification.

Keywords: Agricultural development, rururbs, sustainable intensification, Tanzania, urbanisation

Contact Address: Per Hillbur, Malmö University, Sweden, Dept. of Science, Environment, Society, Ekoxev 8, 24735 Södra Sandby, Sweden, e-mail: per.hillbur@mah.se

Economics Analysis in Rice Production Providing Environmental Services in Central Region of Cambodia

SOCHEAT KEO, MALYNE NEANG

Royal University of Agriculture, Faculty of Agricultural Economics and Rural Development, Cambodia

Payment for environmental services is a programme providing payment to people who join to preserve the environment or keep the environment clean. These payments will contribute to decrease poverty and involve both consumers and suppliers to promote a clean environment through direct and indirect payments funded by environmental service users. This study compares the cost-margin and efficiency of using inputs between rice production providing environmental services and rice production not providing environmental services. It has two specific objectives: (1) define rice production in the study area; (2) analyse the cost-margin and efficiency of using inputs to each type of rice production. Three villages in the central region of Cambodia were selected. To get both qualitative and quantitative data, semi-structured interviews were conducted with 6 key farmers, group discussions were held with farmers and other stakeholders involved in the rice sector, and 86 farm households were selected for an interview based on a quantitative questionnaire.

The study identified 6 rice types: early duration maturity rice, recession rice, medium duration maturity rice, long duration maturity rice, floating rice and organic rice growing in different rice ecosystems. There are currently many changes in rice production in the study area, because many companies and farmers invest much capital in short period rice (early season and recession rice) by building reservoirs, cutting flooded forests, which are fish habitat in the wet season, preparing land, using intensive techniques, modern agricultural equipment and increasing the use of chemical fertilisers, pesticides and herbicides. According to the farmers' perceptions and experiences, these changes in rice production have a strong impact on the environment and human well-being. As a result, the benefit and efficiency of using inputs in rice production providing environmental services is higher than in rice production using much chemical fertilizer, pesticide and herbicide. Value added by the consumers to rice production providing environmental services improves farmers' income and has less negative impact on the environment.

Keywords: Cambodia, economics efficiency, environmental services, rice production

Contact Address: Socheat Keo, Royal University of Agriculture, Faculty of Agricultural Economics and Rural Development, Dangkor District, 694 Phnom Penh, Cambodia, e-mail: lucky_cheat@yahoo.com

Challenges Rural Married Women are Facing after Receiving Microcredit: Evidence from West Cameroon

JOSEPHINE NGUEFO GNILACHI, GERTRUD BUCHENRIEDER
Martin-Luther-University Halle-Wittenberg, Inst. of Agricultural and Nutrition Sciences, Germany

In many parts of the world, women continue to lack voice and decision making ability and their economic opportunities remain very limited. Also in Cameroon, the social and economic status of women, especially in rural areas, remains low. Strengthening the social role and making women more economically autonomous is one of the targets of the Cameroonian government. One of the vehicles considered successful by academia and politicians to empower women is the access to microcredits. However, microcredits are not necessarily a panacea for women's empowerment. Some studies argue that microcredit access can empower women on the one hand, but on the other hand, may provoke violent behavior in their husbands, because they see their authority over their wives being undermined.

This contribution analyzes the role of microcredit access involved in women?s empowerment and investigates challenges faced by married women in West Cameroon when having received a microcredit.

Methodologically, quantitative and qualitative data were collected via household surveys with a questionnaire. A total of 107 women were selected using simple random sampling and among them, 68 have had received microcredit at least once and were married. To measure empowerment, the Women's Empowerment in Activity Index by the International Food Policy Research Institute (IFPRI) was adapted to the research question at hand and applied. It investigates on women?s resources, activities, income, leadership and time.

The results show that microcredit can make a significant contribution to the empowerment of women in Cameroon: that is improving their economic status and offering them potentially the capability of making decisions that can affect their lives and their futures and therefore their well-being in a positive way.

But much more needs to be done to accompany this process. Slightly more than a third of the married women confirmed that their microcredit had been a source of problems in their households. Among them, again a third stated that once they received the microcredit, their spouses did not longer financially assist them and their children as they used to do. Additionally, this ability of making business decisions can give more power to women within the household that might go against the cultural and social norms and therefore creating tension, and conflict at the household level.

Keywords: Decision making, microcredit, Cameroon, women's empowerment

Contact Address: Josephine Nguefo Gnilachi, Martin-Luther-University Halle-Wittenberg, Inst. of Agricultural and Nutrition Sciences, Halle (Saale), Germany, e-mail: josephine.nguefo@unibw.de

Modelling Farmers' Credit Allocation Decisions and Impacts on Farms Technical Efficiency in Benin, West Africa

COMLAN HERVÉ SOSSOU[1], FREDDY NOMA[2], AFOUDA JACOB YABI[3], SIEGFRIED BAUER[1]

[1] *University of Liege, Unit of Economy and Rural Development, Gembloux Agro-Bio-Tech, Belgium*

[2] *Justus-Liebig University Giessen, Inst. of Farm and Agribusiness Management, Germany*

[3] *University of Parakou, Dept. of Agricultural Economics and Rural Sociology, Benin*

This paper models farmers' credit allocation behaviours in schemes and analyses effects of the schemes on farms technical efficiency. Data were collected from 476 farmers using the multistage sampling procedure. The stochastic frontier truncated-normal with conditional mean model was used to assess allocation schemes effects on farms technical efficiency. A Tobit model reveals the impact of farmers' socio-demographic characteristics on efficiency scores. Results revealed that the revenue of 2,262,566 FCFA is positively correlated with acreage, quantity of labour and costs of fertilisers, insecticides, fertilisers. The average technical efficiency score is 0.675 ($\pm$0.137). The scores are diversely distributed across farms, with a median score equal to 0.713. Farmers' behaviour responds to six credit investments schemes, which are categorised in two allocation contexts: in-farm and out-farm allocations. In the latter credit is invested towards social needs (weddings, traditional festivals, etc.) and household needs (health, education, housing, etc.). Credit in-farm allocations are towards production inputs (land, labour, capital). The model showed that only one scheme impacted positively farms' technical efficiency: scheme (e). It is the decision to invest the credit to purchase better quality of pesticides, herbicides, fertilisers, etc. The positive effect of the scheme (c) may be significant under conditions of farmers' education level improvement. Then, scheme (e) is a better investment for all farmers; either they have a high or low level of education. But the credit allocation to buy agricultural materials is positive only for the educated farmers who were 53.5 % of the surveyed farmers. The scores of efficiency are reduced by household size and gender of the household head. Therefore, households with less than 10 members and an educated man as head are likely to improve their farms' technical efficiency through two credit investments schemes: Credit $\times$ Capital and Credit $\times$ Intermediary-inputs.

Keywords: Credit allocation schemes, stochastic frontier model, technical efficiency

Contact Address: Freddy Noma, Justus-Liebig University Giessen, Inst. of Farm and Agribusiness Management, Giessen, Germany, e-mail: orounoma@yahoo.fr

Preferential Microcredit and Poverty Outreach in the Northwestern Mountainous Region of Vietnam

LUAN DO XUAN, SIEGFRIED BAUER

Justus-Liebig University Giessen, Inst. of Farm and Agribusiness Management - Project and Regional Planning, Germany

Microcredit is considered as an appropriate instrument to alleviate poverty, but the provision of credit to the extremely poor may be so risky that micro-credit institutions tend to ignore these clients.

In Vietnam, the subsidised preferential credit programme has provided free-collateral loans to the poor since 4th October 2002. The vietnamese government has concerns over poverty reduction and poverty targeting of the programme. In this context, this paper examines the program's depth of poverty outreach in the poorest region of Vietnam – the northwestern mountainous region. The study used data from Vietnam Household Living Standard Survey in 2012. Accordingly, a sample of 500 households including 200 borrower households and 300 non-borrower households was randomly selected.

Principal Component Analysis was used to compute the relative poverty scores for both credit-users and credit non-users. To use the poverty index for making comparisons, credit non-users were categorized in five poverty groups based on their poverty scores. The cut-off scores for each group define the limits of each poverty group. Credit users were then categorised in the five groups and the proportion difference between credit users and credit non-users in each group would indicate the poverty outreach of credit institutions. We focus on the relative poverty rather than the absolute poverty because the former one reflecting the multi-dimensions of poverty is less dependent on inflation rates over time.

Results showed that preferential credit reaches a quite deep outreach because 70 % of all successful access households belong to three poorer groups. However, the poorest household group just accounts for 15 % of total credit accessed households. The depth of outreach by the preferential credit programs is quite consistent with their missions to serve the poor and the near-poor households. However, the poorest of the poor seem to be still underserved by preferential credit. The findings carry two important policy implications. Because the preferential credit programs target the poorer and face the problem of sustainability, so the governmental subsidies could be necessary. However, in order to target the poorest households, loan policies and credit service packages should be redesigned.

Keywords: Poverty outreach, preferential credit, principal component analysis

Contact Address: Luan Do Xuan, Justus-Liebig University Giessen, Inst. of Farm and Agribusiness Management - Project and Regional Planning, Jl University Giessen, 35392 Giessen, Germany, e-mail: doxuanluan@gmail.com

Is Microcredit Enhancing Ecosystem Payments and Environmental Services among Rural Farmers in Sudan? An Applied Dynamic Modelling Approach

ABDELATEIF HASSAN IBRAHIM[1], SAYED FADUL ELMOLA[2]
[1]*University of Kordofan, Dept. of Agric-Economics and Rural Development, Sudan*
[2]*West Kordofan University, Dept. of Rural Development, Sudan*

Although microcredit is seen as a viable financial instrument for alleviating poverty, enhancing ecosystem payments and environmental development, microcredit providers are lagging behind due to inadequate financial capacity and unclear vision for development. This study intends to discuss the potential impact of socio-economic and environmental factors that hinder investment in ecosystem under the conditions of poverty. In addition, it tries to simulate how farmers would choose to use their loans if they could use them on any ecosystem and environmental services. Evidence will be given to strengthen the argument. The study relies on a field survey, conducted in Kordofan region, Central-West Sudan, during the season 2012, using structured questionnaires. It surveyed 300 farm households, which were selected through a multistage stratified random sampling technique. Descriptive statistical analysis, bivariate model and non-separable dynamic farm household modelling approach were applied to analyse the data. The results of the descriptive analysis showed that 79 % of rural households had a tendency to pay for environmental services and ecosystem enhancement, while 75 % of rural households are more likely to be trained in business related to environmental issues. Results obtained from bivariate probit model showed strong interaction effect between loan use and ecosystem payments variables of farm households. Interestingly, the simulations over a three-year period demonstrated that, about 77 % of farmers decided to invest in ecosystem payments, of which 50 % did so in agricultural activities that enhance environmental sustainability.
The study suggested that in order to improve ecosystem payments and environment, the agricultural investment should be improved, particularly through the adoption of efficient technologies and the enhancement of the commercialisation of farm products. This could be possible through increasing the credit volume and providing "credit plus" services in remote areas.

Keywords: Bivariate model, ecosystem payments, loan use, microcredit, poverty

Contact Address: Abdelateif Hassan Ibrahim, University of Kordofan, Dept. of Agric-Economics and Rural Development, Elgamaih Street, 51111 El-Obeid, Sudan, e-mail: lateif73@hotmail.com

Marginality as a Root Cause of Poverty: Identifying and Analysing Marginality Hotspots in Ethiopia

CHRISTINE HUSMANN

University of Bonn, Center for Development Research (ZEF), Germany

Marginality has been identified as a root cause of poverty and its persistence. Marginality refers to a position of individuals or groups at the margins of social, political, economic, ecological, and biophysical systems and thus helps to explain why certain groups are left behind while other parts of a society prosper. The present study applies this concept to the case of Ethiopia. Marginality hotspots are mapped by overlaying seven different indicators using Geographic Information System software. The indicators used are total expenditure at household level, prevalence of stunting among children under five, travel time to major cities, percentage of households having health problem in last 2 months and not going to health institution or traditional healer, global land area with soil constraints, percent of households getting drinking water from unprotected well or spring and the percentage of women saying wife beating is ok if she neglects children. Results show that marginality is a severe and widespread problem in Ethiopia with more than 40 million people, i.e. almost half of the population, being severely marginalized. People in the South-West and in the North of Ethiopia are most marginalized while people in urban regions are generally less marginalized. Overlaying the marginality map with a map of agro-ecological belts indicates that marginality is not correlated with agro-ecological zones. As agro-ecological zones roughly indicate agricultural potential, this finding reveals that people living in areas with higher agricultural potential are not able to seize this potential and are as marginalized as people living in low-potential areas. Furthermore, overlaying the marginality map with a map showing the distribution of different ethnic groups in the country shows that marginality is not bound to specific ethnic groups. However, using a Kolmogorov-Smirnov test for the equality of distributions it can be shown that ethnic fractionalization is significantly lower in marginality hotspots than in other areas. This result holds even if urban areas, that are likely to be characterized by a higher ethnic diversity due to rural urban migration, are excluded. Thus, this research identifies and locates the poorest and marginalized in Ethiopia. Based on the dimensions of marginality, root causes of poverty can be identified. Especially regarding constraints in the agro-ecological dimension, extension services and access to adequate agricultural inputs can help to contribute to the reduction of poverty and marginality.

Keywords: Agricultural potential, Ethiopia, ethnic diversity, geographic information system, marginality, poverty

Contact Address: Christine Husmann, University of Bonn, Center for Development Research (ZEF), Walter-Flex-Str. 3, 53113 Bonn, Germany, e-mail: husmann@uni-bonn.de

To Develop or To Be Developed: Drivers, Dangers and Opportunities related to focus on rubber in Kesindu, Sarawak, Malaysia

OUMAIMA DRIDI, SOFIA FÖRSTER, MARIUS VON OSTEN BRAATHEN, JACOB RAFFN , HAYET DJEBBI

University of Copenhagen, Fac. of Life Sciences, Denmark

In recent years, conversion of 'idle land' into large-scale rubber and oil palm plantations in Sarawak Borneo occured often without the affected people having a real say in the decision making process. Kesindu, a 44 households village in Sarawak, Malaysia, is affected by this development as several land development organisations have approached the village.

The present study carried out by students from both University of Copenhagen and University of Malaysia Sarawak investigates the conversion of a forest into a large-scale rubber plantation, the drivers behind it, the effects on the environment and the livelihoods of the local population, and the opportunities associated to the land use change in Kesindu.

For the investigation process, open-ended interviews, questionnaires, seasonal calendar, transect walks, focus group discussion and interviews besides natural science methods were carried out all households.

The findings illustrate that lack of finances combined with a "develop or be developed paradigm" in Sarawak is leaving the villagers with little choice in terms of future land development. A 90 ha rubber plantation is being implemented by the government in order to avoid encroachment on their land by private agencies. In order to secure tenure rights, focus on derived effects was lost. Adverse effects include environmental degradation, health issues due to pollution of water sources and social conflict from different points of view towards development. In spite of this, it might still be possible that development schemes involving rubber can be sustainable on both social and ecological indicators if approaches such as diversification of livelihood strategies and agroforestry are pursued.

Keywords: Dangers, drivers, Kesindu, land conversion, large-scale, Malaysia, opportunities, rubber plantation, Sarawak

Contact Address: Oumaima Dridi, University of Copenhagen, Fac. of Life Sciences, Tranehavegaard 31, 2450 Copenhagen, Denmark, e-mail: oumaima.dr@gmail.com

Improving Livelihoods of Rural People through Quality Training Videos: Lessons from Access Agriculture

AUGUSTIN KOUÉVI[1], KOWOUAN FLORENT OKRY[2,1], PAUL VAN MELE[3], BOB MUCHINA[4], JOSEPHINE RODGERS[5], PHIL MALONE[5]

[1]*Access Agriculture, Benin*
[2]*University of Ketou, Benin*
[3]*Agro-Insight, Belgium*
[4]*Access Agriculture, Kenya*
[5]*Countrywise Communication, United Kingdom*

This paper addresses the contribution of quality training videos to sustainable management of natural resources and to the improvement of farmers' livelihoods.
Limited access to relevant knowledge on good farming and natural resources management practices is a key factor affecting livelihoods of farmers and natural resource management (NRM) stakeholders. Most often, project-based livelihoods' and NRM improvement initiatives involve, among others, sensitisation, training, and promotion of income generating activities. Yet, the solutions proposed to farmers and NRM stakeholders tend to disappear once projects come to an end, with the problems often remaining or even getting worse. Therefore, a main challenge for development actors is to make relevant knowledge on technical, social and institutional practices and innovations easily and sustainably accessible to farmers and NRM stakeholders. To help address this challenge, the international NGO Access Agriculture promotes the production, translations and dissemination of quality training videos inspired by scientific knowledge and farmers' good practices, in local and international languages. Access Agriculture makes these videos easily and sustainably accessible to farmers through large-scale distribution of DVDs via existing rural advisory services, researchers, radio and television stations, project actors, etc. Development agencies and services providers are informed about the existence and the free accessibility of the videos through websites where videos can be downloaded (www.accessagriculture.org) and uploaded (www.agtube.org). This paper presents quantitative and qualitative feedback from the field from Asia and Africa. Multiple studies reveal the impact of the Access Agriculture approach on farmers and NRM stakeholders, whereas continuous monitoring also reveals the usefulness of the websites and hosted videos to university lecturers, researchers, trainers, project managers, and radio and television broadcasters. Lessons learned and insights for future developments are shared to inspire food security and NRM promoters around the world.

Keywords: Access agriculture, natural resources management, training videos, small scale farmers

Contact Address: Augustin Kouévi, Access Agriculture, Cotonou, Benin, e-mail: augustin@accessagriculture.org

Spatial Heterogeneity and Fragmentation Status of Ecosystem Services in Tara Gedam Watershed in the Highland of Northwest Ethiopia

MENALE WONDIE[1], KLAUS KATZENSTEINER[1], WERNER SCHNEIDER[2], DEMEL TEKETAY[3], REINFRIED MANSBERGER[2], FENTAHUN MENGISTU[4]

[1]*University of Natural Resources and Life Sciences (BOKU), Inst. of Forest Ecology, Austria*

[2]*University of Natural Resources and Life Sciences (BOKU), Inst. of Surveying, Remote Sensing and Land Information, Austria*

[3]*Botswana College of Agriculture, Dept. of Crop Science and Production, Botswana*

[4]*Ethiopian Institute of Agricultural Research, Research, Ethiopia*

Degradation of land and increase of population in northwest Ethiopian highlands result in fragmented and scattered patterns of land ownership. Because of the small size of plots, it is increasingly difficult to apply proper technology and conservation measures. This consequently leads to shrinkage of effectively cultivable area and to a reduction of the production of ecosystem services (ES). Hence, knowing the parcel size distribution is required to choose and to implement best possible solutions. This requires quantitative information on heterogeneity and fragmentation status of land cover/use types (LCUTs) and ES. The objectives of this study were to spatially characterise LCUTs, to quantify ES at fine scale and to understand heterogeneity and fragmentation status of the highland ecosystem. Field survey was done to collect LCUTs data. Field data collection was supported by high resolution images, Google Earth and topographic maps. Vector data were created for parcels as a land mapping unit (LMU) based on LCUTs and ownership. Spatial metrics (number, density, dominance, variations and others) were used to analyse heterogeneity and fragmentation. Spatial and statistical analyses were done using ArcGIS and SPSS, respectively. LCUTs were summarised as cropland, forestland, grassland, shrubland, agroforestry land and for others. The ES were categorised into subsistence, cultural-spiritual and environmental services. The result showed that 36.3 %, 24.9 %, 21.6 %, 3.2 %, 0.2 % and 13.7 % of the study area were cropland, forestland, grassland, shrubland, agroforestry land and others, respectively. Subsistence services accounted for 57.5 %, cultural-spiritual services covered 12.4 %, environmental services comprised 7.6 % and other uses were estimated to cover 22.5 %. 1763 out of the 1868 LMUs delimited in the watershed are allotted for food production. Highest (199/100 ha) and lowest (1/100 ha) density of LMUs were found for food and for cultural service (church forests), respectively. Small sized LMUs are allocated for food and large sized LMUs are used for conservation/protection. Higher number, higher density, smaller size and higher variability are observed on food providing ES, which is an indication of fragmentation. In conclusion, metrics and indices indicate fragmentation status of LCUTs, ES and ecosystem. Specific socioeconomic and biophysical causes for land parcellation need to be identified to design mitigation measures.

Keywords: Ecosystem services, heterogeneity, land mapping units, spatial metrics

Contact Address: Menale Wondie, University of Natural Resources and Life Sciences (BOKU), Inst. of Forest Ecology, Vienna, Austria, e-mail: menalewondie@yahoo.com

GIZ experience on bridging the gap between increasing knowledge and decreasing resources

Cooperation Between German Universities and GIZ in the Walnut-Fruit Forest Area of Southwestern Kyrgyzstan: Experiences on Integrating Research Findings into a Development Project on Biodiversity Preservation and Poverty Reduction

PETER BORCHARDT[1], UTE FISCHER-ZUJKOV[2], ANDREI DÖRRE[3]

[1] *University of Hamburg, CEN Center for Earth System Research and Sustainability, Inst. of Geography, Germany*
[2] *Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Uzbekistan*
[3] *Freie Universität Berlin, Inst. of Geographical Sciences, Germany*

Kyrgyzstan is one of Asia's most sparsely wooded countries, with a forest cover of only 4 to 5 %. Despite the fact that the world's largest connected natural walnut-wildfruit forests are to be found in southwestern-Kyrgyzstan. They are considered the origin of many domesticated fruit and nut varieties. The *in situ* conservation of these wild varieties seems to be of global importance.

Acknowledging the unique nature of the forests, many research activities on biodiversity and the breeding of new varieties of nuts and fruits were conducted already in Soviet times. After the independence of Kyrgyzstan, within the project 'The Impact of the Transformation Process on Human-Environmental Interactions in Southern Kyrgyzstan' funded by the Volkswagen Foundation, scientists from German and Kyrgyz Universities conducted intensive research on the region, covering ecological as well as socio-economic and natural resource management aspects. The outcomes proved that the forests form a significant basis for rural livelihoods and have important regulating functions for the downstream regions, e.g. for the water regime. Degradation processes, induced by unsustainable resource management and use (firewood, nut harvesting, forest pasture) - performed within the context of legal pluralism and uncertain institutions, changed the forest structure and biodiversity negatively. Walnut harvests have decreased, as has the natural resilience of the forests. The negative impacts on the forests as well as the surrounding ecosystems are additionally exacerbated by the already perceivable adverse impacts of climate change. Additionally, the pressure on the forest resources increases steadily due to the region's difficult economic situation as well challenging social and demographic processes.

In March 2014, in the framework of BMZ's Energy and Climate fund (EKF) the GIZ project 'Biodiversity Preservation and Poverty Reduction in the Walnut Forests of Southern Kyrgyzstan' has been launched. This project integrates the findings of the mentioned research project into its own activities, which encompass i) the improved management of the forests and adjacent pasture lands through participatory land use planning, ii) the plantation of agroforestry systems with local high yield walnut trees as well as iii) the development of agroforestry value chains and alternative income generation measures.The implementation of the chosen measures will be flanked by the advices and assessments of the associated scientists.

Keywords: Climate fund, development project, forestry, Kyrgyzstan

Contact Address: Peter Borchardt, University of Hamburg, CEN Center for Earth System Research and Sustainability, Inst. of Geography, Bundesstr. 55, 20146 Hamburg, Germany, e-mail: pbo1@gmx.de

Making Optimal Use of Reduced Resources: The Role of Food Losses

TANJA PICKARDT

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Agriculture, Fisheries and Food, Germany

Roughly one third of food produced for human consumption is lost or wasted globally, which amounts to about 1.3 billion tons per year. This is inacceptable in regard to rising food prices, growing pressure on natural resources and dramatic famine in eastern and western parts of Africa during the last years. To date, it is difficult to evaluate and quantify food losses and waste. GIZ has therefore engaged in a couple of studies on various products in Africa, with the aim to quantify post-harvest losses by value adding actor.

Rice is a major staple food in Nigeria, with increasing rates of local demand. Its large supply-demand gap is bridged by imports. The average losses along the Nigerian rice value chain sum up to more than 20 % of the total production, contributing to around 0.5 million tonnes of CO_2 to the atmosphere.

Potato is the second most important food crop in Kenya, and mostly cultivated by smallholder farmers. Up to 95 % of the damages and losses recorded in the Kenyan potato value chain are attributed to the production level. They are in particular caused by inappropriate harvesting tools and not well-trained labour. The retail level with a market share of up to 90 % is mostly affected since also low quality produce is supplied to the markets. But missing market signals, in the form "better prices for better quality tubers" contribute to the low performance in potato production.

On the basis of the findings of the two surveys, appropriate measures for reducing food losses in the rice and potato value chains are presented.

Keywords: Potato, rice, value chain, waste reduction

Contact Address: Tanja Pickardt, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Agriculture, Fisheries and Food, Bonn, Germany, e-mail: tanja.pickardt@giz.de

Providing Existing Knowledge through Networks and Knowledge Sharing

FELIX ZEISKE[1], MARITA DIELING[2]

[1]*International Center for Insect Physiology and Ecology (ICIPE), ITAACC, Kenya*

[2]*Association of International Research and Development Centers for Agriculture, Kenya*

Innovation Transfer into Agriculture-Adaptation to Climate Change (ITAACC) is a BMZ funded programme implemented by GIZ and in close collaboration with the International Center for Insect Physiology and Ecology (ICIPE) in Kenya, which through innovative pilot projects seek to more closely integrate scientists and practitioners in Africa. These projects are designed in collaboration with international agricultural research centres and implemented in conjunction with various partners, including private sector and non-governmental organisations. One of the tools being developed is a knowledge transfer platform that matches offers to agricultural demand: www.icipe.org/itaacc.

ICIPE is also part of the Association of International Research and Development Centers for Agriculture (AIRCA, www.airca.org), where networking and knowledge management are important mechanisms that support multi-disciplinary demand driven research.

The various approaches used by ITAACC and AIRCA will be presented, compared and will show how increased knowledge can be used for bridging gaps on different levels.

Keywords: Knowledge networking

Contact Address: Felix Zeiske, International Center for Insect Physiology and Ecology (ICIPE), ITAACC, Nairobi, Kenya, e-mail: fzeiske@icipe.org

Czech development cooperation - Sustainability of development projects in agriculture

Czech Development Cooperation and the Role of the Czech Development Agency

MICHAL KAPLAN

Czech Development Agency, Czech Republic

Lorem ipsum

Keywords: Lorem ipsum

Contact Address: Michal Kaplan, Czech Development Agency, Prague, Czech Republic, e-mail:

Czech Development Cooperation in the Field of Agriculture

HYNEK CIBOCH
Czech Development Agency, Czech Republic

Lorem ipsum

Keywords: Lorem ipsum

Contact Address: Hynek Ciboch, Czech Development Agency, Prague, Czech Republic, e-mail:

Agriculture Projects in Afhanistan – From Relief to Development

JAN SVITALEK

People in Need, Relief and Development Department, Czech Republic

People in Need organisation is working in Afganistan since 2001 and the scale of intervention counts from emergency and relief interventions through recovery, disaster preparedeness, disaster risk reduction down to longterm development projects and programs such as contribution in National Solidarity Program, Agriculture Education Program, Natural Resource Management (NRM) & Agriculture Program or Urban Poverty Program. The NRM and Agriculture programme has been established since 2008 with support of joint funding of European Comission (EC) and Czech Development Agency (CzDA) and focused directly on mountaineous and remote districts in south of Balkh province in northern Afghanistan.The working environment in southern Balkh is challanging from the logistic, environmental and also security point of view, none the less PIN managed to establish firm presence in the area and gained the reputation as virtually only organisation providing the support to local communities on longterm basis, besides relatively weak governemental bodies. This however asks for responsible attitude and longterm planning of the programs and the projects that have to bring visible long-term impacts, based on a good record of good practices and lessons learned.Besides that the understanding the main drivers and bottlenecks is a key for sucessfull planning of the development programs and the recent studies. For example one of the well established beliefs is that the conflicts of last decades had a large impact on quality of agriculture and management of natural resources. Recent studies carried out by PIN however do not bring the evidence of such dynamic. The initial recovery approach that was primarilly building the agriculture assets for food insecure families and returnees turned therefore gradually into capacity building of local communities and authorities in natural mesource management, conservation agriculture and development of agriculture business and value chains. Two recent projects implemented by PIN and funded by CzDA called “Improved Agriculture in Balkh Province” and “Support to small sgriculture enterpreneurs in Balkh” represent well the experience of this transformation, while they included both aspects – the capacity building in Income generation activities and general provision of improved assets.

Keywords: Afghanistan, agriculture extension, natural resource management, recovery

Contact Address: Jan Svitalek, People in Need, Relief and Development Department, Safaříkova 24, 120 000 Prague, Czech Republic, e-mail: jan.svitalek@peopleinneed.cz

Czech Development Assistance Project on Soqotra: Support of Small-Scale Farmers and Agricultural Education on the Soqotra Island

HANA HABROVÁ, PETR NEMEC

Mendel University in Brno, Dept. of Forest Botany, Dendrology and Geobiocoenology, Czech Republic

Landscape of Soqotra Island is a typical example of long-term impacts of cattle grazing. Local people are dependent on cattle, fishing, import of rice, flour and beans from the Yemeni mainland. Cultivation of food-plants, ornamental species or close-to-extinction plants are the key objectives of various projects. Mendel University has been working on the island since 1999. Currently, the project of Czech Development Assistance called "Support of small-scale farmers and agricultural education on the Soqotra Island" came into its third year of implementation. The objective of the project is to support the island population in an effort to improve their food safety and nutritional quality of the food, and to increase food self-sufficiency of local communities through educational activities in the field. Project activities continue mostly in extension of results of previous Czech projects realised on the island. More than 100 interested families were encouraged to establish or expand their home gardens. Nurseries producing seedlings of agricultural crops and endemic trees were supported; seven bigger agroforestry objects were established and serve as practice examples and training centres. Another activity, new on the island, was added. Twenty three schools suitable for school gardens construction or expansion, were selected. Pupils and students led by trained teachers take care of gardens during lessons or in extracurricular activities. Students are tended to cultivate the soil from their childhood, get the consciousness about producing food plants and disperse their knowledge in their families. An inherent benefit of the project is the increased awareness of the target groups of the necessity of a nutritionally balanced diet for overall health condition, as well as the cultivation and subsequent processing of staple crops. This was achieved by implementing a number of trainings focused on human nutrition, cooking from crops grown (including distribution of simple cookbook created within the project) and basic agronomic methods and management practices in home gardens. Czech activities on Soqotra Island are welcome by the community and the cooperation with local people is pleasant and fruitful thanks to its long history and success.

Keywords: Agricultural education, arid tropics agriculture, homegardens, schoolgardens, Soqotra

Contact Address: Petr Nemec, Mendel University in Brno, Fac. of Forestry and Wood Technology, Dept. of the Forest Botany, Dendrology and Geobiocenology, Zemedelská 1/1665, 613 00 Brno, Czech Republic, e-mail: petr.nemec@mendelu.cz

Implementation and Development of Artificial Insemination of Cattle for Small Holder Farmers in Zambia

MICHAL BASOVNIK, EVA REHOROVA

Breeding Cooperative Impuls, Czech Republic

Two projects implemented within the scope of the project of foreign development cooperation of the Czech Republic are focused on support of cattle breeding in Zambia. The main aim is to increase accessibility of services in the area of artificial insemination and maintenance of the genetic potential of the traditional cattle breeds.
With the Ministry of Agriculture and Livestock in Zambia as a partner organisation, the National station for artificial insemination services was settled up and upgraded and the system of distribution to the small holder farmers is recently being implemented. The main role of CHD Impuls as the implementing entity is to realise and coordinate the activities in the place of fulfilment, to supervise the correctness of the implementation and to resolve the problems connected with operation. The basis of the project is delivery of the equipment and training, introduction of consultancy services, proposal of a more efficient system for artificial insemination in Zambia and the setup of an education system.

Keywords: Artificial insemination, cattle breeding, development project, reproduction, Zambia

Contact Address: Michal Basovnik, Breeding Cooperative Impuls, Bohdalec, Czech Republic, e-mail: mbasovnik@chdimpuls.cz

Strengthening Capacity of Bih Veterinary Laboratories and Veterinary Inspection Services for Implementation of National Residue Monitoring Program in Accordance with EU Standards

JAN ROSMUS
State Veterinary Institute Prague, Chemistry, Czech Republic

At the beginning of the project Bosnia and Herzegovina was not able to export products of animal origin and food safety system was not accepted by EU due to lack of accredited laboratories and deficiencies in control mechanisms (inspections). Large number of samples was tested outside Bosnia and Herzegovina (costly services). Our project started in 2012 and originally was planned for two years, was subsequently extended to the end of 2014. Main aim was to carry out audit of the laboratories and in selected laboratories to establish methods for testing of product of animal origin and train veterinary inspectors of the State Veterinary Office of Bosnia and Herzegovina (including inspectors of individual entities – Federation, Republika Srpska and Brcko district). To support selected four laboratories - Federal Agromediterranean Institute Mostar, Veterinary Institute of Republika Srpska "Dr Vaso Butozan" Banja Luka, Veterinary Faculty, University of Sarajevo and Cantonal Veterinary Station, Sarajevo. Different methods of analysis were selected for training - according to assessment of capacities and availability of appropriate equipment. Until today fourteen training sessions were organised in laboratories in the Czech Republic and twelve training programs in Bosnia and Herzegovina. The laboratories were equipped by chemicals, reference materials, glassware, instruments and other laboratory devices and interlaboratory comparsions were organised for designated methods, techniques and matrices. Established analytical methods have been validated and are gradually accredited by a national accreditation body of Bosnia and Herzegovina (BATA). At the same time trained inspectors of the State Veterinary Office train other inspectors.

Keywords: Bosnia and Herzegovina, monitoring of residues, veterinary inspection

Contact Address: Jan Rosmus, State Veterinary Institute Prague, Chemistry, Sidlistni 24, 16503 Praha 6, Czech Republic, e-mail: jan.rosmus@svupraha.cz

Enhancement of Quality and Extent of Extension Services of Angacha Woreda, Kembata Tembaro Zone

KRISTINA RUSAROVA, HIDARE DIRIBA DEBAR

Czech University of Life Sciences Prague, Faculty of Tropical AgriSciences, Czech Republic

The project "Enhancement of Quality and Extent of Extension Services of Angacha Woreda, Kembata Tembaro Zone", financed within the Czech Development Cooperation, deals mainly with improvement of extension services, processing of agricultural products and breeding of small ruminants in Angacha woreda. The project was planned for the period 2011 till 2013 at first, but the implementation was prolonged till the end of 2015 in order to deepen the project sustainability and extent the outputs within the target group of development agents (DAs) and farmers of Angacha woreda. The project objective lies in the enhancement of the extension service capacities in terms of broader range and higher quality of extension services at Angacha woreda. In addition to the support of the five farmer training centres (FTCs), three other FTCs are included to the support in the period 2014 – 2015. Except for the material support of the eight FTCs, trainings of DAs of all 18 kebeles' FTCs at Angacha woreda is realised. The trainings are focused on transfer of innovations and strengthening the knowledge derived from the past trainings, concerning following topics: water harvesting and watershed management, breeding of small ruminants, beekeeping and processing of agricultural products. DAs are trained by local experts, according to their specialisation. Subsequently, the DAs train model farmers directly in the kebeles. Other activities concern support of newly established farmers' cooperative that will manage centre of processing of agriculture products (PC), animal breeding centre and beekeeping centre founded within the project. Machines and implements in the PC include oil pressing machine, hammer mill, stone mill, two moveable threshing machines, solar dryer, kocho squeezers, honey extractor and wax printer. Animal breeding centre is focused on insemination of local farmers' goat and sheep females by the improved breeds Boer and Dorper. The objective of the PC and animal breeding centre is to provide services not only for the members of the cooperative but for the local farmers as well. In the meantime, researches leading to two master theses, two Ph.D. theses and few scientific articles were supported by the project.

Keywords: Animal breeding, beekeeping, Ethiopia, extension services, processing of agricultural products

Contact Address: Kristina Rusarova, Czech University of Life Sciences Prague, Faculty of Tropical AgriSciences, Kamycka 129, 165 21 Praha 6, Czech Republic, e-mail: kristinar@seznam.cz

Panel Discussion + subsequent Poster session - see below from ca. 18:00 onwards

MICHAL KAPLAN

Czech Development Agency, Czech Republic

Panel discussion

Keywords: Panel discussion

Contact Address: Michal Kaplan, Czech Development Agency, Prague, Czech Republic, e-mail:

Increasing Quality of Education at Mongolian University of Life Sciences

JANA MAZANCOVA[1], GANCHIMEG GOMBODORJ[2], JIRI HEJKRLIK[1], ALENA NERADOVA[1]

[1]*Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Czech Republic*

[2]*Mongolian University of Life Sciences, Mongolia*

The project focused on transfer of know-how of institutional management and education process between Czech University of Life Sciences Prague and Mongolian University of Life Sciences (former Mongolian State University of Agriculture) in Ulaanbaatar has been financed by the Government of the Czech Republic within Czech Development Cooperation since 2012. The main target groups involve students, academic staff and management of School of Economics and Business and Institute of Animal Husbandry. The implementation of the project activities is based on direct active participation of Czech experts in education process as well as in management planning. Within the project seven courses have been already improved by revision of their syllabus, introduction of modern teaching methods, and creation of new study supports. Further, Mongolian teachers have attended three two-day workshops on enhancement of pedagogical and didactical competences and three one-day workshops on research and science. Czech and Mongolian teachers have organised two summer schools for Mongolian and Czech students in 2013 and 2014, primarily focused on broadening knowledge on livelihood of small livestock herders and agricultural cooperatives, respectively; on developing scientific and research skills in field surveys and on cultural exchange while working in international research groups. The project has also supported successful students' research grants and students' associations. Every year, Career Day for linking up students with their potential employers and Documentary Film Festival for creating stimulating environment for debates have been organised. The remaining challenges for this year lie in analysing conditions for introduction of Bologna process and preparing joint research grant proposal.

Keywords: Academic staff, summer school, tertiary education, university students

Contact Address: Jana Mazancova, Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Kamycka 129, 19800 Prague, Czech Republic, e-mail: mazan@ftz.czu.cz

European Neighbourhood Programme for Agriculture and Rural Development (ENPARD): Enhancing Small Farmers' Cooperation and Productivity in Imereti Region, Georgia

ALENA NERADOVA[1], JIRI HEJKRLIK[1], PAVLA PIJANOVA[2], BUBA JAFARLI[2]

[1]*Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Czech Republic*

[2]*People in Need, Czech Republic*

The project "ENPARD Georgia: Enhancing Small Farmers' Cooperation and Productivity in Imereti Region" is financed from European Commission – EuropeAid and co-financed by the government of the Czech Republic within the International Development Cooperation of the Czech Republic. The main implementer is the Czech NGO People in Need in partnership with the Czech University of Life Sciences Prague, Association of Young Economists of Georgia and Elkana. The project is planned for the period 2014 till 2017 and deals mainly with the reduction of rural poverty in Imereti. It targets semi-commercial small farmers as well as agribusiness and rural entrepreneurs in order to increase their productivity and income as members of business-oriented groups such as cooperatives and associations. Such groups represent an alternative to current independent farming practices on fragmented plots with limited cooperation and allow for farmers to decrease operational costs, increase the efficiency and quality of their production, improve market access and thus increase their power to influence market prices. With the adoption of the new Law on Agricultural Cooperatives in July 2013, the conditions for the establishment of cooperatives have been improved and there is an unprecedented opportunity for this more efficient business practice to flourish in Georgia. In total, within the project will be established at least 24 cooperatives. These will be chosen on the basis of grant competition with the possibility to reach a technical sub-grants valued from 35,000 € to 60,000 €. In the first initial phase two cooperatives were already supported, another 10–12 cooperatives will receive a grant before the end of the year 2014. As part of the grant competition, a mandatory intensive training course for all applicants focusing on the principles and organisation of cooperatives, development of business plans and drafting of cooperative statutes is provided.

Before the project implementation was conducted a market assessment and value chain analyses of the key sectors identified during the preliminary field assessment: greenhouse herbs, wine, beekeeping, cattle meat and dairy, hazelnuts, poultry and corn. Pre-identified sectors have the most potential for cooperation and market growth and there is a distinct need to strengthen their value chain.

Keywords: Cooperatives, Georgia, market access, small farmers, value chain

Contact Address: Jiri Hejkrlik, Czech University of Life Sciences Prague, Faculty of Tropical AgriSciences, Kamycka 129, 165 21 Prague, Czech Republic, e-mail: hejkrlik@ftz.czu.cz

Capacity Building of Higher Agricultural Education in Cambodia

PETRA CHALOUPKOVA, MILOSLAV PETRTÝL, LUKAS KALOUS, JAN BANOUT
Czech University of Life Sciences Prague, Faculty of Tropical AgriSciences, Czech Republic

The project Capacity Building of Higher Agricultural Education in Cambodia is focused on support of the improvement of quality of agricultural higher education in Cambodia through cooperation between experts from the Czech University of Life Sciences Prague (CULS) and Royal Agriculture University (RUA). The project is running since 2012 and is supported by the Czech Development Agency. The main aims of the project include support of development in the area of research, pedagogical and international activities. The project is based on direct contribution of CULS' lecturers and managers to the development of the RUA, especially at the following faculties: (i) Agricultural Technology and Management, (ii) Fisheries, (iii) Faculty of Agro-Industry and (iv) Agricultural Economics and Rural Development. The target group of the project includes students and teaching staff from RUA. The main activities are oriented to: Analysis of the current situation in the field of education, international relations and research activities at RUA; Building of pedagogical and didactical capacities of local academic staff, including teaching and consultations provided by Czech experts in the fields of fish production, fish identification and genetics; solar drying, marketing, agricultural economics etc.; Organisation of summer school "From net to spoon" for both Cambodian and Czech students. The main purpose of the summer school is to introduce to students from both universities the best practices in aquaculture including fish identification, fish farming and catching, fish transportation, fish processing and product quality evaluation and marketing. Implementation of the system of quality evaluation, organisation of Carrier days and Film festival oriented to actual agricultural topics. Identification and implementation of joint research topics, support of scientific activities of RUA and support of talented Cambodian students and their research projects. Evaluation of accreditation of the joint/double degree programme between RUA and CULS and preparation of joint project oriented to student mobility, providing the practical training for the students how to apply for international grants.

Keywords: Agricultural education, Cambodia, fish production, summer school

Contact Address: Petra Chaloupkova, Czech University of Life Sciences Prague, Faculty of Tropical AgriSciences, Kamycka 129, 16521 Prague, Czech Republic, e-mail: chaloupkova@ftz.czu.cz

Enhancement of Quality of Education at Akaki Tsereteli State University

JANA MAZANCOVA[1], JIRI HEJKRLIK[1], ROMAN KVASNICKA[2]

[1]*Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Czech Republic*

[2]*Czech University of Life Sciences Prague, Fac. of Economics and Management, Czech Republic*

The project funded by the Government of the Czech Republic within Czech Development Cooperation contributes to fulfiling of the current gap in the Georgian tertiary education in the sector of development of cooperatives and small and medium agricultural enterprises, which is the priority of new Georgian Government as well as of international donors (e.g. EU – ENPARD) through know-how transfer between Czech University of Life Sciences Prague and Akaki Tsereteli State University in Kutaisi; Agrarian faculty and Faculty of Business, Law and Social Sciences, in particular. The project design enhances direct active participation of Czech academic and management staff at ATSU in order to establish strong working relationships and challenging environment. The main target groups involve students, teachers and management of ATSU. The project activities focus mainly on improvement of seven study courses, improvement of pedagogical and didactical competencies of university teachers, support of institutional systems of Agrarian faculty, analysis of current international relations and analysis of possibilities for join/double degree, strengthen research and scientific capacities of students and teachers; and providing necessary equipment for education process. The specific emphasis is given to the enhancement of practical research and scientific competencies of students. The project cooperates with People in Need on ENPARD (European Neighbourhood Programme for Agriculture and Rural Development Georgia: Enhancing Small Farmers' Cooperation and Productivity in Imereti Region) project focused on development of agricultural cooperatives and offers so a unique opportunity to students to participate in several analyses. Students will also attend a specific training summer course in 2015 "Institutions and Cooperatives for Rural Development". The project also aims at creating supportive learning environment through organisation of Documentary Film Festival and various specific debates; and at linking up with external commercial partners via Career Day.

Keywords: Cooperatives, Georgia, institutional development, tertiary education

Contact Address: Jana Mazancova, Czech University of Life Sciences Prague, Fac. of Tropical AgriSciences, Kamycka 129, 19800 Prague, Czech Republic, e-mail: mazan@ftz.czu.cz

Czech Republic Development Cooperation in Moldova

TATIANA IVANOVA, BOHUMIL HAVRLAND, ALEXANDER KANDAKOV
Czech University of Life Sciences Prague, Fac. of Trop. AgriSciences, Czech Republic

The project titled "Support to increasing quality of education at the State Agrarian University of Moldova in Chisinau (SAUM)" was formulated within the framework of a broader programme of Czech Development Agency as called "Mission of Czech teachers to developing countries - support to increasing quality of higher education in partner developing countries"; and its implementation started in the year 2012. The main (developing) aim of the project is to support the educational process, research and international activities at SAUM through a series of organisational, professional and material inputs, which will lead the quality of SAUM's main activities to European standards. The project activities focus on higher quality of education by improving pedagogic competences of SAUM's teachers, assistance at formulating new study programmes and support to Scientific-Pedagogic Laboratory, which was established and equipped by the previous project of development cooperation realised in 2006–2008. In the field of science and research the project outputs are focused on identification of the common research topics, formulation of a joint research projects and scientific publications, support of the students' research activities and retrofitting Bio-energy Laboratory, which was also established within previous project. The main topics of Czech lecturers are: Renewable Energy Sources and Bio-energy, Waste Management, Pedagogic and Didactic Competences of University Teachers, IT Programmes in Education, etc. The projects main focus in 2014 is certification of bio-energy laboratory. The reason is that Moldova is short in fossil fuels and provision of fuels of domestic origin is its vital interest; certificates will also give opportunity to Moldovan producers of biofuels to enter European markets. This certification will bring SAUM to prestigious and very important position in the country. The other outputs of the project are focused on international cooperation and the promotion of the project and SAUM. Organisation of a Summer School for Moldovan and Czech (some Polish) students is a remarkable activity and a contribution to SAUM's international renomé. Impact of the project is to improve low quality of Moldovan high agricultural education by better preparation of the agricultural experts; that should reflect in the Moldavian agriculture and rural development.

Keywords: Bio-energy laboratory, education quality, project activities & outputs, SAUM, Scientific-pedagogic laboratory

Contact Address: Tatiana Ivanova, Czech University of Life Sciences Prague, Fac. of Trop. AgriSciences, Kamycka 129, 16521 Prague, Czech Republic, e-mail: ivanova@its.czu.cz

Community development and extension II

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