ETH GLOBAL

Capacity Development

20 years of the Research Fellow Partnership Programme, 1996–2015

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Research Fellow Partnership Programme

Funding and management

The Research Fellow Partnership Programme for Agriculture, Forestry and Natural Resources (RFPP) has been funded by the Swiss Agency for Development and Cooperation (SDC) since 1995. In total, SDC has invested CHF 12.5 million. These SDC funds were complemented by in-kind and cash contributions of at least 50% by the Swiss universities and their international partners. In addition, the programme generated several follow-up projects funded by other sources.

The RFPP has always been managed by ETH Zurich: The Swiss Centre for International Agriculture (ZIL) was the SDC contract partner from 1995 to 2007. In 2008 ZIL transformed into the North-South Centre, from which ETH Global emerged in 2012. The RFPP mandate and management have remained the same throughout these years.

The RFPP contract evolved over time: It started in 1995 with a narrow mandate on agriculture (RFPP-A) with a volume of kCHF 1'200, and was extended in 1997 with a new budget over kCHF 2'400. In 1998, it was complemented by a parallel contract on forestry (RFPP-F) amounting to kCHF 600. In 2002, both contracts were combined into the RFPP for Agriculture, Forestry and Natural Resources with a volume of kCHF 3'000. This contract was renewed in 2005, and has since then been extended a few times with a total budget of kCHF 5'280.

From 1996 until 2008, the programme was open to all research institutions in Switzerland. From 2008 onwards, SDC decided to reduce the scale and scope of the RFPP and to concentrate its investment on ETH Zurich only. Due to the changes in SDC's research policy, the RFPP expires with the last fellowships awarded in 2012, which will be concluded in 2015.

Fellowship portfolio

This folder portrays the entire portfolio of twenty years of capacity building through the RFPP. The first decade is covered by a table listing all 29 projects of that period. 26 projects of the second decade are comprehensively presented in chronological order.

Two doctoral candidates will only start in 2013 and are therefore not yet represented with an individual sheet. Ravinda Lakshan Senanayake will work on "Integrated nutrient management for sustained tuber production in water yam (*Dioscorea alata*)" in Sri Lanka under the supervision of Emmanuel Frossard (Group of Plant Nutrition). Partners of this project will be the Field Crops Research and Development Institute of the Department of Agriculture at Maha Ilupallama and the University of Peradeniya in Sri Lanka. Swati Negi will investigate "Social capital, REDD+ and rural communities in Nepal" under the co-supervision of Claude Garcia (Forest Management and Development Group), Jaboury Ghazoul (Chair of Ecosystem Management) and Klaus Seeland (Group Society, the Environment and Culture). She will collaborate with CIFOR in Bogor, Indonesia, and ICIMOD in Kathmandu, Nepal.

We are convinced that this SDC-funded programme will continue to reveal its impact in multiple ways, not only in the individual lives and careers of the fellows, but also through their contributions to society and through the follow-up of their research results, be they indirect as bases for further research or by direct implementation.

May 2013

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20 years of the Research Fellow Partnership Programme (1996 – 2015)

Philosophy

The Research Fellow Partnership Programme for Agriculture, Forestry and Natural Resources (RFPP) is a capacity building programme for young researchers from Switzerland and developing countries. It provides fellowships to doctoral or postdoctoral candidates who are embedded in a research partnership between a Swiss research institution and a centre of the Consultative Group on International Agricultural Research (CGIAR) or a comparable international or regional research centre.

The overall objective of the RFPP is to enhance the human resource base in international development. The programme aims at training young scientists, generating development relevant knowledge and establishing research partnerships.

It is an ambitious and highly competitive programme with a thorough review and selection procedure. Only about one third of all proposals is approved for funding.

Facts and figures

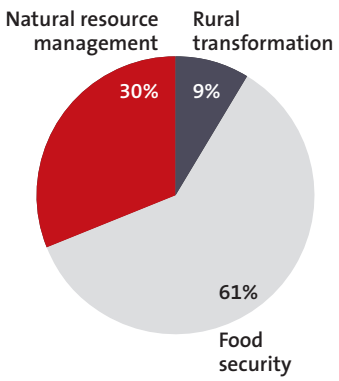
Since 1996, 57 RFPP fellowships have been approved. Among them are 40 fellowships at the ETH Zurich and 17 fellowships at the following Swiss universities: University of Basel incl. STI/Swiss TPH (6), EPF Lausanne (3), University of Zurich (2), University of Neuchâtel (2), IUED/IHEID Geneva (2), University of Berne (1) and the School of Agricultural, Forest and Food Sciences (HAFL) in Zollikofen (3, incl. 2 co-supervisions).

Total number of research fellows: 57	
39 male	18 female
42 doctoral	15 post-doc
25 from the North	32 from the South

Output

The RFPP has produced two types of outputs: research results and human capacities, as illustrated by the two examples overleaf. The individual benefits are further exemplified by the statements of Swiss fellows from the early RFPP period. The project sheets demonstrate the scope of research results. Furthermore, they put them into the context of anticipated development relevance, which is beyond the scope of the individual project.

Geographic distribution of RFPP research projects (1996 – 2015)



RFPP research topics (1996 – 2015)

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Research excellence

Devesh Rustagi was a RFPP doctoral fellow from 2008 to 2010. His work focused on the interaction between human behaviour and economic incentives. He used behavioural experiments to examine the role of diffuse and leader-based sanctioning institutions for forest management in Ethiopia. His study on economic incentives for the conservation of native coffee forests provides policy makers with crucial insights on conditions under which participatory forest management can be sustainably implemented, especially by better understanding the role of social preferences in designing incentives. This is the first study to examine interlinkages between a variety of social priorities and conventional parameters in a field setting, using a large sample of over 700 pastoralists from 50 forest user societies.

Devesh Rustagi (right) and players from a forest user society who took part in an economic experiment. Ethiopia, 2008

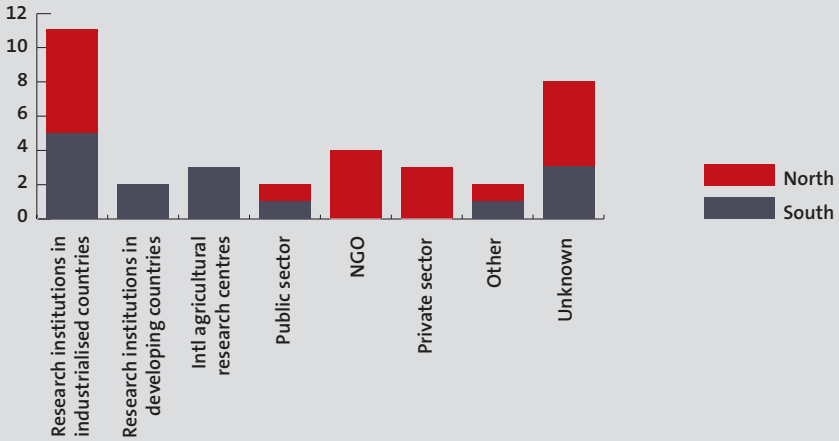
In 2010, Devesh Rustagi was awarded the first prize for excellent and policy relevant research by the KfW Entwicklungsbank. His RFPP research (with Stefanie Engel and Michael Kosfeld) was published in Science. Since 2013, he is Assistance Professor at the University of Frankfurt am Main, Germany.

Impressive careers

Thomas Bernet was a RFPP post-doctoral fellow from 2001 to 2005. In collaboration with the International Potato Center (CIP), SDC and partners in Peru, he developed the Participatory Market Chain Approach (PMCA). The objective of his research was to identify market opportunities for poor farmers. In this way, processed products from native potatoes and other Andean crops could be sold in the supermarkets of cities such as Lima. This generated income for the farmers and prevented their migration from the rural areas to the urban slums.

T. Bernet (left) explains the PMCA to Federal Councillor M. Calmy-Rey. Dare to Share Fair, Berne/Switzerland, 2004

After his RFPP assignment, Thomas Bernet became an independent consultant. “The lessons learnt during the RFPP assignment inspired me to capitalise on them in the private sector. I took on the exciting task of market and product development for underutilized Andean crops and I also got involved in training activities in Uganda, Laos and Nicaragua.” Today, Thomas Bernet is project manager at the Research Institute of Organic Agriculture in Frick (FiBL).



Current positions of former RFPP research fellows

“The RFPP programme has an exceptionally high leverage effect for nurturing long-standing international research partnerships in order to tackle the global research agendas while employing high-end scientific approaches.”

Claudia Daubenberger, Swiss Tropical and Public Health Institute, University of Basel (2011)

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Overview of RFPP fellowships 1996 – 2005

Project Title	Researcher(s) (*Fellowship type and duration*)	Participating Institutes	Participating Researchers	Budget
Barley yellow dwarf virus (BYDV) in bread wheats	Ligia Ayala *PhD* *1996 – 1999*	CIMMYT, Mexico; Institute of Plant Biology, University of Zurich; Institute of Plant Sciences, ETH Zurich	Dr. M. Van Ginkel; Prof. B. Keller; Prof. I. Potrykus	USD 207'558
Phosphorus efficiency in lowland rice cultivars	Olivier Huguenin *PhD* *1996 – 1999*	IRRI; Institute of Plant Sciences, ETH Zurich	Dr. J. Kirk; Prof. E. Frossard; Dr. S. Sinaj; Dr. A. Mozafar	USD 178'505
Rice plastids for insect pest control	L. Nandadeva *PhD* *1996 – 1999*	IRRI; Institute of Plant Sciences, ETH Zurich	Prof. I. Potrykus; Dr. R. Bilang; Dr. J. Wünn; Dr. M. Cohen	CHF 101'980
Micro-satellite markers to facilitate use of the cassava molecular genetic map and provide new genetic information	Chikelu Mba *Postdoc* *1997 – 1999*	CIAT, Colombia; Institute of Plant Sciences, ETH Zurich	Dr. M. Fregene; Dr. J. Tohme; Prof. K. Apel; Dr. S. Melzer	CHF 100'000
Maize genotypes to promote the effectiveness of biological control agents	Mary Fritzsche *PhD* *1997 – 2000*	University of Neuchatel; CIMMYT, Mexico	Dr. T. Turlings; Dr. D. Bergvinson	CHF 203'822
Regeneration and transformation of African cassava germplasm	Bertrand Hankoua *PhD* *1998 – 2003*	IITA, Nigeria; Institute of Plant Sciences, ETH Zurich; Dep. of Crop Protection and Environmental Biology, University of Ibadan, Nigeria	Dr. Shou Yong Choy NG; Dr. Puonti-Kaerlas; Dr. Iyi Fawole	USD 117'111
Enhancing the analytic hierarchy process as a decision tool for biotechnology programs	Thomas Braunschweig *Postdoc* *1998 – 2001*	ISNAR; Institute of Agricultural Economics, ETH Zurich	Dr. W. Janssen; Prof. P. Rieder	CHF 299'700

▶▶

RFPP ermöglichte mir, als Wissenschafter in einem spannenden internationalen Umfeld zu reifen. Durch die Arbeit in mehreren Ländern konnte ich meinen persönlichen Horizont erweitern und ein breites Netzwerk aufbauen. Am Anfang einer beruflichen Karriere ist solche Erfahrung äusserst wertvoll.

Thomas Braunschweig (RFPP Fellow 1998 – 2001)

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Research Fellow Partnership Programme

Project Title	Researcher(s) (*Fellowship type and duration*)	Participating Institutes	Participating Researchers	Budget
Maize genotypes for tolerance to drought, low soil nitrogen and soil acidity	Tenford Manda *PhD candidate* *1999 – 2000* (deceased)	CIMMYT, Zimbabwe; Institute of Plant Sciences, ETH Zurich; CIMMYT, Mexico	Dr. M. Bänziger; Prof. P. Stamp; Dr. W. Richner; Dr. T. Reeves	USD 116'000
The impact of trade reform and other policies on rural poverty and the environment: The case of San Dionisio, Nicaragua	Esther Leemann *PhD* *1999 – 2002*	CIAT, Nicaragua; EAWAG; NSSI, ETH Zurich; CDE, University of Berne	Dr. R. Knapp; Dr. D. Thomas; Prof. P. Baccini; Prof. R. Scholz; Dr. C. Binder; Prof. H. Hurni	CHF 244'800
Evaluation of indicators and verifiers to assess the biodiversity of tropical forests: landscape and water quality indicators	Pascale Derleth *PhD* *1999 – 2003*	Gestion des Ecosystèmes, EPF Lausanne; CIFOR, Indonesia; Museum of Zoology, Lausanne	Prof. R. Schläpfer; Dr. J. Gede; M. Sartori	CHF 199'845
Strategies to increase feed utilization and to limit methane emission of tropical smallholder livestock using the potential of native plants	Hans-Dieter Hess *Post-doc* *2000 – 2003*	Institute of Animal Sciences, ETH Zurich; CIAT, Colombia; CORPOICA, Colombia; National University of Colombia, Bogota	Prof. M. Kreuzer; Dr. C.E. Lascano; Dr. M. Rondòn; Dr. T.E. Diaz; Prof. J. E. Carulla	USD 240'000
Knowledge and strategies of local people in forest management in the walnut-fruit forests in Kyrgyzstan	Kaspar Schmidt *PhD* *2001 – 2004*	Chair of Silviculture, ETH Zurich; CIFOR; University of Reading	Dr. J-P. Sorg; Dr. C. Colfer; Prof. J. Northridge	CHF 195'540
Modelling the growth and development of yam (*Dioscorea* spp.)	Lucien Diby *PhD* *2001 – 2004*	Institute of Plant Sciences, ETH Zurich; CSRS, Côte d'Ivoire; Université de Cocody, Côte d'Ivoire; Ecole Superieure d'Agronomie, Côte d'Ivoire; IITA	Prof. E. Frossard; Dr. Ch. Gujan; Dr. O. Girardin; Prof. A. Assa; Dr. Tie Bi Tra Dr. R. Carsky	CHF 209'300

▶▶

Neben meiner Familie war RFPP etwas vom Besten, das mir im Leben passieren konnte. Ich habe gelernt, internationale Forschungsprojekte über sprachliche und kulturelle Grenzen hinweg aufzubauen und zu leiten, und konnte meine wissenschaftlichen und sozialen Kompetenzen massgeblich verbessern.

Hans Dieter Hess (RFPP Fellow 2000 – 2003)

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Project Title	Researcher(s) (*Fellowship type and duration*)	Participating Institutes	Participating Researchers	Budget
Variability in *Phytophthora infestans* and its potential role in breeding for resistance in potato	Gabriela Chacon *PhD* *2001 – 2004*	CIP, Peru; Institute of Plant Sciences, ETH Zurich	Dr. G. Forbes; Prof. B. McDonald; Dr. C. Gessler	USD 146'000
Effective regional research and development processes in rural areas of the Andes	Thomas Bernet *Post-doc* *2001 – 2004*	CIP, Peru; Institute of Agricultural Economics, ETH Zurich	Dr. M. Herrmann; Dr. Th. Walker; Prof. B. Lehmann	CHF 394'490
Demand and supply for ecosystem services from tropical forestry	Thomas Koellner *Post-doc,* and Joachim Sell *PhD* *2002 – 2004*	NSSI; ETH Zurich; CATIE; CIFOR	Prof. R. Scholz; Dr. L. Pedroni	CHF 327'502
Particpatory development of cassava green mite biocontrol in the higlands of Cameroon	Christine Zundel *PhD* *2002 – 2005*	HAFL Zollikofen; University of Basel; IITA	Dr. Urs Scheidegger; Prof. P. Nagel; Dr. R. Hanna	CHF 273'185
Water savings and increased productivity in water-scarce basins: A DSS for improved irrigation management	Nicolas Roost *Post-doc* *2002 – 2005*	EPF Lausanne; IWMI	Prof. A. Musy; Dr. D. Molden	CHF 226'381
Fiscal incentitives for community forestry: Procedural legitimacy in co-management of forests by multiple stakeholders	Frank Muttenzer *PhD* *2002 – 2005*	IUED Geneva; ESSA, Madagascar; Lab d'Antropologie de Paris	Dr. M. Hufty; B. Ramamonjisoa	CHF 80'000
Development and implementation of an aquaculture health management plan in support of the small-scale fish farming program in rural communities of South Africa	Ralph Knuesel *Post-doc* *2003 – 2005*	Uni Berne; University of Stellenbosch, South Africa; World Fish Centre	Prof. H. Segner; Dr. T. Wahli; Dr. D. Brink	CHF 199'947

RFPP hat den Grundstein für meine berufliche Entwicklung gelegt. Im Dialog mit anderen etwas zu erschaffen, das Hand und Fuss hat, ist heute eine meiner meist gebrauchten Fähigkeiten. Eine weitere Lektion war, das Ziel auch bei widrigen Umständen im Auge zu behalten, aber in der Umsetzung offen und pragmatisch zu sein.

Christine Zundel (RFPP Fellow 2002 – 2005)

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Project Title	Researcher(s) (*Fellowship type and duration*)	Participating Institutes	Participating Researchers	Budget
Improving resistance to barley scald through understanding the processes that govern the evolution of *Rynchosporium secalis* populations	Matthew Abang *Post-doc* *2003 – 2006*	Institute of Plant Sciences, ETH Zurich; ICARDA, Syria	Prof. B. McDonald; Dr. C. Linde; Dr. A. Yahyaoui	CHF 399'948
Indigenous arbuscular mycorrhizal fungi (AMF) from the "yam belt" for improved yam growth and reduced yam nematode infestation in West Africa	Atti Tchabi *PhD* *2004 – 2006*	Institute of Botany, University of Basel; IITA, Benin	Prof. A. Wiemken; Prof. Th. Boller; Dr. F. Oehl; Dr. D. Coyne	CHF 205'588
Development of a second generation anti-tick vaccine using a mimotope-virosome approach	David Odongo *Post-doc* *2004 – 2006*	Swiss Tropical Institute, Basel ILRI, Nairobi	Dr. C. Daubenberger; Dr. R. Bishop	CHF 292'900
Development on an *in vitro* protocol for the production of cassava doubled haploids and its use in breeding	Changhu Wang *Post-doc* *2004 – 2006*	CIAT Colombia; Institute of Plant Sciences, ETH Zurich	Dr. H. Ceballos; Dr. Z. Lentini; Prof. W. Gruissem; Dr. P. Zang	CHF 229'258
The impact of organic cotton cultivation on the livelihood of Indian smallholders	Frank Eyhorn *PhD* *2004 – 2007*	FiBL, Frick; NADEL, ETH Zurich; CDE, University of Berne; IWMI, India; Maikaal bioRe, India	Dr. A. Mäder; Prof. R. Baumgartner; Prof. U. Wiesmann; Dr. T. Shah; Mr. R. Baruah	CHF 55'000
Exotic strains of *Phytophthora infestans* in the Andes – Genetically isolated curiosities or time bombs for native Solanaceous crops?	Ricardo Francisco Oliva Pérez *PhD* *2005 – 2008*	CIP Peru; Institute of Plant Sciences, ETH Zurich; Plant Research International, Wageningen	Dr. G. Forbes; Dr. C. Gessler; Dr. W. Flier	CHF 255'320
Social practices and conservation policies: Enhancing livelihoods through sustainable forest management in Madagascar	Sajad Bukobero *PhD* *2005 – 2008*	IUED, Geneva; ESSA, Madagascar; ETH Zurich; CIFOR, Indonesia	Dr. M. Hufty; Dr. B. Ramamonjisoa; Dr. J-P. Sorg; Prof. B. Campbell	CHF 149'000
Drinking water treatment in Tanzania using seed extracts from the pantropical tree *Moringa oleifera*	Markus Schneider *PhD* *2005 – 2008* (discontinued)	EPF Lausanne; Uni Dar-Es-Salaam, Tanzania; ICIPE, Kenya; ETH Zurich	Dr. I. Marison; Prof. T. Mbwette; Prof. A. Hassanali; Prof. em. P. Lüthy	CHF 286'110
Prosopis in arid and semi-arid regions of Kenya – A case of ecological meltdown?	Walter Ogutu *Post-doc* *2005 – 2007* (deceased)	CABI Africa, Kenya; CABI Switzerland, Delémont; Geobotanical Institute, ETH Zurich	Dr. J. Mauremootoo; Dr. U. Shaffner; Prof. P. Edwards	CHF 322'200

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Understanding yam (*Dioscorea* spp.) response to mineral fertiliser application

Free yam tuber growth (N treatment)
Photo: V. K. Hgaza Kouassi

Research fellow
Valéry Kouamé Hgaza Kouassi

PhD supervisor
Emmanuel Frossard, ETH Zurich, Switzerland

Further institutions involved
Centre Suisse de Recherches Scientifiques (CSRS), Côte d'Ivoire;
Université de Cocody-Abidjan, Côte d'Ivoire

Duration of the project
December 2005 – June 2010

Budget
CHF 448'880
SDC contribution: CHF 210'880 / Partner contribution: CHF 238'000

Objective

Yams (*Dioscorea* spp.) are a staple tuber crop for many of the poorest in Nigeria, Ghana, Togo, Benin, Côte d'Ivoire and Cameroon. This crop demands a very high soil fertility level and therefore is usually grown first after long-term fallowing. Due to increasing population pressure the available area under long-term fallowing is, however, rapidly diminishing in these countries. Nevertheless, the demand for these tubers keeps increasing – also due to the growing population. Therefore, approaches have to be developed to establish yams in crop rotations and to increase their productivity.

Adequate mineral or organic fertiliser inputs could be considered to palliate the low soil fertility of cultivated soils. However, until now, field trials have shown variable response of yams to mineral fertiliser applications – which can be positive, null or even negative. We hypothesised that these variable responses are related to an inefficient uptake of nutrients derived from the fertiliser itself, which in turn is related to a limited root density. This study was undertaken to characterise the root system growth and its spatial distribution in *Dioscorea alata* cv. TDa 95/00010 grown in mounds with and without fertiliser application.

Results

The root system of yam was characterised by low density with shallow and heterogeneous distribution. Mineral fertiliser did not significantly affect root growth. However, roots were longer and thinner under relatively high soil temperature (28 – 31°C) and shorter and coarser roots when soil temperature declined by about 4 – 5 °C. Despite the heterogeneous distribution and the low density of the root system, nitrogen (N) use efficiency by the plant reached 46%, suggesting that the root system was not the limiting factor in yield formation. Mineral fertiliser inputs significantly increased the tuber yield. However, the increase in tuber yield did not reflect the increase in biomass production and nutrient uptake by the plant in the first field trial year (2006). The source-sink relationship study showed that the fixation of carbon by the aerial organs and its partitioning is controlled by the tuber development, but the capacity of the tuber to attract assimilates is strongly linked to the balance between potassium (K) and N in the growing tuber. The tuber dry matter was higher in the second field trial year (2007), when a balance was observed between K and N in the tuber (K:N≈1), compared to the tuber yield in 2006, when K concentration was higher than N (K:N>1). The unbalance between K and N in the tuber was observed in 2006 when the solar radiation was higher ▶▶

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Valéry Kouamé Hgaza Kouassi: Understanding yam (*Dioscorea* spp.) response to mineral fertiliser application

(656 MJ m^{-2}). By contrast, the balance between K and N in the tuber was observed in 2007 when the solar radiation was lower (547 MJ m^{-2}). These results suggest that the weather variability in time and space may explain the year-to-year variability of the yield in response to mineral fertiliser application (NPK) observed across the production areas.

Publications

Hgaza, V.K., Diby, L.N., Oberson, A., Tschannen, A., Tié, B.T., Sangakkara, U.R., Aké, S. and Frossard, E., 2012: Nitrogen use by yam as affected by mineral fertilizer application. *Agronomy Journal*, 104:1558 – 1568.

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Hgaza, V.K., Diby, N.L., Aké, S. and Frossard, E., 2009. Leaf growth and photosynthetic capacity as affected by leaf position, plant nutritional status and growth stage in *Dioscorea alata* L. *Journal of Animal & Plant Sciences* 5(2):483 – 493.

http://m.elewa.org/JAPS/2009/5.2/4.pdf

Root system of yam (*Dioscorea* spp.) consisting of adventitious roots originating from the primary nodal complex and tuber roots arising from the tuber
Photo: V. K. Hgaza Kouassi

Further information

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Enhancing the livelihood of the local population in a biodiversity hotspot

Students learn the ways of cultivation during an informal talk in a cassava field
Photo: L. Andriambelo

Research fellows
Lanto Herilala Andriambelo, L'Ecole Supérieure des Sciences Agronomiques (ESSA), Madagascar; Clémence Dirac, ETH Zurich, Switzerland

PhD supervisors
Alexandre Buttler, EPF Lausanne, Switzerland; Gabrielle Rajoelison, ESSA, Madagascar; Jean-Pierre Sorg, ETH Zurich, Switzerland

Further institutions involved
University of Neuchâtel, Switzerland; The Graduate Institute, Geneva, Switzerland; Center for International Forestry Research (CIFOR), Indonesia; Le Centre de Formation Professionnelle Forestière, Madagascar; Centre National de Recherches sur l'Environnement, Madagascar; Programme SAHA Menabe, Madagascar

Duration of the project
November 2005 – October 2009

Budget CHF 348'495
SDC contribution: CHF 249'995 / Partner contribution: CHF 98'500

Objective

In the dry region of Central Menabe, along the west coast of Madagascar, clearing has drastically reduced the once large forests. The main goal of this project was to set up scientific recommendations for a multifunctional and participatory management of this forest landscape.

Results

Of the 192 inventoried wood species, about 30 are traditionally collected and used by the local population. The population prefers six of these because of their technical characteristics. Although these species are decreasing, the population can satisfy its needs by adapting to other species. Villager associations manage the forests in five of the seven studied villages. However, the members of these associations are obliged to participate by NGOs and the state. Therefore, they do not feel responsible for the forest.

With respect to agricultural land use, extending rain-fed rice cultivation areas and using agricultural natural fertilisers are suitable means to improve rural livelihoods and to conserve biodiversity. Under certain conditions, improving the sanitary state of chicken and introducing payments for environmental services would be suitable as well. However, such programmes need appropriation by locals.

Based on our findings we furthermore recommend reducing the ecological degradation by improving the management of pasture lands; managing the forest landscape in order to satisfy the needs of the local population as regards forest products for local use; including commercial activities into the forest management which do not exploit wood (such as ecotourism, or apiculture); conveying a sense of responsibility to the local population by including them in the forest management.

Development relevance

The researchers proposed management recommendations for the central Menabe forest landscape taking into account the local population and biodiversity. These recommendations could be the basis for a political discussion on how to improve the forest landscape management of the region. All partners thought that the diffusion of this scientific information to the local stakeholders (local NGOs, villagers, regional Government, etc.) was necessary. A follow-up project for the validation and extrapolation of the results could unfortunately not be realised due to the lack of funds.

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Lanto Herilala Andriambelo and Clémence Dirac: Enhancing the livelihood of the local population in a biodiversity hotspot

Dissemination

The project resulted in two PhDs and seven students with different diplomas (DEA or Master). Altogether, 14 publications have been written, and the PhD students presented the project and their theses 20 times in conferences.

Publications

Andriambelo, L. H., 2010: Critères de gestion durable des ressources ligneuses de l'espace forestier du Menabe Central, Madagascar. PhD thesis, ESSA Antananarivo, Madagascar.

Graf, E., Andriambelo, L.H. and Sorg, J.-P., 2009: Availability and utilization of four timber tree species in Menabe, Madagascar. *Bois et Forêts des Tropiques, Forêts Sèches, Problèmes Écologiques et Sociaux*, 302(4): 33 – 41.

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Andriambelo, L. H., 2008. A sensitive question: Biodiversity conservation with the local population: A case study in Central Menabe, Madagascar. *Tropentag 2008 "Conference on International Research on Food Security, Natural Resource Management and Rural Development"*, University of Hohenheim, Stuttgart, Germany, 7 – 9 October 2008.

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Dirac Ramohavelo, C. and Sorg, J.-P., 2008: Using NTFPs to drive rural development without threatening biodiversity? A concrete example concerning four NTFPs in Central Menabe, Madagascar. *Tropentag 2008 "Conference on International Research on Food Security, Natural Resource Management and Rural Development"*, University of Hohenheim, Stuttgart, Germany, 7 – 9 October 2008.

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Cooking as an example of everyday use of wood products
Photo: L. Andriambelo

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Control options for the African root and tuber scale on cassava

Monitoring of soil temperature in the forest, southern Cameroon
Photo: Apollin Fotso Kuate

Research fellow
Apollin Fotso Kuate

PhD supervisors
Peter Nagel, University of Basel, Switzerland;
Rachid Hanna, International Institute of Tropical Agriculture (IITA), Cameroon

Further institution involved
University of Douala, Cameroon

Duration of the project
November 2006 – March 2010

Budget
CHF 312'680
SDC contribution: CHF 160'000 / Partner contribution: CHF 152'680

Objective

The African root and tuber scale *Stictococcus vayssierei* is a major pest in the forest zone of Central Africa where it infests at least ten cultivated crops with greatest occurrence on cassava. In southern Cameroon, our research has focused on understanding factors responsible for the recent increase in pest status of *S. vayssierei*. The scale is closely associated with the ant *Anoplolepis tenella*, which is considered essential for scale survival and dispersal. One of the key questions that we have addressed in the process of developing scale control options is the question about the nature of its interactions with the ant *A. tenella*, and the conditions that promote the abundance and proliferation of the ant.

Results

In initial studies, we monitored ant diversity in the predominant vegetation types in the forest zone of southern Cameroon and collected various associated data to determine the factors affecting the observed distribution. We then conducted laboratory and screenhouse experiments to understand how *A. tenella* interacts with other dominant co-occurring ant species and completed experiments that demonstrated the active role of *A. tenella* in scale dispersal. Subsequently, we devoted much of our efforts to the development of baits for *A. tenella*. Ant control in cassava farms using boric acid-sucrose solution could reduce scale infestation on cassava and increase yield by 16%.

In brief, we achieved the following results:

- The diversity and abundance of ants in southern Cameroon is known;
- The factors affecting ant assemblage in southern Cameroon is known;
- Six new ant species were found;
- The toxicity of boric acid on *A. tenella* is known;
- The role of ants in scale dispersal has been established.

With respect to application the most relevant results were:

- Scale infestation tolerance has been shown on IITA-improved cassava TMS96/0023;
- Scale infestation has been reduced with removal of the scale host plant before cassava planting.

Development relevance

The project has been successful in developing baits for the control of the ant that tends the African root and tuber scale. This solution however needs further development to make an attractant with composition similar to scale honeydew to make it more efficient. The deliverable result we are implementing with farmers in various locations in Cameroon is the distribution of scale tolerant cassava varieties.

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Apollin Fotso Kuate: Control options for the African root and tuber scale on cassava

Dissemination

We have been assisting the national program of root and tuber in the dissemination of five tolerant cassava varieties at the farmer level. To make this operation more successful, small-scale farmers in central Africa will require diffusion of improved cassava varieties and technology transfer for better agronomic practices. The project could also help in identifying factors limiting the adoption or the diffusion of improved varieties through social studies.

Publications

Fotso Kuate, A., 2011: Towards the development of sustainable control options for the African root and tuber scale on cassava in Central Africa. Understanding the biology and ecology of the tending ant *Anoplolepis tenella* (Hymenoptera, Formicidae). Dissertation, University of Basel, Faculty of Science.

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Fotso Kuate, A., Tindo, M., Hanna, R., Kenne, M., and Goergen, G., 2008: Foraging activity and diet of the ant *Anoplolepis tenella* Santschi (Hymenoptera: Formicidae) in southern Cameroon. *African Entomology*, 16(1): 107 – 114.

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Fotso Kuate, A., Tindo, M., Hanna, R., Kenne, M., and Goergen, G., 2006: Field abundance and nest structure of the ant *Anoplolepis tenella* associated with the African root and tuber scale in the Congo Basin. *1st International Symposium on Crops Integrated Pest Management in the CEMAC Zone*, Dschang, Cameroon, 6 – 9 December 2005.

Village meeting with farmers in Awae, Cameroon
Photo: Apollin Fotso Kuate

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Analysis and initial exploitation of resistance to wheat stem rust race Ug99

The Avocet/Pavon population at KARI-Njoro showing different entries at different levels of infection
Photo: P. N. Njau

Research fellow
Peter Njoroge Njau

Postdoc supervisors
Beat Keller, University of Zurich, Switzerland;
Ravi P. Singh, International Centre for Maize and Wheat Improvement (CIMMYT), Mexico

Further institution involved
Kenya Agricultural Research Institute (KARI), Kenya

Duration of the project
January 2007 – July 2011

Budget
CHF 249'471
SDC contribution: CHF 168'471 / Partner contribution: CHF 81'000

Objective

Ug99 is a lineage of wheat stem rust (*Puccinia graminis* f. sp. *tritici*), which is present in wheat fields in several countries in Africa and the Middle East and is predicted to spread rapidly through these regions and possibly further afield, potentially causing a wheat production disaster that would affect food security worldwide. It can cause up to 100% crop losses and is virulent against many resistance genes which have previously protected wheat against stem rust. This project aimed at (i) identifying improved wheat germplasm resistant to the Ug99 race of stem rust, and (ii) characterising the "Avocet/Pavon 76" mapping population for stem rust.

Results

The status of Kenyan varieties in relation to resistance to stem rust was documented. This information has been used in designing the wheat breeding programme in Kenya. Advanced lines from CIMMYT were classified according to the type of resistance, either adult plant or major gene. Main sources of resistance to stem rust Ug99 were found to be Sr25 and Sr24. Sr2 has been found to offer partial resistance. Resistance was also found in some lines with Chinese background while in a few lines the sources of resistance were not known. This information was used to develop mapping and breeding populations. Five QTL for adult plant resistance were mapped using the Avocet / Pavon populations.

Development relevance

Two wheat varieties with partial resistance to stem rust were released in Kenya: Robin, a red grained hard wheat and Eagle10, a red wheat, which is early maturing. These varieties are already being grown by our wheat farmers.

The varieties have been registered in Kenya for commercial production. In 2011 we produced breeder seed which was taken by one of the leading seed companies in Kenya (Kenya Seed Company). Through collaboration with a project funded by the World Bank we have been able to multiply and distribute over 100 tons of seed of the new varieties to small-scale farmers in Kenya. In addition, in 2012 we produced and distributed over 300 tons of seed to commercial farmers. We are also promoting the new varieties through field days and demonstrations. In 2013 we expect to produce and distribute more than 1000 tons of seed. The two varieties are expected to cover 30% of all wheat grown in Kenya in 2014.

Dissemination

400 tons of seed have been distributed to farmers who own less than 2 acres each (4000 farmers). The varieties have also been sent to Uganda for evaluation and adoption by wheat farmers. We have also used the two varieties in our breeding program with the aim of introducing the resistance into our new varieties. ▶▶

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Peter Njoroge Njau: Analysis and initial exploitation of resistance to wheat stem rust race Ug99

Publications

Njau, P. N., Bhavani, S., Huerta-Espino, J., Keller, B. and Singh, R. P., 2013: Identification of QTL associated with durable adult plant resistance to stem rust race Ug99 in wheat cultivar "Pavon76". *Euphytica*, 190: 33 – 44.

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Njau, P.N., Wanyera, R., Macharia, G. K., Macharia, J., Singh, R. and Keller, B., 2009: Resistance in Kenyan bread wheat to recent eastern African isolate of stem rust, *Puccinia graminis* f. sp. *tritici*, Ug99. *Journal of Plant Breeding and Crop Science*, 1(2): 022 – 027.

http://www.academicjournals.org/JPBCS/PDF/pdf2009/Apr/Njau%20et%20al.pdf

Blocks of the new wheat lines at a trial site in Timau, Kenya
Photo: P. N. Njau

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Estimating effective population size for the conservation of African cattle breeds

Sheko heifer in Ethiopia
Photo: A. Workneh

Research fellow
Christine Flury

Postdoc supervisors
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Henner Simianer, University of Goettingen, Germany;
Olivier Hanotte, University of Nottingham, UK

Further institution involved
International Livestock Research Institute (ILRI), Kenya

Duration of the project
February 2007 – March 2010

Budget
CHF 318'000
SDC contribution: CHF 180'000 / Partner contribution: CHF 138'000

Objective

Demographic information is often lacking for livestock breeds of the developing world. Therefore, effective population size – a major criterion to assess the degree of breed endangerment – cannot be calculated. However, basic population information is crucial for priority-setting and decision-making in livestock conservation, and consequently, for a sustainable management of local breeds. In this project, a molecular method for the efficient estimation of effective population size is proposed. We are investigating the use of genome-wide Single Nucleotide Polymorphisms (SNPs) to estimate the effective population size of two indigenous African cattle populations (N'dama, Sheko) and one reference population (Swiss Eringer).

Results

Effective population size (Ne) is an important parameter for the assessment of genetic diversity within a livestock population and its development over time. If pedigree information is not available, linkage disequilibrium (LD) analysis might offer an alternative perspective for the estimation of effective population size. For all three breeds derivation of effective population size using the information from LD was possible. In the reference population the estimates for recent Ne using pedigree information were slightly higher than the marker based estimates. This slight upward bias is explained with the restricted nature of pedigree information. All three breeds showed a drastic drop in recent Ne from Ne > 300 animals 25 generations ago to 28 animals (N'Dama), 41 (Sheko) and 92 animals (Swiss Eringer, reference breed) for actual Ne (1 generation ago). The lowest recent Ne for N'Dama is suprising, as this breed is the one with the highest actual population size (> 3 Mio heads (DAD-IS, 2010)). The unexpected low recent Ne might be a result of the sampling procedure (e.g. sampling within inbred herds). For conservation activities, requiring knowledge on recent population history (< 50 generations) and using physical map distances directly for the estimation of effective population is adequate.

Development relevance

The research stays at ILRI offered interesting insights in a CGIAR centre. The exchange with scientist from around the world working on animal breeding and genetics was very interesting. Beside the Biotechnology group (ILRI-theme 4) researchers of other relevant areas related to livestock could be met. The collaboration with the project partners allowed the expansion and strengthening of networks – besides others namely with ILRI and the University of Goettingen.

Dissemination

The results were subject to one peer-reviewed publication in a scientific journal and four contributions to scientific conferences and the corresponding books of abstracts.

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Christine Flury: Estimating effective population size for the conservation of African cattle breeds

Publications

Flury, C., 2009: Bestimmung der Diversität von Rinderrassen – hilft genomweite Information weiter? *Impuls* 11/2009.

Flury, C., Tapio, M., Sonstegard, T., Drögemüller, C., Leeb, T., Simianer, H., Hanotte, O. and Rieder, S., 2010: Effective population size of an indigenous Swiss cattle breed estimated from linkage disequilibrium. *Journal of Animal Breeding and Genetics*, 127(5): 339 – 347.

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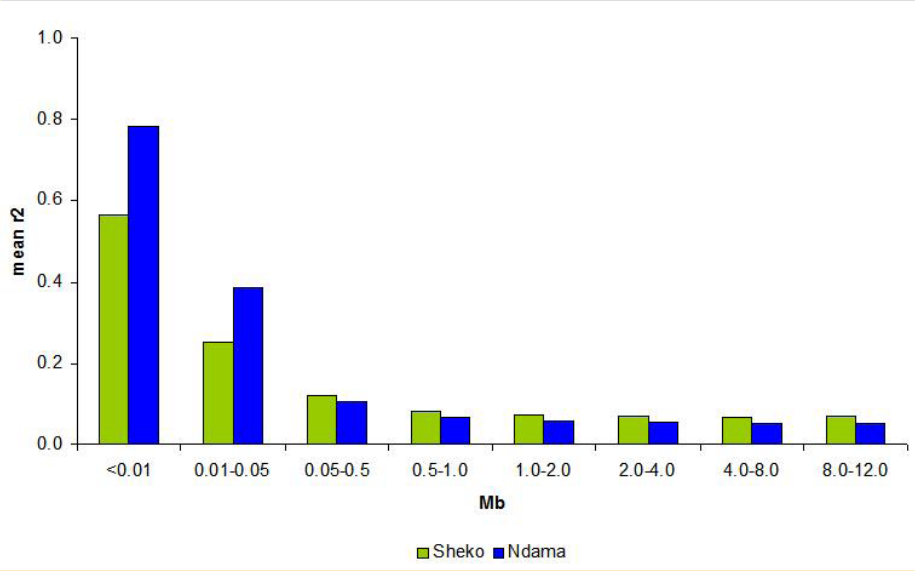

Levels of LD based on 132'826 and 77'257 SNP-pairs for the Sheko and N'Dama sample, respectively

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Exploiting scents of distress: Making maize plants more attractive to beneficial insects

Maize plant infested with a larva of the fall armyworm
Photo: M. D'Alessandro

Research fellow
Marco D'Alessandro

Postdoc supervisor
Ted Turlings, University of Neuchâtel, Switzerland

Further institutions involved
International Centre for Maize and Wheat Improvement (CIMMYT), Mexico;
Max Planck Institute for Chemical Ecology, Germany

Duration of the project
May 2007 – September 2009

Budget
CHF 511'246
SDC contribution: CHF 170'046 / Partner contribution: CHF 341'200

Objective

The fall armyworm *Spodoptera frugiperda* is one of the most destructive insect pests of maize in the Americas, where it causes severe economic losses to farmers. In Mexico, this pest is commonly controlled with synthetic insecticides, which pose hazards to the environment and humans. Moreover, resistance has been observed and many small-scale farmers might not be able to cope with an increasing demand of insecticides. Thus, biological control of fall armyworm is considered a highly desirable alternative to reduce the damage by *S. frugiperda* on maize. The aim of this project was to improve biological control in maize against the fall armyworm by exploiting the plants' natural indirect defence mechanisms. Such a mechanism is the emission of volatile compounds upon herbivore attack. These so-called herbivore-induced plant volatiles are highly attractive to natural enemies of the herbivore, but they also induce defence mechanisms in nearby plants. Manipulating the emission of such volatile compounds constitutes a promising approach to improve biological control in maize.

Results

We made significant progress towards a better understanding of volatile compounds. In particular, we observed a remarkably strong attraction of the parasitic wasp species *Cotesia marginiventris* to some minor compounds that are only emitted in low quantities, below the detection threshold of chemical analysis methods. In a second part, we assessed the attractiveness of several CIMMYT maize lines, i.e. drought resistant, insect resistant, and high quality protein breeding lines. We found considerably differences in the volatile emission of these maize varieties and resulting differential attraction of two parasitoid species.

Two approaches aimed to enhance biological control in the field. The first one consisted in spraying plants with elicitors that induce plant defences. We observed that this compound made young maize seedlings more resistant against *Bipolaris maydis*, a major fungal pathogen at the CIMMYT field station in Agua Fria. Concerning parasitism rates and herbivory damage the results were inconsistent and showed strong seasonal variations. In a second approach we applied dispensers releasing so-called green leafy volatiles (GLVs) next to maize plants. Our data suggest that plants exposed to GLVs released indeed significantly higher amounts of certain herbivore induced plant volatiles than plants that were not exposed to these compounds. However, instead of enhancing biological control they rather increased the number of plants infested with *S. frugiperda* in certain fields that we sampled during the year. This work illustrates the enormous importance of volatile compounds, both in affecting defence responses of plants as well as in shaping the insect community structure.

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Marco D'Alessandro: Exploiting scents of distress: Making maize plants more attractive to beneficial insects

Development relevance

We now better understand the role that certain volatile compounds emitted by herbivore-infested maize seedlings play in attracting natural enemies. This work contributes to further evaluate different approaches to enhance biological control in maize. Finally and most important, as volatile compounds have multiple signalling functions, ranging from the activation of plant defences to the attraction or repellence of certain herbivores and their natural enemies, it seems important that any approach aiming to manipulate the volatile blend to improve biological control also includes rigorous fields tests before being widely propagated.

Dissemination

We discussed our approaches with maize breeders of CIMMYT Mexico, and shared ideas with Mexican researches at the Instituto Politécnico Nacional (CINVESTAV). A review paper has been presented at the Third International Symposium on Biological Control of Arthropods in February 2009 in Christchurch, New Zealand.

Publications

D'Alessandro, M., Brunner, V., von Mérey, G., and Turlings, T., 2009: Strong attraction of the parasitoid *Cotesia marginiventris* towards minor volatile compounds of maize. *Journal of Chemical Ecology*, 35: 999 – 1008.

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Erb, M., Flors, V., Karlen, D., De Lange, E., Planchamp, C., D'Alessandro, M., Turlings, T. and Ton, J., 2009: Signal signature of aboveground-induced resistance upon belowground herbivory in maize. *The Plant Journal*, 59: 292 – 302.

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D'Alessandro, M., Hiltpold I., von Mérey, G., and Turlings, T., 2008: Prospects of exploiting herbivore induced plant volatiles to enhance biological control in maize. In: Mason P.G., Gillespie D.R. & Vincent C. (ed.), *Proceedings of the Third International Symposium on Biological Control of Arthropods*. Christchurch, New Zealand, 8 – 13 February, 2009. United States Department of Agriculture, Forest Service, Morgantown.

Ton, J., D'Alessandro, M., Jourdie, V., Jakab, G., Karlen, D., Held, M., Mauch-Mani, B. and Turlings, T., 2007: Priming by airborne signals boosts direct and indirect resistance in maize. *The Plant Journal*, 49: 16 – 26.

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Entomology team at the CIMMYT Station in Agua Fría near Poza Rica, State of Veracruz, Mexico, 2007
Photo: M. D'Alessandro

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Mycorrhiza and maize yields in different land-use systems in Southern Cameroon

Flowering of maize in a P-fertilised plot in the third cropping cycle on a previously forested area, Cameroon
Photo: M. Jemo

Research fellow
Martin Jemo

Postdoc supervisors
Emmanuel Frossard and Jan Jansa, ETH Zurich, Switzerland

Further institutions involved
University of Basel, Switzerland;
International Institute of Tropical Agriculture (IITA), Nigeria;
University of Yaoundé, Cameroon;
Institute of Agricultural Research for Development, Cameroon

Duration of the project
June 2007 – December 2010

Budget
CHF 489'040
SDC contribution: CHF 180'040 / Partner contribution: CHF 309'000

Objective

Mycorrhizal symbiosis is commonly established by many crop plant species and has the potential to improve plant nutrition and resistance against diseases and parasites. The mycorrhizal benefits can deteriorate due to changes in the composition and/or activity of indigenous mycorrhizal communities. Therefore, this project addressed whether this deterioration could explain the rapid yield decline occurring during cropping following forest clearance in the humid tropics.

Results

The project consisted of a three-season field experiment with continuous maize cropping on three sites, which differed in their previous land use: Cleared forest, chromolaena fallow, and continuously cropped land. The trials addressed the effect of phosphorus (P) fertilisation and the removal of mycorrhizal fungi by application of a fungicide on maize P acquisition, biomass production and seed yield. Pot experiments validated the observations from the field with the aim to quantify the symbiotic benefits of the indigenous mycorrhizal communities and to address their functional diversity.

Both P and fungicide applications resulted in higher growth and yields of maize in the field trials, with lower yields more often found in continuously cropped than in fallowed or cleared forest soils. The pot experiment with sterilised soil showed significantly lower symbiotic benefits (support of maize growth and P uptake) of the mycorrhizae from cleared forest soil as compared to the mycorrhizae from the chromolaena fallow or cropped land soils. Therefore, we conclude that yield decline during the cropping sequence following forest clearance cannot be attributed to declining mycorrhizal benefits or mycorrhizal activity in continuously cropped soils. This is valid in spite of the differences in functioning of different mycorrhizal species.

This project showed that, in contrast to the original expectations, mycorrhizal communities in previously cropped fields may provide substantial benefits to maize and that mycorrhizal fungi from previously forested soil may not be that efficient. The field experiment showed that phosphorus deficiency and possibly other stress conditions (aluminium toxicity, pathogen pressure) may play a role in maize performance and yields in Southern Cameroon.

Development relevance

At the end of the project the mycorrhizal fungi isolated from the studied soils (*Glomus intraradices, Acaulospora scrobiculata, Paraglomus occultum*) were sent as scheduled to our partners in Cameroon and at IITA.

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Martin Jemo: Mycorrhiza and maize yields in different land-use systems in Southern Cameroon

The project provided substantial support for several Cameroonian scientists besides Dr. Martin Jemo, including several undergraduate students, and provided novel collaboration opportunities.

Publications

Nwaga, D., Jansa, J., Abossolo Angue A. and Frossard, E., 2010: The potential of soil beneficial microorganisms for slash-and-burn agriculture in the humid forest zone of sub-Saharan Africa. In: Dion, P., (ed.), *Soil Biology and Agriculture in the Tropics*. Springer, Berlin, Germany: 81 – 107.

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Jansa, J., Jemo, M., and Frossard, E., 2010: Importance of mycorrhizal symbiosis for maize in a Cameroonian soil. In: Tielkes, E., (ed.), *Tropentag 2010, Book of Abstracts: World Food System – A Contribution from Europe*, Cuvillier Verlag, Göttingen, Germany: 224.

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Exploration of the effects of anti-tick vaccines on the transmission of *Theileria parva*

Syncerus caffer, the African buffalo is the natural reservoir of *T. parva*
Photo: C. Olds

Research fellow
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PhD supervisors
Claudia Daubenberger, Swiss Tropical and Public Health Institute (Swiss TPH), Switzerland;
Richard Bishop, International Livestock Research Institute (ILRI), Kenya

Further institution involved
Onderstepoort Veterinary Institute, South Africa

Duration of the project
May 2008 – December 2012

Budget
CHF 271'500
SDC contribution: CHF 181'500 / Partner contribution: CHF 90'000

Objective

East Coast Fever (ECF) is a disease of cattle, caused by the protozoan parasite *Theileria parva*. East Coast Fever is probably the most important livestock disease in Africa, causing an annual loss of more than 1 million cattle as well as high economic losses. In an attempt to decrease the overwhelming burden of tick-borne diseases (TBD) faced by both large-scale and subsistence farmers, tick vaccines have been proposed as a method to control various TBDs. In this project we evaluated two anti-tick vaccines (ATV) for their ability to interfere with the transmission of *Theileria parva* by the tick vector *Rhipicephalus appendiculatus*.

Results

The potential of various anti-tick vaccine candidates was evaluated in their natural host-pathogen-vector system for their ability to control *R. appendiculatus* populations and interfere with *T. parva* transmission to the cattle host. Vaccination with the *R. appendiculatus* Ra86 antigen did not affect female adult tick engorgement weight and reproductive capacity but did affect nymph ticks. Significantly higher proportion of nymphal ticks failed to molt to the adult stage after feeding from calves vaccinated with Ra86. This effect has important implications for the transmission of *T. parva* and ECF severity. Modelling of herd vaccination experiments confirmed that through nymphal tick population reduction a general decrease in the *R. appendiculatus* tick population would occur over time.

Secondly, a multivalent transmission-blocking vaccine was designed to inhibit *T. parva* parasite transmission from an infected tick vector to susceptible cattle. In comparison to the control group, vaccination increased the number of animals undergoing primary *T. parva* infection without developing any or only mild clinical symptoms. Multivalent vaccination reduced clinical ECF symptoms while at the same time allowed the establishment of a protective immune response showing that transmission-blocking vaccination for the control of ECF is feasible.

Development relevance

This work is still in the initial stages of development and constitutes fundamental research into anti-tick vaccines for the control of tick and tick-borne diseases. With continued research we believe that anti-tick vaccination could form an integral part of *T. parva* control in the future.

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Cassandra Leah Olds: Exploration of the effects of anti-tick vaccines on the transmission of *Theileria parva*

Publication

Olds, C., Mwaura, S., Crowder, D., Odongo, D., van Oers, M., Owen, J., Bishop, R., Daubenberger, C., 2012. Immunization of cattle with Ra86 impedes *Rhipicephalus appendiculatus* nymphal-to-adult molting. *Ticks and Tick-borne Diseases*, 3(3): 170 – 178.

http://www.sciencedirect.com/science/article/pii/S1877959X12000325

Ra86 vaccination on female ticks causes a decreased engorgement weight.
Left: Tick fed on a control animal
Right: Tick fed on a Ra86 vaccinated animal
Photo: C. Olds

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Cooperativeness in adopting sustainable common resource management

Fishermen fabricating a shrimp trap
Photo: C. Cavalcanti

Research fellow
Carina Cavalcanti

PhD supervisor
Stefanie Engel, ETH Zurich, Switzerland

Further institutions involved
University of Zurich, Switzerland;
Indiana University, USA;
World Fish Centre, Malaysia

Duration of the project
May 2008 – April 2011

Budget
CHF 199'565
SDC contribution: CHF 149'565 / Partner contribution: CHF 50'000

Objective

Experimental research has shown that individual cooperation behaviour in social dilemmas often deviates from the predictions of the model of selfish agents. However, it is less clear how such social behaviour relates to the support and successful enforcement of collective rules and policies in the field. For instance, it has not yet been examined how cooperative behaviour in experiments relates to cooperation regarding the management of common resources, or how it relates to voting behaviour concerning the adoption of sustainable resource management policies.

To provide empirical evidence on cooperative behaviour, the research took place in the context of an environmental programme (EP) targeting fishermen living in a natural reserve in Brazil. In this natural reserve, one of the most important income sources, fishing, is threatened by over-fishing. In addition to catching fish, many fishermen have started to catch shrimp. This has led to the decline of the shrimp population because fishermen use traps which capture large amounts of not yet fertile shrimp. The main objective of this project was (i) to better understand the roles of cooperative and less cooperative fishermen in introducing a new policy for the management of shrimp resources, and (ii) to help policy-makers to design suitable institutions in this regard.

Results

Fieldwork was conducted with 143 fishermen. It included replacing some of the current traps, and manufacturing less exploitative shrimp traps. Additionally, the fishermen were asked to (i) participate in laboratory experiments, (ii) vote on participation/non-participation in the programme, and (iii) take part in a survey in which we asked questions on their social networks, perceptions and beliefs. This unique sequence of measures with the same individuals helped to understand the role of experimentally observed cooperative behaviour in the adoption of a sustainable policy.

The findings show that fishermen who are well integrated in the social network of their community, and fishermen who participated in the development of the EP cooperate more during the programme than others. The perception of the necessity of this EP plays an important role for cooperation during the programme. There was no evidence that individuals are more likely to be friends with individuals who share similar economic preferences than with others. On the contrary, the findings suggest that opposites attract when it comes to risk and time preferences. Risk and competition preferences are related to the centrality in the network: Individuals who are more central in the network are more likely to take risks and compete more than individuals at the periphery. Social preferences are not significantly related to network structure and network centrality.

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Carina Cavalcanti: Cooperativeness in adopting sustainable common resource management

Development relevance

The results provide empirical evidence for the role of social integration, participation, and perceptions for community resource management. Our findings may also be useful for the interpretation of relationships between social network characteristics and economic behaviours.

Publications

Cavalcanti, C., Engel, S., and Leibbrandt A., 2013: Social integration, participation, and community resource management. *Journal of Environmental Economics and Management*, 65(2): 262 – 276.

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Brazilian fishermen with their new shrimp traps
Photo: C. Cavalcanti

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Understanding the views of the rural poor in two territories in Honduras

Trading at the local market is one of several income-earning strategies of poor peasant households
Photo: S. Contzen

Research fellow
Sandra Contzen

PhD supervisors
Ulrike Müller-Böker and Urs Geiser, University of Zurich, Switzerland;
Urs Scheidegger, School of Agricultural, Forest and Food Sciences (HAFL), Switzerland

Further institutions involved
International Center for Tropical Agriculture (CIAT), Nicaragua;
Zamorano University, Honduras;
Swiss Agency for Development and Cooperation (SDC), Honduras

Duration of the project
June 2008 – May 2012

Budget
CHF 372'151
SDC contribution: CHF 165'451 / Partner contribution: CHF 206'700

Objective

In Honduras, about half of the population live and work in rural areas. Their economic activities are based on agriculture, predominantly small-scale or subsistence farming. Access to services and economic opportunities other than agriculture is low and the poverty rate is very high. In 2001, Honduras introduced an ambitious Poverty Reduction Strategy (PRS). The strategy included measures such as a general increase in social expenditure, the set-up of a decentralised poverty reduction fund, or specific programmes aiming at improving the agricultural production and reactivating the rural economy. This project aimed at analysing the PRS experience in two municipalities in western Honduras by exploring the livelihoods of the rural poor and the PRS processes and projects carried out locally. The project focused on the benefits for poor and marginalised households in view of future development strategies.

Results

Local projects of the Honduran PRS did fit with the livelihoods of rural poor of the two case study municipalities. However, the PRS was not successful in reducing poverty: The exclusion of the poorest was reproduced at three levels: through discourses (including the PRS discourse), through political practices (although participation of the poorest was an aim of the PRS) and through the types of projects and their implementation (elite capture of projects).

Rural development projects need to focus on the inclusion of the poorest. Real participatory approaches must be pursued which require time but allow gaining trust of the poorest and including them into projects. Often, the poorest are excluded from projects, because they lack own land or money. The thesis proposes two measures to include the poorest: (i) access to land through the establishment of long-term tenant arrangements, and (ii) access to credits of rural saving banks through "risk-funds", for which entities such as the local government should act as guarantors for the poorest.

Development relevance

The results confirm that current development approaches often exclude the poorest. If the inclusion of the poorest and the reduction of extreme poverty is the aim of future development agendas, appropriate measures are required. The results further confirm the known critical literature that the PRS represent more of the same. The Honduran PRS was the continuation of development projects which had already been implemented. Furthermore, the original PRS strongly relied on neoliberal assumptions, which were inherent in the Structural Adjustment Programmes preceding the PRS approach.

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Sandra Contzen: Understanding the views of the rural poor in two territories in Honduras

Dissemination

Dissemination events took place (i) in Tegucigalpa with SDC, CIAT and Zamorano (the project partner institutions) and collaborators of local NGOs and other interested people (in total about 25 participants), (ii) in both case study municipalities, to which the interviewees and their families, as well as local leaders, local government and local NGOs were invited (90 respectively 50 participants).

Publication

Contzen, S., 2013: The PRS is out but Poor People are Still There. The Hondurian Poverty Reduction Strategy and Campesino Livelihoods in Western Honduras. Dissertation, University of Zürich, Departement of Geography.

Election of the transparency commission which is responsible for auditing local PRS projects in Honduras
Photo: S. Contzen

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Governance, collective action and development interventions in vegetable value chains

Farmers setting stakes for tomatoes, Northern Tanzania
Photo: M. Zoss

Research fellow
Marc Zoss

PhD supervisors
Stefanie Engel and Dominique Barjolle, ETH Zurich, Switzerland;
Bernard Lehmann, Federal Office for Agriculture, Switzerland

Further institutions involved
World Vegetable Center, Tanzania;
Sokoine University of Agriculture, Tanzania

Duration of the project
August 2008 – May 2013

Budget
CHF 284'940
SDC contribution: CHF 199'940 / Partner contribution: CHF 85'000

Objective

Vegetables are considered to be high-value agricultural products. These products have relatively high unit prices, a high income elasticity of demand and their production requires a considerable amount of labour. Due to rapid urbanisation in developing countries and globally changing consumption patterns, the demand for vegetables is expected to rise substantially. The project analyses the potential for African smallholder producers to benefit from these developments. It addresses (i) governance modes of vegetable value chains, (ii) collective organisation for marketing the produce, and (iii) interventions of external facilitators in vegetable value chains.

The research was conducted in Northern Tanzania because there vegetable production is of domestic and regional relevance. Furthermore, a small but growing industry of high-value vegetables for export to developed countries exists in this region.

Results

The following vegetable value chains were identified: urban and local green markets, seed production, processed vegetables, institutional buyers and tourism, and fresh vegetable exports. There is a continuum in terms of organisational and logistical complexity with the lowest requirements in green markets and the most sophisticated arrangement in the fresh vegetable value chain.

In terms of volume and relevance for the local economy, the green market is by far the most important value chain. The average gross margin for the producers across all value chains is 72%. There is a significant positive correlation between the complexity of the value chain and its profitability; integration into complex value chains has shown to be the most robust predictor for high profitability. Producers engaged in complex value chains have higher capital endowments in terms of natural, physical, human, and social capital. Interventions of external facilitators are highly concentrated in the complex value chains, while the default value chain – the green markets – receive very limited support.

Development relevance

The results are relevant for all actors involved in vegetable production and marketing. They are valid for large parts of sub-Saharan Africa, where complex value chains of high-value agricultural products are emerging. They are of particular interest to vegetable producers and external facilitators. For the producers the research indicates that despite the general high capital requirements smallholders can successfully participate in complex value chains. Such an inclusion offers not only a potentially profitable business opportunity but it also reduces the financial risks of producers. With respect to external facilitators, the current focus of donors on interventions in complex value chains –

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Marc Zoss:
Governance, collective action and development interventions in vegetable value chains

such as the fresh vegetable exports – led undoubtedly to increased integration of African smallholders into this global value chain. However, it represents a rather isolated intervention, and since the green markets will remain the default value chain at least in the medium term, investments into these basic value chains have the potential to reach a much larger group of beneficiaries.

Dissemination

The results are disseminated through the World Vegetable Center and the organisations the project was collaborating with during the fieldwork phase.

Publications

Zoss, M., forthcoming: Mode of Governance, Collective Action and Development Interventions in Vegetable Value Chains in Tanzania. Dissertation, ETH Zurich, Department of Environmental Systems Science.

Zoss, M. and Pletziger, S., 2009: Linking African vegetable smallholders to high value markets: Potentials and constraints in smallholders' integration into GLOBALGAP-certified and/or domestic African high-value supply-chains. In: Tielkes, E. (ed.), *Book of Abstracts of Tropentag 2009, Biophysical and socio-economic frame conditions for the sustainable management of natural resources*. DITSL GmbH, Witzenhausen, Germany

http://www.tropentag.de/2009/proceedings/proceedings.pdf

Washing harvested carrots, Northern Tanzania
Photo: M. Zoss

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Behavioural heterogeneity and human cooperation

Devesh Rustagi (centre) with farmers who took part in various economic experiments
Photo: D. Rustagi

Research fellow
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PhD supervisors
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Michael Kosfeld, Goethe University Frankfurt, Germany

Further institutions involved
Center for International Forestry Research (CIFOR), Indonesia;
Center for Development Research (ZEF), University of Bonn, Germany;
Oromia Forest Enterprises Supervising Agency, Ethiopia;
GTZ Sustainable Use of Natural Resources for Food Security, Ethiopia

Duration of the project
September 2008 – February 2010

Budget
CHF 150'445
SDC contribution: CHF 70'700 / Partner contribution: CHF 79'745

Objective

There is considerable heterogeneity in human behaviour with regard to cooperation, with most subjects behaving as conditional cooperators. Evidence supports the view that conditional cooperation together with costly punishment can stabilise cooperation in large groups of non-kin individuals. However, none have systematically investigated how inter-individual and inter-group differences with regard to conditional cooperation, free riding, costly enforcement, leadership, and beliefs affect cooperation in the real-world, simultaneously controlling for conventional determinants of cooperation.

Through a public goods game, we measured these behaviours and studied their effect on the outcomes of common property forests being managed by 49 different groups of the Bale Oromo people in Ethiopia.

Results

The results on behavioural heterogeneity and its effect on forest management outcomes confirmed that a higher share of conditional cooperators (or lower free rider shares) in a group has a positive and highly significant effect on the outcomes. Costly monitoring represents a key mechanism by which conditional cooperators sustain cooperation.

The study of group leaders' punishment behaviour in response to deviations from cooperation norms and its effect on forest management outcomes revealed that leaders varied substantially in their punishment behaviour. Norm-driven leaders who explicitly punish deviations from the conditional cooperation norm have a positive but insignificant effect on forest management outcomes, but spiteful leaders who punish cooperators have a negative effect on forest management outcomes. These findings imply that gains from leadership in sustaining cooperation need to be assessed in the light of leaders' behaviour.

The investigation on differences between student and non-student behavioural types, and how behavioural heterogeneity and beliefs interact in voluntary cooperation, showed that most Bale Oromo conditional cooperators exhibit "altruistic" biases by contributing slightly more than the partner player. This challenges the hypothesis that imperfect conditional cooperation causes decline in cooperation over time. Behavioural heterogeneity is a highly significant predictor of voluntary cooperation, and beliefs have a positive and significant effect on cooperation only when a player is a conditional cooperator.

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Devesh Rustagi: Behavioural heterogeneity and human cooperation

Development relevance

The results are useful in developing a coherent behavioural theory of collective action and for testing the theories of multi-level selection. Policies targeting the commons could be improved by taking behavioural heterogeneity into consideration and by designing institutions that provide incentives for selfish individuals to cooperate and that foster conditional cooperation, either through belief management or leadership. Insights on cultural differentiation provide a scope for future studies on cultural group selection and conditions under which "altruism" could evolve.

Dissemination

Through a one-month field visit to Ethiopia the findings from this study were disseminated to the local people, agencies and international partners. A four-page policy brief along with the paper published in *Science* was sent in advance to the Oromia government and GTZ. In addition, networks with Farm Africa and SOS Sahel were built, as these NGOs are now responsible for the management of the forest commons in the Bale Mountains. Workshops with all the communities that took part in the study were conducted. During the workshop, members of forest user groups were given a simple feedback on factors behind the successful management of the commons. The groups were elated and requested to continue the research in their area.

Publications

Rustagi, D., Engel, S., and Kosfeld, M., 2010: Conditional cooperation and costly monitoring explain success in forest commons management. *Science*, 330: 961 – 965.

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Playing the public goods game in order to raise individual cooperation and to reduce excessive punishment in Ethiopia
Photo: D. Rustagi

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The importance of forest fragments in local livelihood systems

Farmers collecting wild honey in forest fragments in Madagascar
Photo: Z. Urech


Research fellows
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and Zora Lea Urech

PhD supervisors
Jean-Pierre Sorg, Hans Rudolf Felber and Jaboury Ghazoul, ETH Zurich, Switzerland; Gabrielle Rajoelison, L'Ecole Supérieure des Sciences Agronomiques (ESSA), Madagascar

Further institutions involved
Center for International Forestry Research (CIFOR), Indonesia;
Helvetas Intercooperation, Switzerland;
Université d'Antananarivo, Madagascar

Duration of the project
September 2008 – June 2012

Budget
CHF 258'050
SDC contribution: CHF 135'525 / Partner contribution: CHF 122'525

Objective

At our study site on the east coast of Madagascar, most contiguous forests have been cleared or separated, resulting in forest fragments which are embedded in mosaic landscapes. Forest fragments provide substantial products and environmental services for the livelihoods of the local population. They are threatened, however, by deforestation due to slash-and-burn agriculture.

The aim of this research project was to gain an improved understanding of the role that forest fragments play in the daily life of rural households. This allowed us to identify the driving forces of deforestation and possible ways to improve forest management within the given livelihood systems.

Results

Our results refer to an improved understanding of decision making processes and of traditional forest management practices and rules. They comprise the identification of wealth and village specific interests, and of sustainable traditional harvest practices of the genus *Pandanus*.

The diverse factors which influence local farmers in their decision-making process, leading to forest clearance and fragmentation, have been identified. Farmers' interest in preserving forest fragments depends on their wealth and access to forest resources, as well as their access to markets.

Women apply traditional harvest practices which allow the *Pandanus guillaumetii* plants to recover after harvest. However, these practices tend to disappear with growing population and decreasing forest resources.

Following the local customary law, forest fragments are owned by individual farmers. Only the traditional owners have the right to clear these fragments. This knowledge is crucial in order to reduce future conflicts in the framework of community-based forest management.

Recommendations for future sustainable forest management, which benefits the poor, have been identified, formulated and communicated.

Development relevance

We adapted the discussion of our data according to the local community based forest management (CBFM) project. We found that the population of the Manompana corridor is not yet prepared for CBFM. Furthermore, the context in which farmers are living is not appropriate for implementing CBFM. At the moment, local livelihood systems are not compatible with a

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Mihajamanana Fetra Rabenilalana and Zora Lea Urech: The importance of forest fragments in local livelihood systems

sustainable forest management. It would be essential to fundamentally improve the local, regional and national context in which farmers are operating. In addition, a thorough modification of cultural attitudes should be envisaged. Thus, combining the conservation of remaining forests with the local livelihood systems and with poverty alleviation is a highly challenging goal requiring a long-term process. For its realisation, different stakeholders have to contribute: the state government, multilateral donors, researchers as well as the local population.

Dissemination

A number of workshops was conducted with farmers, the state forest service, the local forestry project KAM, a local NGO (AIM) and researchers. The project was presented annually to Helvetas Intercooperation in Madagascar. Constant exchange of data and results with the teams of the local forestry project and the local research project of CIFOR took place. The project was well integrated into the CIFOR Landscape Mosaics Project, which collaborated intensively with the local forestry project.

A documentary movie on deforestation and local farmers was prepared (Bernier, F., Guiton, S., Toutain, S., Barnier, C., Delhut, L., and Delben, S., 2010: *Demain, c'est loin*. IFFCAM Production, France). In April 2013 the project was presented at the ETH Zurich / Zoo Zurich symposium with representatives from the Malagasy Government, the Masoala Park, and the Wildlife Conservation Society.

Publications

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Characterisation of drought tolerance in cassava

Contrasting cassava genotypes for drought tolerance screening under controlled greenhouse conditions, Switzerland
Photo: C. Orek

Research fellow
Charles Orek

PhD supervisors
Wilhelm Gruissem and Herve Vanderschuren, ETH Zurich, Switzerland; Morag Ferguson, International Institute of Tropical Agriculture (IITA), Kenya

Further institution involved
Kenya Agricultural Research Institute (KARI), Kenya

Duration of the project
November 2009 – December 2012

Budget
CHF 192'985
SDC contribution: CHF 142'645 / Partner contribution: CHF 50'340

Objective

Breeding drought-tolerant crops is an option to mitigate the threats posed by droughts that significantly constrain world agriculture. The application of advanced technologies could substantially increase the efficiency and success of breeding programmes. In turn, the improved cultivars could contribute to food and income security and to the development of a sustainable agriculture in a potentially adverse environment. This project focuses on drought tolerance in cassava, a staple crop for nearly one billion people in more than hundred countries. Cassava yields more than most crops on low fertility soils and in areas of uncertain rainfall patterns, which often lead to prolonged drought periods. Cassava exhibits various traits that are directly linked to its ability to sustain yield under drought conditions. The staygreen phenotype has been suggested as a possible means to increase cassava productivity in such conditions. Cassava cultivars with the staygreen trait have been found to produce more total fresh biomass and higher root dry matter than cultivars without that trait.

Results

Field-based multi-seasonal drought trials were used to evaluate drought tolerance phenotypes in more than 20 cassava genotypes in Kenya. Differences in primary data such as storage root fresh weight, harvest index, root yield gap, number of edible roots and staygreen were statistically significant between genotypes. The tolerant (94-0039 & 95-0306) and susceptible (92-0427 & TME-419) genotypes were selected and further analysed under greenhouse assays to confirm consistency and to generate materials for transcriptomics. From literature and *in silico* methods, identification and selection of drought responsive candidate genes and associated biochemical pathways that encode chlorophyll degradation, photosynthesis, phytohormones (abscisic acid, cytokinins and ethylene), leaf senescence, stomatal sensitivity, plant-water channels and fibrous root development was completed. Primers for quantative real time polymerase chain reaction (qRT-PCR) have been designed and tested for specificity and efficiency and hence tentative characterisation of molecular markers.

Development relevance

Drought tolerant crops contribute towards sustainable agriculture. This project evaluates cassava morphology and physiology under drought. A complete characterisation of molecular pathways activated by drought stress in cassava will be published. Candidate genes expected to play a key role in the staygreen or drought-tolerance phenotype will be released. These results will serve as a basis for drought-tolerance marker development. ▶▶

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Charles Orek:
Characterisation of drought tolerance in cassava

Molecular techniques optimised and developed during the project will be transferred for enhanced capacity building in Africa. Evaluation of traditionally bred stay green cultivars combined with development of molecular markers for rapid introgression of the stay green trait is a valuable output for global cassava researchers and breeders.

Dissemination

Direct beneficiaries will be technical staff and scientists from Eastern and Central Africa. The knowledge gained will be used to improve extension services for the benefit of local cassava farmers.

Harvesting and weighing of cassava storage roots in Kenya
Photo: C. Orek

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Whole genome profiling of *Theileria parva* isolates

The infection and treatment method (ITM) vaccine being administered to a calf in Kenya
Photo: S. Henson

Research fellow
Sonal Henson

Postdoc supervisors
Claudia Daubenberger, Swiss TPH, Switzerland;
Richard Bishop, ILRI, Kenya

Further institution involved
University of Zurich, Switzerland

Duration of the project
August 2009 – March 2012

Budget
CHF 300'000
SDC contribution: CHF 140'000 / Partner contribution: CHF 160'000

Objective

Theileria parva is a protozoan parasite that causes East Coast Fever (ECF), a fatal lympho-proliferative disease inflicting cattle in East, Central and Southern Africa. It causes an economic loss of at least USD 168 million annually. The infection and treatment method (ITM) of vaccination confers some protection resulting in a carrier state. ITM is composed predominantly of three strains of *T. parva* – Muguga, Serengeti and Kiambu 5 – the combination of which is believed to protect across strains. However, the mechanism by which this is achieved is unknown.

Results

Whole genomes of seven *Theileria parva* isolates from different geographical regions were sequenced, including one of the three components of the cocktail of *T. parva* strains used in the ITM of vaccination in some countries, and two recombinant strains.

Whole genome comparative analysis led to identification of 115,005 single nucleotide polymorphisms (SNPs) – more than 65% of which were found in exons, while 14 – 17% were in introns and 18 – 19% in intergenic regions. This is in concordance with the finding that the *T. parva* genome is composed of 68.4% coding sequence. The SNPs identified increased the resolution of the existing genetic map of *T. parva* by 800 times compared to previously published data.

We found 15 and 24 crossovers and 52 and 56 gene conversions in the two recombinant strains. In addition, the Ka/Ks analysis of the ratio of the number of nonsynonymous substitutions (KA) to the number of synonymous substitutions (KS) identified 81 genes that might be involved in host parasite interactions that are potentially under positive selection.

Development relevance

Piroplasms from the third component of the ITM vaccine cocktail, that had been challenging to raise in the past, were successfully obtained in this project. These samples are currently being sequenced and analysed in another study.

Not only has the project built capacity for next generation sequence analysis in Kenya, it has fostered new scientific collaborations between Europe, Africa and the USA.

Dissemination

The sequence data generated for the seven isolates has been deposited in the public nucleotide repository, Genbank.

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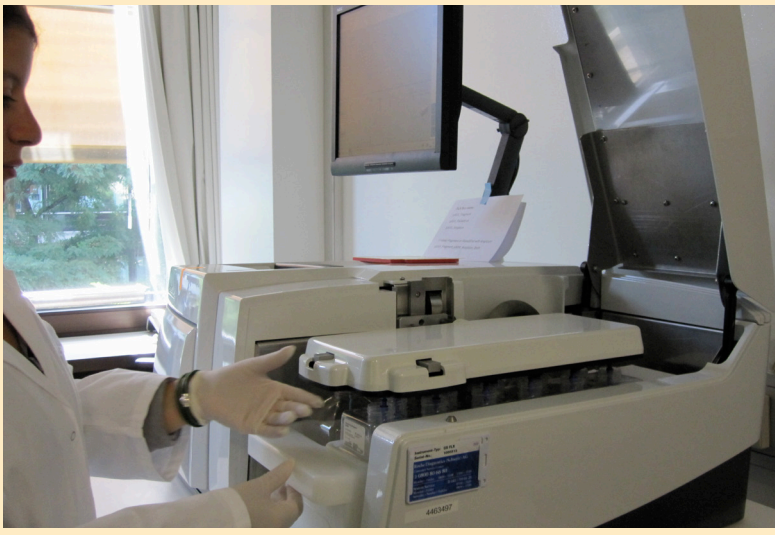
Swiss Federal Institute of Technology Zurich

Sonal Henson: Whole genome profiling of *Theileria parva* isolates

Publication

Henson, S., Bishop, R.P., Morzaria, S., Spooner, P.R., Pelle, R., Poveda, L., Ebling, M., Küng, E., Certa, U., Daubenberger, C., and Qi, W., 2012: High-resolution genotyping and mapping of recombination and gene conversion in the protozoan *Theileria parva* using whole genome sequencing. *BMC Genomics*, 13: 503. *http://www.biomedcentral.com/1471-2164/13/503*



A 454 sequencing specialist preparing the machine for a sequencing run
Photo: S. Henson

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Phosphate nutrition of crops in lixisols from semi-arid West Africa

Measurement of cowpea yield in farmers' fields, Burkina Faso
Photo: D. I. Kiba

Research fellow
Delwendé Innocent Kiba

PhD supervisors
Emmanuel Frossard, ETH Zurich, Switzerland;
Michel P. Sedogo, Université Polytechnique de Bobo, Burkina Faso;
François Lompo, l'Institut de l'Environnement et de Recherches Agricoles (INERA), Burkina Faso

Further institution involved
International Center for Tropical Agriculture (CIAT), Kenya

Duration of the project
May 2009 – December 2012

Budget
CHF 369'300
SDC contribution: CHF 140'000 / Partner contribution: CHF 229'300

Objective

This project conducted on fragile soils (lixisols) in Burkina Faso aims at evaluating the effects of organic amendments on soil phosphorus (P) dynamics, on crop nitrogen (N) and P nutrition, as well as on crop productivity. The model crops used are sorghum (*Sorghum bicolor*) and promiscuous cowpea (*Vigna unguiculata*). The project is based on an on-farm study, complemented by a long-term field trial and laboratory experiments.

Results

On farmers' fields the variability of cowpea yields in monoculture and sorghum yields in mixed cropping of sorghum-cowpea were significantly explained by major soil chemical properties and farmers' practices of soil fertility management. However, a large part of yields variability mostly for sorghum (about 70%) remained unexplained, and cowpea yields in mixed cropping could not be explained by the considered parameters.

On farmers' fields soil available P is determining grain yields of sorghum in mixed cropping and cowpea in monoculture while for cowpea in mixed cropping, the grain yields were mostly determined by the sowing density. However, high soil available P does not always lead to high sorghum and cowpea grain yields confirming that "non-fertilisation" management practices are also important for improving sorghum and cowpea yields.

On the farmers' fields we showed that cowpea takes up about 70% of its N from the atmosphere and that local cowpea varieties have a higher proportion of N derived from the atmosphere than improved varieties, and the low yields of the local varieties finally limit the quantity of N fixed.

Farmers invest more finances in soil fertility management (P fertilizer) in cowpea than in sorghum as cowpea leads to higher economic return. Farmers having their fields close to the research station (<5 km) apply more fertilisers in their fields compared to farmers located far away. They have probably understood the benefits of organic and mineral inputs shown in the trials in the research station.

The "Zaï technique" leads to a significant increase of sorghum yields. It consists in digging holes on the fields where about 100 g of organic amendment is applied and sorghum is sown. In mixed cropping of sorghum-cowpea, sorghum grain yields with Zaï technique reached in average 1 t ha^{-1} while without Zaï technique it was only about half. However, application remains limited because of the scarcity of organic amendments and the high labour requirement.

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Delwendé Innocent Kiba: Phosphate nutrition of crops in lixisols from semi-arid West Africa

Development relevance

Besides three students, two technicians and ten researchers from Burkina and Switzerland, about 170 smallholder farmers were involved in this project. As the farmers took part from the beginning, the results were disseminated to them through meetings and field days. This interaction with farmers also allowed identifying their needs for further agricultural research.

Dissemination

At the 50th anniversary of the long-term field trial of Saria the results were presented during the colloquium organised by INERA which numerous researchers attended. The results were also presented at the conference on integrated soil fertility management in Nairobi, Kenya, in October 2012. In addition, the project allowed the research fellow to establish his scientific network, e.g. during the conference on applied soil science in Wageningen, Netherlands, in September 2011. The contacts established during this conference resulted in a publication on the impact of soil degradation and food production. Finally, the project has strengthened the partnership between INERA and the Group of Plant Nutrition from ETH Zurich, on which future collaboration will be built.

Publications

Kiba, D.I., Lompo, F., Compaoré, E., Randriamanantsoa, L., Sedogo, P.M, and Frossard E., 2012: A decade of non-sorted solid urban waste inputs safely increases sorghum yield in periurban areas of Burkina Faso. *Acta Agriculturae Scandinavica, Section B – Soil & Plant Science*, 62(1): 59 – 69.

http://www.tandfonline.com/doi/abs/10.1080/09064710.2011.573802

Kiba, D.I., Zongo, N.A., Lompo, F., Jansa, J., Compaore, E., Sedogo, P.M., and Frossard, E., 2012:The diversity of fertilization practices affects soil and crop quality in urban vegetable sites of Burkina Faso. *European Journal of Agronomy*, 38: 12 – 21.

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Bindraban, P.S., van der Velde, M., Ye, L., van den Berg, M., Materechera, S., Kiba, D.I., Tamene, L., Ragnarsdóttir, K., Jongschaap, R., Hoogmoed, M., Hoogmoed, W., van Beek, C., and van Lynden, G. 2012. Assessing the impact of soil degradation on food production. *Current Opinion in Environmental Sustainability*, 4(5), 478 – 488.

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A meeting with representatives of farmers' organisations, Burkina Faso
Photo: D. I. Kiba

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Ethanol production impacts on land use and deforestation

Sugarcane harvesting in São Paulo state, Brazil
Photo: S. Andrade de Sa

Research fellow
Saraly Andrade de Sá

PhD supervisors
Stefanie Engel, ETH Zurich, Switzerland;
Charles Palmer, London School of Economics, UK

Further institutions involved
Roundtable on Sustainable Biofuels/EPF Lausanne, Switzerland;
Center for International Forestry Research (CIFOR), Brazil;
Amazon Centre for Environmental Research, Brazil

Duration of the project
February 2009 – October 2011

Budget
CHF 207'775
SDC contribution: CHF 93'550 / Partner contribution: CHF 114'275

Objective

Biofuel production has grown rapidly in the last few decades and is expected to continue doing so. However, at the time the project started, the links – either direct or indirect – between bio-ethanol production, land use and forest conversion were still not well-understood, neither at the conceptual nor the empirical level. Therefore, the objective of the project was to fill this gap in the literature, by investigating these direct and indirect links, and measuring them empirically.

Results

The first phase of the project consisted in conceptualising the impacts of ethanol production. We were able to disentangle three different effects (direct land competition, indirect land competition and labour mobility) and specify under which conditions the latter materialise.

The second phase of the project intended to test the theoretical results previously obtained, using empirical data from Brazil. Sugarcane is the energy crop used to produce the Brazilian ethanol. The results suggest a relationship between sugarcane expansion and deforestation in the Amazon. The main intuition we get from the regressions is that the impact of cattle ranching in forest conversion is indeed sensitive to levels of sugarcane acreage in the southern region, which can be interpreted as a displacement effect. In fact, in the last three decades the expansion of sugarcane acreage in the Central-Southern region of the country induced the displacement of ranching activities toward the Amazon forest frontier, located further north.

Development relevance

If biofuel-producing countries decide to continue ethanol production, new environmental policies will be needed. It is important to ensure that displaced activities are directed towards unoccupied land and not towards forest frontiers. Additionally, since indirect displacements may take a certain number of years to materialise, impact of policies favouring biofuels production should be monitored over a long period of time.

Dissemination

The results of this project were widely disseminated among the scientific community via participation in several international scientific conferences. The publication of two articles in well-ranked scientific journals is still contributing to that dissemination.

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Saraly Andrade de Sá: Ethanol production impacts on land use and deforestation

Publications

Andrade de Sá, S., Palmer, C and Di Falco, S., 2013: Dynamics of indirect land-use change: Empirical evidence from Brazil. *Journal of Environmental Economics and Management*.

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http://download.springer.com/static/pdf/359/art%253A10.1007%252Fs10640-011-9516-4.pdf?auth66=1365501174_3e84f0f941842c91cab290fd684f813e&ext=.pdf

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Sugarcane fields in São Paulo state – Brazil
Photo: S. Andrade de Sá

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Healthy rice for healthy people: Biofortification of zinc in rice

Rice (*Oryza sativa* L. var IR74) growing in a greenhouse at IRRI, Philippines
Photo: S. Impa Muthappa

Research fellow
Somayanda Impa Muthappa

Postdoc supervisors
Rainer Schulin, ETH Zurich, Switzerland;
Sarah Beebout and Abdelbagi Ismail, International Rice Research Institute (IRRI), Philippines

Further institution involved
IRRI, Philippines

Duration of the project
October 2009 – December 2011

Budget
CHF 323'858
SDC contribution: CHF 200'000 / Partner contribution: CHF 123'858

Objective

Zinc (Zn) deficiency is a widespread micronutrient disorder in humans and plants. The severity of soil Zn deficiency is further enhanced under the flooded conditions that are typical of rice production. Rice, being a poor source of Zn, leads to Zn deficiency-induced malnutrition in humans who are dependent on rice as a staple diet. Understanding and identifying the physiological mechanisms controlling Zn uptake and transport into rice grains is crucial in terms of increasing both the productivity and nutritive value of the crop. This project aimed at understanding the physiological mechanisms influencing Zn deficiency tolerance, Zn uptake, and internal Zn transport in a range of rice genotypes.

Results

Ideal conditions for the growth and development of rice genotypes in agar nutrient solutions (ANS) until maturity were established for the first time. The severe Zn deficiency induced in ANS facilitated the identification of rice genotypes with true tolerance or susceptibility to low Zn conditions. The set of rice genotypes used in our experiments showed considerable genetic variation for Zn deficiency tolerance and grain Zn. Our studies identified three genotypes, namely SWHOO, Joryoongbyeo and IR69428, which recorded improved grain Zn both at Zn sufficient and deficient condition.

^{65}Zn leaf labeling of Zn efficient and Zn inefficient lines showed that under Zn deficiency the phloem mobility of Zn is restricted compared to Zn sufficient condition and this effect was more pronounced in Zn inefficient genotypes. The genotypic variability for predominant source of grain Zn loading – remobilisation vs. continued root uptake – was determined based on the difference in shoot Zn and panicle Zn content between 50% flowering and maturity; it was additionally confirmed with ^{65}Zn labeling studies. Our studies also showed that high grain Zn lines recorded higher root exudation of citric and succinic acid at flowering stage, indicating their role in high root uptake or translocation of Zn. These results have to be confirmed in different soil environments and have the potential to be used as physiological markers to identify high grain Zn lines.

Moreover, the microcosm experiments carried out to understand the Zn dynamics in different paddy soils varying for their physico-chemical properties revealed the reasons for lower availability of Zn under prolonged submergence. These findings can help in formulating management options for alleviating Zn deficiency.

Development relevance

Some of the contrasting genotypes whose performances were consistent across experiments are now being tested under ▶▶

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Somayanda Impa Muthappa: Healthy rice for healthy people: Biofortification of zinc in rice

different soil conditions and included as donors for Zn deficiency tolerance and Zn biofortification breeding.

Dissemination

The primary target groups are scientists – mainly breeders, agronomists and plant physiologists. The ultimate target groups are rice farmers and consumers.

Under this project one postdoctoral fellow, three researchers and a technician were trained to understand the mechanisms influencing Zn uptake and transport in rice. The results of this project formed the basis for a follow-up proposal which is currently under progress. The institutional collaboration established through this project was expanded to include colleagues from JIRCAS, Japan, and Imperial College, London, UK.

Publication

Impa, S.M., and Johnson-Beebout, S.E., 2012: Mitigating zinc deficiency and achieving high grain Zn in rice through integration of soil chemistry and plant physiology research. *Plant and Soil*. 361: 3 – 41.

http://link.springer.com/article/10.1007/s11104-012-1315-3#page-1

Zn deficient low land rice field at IRRI, Philippines
Photo: S. Impa Muthappa

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Contribution to food security by improving farmers' responses to climate change

Interview with smallholders in Korhogo (Northern Côte d'Ivoire)
Photo: H. Comoé

Research fellow
Hermann Daisy N'nhon Comoé

PhD supervisors
Michael Siegrist, ETH Zurich, Switzerland;
Bernard Lehmann, Federal Office for Agriculture, Switzerland;
Dominique Barjolle, FiBL, Switzerland

Further institution involved
Centre Suisse de Recherches Scientifiques (CSRS), Côte d'Ivoire

Duration of the project
February 2010 – May 2013

Budget
CHF 218'115
SDC contribution: CHF 169'600 / Partner contribution: CHF 48'515

Objective

As most developing countries in Africa, Côte d'Ivoire has experienced an increase in climatic variability since the late 1960s. A reduction of up to 28% in rainfall and an increase in temperature has severely affected both food crops and livestock. This project aims at analysing farmers' decision-making processes related to climate change and their risk management strategies when faced with its negative impacts. Furthermore, we will investigate farmers' perceptions of climate change and their adaptation behaviour taking into account the institutional context in Côte d'Ivoire.

Results

Farmers have a strong perception of changes in climatic conditions. In Korhogo, (Northern Côte d'Ivoire) farmers most frequently describe climate change by the changes and characteristics in rain patterns, changes in the local environment, and the disappearance of some farming practices. In contrast, farmers from Toumodi (Central Côte d'Ivoire) rather perceive the disruption of key time reference periods and the shift in rainy seasons.

Farmers mainly attempt to adapt to climate change by adjusting their agricultural calendar, adopting new short-season varieties, and using mixed cropping techniques. The decision to adapt occurs when farmers make the link between climate change and its negative impacts. Four groups of farmers can be distinguished based on their evaluation of the feasibility of adaptation strategies, their intention to adapt, the perceived social pressure, and agro-economic barriers: *innovators* (10%), *early adaptors* (47%), *late adaptors* (24%), and *non-adaptors* (19%).

A Social Network Analysis of the stakeholder networks in the agricultural sector regarding adaptation to climate change revealed that in Toumodi the network structure was highly dependent on one major actor while a group of diverse actors appeared central in the networks in Korhogo.

Development relevance

Advice on adaptation strategies by national and international organisations will have to take into account the perceived impact of climate change by farmers, the agro-ecological zone, and the farmers' characteristics. Mainstreaming our findings in the strategic planning of local actors in the agricultural sector is essential for impact at large scale. Improved integration of farmers' cooperatives in the stakeholders' networks could generate sharing of experimentation and knowledge to better adapt to climate change.

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Hermann Daisy N'nhon Comoé: Contribution to food security by improving farmers' responses to climate change

Future agricultural policies should consider farmers' perception, provision of suitable climate forecast, investment in agricultural extension at a national level, and the promotion of non-governmental organisations. Policy interventions must promote more interaction among researchers, extension agents, and farmers to facilitate better communication flow in all directions. Indeed, climate is infrequently integrated with development policy and investment decision-making. Cognitive aspects of adaptation to climate change at the local level have to be taken into account.

Dissemination

The target group are local smallholder farmers. So far, we addressed about 60'000 farmers in the North and 25'000 in the Centre. In addition, published articles and reports addressing institutional actors aim to speed up the transfer of the research findings to farmers.

Publication

Comoé H., Finger R., and Barjolle D., 2012: Farm management decision and response to climate variability and change in Côte d'Ivoire. *Mitigation and Adaptation Strategies for Global Change.* *http://link.springer.com/article/10.1007%2Fs11027-012-9436-9*

A herd of cattle in the north of Côte d'Ivoire
Photo: H. Comoé

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Reducing the impact of cassava brown streak disease

Evaluating CBSV resistance by grafting symptomless cassava accessions onto CBSD-infected rootstocks
Photo: R. B. Anjanappa

Research fellow
Ravi Bodampalli Anjanappa

PhD supervisors
Wilhelm Gruissem and Hervé Vanderschuren, ETH Zurich, Switzerland

Further institutions involved
University of Greenwich, UK;
International Institute of Tropical Agriculture (IITA), Tanzania

Duration of the project
April 2010 – April 2013

Budget
CHF 271'230
SDC contribution: CHF 188'624 / Partner contribution: CHF 82'606

Objective

Cassava serves as staple food for nearly a billion people in 105 countries of the tropics and sub-tropics, where it provides as much as one-third of the daily calories, particularly in Africa. Cassava is vulnerable to at least 20 different viral diseases. More recently, cassava brown streak disease (CBSD) has caused devastating losses in cassava fields in East Africa. CBSD is endemic to Africa and caused by the cassava brown streak virus (CBSV) and the Ugandan cassava brown streak virus (UCBSV). Our project aims at contributing to the protection of cassava from the devastating effects of viral diseases.

Results

Natural resistance to CBSD was evaluated in 14 elite cassava lines. A standard and robust evaluation was adapted from a method previously established at ETH Zurich. Molecular quantification of viral loads allowed the identification of cassava accessions in which viruses could not replicate.

Cassava accessions contrasting for CBSV replication (CBSV-susceptible and -resistant) were selected to perform transcriptome profiling (Illumina sequencing technology) to investigate transcriptional changes upon CBSV inoculated. Regulated transcripts are being validated in various cassava accessions to decipher molecular determinants of susceptibility and resistance to viruses causing CBSD.

Resistance to viruses causing CBSD has been investigated and validated at the molecular level in several cassava accessions. Additional investigation of cassava accessions includes performance upon infections by multiple viral species (i.e. CBSVs and cassava geminiviruses).

Development relevance

We are in regular contact with collaborators in Africa (Kenya, Tanzania, South Africa) to discuss our findings and help establishing our robust methods for virus resistance evaluation and virus quantification. Our research activities on CBSD have prompted us to establish new contacts with African research institutions in Kenya, Nigeria and Uganda.

Some of the resistant lines characterised at ETH Zurich are being considered for variety release by IITA. In collaboration with the IITA team in Tanzania we have identified new CBSV variants in the field. We are currently collaborating with DSMZ (Plant Virus Division, Leibniz-Institut, Germany) to sequence those isolates. ▶▶

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Ravi Bodampalli Anjanappa: Reducing the impact of cassava brown streak disease

Dissemination

The findings were presented at the international "Global Cassava Partnership" conference in Uganda (June 2012). The work attracted interest from the community due to the importance to identify sources of robust resistance to viral diseases in the cassava germplasm.

Two scientific publications are in preparation, on (1) identification and characterisation of CBSD resistance in cassava germplasm and (2) transcriptome profiling of CBSV resistant and CBSV susceptible cassava accessions.

Publication

Vanderschuren, H., Moreno, I., Anjanappa, R.B., Zainuddin, I.M., and Gruissem, W., 2012: Exploiting the combination of natural and genetically engineered resistance to cassava mosaic and cassava brown streak viruses impacting cassava production in Africa. *PLoS ONE*, 7 (9), e45277.

http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0045277

Evaluating the resistance/tolerance of select cassava lines with CBSV
Photo: R. B. Anjanappa

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Enhancing tree growth by exploiting beneficial insects and defensive plant traits

The leaf beetle *Walterianella inscripta* was identified as a key pest of the native timber tree *Tabebuia rosea* in Panama
Photo: K. Mody

Research fellow
Judith Riedel

PhD supervisors
Silvia Dorn and Karsten Mody, ETH Zurich, Switzerland

Further institutions involved
Smithsonian Tropical Research Institute (STRI), Panama;
The Native Species Reforestation Project (PRORENA), Panama;
Autoridad Nacional del Ambiente (ANAM), Panama

Duration of the project
May 2010 – May 2013

Budget
CHF 501'000
SDC contribution: CHF 195'000 / Partner contribution: CHF 306'000

Objective

The establishment of native timber trees on deforested land such as cattle pastures in Central and South America could contribute to the livelihood of small-scale farmers and to the protection of remaining forests. However, tree-damaging insect pests often impede successful timber tree establishment and growth. The design of environmentally-friendly pest management strategies is hence imperative for the implementation of sustainable agroforestry and, as such, a relevant development goal.

Along these lines, this project aimed at investigating environmentally-friendly pest management strategies: top-down control of insect pests through the impact of beneficial insects and bottom-up through the impact of defensive plant traits. Both strategies aim at enhancing tree growth owing to favourable planting systems. Beneficial insects may comprise ants or parasitoid wasps. Defensive traits are chemical or physical plant properties that reduce the survival and performance of pest species (antibiosis) or make the plant less attractive to them (antixenosis).

Results

Timber tree performance is affected by species identity, tree stand diversity, insecticide treatment, environmental heterogeneity, and border effects. Depending on adequate species selection, companion trees can support timber tree growth in silvopastoral reforestations. Herbivores show contrasting responses to planting systems and associated host tree density.

Development relevance

Tabebuia rosea was identified as promising native timber tree species for pasture reforestation in Central America. A novel silvopastoral reforestation system was designed. Key insect pests of *T. rosea* were identified and sustainable pest management strategies were developed.

Dissemination

To promote dissemination of results on a broad scope, results were intensively discussed with project partners (STRI and PRORENA), who have excellent and well established contacts to reforestation specialists and farmers throughout Panama. At the University of Panama, the project was discussed with interested students and faculty members of the agricultural department. Two post-master students received technical training.

Small-scale farmers around the field site in Panama gained direct insight into different aspects of pasture reforestation with native trees while working temporarily on the project. The more than 25 local men and women involved benefitted regarding ▶▶

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Judith Riedel: Enhancing tree growth by exploiting beneficial insects and defensive plant traits

income generation and enhanced land utilisation. To facilitate the direct communication with farmers and stakeholders, a final workshop was organised, during which key aspects of the project were presented to a total of 32 participants.

Publications

Riedel, J., Dorn, S., Plath, M., Potvin, C., and Mody, K., 2013: Time matters: temporally changing effects of planting schemes and insecticide treatment on native timber tree performance on former pasture. *Forest Ecology and Management*, 297: 49 – 56.

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http://e-collection.library.ethz.ch/view/eth:6784?q=%28author:Riedel%29

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http://onlinelibrary.wiley.com/doi/10.1111/jen.12009/pdf

Plath, M., Dorn, S., Riedel, J., Barrios, H. and Mody, K., 2012: Associational resistance and associational susceptibility: specialist herbivores show contrasting responses to tree stand diversification. *Oecologia*, 169(2): 477 – 487.

http://link.springer.com/article/10.1007/s00442-011-2215-6

Local assistants measuring the growth of native timer trees in Panama
Photo: J. Riedel

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Forest dwellers and biodiversity in the context of industrial forestry

Discussing wildlife with forest dwellers, Congo Basin
Photo: O. Rickenbach

Research fellow
Olivia Rickenbach

PhD supervisors
Jaboury Ghazoul, Jean-Pierre Sorg and Claude Garcia, ETH Zurich, Switzerland; Jerome Lewis, University College London, UK

Further institutions involved
Center for International Forestry Research (CIFOR), Indonesia; CIFOR, Cameroon; Wildlife Conservation Society (WCS), Congo; Interholco (Danzer Group), Switzerland

Duration of the project
October 2010 – March 2014

Budget
CHF 288'732
SDC contribution: CHF 166'482 / Partner contribution: CHF 122'250

Objective

The North of the Republic of the Congo lies in the heart of the Central African rainforest and large forest concessions are attributed to logging companies. Wildlife management presents a major challenge to responsible logging companies operating in that region. It is a key focus of many Western conservation efforts and plays a central role in the forest dwellers' livelihoods. The overall objective of this research project is to contribute to the development of collaborative wildlife management strategies that are beneficial to conservation goals, thus considering the interests of logging companies and other international stakeholders, but also taking into account forest dwellers' needs and interests.

Initial problem analysis showed that the core of the wildlife management problem is commercial wildlife use. Wildlife management strategies which are primarily based on the idea of law enforcement through suppressive measures aiming at hunting control are inefficient and discriminating against the poor. Therefore, alternative strategies are needed which are more effective and inclusive of local forest dwellers and considering their needs.

In order to contribute to problem solving, the specific objectives and respective research questions are: (i) to identify ***trends*** – is current wildlife use in local livelihood systems sustainable?, (ii) to understand ***drivers*** – what are the drivers of local livelihood strategies?, and (iii) to draw conclusions regarding ***alternatives*** – what do these drivers predict with regards to alternative more sustainable livelihood strategies?

Results

After an initial qualitative situation and problem analysis of wildlife management in the study site, aspects of forest dwellers' livelihoods were investigated in order to propose sustainable, workable and people-centred solutions.

In three villages with different market integration, but with similar infrastructure, similar size and more or less similar ethnic composition, a total of 130 household surveys were performed to understand household activities and their importance for people's livelihoods. In order to assess the role of wildlife in people's livelihoods in more detail, this data was complemented through (i) in-depth quantitative (N=200) and qualitative (N=10) studies on the wildlife values of the local population, (ii) monitoring data on hunters and their activities (N=38), and (iii) data on the perception of wildlife abundance (N=110).

The resulting four data sets are currently being scientifically analysed. The findings should feed into a sustainable develop- ▶▶

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Olivia Rickenbach: Forest dwellers and biodiversity in the context of industrial forestry

ment project which is being developed by the Wildlife Conservation Society (WCS), logging companies in the region and other partners.

Development relevance

Based on the evaluation of local community-based micro-projects directed at agriculture and fishing, the steering platform of these projects adopted the employment of an expert as an organisational change favoured by the communities. However, in February 2013 the president of the platform blocked the previously adopted decision in the last minute.

Dissemination

The "North Congo Project" currently being developed by WCS, logging companies in the region and other partners has invited the fellow to participate as an expert in the project preparation. The intended project strives to assure a large ecological continuum of the current forest ecosystem by improving sustainable forest management and by reducing the human pressure through fostering of activities which are sustainable and increase people's well-being.

Publications

in preparation

The Ouesso-Mbila hunters making drawings of their hunting tools
Photo: O. Rickenbach

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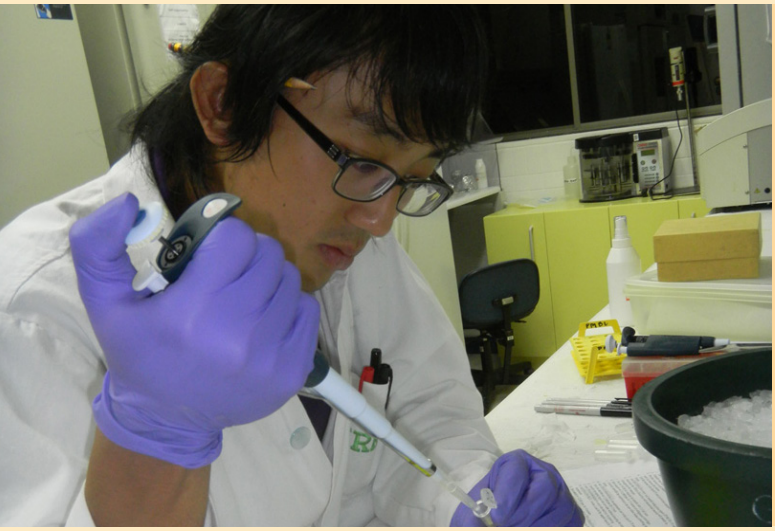
Ancient genes for future rice



RNA extraction of rice roots at IRRI, Philippines
Photo: J. Park

Research fellow
Jonghwa Park

PhD supervisors
Wilhelm Gruissem and Navreet Bhullar, ETH Zurich, Switzerland;
Sigrid Heuer, International Rice Research Institute (IRRI), Philippines

Duration of the project
February 2011 – January 2014

Budget
CHF 280'420
SDC contribution: CHF 180'000 / Partner contribution: CHF 100'420

Objective

More than half of the world's population depends on rice as their main staple food. Most of the rice farmers and consumers live in Asia and Africa with a large proportion of urban and rural poor. Considering the growing population and climatic changes which increasingly threaten rice production, it is critically important to develop new rice varieties that maintain high yield and good grain quality under adverse conditions, most importantly under drought stress and flooding. Drought stress is recognised as one of the most significant environmental stresses in global agriculture and is closely linked with problem soils, especially phosphorus (P) deficient soil. Thus, securing yield under multiple stress environments stands as a major challenge for crop breeding.

Our strategy for developing stress-tolerant cultivars is to uncover the underlying genetic components from unadapted rice varieties that have poor agronomic performance but stronger tolerance mechanisms. Recently, aus-type varieties have been reported as good donors, especially for abiotic stress tolerance.

Results

In order to identify novel genes related to drought tolerance and phosphorous deficiency stress in rice, two tolerant aus-type varieties (Dular and Kasalath) and one susceptible indica cultivar (IR64) were grown in the greenhouse under control and stress conditions. Total ribonucleic acid (RNA) was isolated from roots of these plants collected at different time points (water level ranging from 70% to 40%) and was subjected to Illumina RNA-sequencing. In total, 44,018 genes aligned to the reference genome (Nipponbare) and 5,188 genes were found to be significantly ($P < 0.05$) and differentially (fold change ≥ 2) expressed. De novo assembly was used for the transcripts that did not align to the reference genome and among these, 241 transcripts were significantly ($P < 0.05$) and differentially (fold change ≥ 2) expressed. At this stage, the specific expressions of the most promising genes are being re-confirmed by semi quantitative real time polymerase chain reaction (qRT-PCR). In addition, a selection of candidate genes for further testing is being populated.

Development relevance

This project provides a realistic opportunity to identify novel genes and traits with significant positive effect on root performance under drought and P-deficiency stresses and the potential to improve rice yields in unfavourable environments. The likelihood of success of this project is considered high since the two varieties chosen for this study have been scored as highly tolerant in independent studies on drought and phosphorus deficiency stress. The results will provide rice breeders with (i) novel root traits that have the potential to improve rice yield in ▶▶

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Jonghwa Park: Ancient genes for future rice

problem soils and under drought stress, and (ii) with gene-based molecular markers for marker-assisted breeding.

In addition to the scientific achievements, the project provided a unique opportunity to the fellow for refinement of his scientific profile.

Dissemination

The project outcomes have been presented in international meetings and publication of results in peer-reviewed journals is foreseen.

Rainfed lowland area mostly consists of problem soils and heterogeneous environments. Soil used in our experiments was obtained from such an area in the Pangil province, Philippines
Photo: J. Park

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REDD+ and "fragile states": Political economy of avoided deforestation in Central Africa

Civil servant of ministry in charge of forestry controlling of illegal logging in Cameroon
Photo: Symphorien Ongolo

Research fellow
Symphorien Ongolo

PhD supervisors
Stefanie Engel and Christian Hirschi, ETH Zurich, Switzerland;
Alain Karsenty, Centre de coopération internationale en recherche agronomique pour le développement (Cirad), France

Further institution involved
Center for International Forestry Research (CIFOR), Cameroon

Duration of the project
March 2012 – March 2015

Budget
CHF 128'132
SDC contribution: CHF 95'998 / Partner contribution: CHF 32'134

Objective

Reducing Emissions from Deforestation and Forest Degradation (REDD) is an effort to create a financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. "REDD+" goes beyond deforestation and forest degradation, and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks. Using the example of Cameroon, this research project addresses the question: is the REDD+ process changing the processes of governmental decision-making on public policies related to land use change in developing countries?

Results

The research methodology is divided into three phases. In the first phase the coherence between the global REDD+ regime, the national REDD+ strategy and the national land use policies will be analysed. The second phase focuses on organisation issues of national land-use policies and the coordination weaknesses which influence tropical deforestation and forest degradation. This second phase aims to enlighten the issue of multi-level/sectoral governance structures in the context of national REDD+ strategies. The third phase consists in investigating the chance of success, policy stability and sustainability of change induced by the REDD+ process in "fragile states".

Dissemination

One of the main outputs of the project is a book section which will be published in mid-2013 on the topic of "REDD+, fuelwood and challenges of sustainable development in Central Africa" with S. Ongolo as main author. He also contributed in a regional forest project financed by the European Union, IUCN, and the Commission for Central African Forests (COMIFAC), where he co-authored one of the project's working papers on the future challenges of the Congo basin forests in the 2040 horizon[1].

[1] *http://www.comifac.org/prospective-efbc-2040/etat-davancement/view?set_language=en*

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Symphorien Ongolo:
REDD+ and "fragile states": Political economy of avoided deforestation in Central Africa

Publications

Karsenty, A. and Ongolo,S., 2012: Les terres agricoles et les forêts dans la mondialisation: de la tentation de l'accaparement à la diversification des modèles? *Agriculture et alimentation: Des champs géopolitiques de confrontation au XXIe siècle*. Paris. Club Déméter, Cahier Demeter, 13: 99 – 108.

http://agents.cirad.fr/pjjimg/alain.karsenty@cirad.fr/DEMETER_Accaparement_des_terres_et_mondialisation.pdf

Karsenty, A. and Ongolo, S., 2012: Can "Fragile States" decide to reduce their deforestation? The inappropriate use of the theory of incentives with respect to the REDD mechanism. *Forest Policy and Economics*, 18: 38 – 45.

http://www.sciencedirect.com/science/article/pii/S1389934111000748

Ongolo, S. and Karsenty, A., 2011: La lute contre la déforestation en Afrique centrale: Victime de l'oubli du politique? *Ecologie & politique*, 42: 71 – 80.

http://www.pressesdesciencespo.fr/en/livre/?GCOI=27246100428760&fa=sommaire

Slash-and-burn farming in Cameroon
Photo: Symphorien Ongolo

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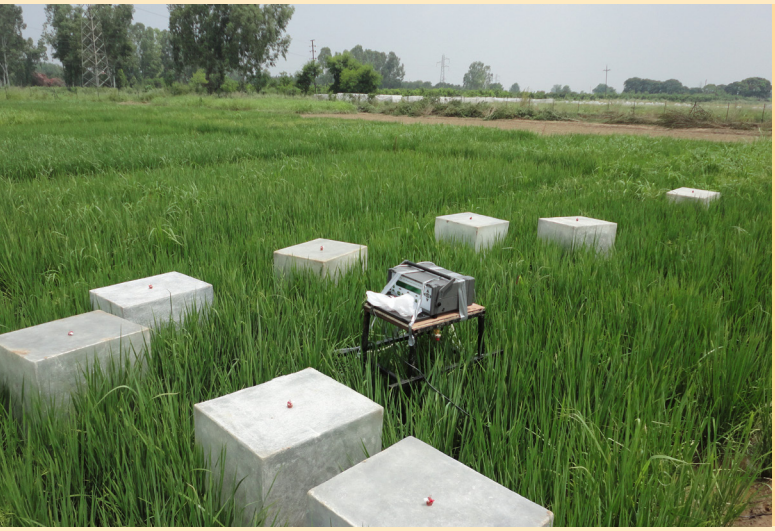
Mitigating greenhouse gas emissions from paddy farming



Measurement of greenhouse gas emissions from rice in the research fields of Punjab Agricultural University, India
Photo: Gurbir S. Bhullar

Research fellow
Gurbir S. Bhullar

Postdoc supervisor
Peter Edwards, ETH Zurich, Switzerland

Further institutions involved
Punjab Agricultural University, India;
International Rice Research Institute (IRRI), Philippines

Duration of the project
December 2011 – November 2013

Budget
CHF 303'975
SDC contribution: CHF 200'000 / Partner contribution: CHF 103'975

Objective

A major increase in the production of rice, the world's most important staple crop, will be indispensable in order to feed the burgeoning global population. This in turn is bound to increase greenhouse gas (GHG) emissions (particularly methane and nitrous oxide) unless new mitigation strategies are developed and applied. This project explores the potential for developing new rice based cropping system integrated with novel strategies to mitigate GHG emissions.

During our previous research with wetland plant species, we found that some plant species can reduce methane emissions from soil, whereas others do not. There are a number of aquatic plant species which exist naturally in rice producing regions and are already part of human consumption in local cultures.

Results

The results clearly suggest that co-cultivation of rice with some aquatic plant species (namely, *Anemopsis californica*, *Sagittaria latifolia*, *Cyperus esculentus* and *Cyperus rotundus*) results in lower methane emissions. Mesocosms with two rice plants grown together did not show any lower emissions compared to single rice plant mesocosms. This shows that the reduction of methane emission from the mesoscosms with rice and another aquatic species was likely a result of increased rhizosphere oxidation and not just resulting from direct competition. This might be associated to occupation of different rhizosphere zones by the roots of two different plant species (i.e. rice and another aquatic plant species).

The biomass data show that co-cultivation with *S. latifolia* significantly affected the productivity of rice. Therefore, despite significant reductions in methane emissions it could not be the plant of choice for intercropping with rice. In contrast, co-cultivation with *A. californica*, for example, contributed towards significant reduction of methane emissions without affecting the productivity of rice. Therefore, *A. californica* might be a suitable plant for intercropping with rice in the field.

A number of different factors including agronomic practices, compatibility with available agricultural technology and plant protection measures would need to be assessed before considering any of these aquatic plants for intercropping with rice. Different plant species might be suited for intercropping with rice at different places depending upon local conditions. To test the hypothesis in field, we are planning field studies in collaboration with our Asian partners. ▶▶

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Gurbir S. Bhullar: Mitigating greenhouse gas emissions from paddy farming

Development relevance

GHG reduction is a global goal, benefitting all mankind. Therefore, the relevance of this research cannot directly be translated into development impact. However, besides the research objectives, this project aims at capacity development in the global south. We are training master students for conducting field experiments in agro-ecological research.

Publication

Bhullar, G., Edwards, P.J., and Olde Venterink, H., 2013: Variation in the plant mediated methane transport and its importance for methane emission from intact wetland peat mesocosms. *Journal of Plant Ecology.*

http://jpe.oxfordjournals.org/content/early/2013/01/03/jpe.rts045.full.pdf+html

Gurbir Bhullar measuring GHG emissions using a photoacoustic gas monitor in the greenhouse facility of ETH Zurich
Photo: Anett Hofmann

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Determining the effectiveness of super-absorbent polymers in drying maize

Super-absorbent polymers (powder at the bottom of the bottles) used to dry maize in an enclosed environment
Photo: Duncan Onyango Mbuge

Research fellow
Duncan Onyango Mbuge

Postdoc supervisor
Raffaele Mezzenga, ETH Zurich, Switzerland

Further institution involved
International Centre of Insect Physiology and Ecology (icipe), Kenya

Duration of the project
January 2012 – December 2012

Budget
CHF 153'320
SDC contribution: CHF 49'840 / Partner contribution: CHF 103'480

Objective

The goal of the project was to develop a system that farmers who dry their maize using solar energy and who have no access to modern drying technology could use to dry their maize during seasons when it rained during harvest. Super-absorbent polymers (SAP) were identified as possible desiccant to use in these circumstances to dry maize due to their high moisture absorption capacity and rate. The objective was to determine the effectiveness of SAPs in drying maize.

Results

The experiments have shown that SAPs are good drying agents and may be used for drying maize grain and seed. At ratios of SAP:maize of 1:1, 1:2 and 1:5, the drying takes place without the need to change the SAP; for ratios such as 1:10, 1:20 up to 1:60, drying may take place as long as the SAP is replaced every 24 hours. The SAP may be used over and over again without loss of absorption rate or capacity, which makes it less costly for farmers. SAP dries maize through absorption of vapour in the store, which demonstrated that SAPs still dry grain even if they are enclosed in a porous membrane such as a tea bag. This will ensure that drying can be done when the SAP is not in contact with the grain and which reduces the possibility of the SAP mixing with the grain. The work on the effect of SAPs on aflatoxins is still on-going.

Development relevance

The study was a baseline survey whose objective was to establish whether indeed the SAPs may be used effectively for drying grain. Since the results have shown that it is possible to use SAPs for drying grain, the next step is to develop a prototype for field scale testing. It is hoped that from this work, a prefabricated granary can be manufactured that incorporates SAPs, prevents postharvest aflatoxin contamination and is affordable to farmers.

The prefabrication of granaries will address policy issues regarding grain storage. In most African countries the governments offer extension support when the crop is growing, while they do not invest in follow-up measures after the grain is harvested. The result of this policy is that half of the grain is lost after harvest. The manufacture of this granary will not only reduce postharvest losses but will provide well-designed granaries and remove the burden of design from the farmers.

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Duncan Onyango Mbuge: Determining the effectiveness of super-absorbent polymers in drying maize

Dissemination

So far the work has been done up to the level of baseline survey of the technology and is not ready for the intended beneficiaries. Once in place, the technology will serve farmers in areas affected by aflatoxin or other less lethal pathogens. The result will be good for seed maize companies since seed is very sensitive to temperature and this method offers a drying technique at ambient temperatures that will maximise the viability and vigour of seed.

Currently there is a proposal being developed by the postdoctoral fellow together with ETH Zurich as a follow up to the first part of the project funded by RFPP. The proposal seeks to apply the findings with farm-scale experiments to build a prototype for a maize granary incorporating hydrogels.

The LC-MS machine used to determine levels of aflatoxin contamination in maize at icipe, Nairobi
Photo: Duncan Onyango Mbuge

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