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Proceedings of

The SLU Africa Food Security Research Symposium

Outcomes of a Swedish Government Initiative

Kampala 4-6 December 2012

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Agricultural Sciences for Global Development (SLU Global)

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Outcomes of a Swedish Government Initiative

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Introduction

In October 2010 the Swedish Ministry of Foreign Affairs decided to contribute 40 million SEK to the Swedish University of Agricultural Sciences (SLU) from its special allocation within the Government's development budget supporting global food security. This allocation was done with the aim to reduce hunger and malnutrition, and to this end a further 60 million SEK were donated to the Alliance for a Green Revolution in Africa (AGRA) to support their work in sustainably improving the productivity and incomes of resource-poor farmers in Africa. In the medium to longer term future needs were to be secured by research and development. SLU's mission was thus to engage with institutions in low-income countries, conduct high quality collaborative research and implement its results. Research collaborations should also enhance the capacity development of partner institutions. Priority research areas included plant breeding, farming systems, animal health and disease control.

In these proceedings data generated from 21 subprojects, from a total of 11 main projects within the collaborative research program on food security, are presented. Most of these projects were conducted in Africa, although two were in central Asia. It was thus deemed appropriate to hold a symposium to present the results in an African country and the choice fell upon Uganda. This enabled both Swedish researchers and their African and Central Asian partners to interact, discuss the results so far achieved and, more importantly, to plan future collaborative projects. The importance of the symposium was highlighted by the attendance of the Swedish ambassador to Uganda, and of representatives from AGRA, RUFORUM, TEAM-Africa, Sida, Makerere University and other universities from the East African region and Central Asia.

On behalf of SLU and of our partner universities in Africa and elsewhere we wish to thank the Swedish Ministry of Foreign Affairs and the Swedish International Development Cooperation Agency (Sida) for their foresight and generous support of our research. It ultimately aims to secure a sustainable production of nutritious food for smallholder farmers in order to guarantee their livelihoods.

Arvid Uggla, Director, SLU Global

Malin Planting, Head of Communications, SLU Global

Some of the participants of the SLU Africa Food Security Research Symposium.

Kampala, December 2012

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Introductory session

Welcome address

Prof. Arvid Uggla, Director of SLU Global, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden

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Your excellency Mr Urban Andersson, Swedish ambassador to Uganda, representatives and guests from AGRA[1], RUFORUM[2], TEAM-Africa[3], Sida[4], Makerere University and a number of other universities in Africa and other countries, alumni of SLU – dear participants of the ”SLU Africa Food Security Research Symposium” subtitled ”Outcomes of a Swedish Government Initiative”.

After an intense period of planning we are now happy to be here in Kampala, Uganda, especially those of us from Scandinavia who have fled the snow and cold to meet warmth and friendliness in this beautiful part of the world – and we are full of expectations for the 3-day conference that is lying ahead of us. More than 100 participants have registered for the symposium which is dealing with research aspects of how to supply a growing global population with safe and nourishing daily food while also considering the need for environmental, social and economic sustainability in agricultural production.

The host of this conference is SLU, the Swedish University of Agricultural Sciences, one of the foremost universities within Sweden according to national rankings and one of the world leading universities in the fields of agricultural and environmental sciences according to international rankings. SLU is a university devoted to agricultural sciences in a broad sense – it includes forestry, veterinary and animal sciences, landscape architecture as well as our special governmental mission to conduct environmental monitoring and assessment.

SLU has a long tradition of participating in development cooperation and capacity building activities, which we do together with partner universities and research institutes in different parts of the world. These activities are integral parts of our mission. To make our efforts more visible and to increase our power SLU has created a programme called *Agricultural Sciences for Global Development* – or in brief just *SLU Global*. This programme creates a platform for the activities in our university that are directed towards international development cooperation in research and higher education, with a particular focus on Africa.

In 2010 SLU received 40 million SEK, equivalent to circa 6 million USD, from the Swedish Ministry of Foreign Affairs. This grant, colloquially known at SLU as ‘UD40’, came from a special government allocation within the development cooperation budget which was destined to support global food security through increased agricultural production and to diminish risks for malnutrition and hunger caused by climate change. It was an investment in future needs, primarily through research

[1] Alliance for a Green Revolution in Africa
[2] Regional Universities Forum for Capacity Building in Agriculture
[3] Tertiary Education for Agriculture Mechanism for Africa
[4] Swedish International Development Cooperation Agency

and development, to be performed in collaboration with research institutions in low-income countries within the areas of crop breeding, farming systems, animal health and disease control. The UD40 program was to be run over two years, 2011 and 2012.

SLU was very pleased to see that the *Alliance for a Green Revolution in Africa*, AGRA, also received funding from the same allocation, and a joint inception seminar was held at SLU early in 2011. This inception seminar was honoured by the presence of Mrs Gunilla Carlsson, the Swedish Minister for International Development Cooperation.

Now, two years later, the UD40 research program that SLU has conducted in close collaboration with partners particularly in African countries, but also in central Asia, has soon reached a conclusion, and it is time to summarize some of the results, which is the primary purpose of this symposium. The ultimate date for the final report to the Swedish Government is October 2013, and a final seminar will be held at SLU in Uppsala by June 2013. This will include four additional projects not presented at this seminar.

However, this symposium in Kampala gives us a golden opportunity – which is the second purpose of the conference – to gather a number of our African and other international collaborators and partners to digest the science thus far produced and give each of us the opportunity to forge collaborative research and higher education plans for the future.

As you can see from the program there is time set aside for breakout sessions that will enable us to discuss future collaboration. The latter exercises are equally as important as the presentations of data from the projects. I urge you all to take active part in these discussions so that this symposium will not only be a concluding seminar but will also become the start of new collaborative initiatives and interdisciplinary partnerships. I trust we will all contribute to a successful outcome aiming ahead at new solutions to the great challenges our globe is facing.

Welcome remarks

Prof. Eli Katunguka Rwakishaya, Director of Research and Graduate Training, Makerere University, Kampala, Uganda

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I am delighted to have been invited to give welcome remarks at this very important Swedish University of Agricultural Sciences Africa Food Security Research Symposium, the first of its kind to my recollection.

Since 2005 I am the Director of Research and Graduate Training at Makerere University. Before that I was the dean of the Faculty of Veterinary Medicine for eight years and I have spent more than 30 years working in the university where most of this time was in the area of animal health and production. I am therefore conversant with the issues of food security, the focus of this symposium.

I wish to especially welcome to Uganda all delegates from outside our country and I urge you to enjoy the special Ugandan hospitality and the good weather while you are here.

Makerere, the oldest and largest university in Uganda and possibly East Africa, has had long standing relationship with Swedish Institutions particularly SLU which combines both agriculture and veterinary medicine. This is the only university, to my knowledge, that has successfully combined animal science with veterinary medicine to form a joint faculty hence allowing a wholesome approach to addressing issues of animal health and production.

Since the year 2000, SLU has been working with Makerere Faculty of Agriculture to build research capacity through PhD and postdoctoral training. The Faculty of Veterinary Medicine at Makerere developed a partnership with SLU to train young upcoming scientists to PhD level and joined the collaboration in 2010. This is in a bilateral Sida-Makerere Research Capacity Building Programme which involves Makerere University and 13 Swedish universities of which SLU is one. I am privileged to be the coordinator of this programme, the largest research programme in the university involving more than 150 PhDs and 20 research teams and 13 higher education institutions in Sweden. The main focus of this programme is to support research that comes up with solutions to people's problems with the eventual aim of reducing/alleviating poverty.

Turning the topic of Food Security

The world food summit of 1996 defined food security as existing "when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life". The concept of food security therefore includes both physical and economic access to food that meets peoples dietary needs as well as their food preferences.

Food security is built on three pillars namely: 1) Food availability – sufficient quantities food available on a constant basis, 2) Food access – having sufficient resources to obtain appropriate foods for a nutritious diet, and 3) Food use – appropriate use based on knowledge of basic nutrition and care, as well as adequate water and sanitation. This implies that food security is a complex sustainable

development issue, linked to health through malnutrition but also to sustainable economic development, environment and trade.

In Africa, it has been argued that the root cause of food insecurity is the inability of people to gain access to food due to poverty especially in sub-Saharan Africa. Factors responsible for this may include: high prevalence of diseases especially HIV/AIDS and malaria, civil wars, poor governance, frequent drought and famine, agriculture dependence of climate and environment, and a rapidly increasing human population. Food security on the continent has continued to worsen since 1970 and the proportion of malnourished population has remained at 33-35 per cent in sub-Saharan Africa (ranging from 4 per cent in Northern Africa to 40 per cent in Central Africa). This highlights the importance of food security and hence the need to address it.

The initiative by the Swedish Government to support SLU to tackle this challenge is very welcome. This is one of numerous initiatives by different governments and organisations to address food security in Africa but with varying degrees of success. To give some examples: 1) US President Barack Obama has announced a 3 billion USD plan to boost food security and food productivity in Africa. Food security was also discussed at the recent 38th G8 summit in Maryland, USA. President Obama declared that food security is a moral imperative, an economic imperative and a security imperative. 2) The UK Department for International Development announced that 45 leading companies plan to invest 4 billion USD in developing African agriculture. As governments cannot tackle this challenge alone, the skills, resources and financial expertise of leading businesses will help transform African agriculture, giving poor farmers the chance to pull themselves out of poverty, hunger and malnutrition – said the UK International Development Secretary, Andrew Mitchell. 3) In 2009, at the G8 summit in Italy, major industrialized countries promised more than 20 billion USD over three years to improve food access to Africans and others hit by high prices. The background was the food shortages that led to price rises and unrest in many import-dependent countries, including many in Africa.

So despite many initiatives and promises of large sums of money, food shortages remain in Africa. However, what is clear is the absence of the voices of Africans who are the targets of these initiatives. Another mistake is that many of these foreign governments imagine that food security in Africa can be addressed by a single uniform prescription. Africa is not a homogenous entity, it has numerous agro-ecological zones, different climates and rainfall patterns, a large section of Africa is arid etc.

The difference between these initiatives and the one we are discussing today is that this one is driven by research. What is even more encouraging is that the African scientists have an opportunity to make a contribution to the research agenda by defining what it is that needs research solutions in an attempt to address food insecurity.

I want to thank the Ministry of Foreign Affairs of the Swedish Government for coming up with this boost to African agricultural research involving SLU. Makerere already had ongoing programmes in veterinary medicine and in agriculture and more money was injected to promote joint research activities all geared towards contributing to alleviation of poverty amongst the Ugandan people. I pledge our continued support to these initiatives and look forward to very frank and fruitful deliberations in the next two days.

I thank Professor Arvid Uggla and his team at SLU Global for organizing this meeting and for involving us in these discussions.

Once again, welcome to Uganda and this very important symposium.

Keynote presentation

Building sustainable food systems in Africa – Sweden-AGRA partnership

Dr. Rufaro M. Madakadze, Program Officer for Education and Training, Alliance for a Green Revolution in Africa, Nairobi, Kenya

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Growing commitment to agricultural transformation in Africa

Agriculture and its related industries contribute an average of 30% of GDP in most sub-Saharan African countries. Poverty reduction and achieving food security in these countries requires agriculture transformation. The Comprehensive Africa Agriculture Development Programme (CAADP) has ambitious targets for transforming African agriculture with an overall goal of sustained 6% per annum growth in agricultural production. Twenty-six countries have signed the CAADP compact and committed to significantly increase agriculture sector funding although only nine have exceeded the 6% per annum growth target. There is therefore a new focus to increase productivity sustainably through holistic value chain approaches by all stakeholders, tapping into significant technological and market opportunities. Although crop productivity has started to increase in sub-Saharan Africa this is not commensurate with the population growth and needs to be adapted to respond to rapidly evolving challenges and complexities in agricultural systems. The increases are due to a refocus of donors' higher funding toward agriculture and a few countries honoring their Maputo Declaration (2003) pledges to provide 10% budgetary allocation to agriculture. The Alliance for a Green Revolution in Africa (AGRA) has a vision of "A food secure and prosperous Africa" with a mandate that seeks to address smallholder farmer needs using science and technology, access to markets, providing an enabling policy environment, while including all genders and building the capacity of smallholder farmer organizations.

Sustainability requires comprehensive interventions

Food systems that are sustainable in both environmental and institutional terms are those that meet the needs of the present, without compromising the ability of future generations to meet their own. Fostering sustainability therefore involves creating and strengthening self-perpetuating mechanisms that will ensure system improvements endure. Tapping into the promise of agricultural transformation sustainably also means addressing the whole value chain in a comprehensive and integrated manner with no broken links, identifying opportunities for interventions along the chain and precisely addressing them. Building sustainability can involve strengthening local institutional and human capacity to address problems using science and technology, in a socially relevant context and fostering the private sector to bring to scale interventions that demonstrate potential for transformation. Effective public-private sector partnerships are therefore critical to ensure sustainability and require both sectors to effectively address parts of the value chain.

The Sweden-AGRA partnership is helping to catalyze sustainable change

The Swedish Government has partnered with AGRA to address some of the evolving challenges for smallholder farmers – and specific attention to women's needs – while strengthening selected staple food value chains. AGRA's partnership with Sweden emphasizes integrated interventions that address challenges across the value chain (including cross-cutting issues) and incorporates all the critical elements needed to foster sustainability through building institutional, human and private sector capacity while fostering public-private sector partnership and ensuring gender equity. The Swedish Ministry of Foreign Affairs is supporting two programs – one in East and Southern Africa and the other in the Sahel – through 12 million USD of funding. The two programs in total target over 120,000 smallholder farmers and each builds on and links to previous and current AGRA investments to enhance the overall transformative impact. A new 6 million USD program under this partnership, funded towards the end of 2012, aims to improve access to finance and markets in both East and West Africa. Enabling farmers and other actors along the value chain to obtain credit is a critical factor in strengthening food systems.

The first program in the partnership entitled "Comprehensive Value Chain Program Scaling of Staple Food Production in Malawi, Rwanda and Zambia" was funded in 2010. It is an integrated program with access to markets as the main focus but also includes seeds, soil health and water management, land tenure for women and farmer organization support. The overall goal of the program is to rapidly scale up food production in the three countries and increase agricultural productivity, food security and income among smallholder households – particularly among women. The specific objectives are to: promote efficient and profitable output markets that offer higher returns to smallholder farmers; increase smallholder farmer productivity from the use of new crop technologies that are delivered to them efficiently and effectively (seeds and integrated soil fertility management (ISFM)); increase agricultural productivity through better soil health and water management; improve security of land rights to accelerate investment in sustainable soil, land and water management technologies; and build the capacity of farmer organizations to improve their ability to respond to the agriculture-related needs of their members.

The second program targeting West Africa entitled "Strengthening sustainable staple food production in selected Sahelian countries: Burkina Faso, Mali and Niger" was funded in 2011 and will run to 2013. The main objective of this program is to rapidly scale up food production in the three selected Sahelian African countries and includes one additional specific objective to increase the number of crop scientists able to develop locally-relevant staple food seed varieties through improved training and research.

In these projects AGRA identified implementation partners (local institutions) that developed project proposals and plans with teams of AGRA program officers guiding the proposals through AGRA's rigorous grant approval process and rolling out the projects to work while it gives oversight and builds capacity to deliver the intended outcomes. Twenty-eight projects in the six countries have received funding. The areas funded are shown in Table 1 below and highlight the integrated nature of the programs.

Table 1: Number of projects AGRA has funded with the Swedish grant per country and program

Program/Country	Malawi	Rwanda	Zambia	Burkina Faso	Mali	Niger
Education and policy	1 (women and land rights)			1 (MSc plant breeding)		
Seed production	2	3	2	1	1	
Agro-dealer development	2	2				
Soil health and farmer organization		1				
Market access and farmer organization	3	2	2	1	1	2

Projects in two of the countries – Malawi and Rwanda – are briefly presented to show the results to date from integrated interventions that target specific geographical locations and work across the value chain to ensure sustainability. In Malawi the projects are focusing on the central province and target a total of 50,500 farmers directly while projects in Rwanda are in four provinces, targeting 38,000 farmers directly. Further indirect benefits are expected, particularly from the land rights advocacy work in both countries and from access to certified seed in Rwanda.

Three Market Access projects in Malawi are promoting alternative uses of cassava, post-harvest handling, capacity building for farmer organizations and linking smallholder farmers to markets and began in 2011. AGRA's Soil Health Program (SHP) and Farmer Organization Support Centre in Africa (FOSCA) are co-funding two of these projects. SHP is training farmers on integrated soil fertility management (ISFM) skills. The crop value chains are maize, groundnuts, soybean, and common beans. The projects have trained over 5,000 farmers in postharvest commodity management, marketing and business skills; over 5,100 megaton of produce sold valued at 236,600 USD; and more than 10,400 farmers aggregating their produce. About 2,000 farmers have accessed financing for their input purchases. The cassava-focused project has exceeded expectations by setting up 69 seed material multiplication centres against a target of 20, mainly due to growing demand for cassava (for both fresh and industrial use). It is benefitting from AGRA-supported breeding of high-yielding, disease-resistant cassava varieties.

The Program for Africa's Seed Systems (PASS) project on agro-dealer development is deepening and expanding the retail networks for farm inputs. Forty-two agro-dealers have been trained. A seed company supported to expand its multiplication and distribution of certified seed to farmers has produced 480 megaton of certified seed of maize, beans, soya, peas and groundnuts. The Policy program's initiative in partnership with the Women's Land Resource Centre (WOLREC), Farmers Union of Malawi (FUM) and Landnet Malawi to advocate for improved land rights for women, including support to develop a pro-poor, pro-women land law has just started.

The results reported are for one cropping season. Malawi's paucity of foreign exchange over the past two years has caused major challenges for projects especially as fuel availability and cost became problematic.

In Rwanda, the investments are building on previous or current AGRA projects and expanding into

new areas. The projects in Rwanda target a total of 88,000 farmers directly. Two Market Access projects are aiming at reducing transaction costs by promoting aggregation of produce for sale among smallholder farmers, and linking them to markets with additional funding from SHP and FOSCA, helping to improve productivity and the effectiveness of farmer organizations. PASS is strengthening two seed companies to produce and distribute certified seed of maize, beans and soybean, wheat and Irish potato. The target is to produce over 930 megaton, with activities to increase awareness among farmers. Women were the majority of the farmers who attended field days for one of the companies. A major challenge for the seed companies is the Rwanda Government's distribution of free maize seed.

In both Malawi and Rwanda the Swedish funding to AGRA has enabled AGRA to support some activities within the value chain that were missing or needed to expand in its other activities ensuring that all aspects of the value chain are addressed while building institutional and human capacity and fostering public-private sector partnerships. Both countries also have significant government contributions to the agriculture sector ensuring sustainability. However, in both Malawi and Rwanda, farmers clearly need more and better storage facilities.

Programs in the other four countries similarly identified smallholder farmer needs and are working in an integrated manner. Overall, the Sweden-AGRA partnership is contributing to sustainable food systems by building scientific and farmer organization capacity, imparting knowledge of good agricultural practices, increasing access to input and output markets as well as access to finance, and helping to improve access to land rights for women. The interventions are expected to have spillover effects that will catalyze change, thereby increasing food security and smallholder farmer incomes.

Keynote presentation

Challenges for African tertiary agricultural education. The Tertiary Education for Agriculture Mechanism (TEAM-Africa) initiative.

Prof. Hamidou Boly, TEAM-Africa coordinator, Bobo-Dioulasso, Burkina Faso

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1. Background

Increasingly, Africa's leaders have been calling for urgent reform and renewed investment in Tertiary Agriculture Education (TAE). The urgent requirements culminated nearly two years ago in the Ministerial Conference on Higher Education in Agriculture in Africa (CHEA), which was organized in November 2010 in Kampala, jointly by RUFORUM, ANAFE, FARA, the World Bank and the EU Technical Centre for Agricultural and Rural Cooperation CTA. Among the outcomes of the CHEA, as articulated in a communiqué from the attending ministers of agriculture and ministers of education, were calls for:

- The development of an African strategic plan for TAE in Africa;
- Increased investments in higher education in agriculture to be included as an integral part of the CAADP process through the development of technical tools to provide guidance for planning and investment in TAE and through much more systematic engagement of people from the TAE community in CAADP processes at every level
- A renewed and vigorous emphasis by African governments on restoring the quality of higher education in agriculture

The Tertiary Education for Agriculture Mechanism (TEAM-Africa) is a direct response to a call by African ministers of agriculture, higher education, science and technology, and finance at the (CHEA) and was then created to follow up how to *i)* articulate a shared strategic vision for TAE transformation and capacity building in Africa; *ii)* provide information to support evidence-based priority setting on investments in TAE to all interested parties but especially to DPs and African TAE institutions; *iii)* provide guidance on best approaches to transformation and investment in TAE; *iv)* work to integrate TAE into CAADP investment plans; and to *v)* do all of the above, while promoting common principles of support to TAE working through and strengthening existing and promising new TAE networks.

Agriculture remains the dominant economic sector in sub-Saharan Africa, accounting for 40% of GDP, 25% of exports and 60-80% of employment across the continent and is therefore the most important sector for poverty reduction and food security. The African heads of state and leaders acknowledged this when they agreed in 2003 on the Comprehensive Africa Agriculture Development Programme (CAADP) followed by the Framework for Africa Agriculture Productivity FAAP, adopted in 2006. This is a direct response to the fact that agriculture in Africa and particularly in sub-Saharan Africa has performed worse than in other regions of the world over the past five decades. Per capita production of cereals over that time has fallen by 15%; cereal yields have risen less than 50%

over the same period, compared to an increase of 180 to 300% in Asia. Meanwhile, Africa's share of world agricultural trade fell from 5-6% during the 1960s and 1970s to 2% in 2000, before recovering somewhat to 3.5% by 2008 (FAOSTAT, October 2011). Reversing sub-Saharan agriculture's poor performance is an urgent priority for the continent.

The African vision for agricultural development established by AU-NEPAD aims to achieve an annual growth of 6% per annum with a request of 10% of public expenditure towards agricultural sectors. This is supported by an innovative Framework of African Agricultural Productivity (FAAP) which provides guidelines and criteria designed to encourage implementers and investors in TAE to work in harmony at the scale sustained over sufficient time to achieve the African Vision.

CAADP is entering in its 10 years of processes to reach a higher path of economic growth through agriculture-led development which eliminates hunger, reduces poverty and food insecurity and enables expansion of exports. Despite the measures adopted for the sustainable increase in production to meet growth targets that are set out in the national investment plan (NAIPs), the implementation of actions in the ground suffers from lack of qualified technical players' enforcement reforms production. Over 40% of the current agricultural investment plans aim to achieve growth by promoting value chains. This calls for the adequate qualification both of the value chain actors and the CAADP implementing institutions. There are no enabling policy for knowledge and capacity building improvement, legal and economic frameworks and qualified staff is lacking at all levels, e.g. in the respective CAADP country teams and the education and agriculture ministries. Hardly any properly prepared capacity development (CD) systems are available for CAADP country teams to carry out efficiently the planned investment plans and to raise agricultural output. The main actors of women and young men are particularly underprivileged groups in rural areas and education system and their potential is wasted without access to appropriate knowledge.

The quality of tertiary agricultural education is critical because it determines the expertise and competence of scientists, professionals, technicians, teachers, and civil service and business leaders in all aspects of agriculture and related industries. It raises their capacities to access knowledge and adapt it to the prevailing circumstance, and to generate new knowledge and impart it to others. There is a consensus in recent studies, such as those by the Inter-Academy Council and the Commission for Africa, that urgent action must be taken to restore the quality of undergraduate and postgraduate agricultural education in Africa. The number of private education institutions in Africa has increased dramatically, but their contributions are still marginal for agriculture in comparison to public institutions. Public support for strengthening agricultural education should promote a radically new approach to solving individual and institutional problems and maintaining global standards.

2. The TEAM-Africa concept

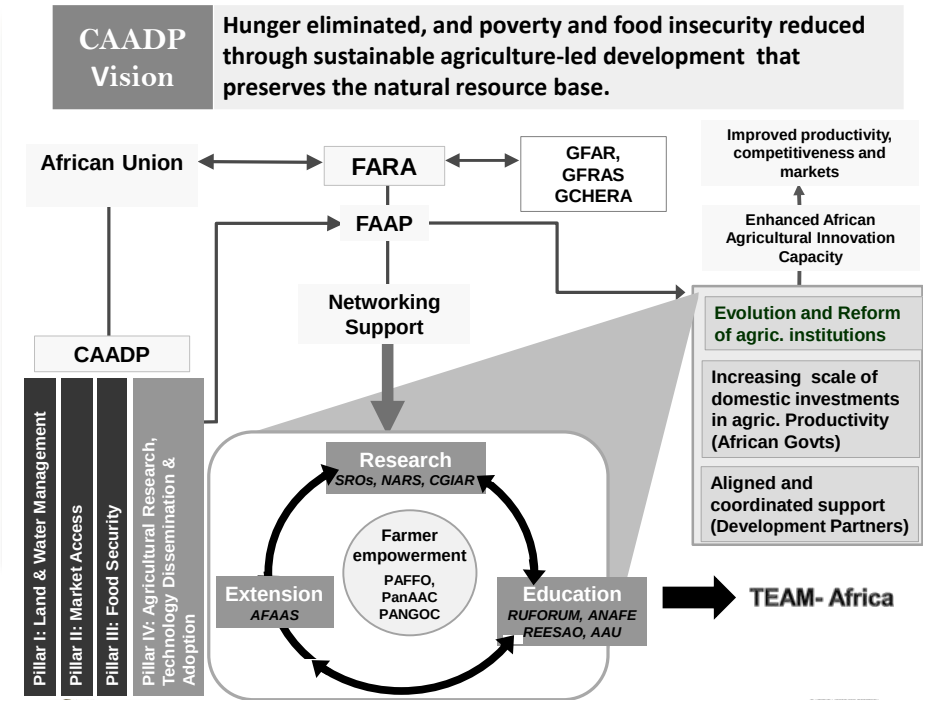
The hallmark of TEAM-Africa is to serve as a continental platform for advocacy, synergy building, and enhancement of policy for education systems through the CAADP Pillar IV mechanism under the FARA umbrella and the education networks in Africa.

The main objectives are to *i)* facilitate TAE systems to improve learning content and delivery that respond to the modern and dynamic society; *ii)* bring greater coherence and coordination on the transforming processes in TAE institutions and networks in Africa; *iii)* promote inclusion of TAE into

the framework of CAADP processes and plans, and *iv)* support better linkages between education systems, research actors, private sector and extension services.

The implementation processes concern all education stakeholders including the key education networks which initiated the mechanism (ANAFE, RUFORUM); other agriculture education networks and associations (ATVET, AAU, REESAO), TAE-Partnership composing by development partners, TAE experts and donors led by the World Bank; the Advisory Board (AB) chaired by FARA with a co-chaired of NPCA and including TAE networks, Africa University Association (AAU), and representatives from development partners, private sector, farmers organizations and NGOs.

TEAM-Africa is now building up a future Africa with education systems playing a central role in meeting labour market needs for agriculture, rural development and natural resource management, both in the public and private sectors – and providing catalytic impacts on rural innovation systems.



Panel discussion

PARTICIPANTS: *Dr. Rufaro Madakadze (AGRA), Prof. Ingrid Öborn (ICRAF), Prof. Eli Katunguka (Makerere University), Dr. Ekwamo Adipala (RUFORUM), Prof. Hamidou Boly (TEAM-Africa), Prof. Barbara Ekbom (SLU), Dr. Katri Pohjalainen Yap (Sida, Swedish Embassy in Uganda)*

The panel discussion was chaired by *Dr. Inge Gerremo, Senior Advisor at SLU Global.*

Inge Gerremo noted that the presentations made on this first day of the SLU Africa Food Security Research Symposium demonstrated the breadth as well as the depth of competences gathered here and the fact that this had been confirmed by the quality of the presentations. The following text gives an outline of the discussions during this session.

The aim of this panel disussion is to set the stage for workshop discussions in the days to come. We welcome our panel members who have kindly agreed to give their perspectives on the challenges we face and their ideas on potential ways forward within the field of food security. The panel members represent expertise within the areas of European and African university research, African research institutions, African research, education and capacity building organizations, and not least, the Swedish Government which has funded the food security initiative of which this workshop is a part.

Unfortunately, we did not manage to attract the politicians and decision-makers from Africa and Sweden that we had hoped for. But we ask that each of the members of the workshop use their own networks to convey the message that the agricultural sector, specifically within research and higher education, is vital to solve the food security challenges that we face today. Investments in higher education and capacity building in agricultural universities/faculties in low-income countries will have a definitive effect on food production and need to be strongly supported by donors.

The focus of this workshop is research within the field of food security and even though there is no one here to represent farmers or people involved in agricultural businesses and marketing, we recognize the importance of the perspectives and practical expertise of these people involving the entire food chain including consumers.

Thus, Dr. Gerremo asked the panelists to elaborate on two issues and by doing so provide arguments for convincing African and Swedish Politician of their importance:

1) Why is agriculture important for Africa's development ahead?
2) Why specifically is higher education in agriculture important?

A number of important views came out of the panel discussion and a brief summation follows:

The conversation started by discussing how research and education are of importance and what can be done to improve the understanding that they are vital mechanisms in addressing food security issues. One urgent voice came from the panel – researchers must be better at transferring research results to end users, that is to say farmers, members of the business sectors, and consumers.

A panelist challenged the workshop participants to ask themselves 'What have you recently told the press about your research? How much effort do you and your organization devote to scientific communication?'

Another panelist said that communication with politicians is essential. Focus should not only be on

issues of farmers' production but also on market aspects. In some African countries agriculture is the most important natural resource and essential for the livelihoods of the people.

Another view that came up is that knowledge transfer works two ways; from farmers to researchers as well as from researchers to farmers. There is a need for the high level of knowledge among local farmers and business owners to be used when formulating research questions and in agricultural education at higher levels.

The discussion turned to the next phase of the Sweden/Uganda agreement that is planned for a five-year period, starting in 2015. Sida is the largest research donor to Uganda and it is essential that these resources are used in the very best way. The Sida representative asked panelists and audience to consider the following questions:

- Which are the key future issues in the areas of agriculture and land use?
- What capacity is needed and where are the gaps – which institutions are critical?
- Which institutions are important in the region?
- Which multidisciplinary approaches are feasible and how can social sciences be incorporated into a multidisciplinary research approach?
- Is regional collaboration possible?
- How can research in the areas of food security translate to the policy level?
- Are the resources that are currently generated used strategically?

It was emphasized that there is no given format for future scientific cooperation, and suggested to use the Ugandan context as a starting point when formulating future issues and needs. Two points are of importance; long-term working relationships and high scientific standards, including publication in international journals and international exchange.

A member of the audience took up the point that it is important to work toward a long-term horizon. There is a recent shift, in the EU vocabulary, from a *biobased economy* to a *bioeconomy* in the upcoming Horizon 2020. This means that the issues we address should include consideration of 1) food as a primary issue, 2) products from biological resources, 3) the environment, 4) social aspects of food security, and 5) the relationship between consumers and industry.

The Sida representative responded by saying that we must address issues in more complex ways than before. Multidisciplinary and multifaceted answers are needed to these complex question and Sida therefore wants to support multidisciplinary themes.

A panel member suggested that as a means of addressing complex questions, Sida could consider supporting initiatives that are based on larger geographical contexts. It was also suggested that those initiatives that receive Sida funding could be asked to make links and find synergies between, e.g., CGIAR institutes, regional networks, and universities. There is a need to make better use of the CGIAR system but also to build up national research institutions, ideally integrated with the universities.

A specific issue was raised by a panel member: Why is adoption and adaption not greater? The audience responded that it is important to promote the spread of good examples and success stories to young people in order to make them interested in the agricultural sector. Young people are interested in business and it is therefore essential to point at the potential business aspects of the processing and marketing sectors.

Additional voices from the audience in response to the request to identify key issues of the future included discussion on: Losses at farm level and post-harvest losses, animal and plant genetics, business for development, and the need for better dissemination of results produced within collaborative research projects.

The discussion then turned to the need for strengthening links between new knowledge produced at African universities and governmental policy making. A member of the audience stated that several African governments have showed a renewed interest in agriculture and see a potential within the areas of agricultural processing and marketing.

When the discussion became more specific, ideas began to flow as to how we could cooperate on some of the issues that were mentioned above. SLU and AGRA, for example, could establish a partnership with a focus on the analyses of genomic data. SLU and Makerere can cooperate with practical training of postgraduate students. PhD programs and post-graduate training using new teaching methods and curricula which incorporate future issues such as climate change and internet-based technologies are other areas of potential cooperative endeavors. The climate debate might make it easier to argue about the importance of agriculture.

African vice-chancellors have discussed issues where they would like to establish collaboration with SLU. These include:

- Building capacity for resilience
- Building capacity for nutrition security
- Building capacity within the environmental sciences
- Linking to policy making (e.g. FARA, RUFORUM, ANAFE, TEAM-Africa)

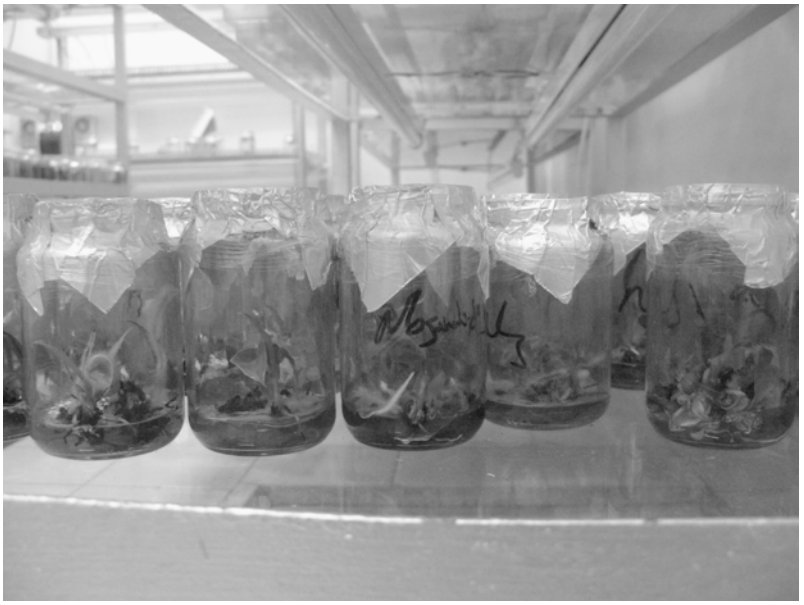
By building joint knowledge centers within these fields, there will be mutual benefit for both African universities and SLU. A representative from SLU Global pronounced that SLU is eager to advance its collaboration with African partners, also as this is part of the university's responsibilities within the Swedish Government's Policy for Global Development.

Dr. Gerremo thanked the participants for their valuable inputs and concluded the discussion by underscoring a statement made by one of the panelists: "Partnership between research, education and extension is key in the development of a sustainable African agriculture."

Scientific session 1

Crop breeding and genetics

Chair: Prof Ingrid Öborn



Keynote introduction

Plant breeding perspectives for Africa

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1. SUMMARY

Africa faces a number of development challenges and must work to turn its opportunities into wealth and sovereignty. For Africa, agriculture is the largest economic sector, representing 15% of the total GDP or more than 100 billion USD. In this decade, the sector has been growing at between 2-5% per annum along with the overall economy. This resurgence of the economy provides unparalleled opportunities for science and technology to impact the continent positively. But for that to happen, there is need to strengthen the innovation systems. Technological innovations are required to enable Africa's agriculture, the continent's backbone sector to adapt to new challenges, while at the same time producing at optimal levels. Crop improvement has been one of the cornerstones of improving crop productivity worldwide from which Africa has marginally benefited. In this paper I review opportunities to harness science and technology for crop improvement. But more specifically argue that for crop improvement to underpin Africa's agricultural growth through a doubly green revolution, there is need to i) intensify generation of new resilient and high yielding varieties using new technologies, ii) develop functional seed systems and strengthen related support services, iii) develop new management options that promote agro-ecological "fit" for new crops and new and or changing environments, iv) train the next generation of scientists, and finally v) build strong partnerships to underpin innovation, development processes and practice.

2. INTRODUCTION

Agriculture and Africa's economy. Agriculture is Africa's largest economic sector, representing 15% of the total GDP or more than 100 billion USD annually. After decades of decline, sub-Saharan Africa's (SSA) agricultural sector, 80 % of which consists of smallholder farmers, grew by more than 3.5% in 2008, well above the 2% rate of population growth (FAO, 2008; FAOSTAT, 2009). Improvement in growth of the agricultural sector has underpinned overall GDP growth in Africa over the last decade which grossed 4.5% (Barton, 2010). Growth in the agricultural sector has been strongly tied to economic growth and poverty reduction. Yet that growth in agricultural output is mainly associated with 10 African countries that account for 75 % of Agricultural GDP growth (Jayaram et al. 2010). In general, production in many countries is still low below world averages, inadequately supplying food for both local and international markets. Moreover, the continent's agro-ecological potential is massively larger than its current output. A major paradox therefore is that while more than one-quarter of the world's arable land lies in Africa, the continent generates only 10% of

global agricultural output. These inconsistencies clearly show that there is scope to increase production, but the challenges must first be adequately addressed. The key challenges to increasedperformance of Africa's agricultural sector are well known; investments to address them have however been fragmented with limited impacts. The positive wind of change that has swept across the continent over the last decade has nonetheless impacted on the agricultural sector-causing resurgence and created new opportunities to address food and income security challenges of the continent.

Vital signs of Africa's agricultural sector. The continents economic pulse has quickened creating many new opportunities which until ten years ago where just a dream. The agricultural sector is growing once again but still faces some challenges that are highlighted below:

1. **Stresses.** The tropical African environment is conducive for a number of pests and diseases which collectively can cause up to 60% yield loss, or 9, 000 metric tons of grain approximately 2.5 million USD per year (Ndulu et al., 2007). Such losses complicate efforts to improve food sovereignty in the region and require massive investments in development of resilient crops plants and management systems.
2. **Low adoption and use of agri-innovations.** Taking maize as an example, estimated adoption rates for the period 2006- 2007 in selected countries is just about 30%, with most production being under low yielding crop varieties and a yield gap of 400% (Langyintuo et al., 2010). Adoption and use of yield enhancing technologies was the major success factor behind the green revolution in Asia, which started more than 50 years ago. Africa will need new business model where yield-enhancing technologies are used.
3. **Climate change.** Africa's climate in itself poses some risks to the continent that will only be exacerbated by global warming. Indeed, Africa will experience up to 25% reduction in grain production due to climate change. In some cases crop productivity will increase slightly at mid- to high latitudes agro-ecologies for temperature increases of up to 1 to 3°C depending on the crop, and then decrease beyond that in some regions. At lower latitudes, especially in seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases (1 to 2°C) (World Bank, 2012). Most of Africa fall in the low altitude zones and will therefore be affected gravely. These issues are of such strategic importance to the continent that it forms part of Africa's foresight planning efforts from policy through research to development practice.
4. **Low opportunity for economies of scale.** Eighty five percent of Africa's farms occupy less than two hectares, such small farms tend to be under resourced and are not attractive for investment support from formal finance systems. Moreover, Africa has diverse agro-ecological conditions, with a need to adopt different farming systems for success. The question of replicability often rises and poses a major challenge to R&D processes that tend to produce few innovations presumably for wide-scale adoption. Therefore, Africa needs R&D and industry models that will adequately address such complexities and allow small farms to gain some of the benefits of scale.
5. **Improving total factor productivity.** Sustainable agricultural intensification is complex, involving mixtures of crop plants and livestock, and their associated management techniques. In the long run, sustainable agricultural growth can only be achieved through increased total

factor productivity (TFP), the amount of output per unit of total factors used in the production process (Winters et al., 1998). TFP estimates for Africa show a remarkable recovery in the performance of SSA's agriculture. However, a slowdown in TFP growth is already apparent among leaders of the recovery of SSA's agriculture this is a challenge to maintenance of current growth rates especially as countries catch up with efficiency levels at the production frontier further reducing TFP (YU and Nin-Pratt, 2011).

3. TOWARDS A DOUBLY GREEN REVOLUTION

Which way to go. Africa has more than 50 countries, with large differences in agro-ecological conditions as well as spending power and consumer behavior, so a one-size-fits-all approach in the design of agricultural growth strategies will and may not work. Each country may therefore take its own growth path, but sharing commonalities in the basic framework. It is along these lines that Africa's leadership has through the Comprehensive Africa Agricultural Development Programme (CAADP) put in place a framework to guide investments in agriculture to underpin the continent's development. Africa just like the rest of the world will have to rely on science and innovations to improve its vital signs of economic recovery and growth. For the agricultural sector, lessons could be learnt from elsewhere. The green revolution initiated over 50 years ago managed to turn Asia around from dire straits onto growth paths, with China and India now joining new economic leaders along with Brazil – another country that exploited science and technology to develop. For Africa, food security is still an issue for the present and future. World over, increases in agricultural productivity and improvements in the capacity to manufacture and preserve food have enhanced the availability of food to feed larger populations (Juma, 2011). Africa is yet to harness these innovations and indeed has potential to do so. The recent McKinsey report on Africa shows that the continent annually adds 2 million consumers to its markets, with consumer spending across the continent increasing at a compound annual rate of 16%, more than twice the GDP growth rate. Additionally, many consumers have moved from the destitute level of income (less than 1,000 USD a year) to the basic-needs (1,000 to 5,000 USD) or middle-income (up to 25,000 USD) levels (Fiorini and Russo, 2010). These developments mean that Africa must grow its agricultural production perhaps at rates faster than Asia and South America did. But the developments will have to be undertaken within the context of new threats such as climate change, rapidly growing populations and increased demand in general for natural resources which African economies have for long depended on. To be sure, Africa will need to pursue what other authors have termed a "doubly green revolution" – one where innovations are generated and harnessed to underpin growth strategies (Conway, 1997; Juma, 2011). The doubly green revolution will require among others that Africa utilizes the large aggregation of knowledge and innovations available, learning lessons to improve performance and efficiency through adaptive processes as well as institutional arrangements. Key among the developments is the advance in genomics which now provides enormous amounts of information for better understanding and design of appropriate innovations for mankind. Coupled with the fact that Africa is improving data access via deep sea cables, and has one of the fasted growing ICT sectors globally, and plus the general

infrastructural growth, the continent has an opportunity to chart its own growth path building on best practices from older economies. In this section, I will share different opportunities available that could be pursued to engender a doubly green revolution citing on going examples.

Crop improvement opportunities. Essentially development of new crop varieties requires three basic steps, i) germplasm development, ii) testing and registration, and iii) promotion and marketing. The key knowledge centers are i) genetics and biometry (breeding), ii) variety evaluation, iii) seed production, and iv) variety evaluation (Figure 1). Within these processes there is a wide scope for African agriculture. Some of the critical issues to be addressed include improving access to germplasm, new variety promotion, breeding complex traits as well as strengthening the weak capacity (human and infrastructure). There are options to address these challenges. One of the ways to go round these problems is via shuttle breeding between strong and weak centers. This process will, address capacity issues, support extra season gains for countries with only one growing season, support wide adaptability testing for large-scale variety promotion and most importantly allow rationalized resource. These processes could be used to generate both resilient and novel crop varieties for local and global markets. Equally important is the need to harness new advances in genomics to support crop breeding. Today, with several genomes sequenced, we can more precisely breed crop plants including targeting for very specific ecological niches much faster and perhaps much cheaper. Brazil and Argentina have benefited from the gene technology however for Africa this is still a challenge due to GMO trade difficulties with Europe, Africa's main trading partner. Africa should however not miss the gene revolution, there are alternatives to address the challenges posed by transgenic which in fact are not the only opportunities becoming available to scientists for crop improvement. Perhaps the focus on new thrusts such as genomic selection is the way to go for Africa

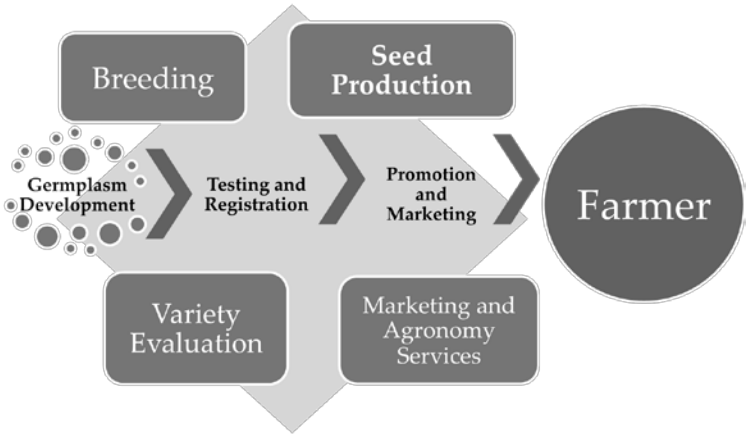

Figure 1. Crop improvement: Product development pathway and competencies required

Supporting ecological intensification for climate change proofing. New results published since 2007 point to a more rapidly escalating risk of crop yield reductions associated with global warming than previously predicted (World Bank, 2012). This will require new ways of undertaking crop production, which anyway must be done in earnest to meet both local and global food, energy and fibre requirements. One of the approaches being proposed to proof tomorrow's agriculture against the

dangers of climate change is ecological intensification (Pretty et al, 2011). Ecological intensification means designing sustainable production systems that save on inputs and are less harmful to the environment. The implication for crop improvement is the need for more agro-ecologically focused breeding of varieties as well as invention of new pest and disease management approaches. There will also be need to study the interactions between crops, pests and diseases, and use model plants to develop crops that adapt better to climate change. There will also be need to develop better production systems that take into account local knowledge, fit seamlessly into environments and satisfy consumer requirements by understanding the interactions between the biotic and abiotic factors of ecosystems, making better use of biodiversity and taking account of product quality, ecological services, co-product added value and market expectations. This requires understanding of how nature functions in order to exploit without destroying it. Again, the advances in genetics especially evolution which has received unprecedented boost with advances genomics and bioinformatics will be required. These opportunities will allow more precise design of agro-ecological intensification interventions.

Delivering technology to farmers: the seed. Seed represent innovations and knowledge packaged into seed for production by farmers. Indeed improved seed is the cornerstone of a doubly green revolution. Studies have shown that access to improved seed in Africa is one of the most important rate determining steps to improved productivity. In fact, in countries registering positive total factor productivity, the growth has in large measure been attributed to access to improved seed and fertilizers (Yu and Nin-Pratt, 2011). Breeding programmes will need to develop functional seed systems to deliver seed to farmers. Seed roadmaps will be needed and must capture farmer-preferred traits and easy-to-produce varieties, include seed production strategy, variety demonstrations and promotions strategies and building capacity of the seed partners. Certainly, there will be need to partner with other critical input suppliers especially fertilizers.

4. CONCLUSIONS

Whereas crop improvement has been one of the cornerstones of improving crop productivity worldwide, Africa has only marginally benefited due to a number of reasons. The resurgence of Africa's economy now provides unprecedented opportunities for science and technology to impact the continent positively. But for that to happen there is need to strengthen innovation systems. Technological innovations will be required to enable Africa's agriculture, the continent's backbone sector to adapt to new challenges while at the same time producing at optimal levels. For crop improvement there is need to i) intensify breeding, generating new resilient and high yielding varieties using new technologies, ii) develop functional seed systems and strengthening support services, iii) develop new management options that promote agro-ecological "fit" for new crops and new and or changing environments, iv) train the next generation of scientists to generate even better innovations, and finally v) build strong partnerships to underpin innovation and development processes and practice.

5. REFERENCES

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Disease breeding in sorghum

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This project is about sorghum improvements, particularly on enhancing our understanding on resistance responses to fungal pathogens and to identify plant defense genes. The work is the final part of two PhD theses and a future expanding reach-out comprising molecular markers for a suite of desired traits using plant genomic information. Sorghum domestication probably dates back to the advent of agriculture in sub-Saharan Africa. Conclusive evidence when sorghum was first brought into some type of cultivation from a prehistoric gathering practice is however lacking. Today it is an established understanding that the sub-Saharan and North East regions of Africa are the primary centers of sorghum diversity. Sorghum can be used for food, feed, fiber and fuel. The crop is resilient and well placed to cope with climate change but production is well below its potential. Environmental stresses are the major determinants of present sorghum production and yield losses. Sorghum is closely related to sugarcane and maize. The evolutionary divergence between sorghum and sugarcane is estimated to have occurred as recent as ~ 5 million years ago (mya) while maize separated from sorghum ~ 15 mya. The *Sorghum bicolor* genome of 730 Mbp is relatively small. In comparison, maize has a genome of 2,500 Mbp, densely saturated with transposable elements. It is further predicted that the sorghum genome harbors 27,640 bona fide protein-coding genes derived from 34,496 gene models. We have identified resistance genes (NB-LRR type) to the disease inciting fungi *Setosphaeria turcica* (St genes) and *Colletotrichum sublineolum* (Cs genes) causing turcicum leaf blight and sorghum anthracnose respectively, using a differential transcriptomic approach applied on Ugandan sorghum genotypes. This information is currently being used to develop useful molecular markers to speed up the resistance breeding, and genotypes have been produced harboring the two sets of traits. We have now taken a new step to expand our breeding toolbox with new sequence data and molecular markers, aiming to combine a series of desired traits for genetic improvements in sorghum. Presently there are two major directions in the work. One is focusing on SNP development on *S. bicolor* genotypes and the other comprise similar analysis of closely related Sorghum species carrying additional or new traits to widen the gene pool in sorghum. To further advance the use of the expanding SNP and genome sequence knowledge, we have begun to develop a platform for genomic selection. Genomic prediction combines marker data covering the whole genome with phenotypic and pedigree data in an attempt to increase the accuracy of the prediction of breeding and genotypic values. The key for success however is the prediction of plant phenotype from genotype markers. The final matchmaking will be done at the NARO station at Serere, and Makerere University.

Exploring genetic diversity and variability in tuber composition of yellow nutsedge – a potential crop for East Africa

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Parts of East Africa suffer from food insecurity mainly because of dependency on a narrow range of staple food crops. Therefore there is the need to diversify food sources by adopting non-conventional crops. Tubers are among the major food security crops in Africa. Yellow nutsedge *(Cyperus esculentus)* is a widely distributed sedge, which, although regarded as a weed in Eastern Africa, is grown as a crop for its edible tubers in some countries. The cultivated and wild forms exhibit notable differences in form and phenological characteristics. The goal of this project is to assess the potential of yellow nutsedge as a crop for East Africa by determining the amount of genetic diversity, yield and oil composition of tubers of nutsedge accessions collected from different localities in East Africa. Thirty three (33) wild nutsedge accessions from Kenya, Uganda and Tanzania and 5 cultivated types commercially grown in Egypt or Spain were used. The thirty eight (38) accessions varied morphologically and produced distinct tubers in terms of colour, size and number. A large sequence database assembled by sequencing the transcriptome of developing tubers of one cultivated type was used to generate 89 putative simple sequence repeat (SSR) markers. Twenty (20) of the markers were the most reliable and polymorphic among yellow nutsedge accessions. This is the first attempt to develop and use SSR markers for yellow nutsedge genetic diversity studies. Twenty eight (28) accessions were grown under controlled conditions in a climate chamber. The tubers were harvested, dried and analyzed for oil content and fatty acid composition. There was significant variation in both the oil content (6.57 - 28.23 mg/100 mg of dry tuber) and quality among the accessions. The variation in oil content, as well as the finding of two of the wild accessions having higher oil content than some of the cultivated types, indicates great potential for improvement through breeding. The fatty acid profile was similar for both the wild and the cultivated types, with oleic acids contributing 70 %, and palmitic and linoleic acids each making up 10 % of the total fatty acid, Based on results on the nutritive and economic potential, field trials will be conducted in Kenya to evaluate selected nutsedge clones for agronomic characteristics.

Plant breeding and genetic resources – Collaborations between SLU, South Africa and Southern Africa.

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The aim of the present project was to increase cooperation between Sweden, the Republic of South Africa and other southern African countries in plant breeding science through joint education on the PhD and MSc levels and exchange of students at MSc, PhD and post-doc levels. The focus subjects have been plant breeding for increased yield, food quality as well as food safety and security. Priority crops within the project were wheat and sorghum although also crops like water-melon and vine were incorporated as targets for subprojects. The project as a whole has so far generated one PhD-student, two MSc-students, one Honours student and one joint PhD course. In addition, an expected number of ten scientific papers are likely to come out of the project. Further, continued collaboration is expected through a joint PhD-student, and proposals are under way for further continued collaboration. Below are some examples of results from our collaboration.

The first example is a study of baking and nutritional quality of South African wheat. The content of antioxidants correlated negatively with most baking quality characteristics. However, some exceptions were found; the cultivar Caledon had good quality characteristics for both tocopherols and baking quality. Highest content of tocopherols were found in whole meal as compared to white flour.

The second example is a study evaluating sorghum lines for grain yield, protein and micronutrients content. The results showed that significant genetic variation was present among the sorghum lines and positive correlation among the traits indicated possibility of improvements for more than one trait.

The third example is a study comparing the genetic resources of sequenced plant genomes. Gene family networks were constructed across 26 plant species using a parallel-OrthoMCL computer script. The network was used to identify correlations between species based on gene family content as well as putative homologs, and thus identified enriched and shared functions between crop plants in an efficient way. Further, putative new RNA-editing sites were identified in the model plant *Arabidopsis thaliana* by mining transcriptome data generated by next-generation sequencing.

In a PhD course (Fieldomics, 3 ECTS), 11 invited faculty presented aspects of how to sample, phenotype, record climate data, choose appropriate molecular biological methods, apply suitable statistics etc, in order to facilitate integration and combined analysis of field and molecular biology data. A better understanding of the fundamental relationship between genotype, phenotype and environmental cues is important and can be reached by incorporating molecular techniques generating large amount of data, such as genomics, proteomics and metabolomics.

Genetic resources and plant breeding – Collaboration between SLU and Central Asia

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The aim of the current project was to increase and further develop the established cooperation between Sweden and Central Asia in the research areas of genetic resources and plant breeding for increased yield, food quality and food safety and security. The collaboration has been strengthened by training of students and their involvement in plant breeding oriented activities in Sweden as well as in Tajikistan and Kyrgyzstan. Different crops were involved in the project: wheat, chickpea and apple.

In the Central Asian region wheat is the most important crop and an increased production is necessary for the rapidly growing population in the area. Pathogens and pests affect grain yield of wheat significantly and may end in almost complete failure of harvest. Farmers use either insecticides and fungicides or cultivars with relevant host plant resistance genes to control these biotic factors.

New sources of resistance genes are needed for wheat breeding to control this permanent race between the host plants and their co-evolving pathogens and pests. Rye *(Secale cereale)*, *Leymus spp.* and other relatives to wheat have qualities such as resistance against different pests, diseases and positive responses to various stresses. Approx. 300 lines of wheat with various translocations and substitutions with rye, *L. mollis*, and *L. racemosus* were investigated for different important diseases and pests, i.e. stem rust *(Puccinia graminis)* var. Ug99, stripe rust (yellow rust*)* *(Puccinia striiformis)*, Hessian fly *(Mayetiola destructor)*, and the Russian wheat aphid *(Diuraphis noxia)*. So far, the investigations have focused on identifying new sources of resistance in both adult and seedling tests, including different pathotypes, for stem rust and stripe rust, and seedling tests for Hessian fly and the Russian wheat aphid. Many new genetic sources have been discovered for all investigated pathogens and pests. The plant material show various degree of resistance depending on alien chromatin involved and pathotype, including high resistance to all investigated pathogens and pests. Many lines show moderately/partial resistance. This work was performed in collaboration with CIMMYT, ICARDA and University of Minnesota. Further investigations will be made to identify resistance genes and transfer them into locally adapted wheat cultivars.

Improved quality is also necessary for wheat to be of interest for in-country trade and export. Protein concentration and composition were analysed in diversified wheat materials including Tajik breeding lines grown under natural and controlled conditions to identify desirable wheat genotypes, which can be used for breeding varieties with improved baking quality and tolerance to heat stress.

The collaboration with Kyrgyzstan is mainly focused on chickpea *(Cicer aretinum)*, an important legume crop in Kyrgyzstan due to the high protein content (20-30%), along with common bean, soybean and pea. Chickpea is used mainly for direct consumption and is mainly grown in the southern part of Kyrgyzstan. The genetic diversity in Kyrgyz chickpea has been assessed by morphological characters and molecular markers (Simple Sequence Repeats) and was compared to chickpea material introduced by ICARDA. In addition, the protein content of Kyrgyz and introduced materials was evaluated. Collaboration on use of genetic resources in apple has been initiated, since this crop gets more attention in the country.

Overall, the project has had a great impact on the capacity building and strengthening of collaboration between Central Asia and Sweden and has led to increased knowledge that will result in more efficient crop improvement programs in Central Asia.

Scientific session 2

Animal health and production

Chair: Prof Elly Sabiiti

Keynote introduction

Livestock production in Uganda: Opportunities and challenges for food security

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Over 85% of the Ugandan population live in rural areas and are engaged in subsistence mixed farming for their livelihoods. In this farming, livestock production contributes 5% and 13% to total and agricultural GDP, respectively. Livestock production contributes to rural livelihoods by serving as a source of food, a store of wealth, and a source of cash. This is because Uganda's natural environment provides good grazing for cattle, sheep, and goats in addition to being conducive to pig and poultry production. In the national livestock census conducted in 2008, livestock population increased at rate of approximately 4% from 2001-2008. However, livestock production is predominantly (>90%) based on unimproved indigenous breeds characterized by low productivity and suboptimal management.

Cattle are the most important livestock and they are mainly Ankole longhorn, the Karamajong and the shorthorn Zebu with a few exotic breeds. Mixed farming, small holders and pastoralism form about 95% of the cattle herds. These indigenous breeds are hardy and survive the harsh environment and the suboptimal management in which they are reared. However, studies conducted by Rossetti and Bahiigwa (2003) and Ocaido et al. (2009) ranked diseases and parasites highest as major constraints to cattle productivity. The major parasitic diseases of cattle are East Coast fever (ECF), trypanosomosis and helminthoses (Waiswa & Katunguka, 2004; Otim et al., 2004; Ocaido et al., 2009). A serological study conducted in some pastoral areas of Uganda by these authors showed that up to 93.3% of cattle were exposed to ticks responsible for the transmission of ECF. Unfortunately recent reports show a serious challenge of tick resistance to nearly all the major acaricides available on market. This has resulted to severe loses of especially the exotic cattle due to babesiosis, a disease transmitted by Boophilus ticks that easily develops resistance to many types of accaricides.

On the other hand, there is a challenge of zoonotic trypanosomosis in some parts of the country. In 2004, 354 cases of human African trypanosomosis associated with mainly *Trypanosoma gambiense* were reported in north-western districts of Adjumani, Moyo, Arua and Yumbe. Meanwhile in the south-eastern and eastern districts, 154 cases and 7 deaths associated with *T. rhodesiense* were reported in 2005 (Kolaczinski et al., 2006). This poses a serious threat to production in the affected areas as both livestock and humans are affected.

A recent study on the major infectious diseases afflicting cattle production in Uganda ranked Foot-and-mouth disease (FMD) as the most important infectious disease of cattle, followed by lumpy skin disease (LSD) and contagious bovine pleuropeumonia (CBPP), according to the farmers' perspectives (Ocaido et al., 2009). There is no doubt that FMD is the most important infectious disease of cattle in Uganda. A study by Ayebazibwe et al. (2010) showed that 311 FMD outbreaks were reported in 56 (70%) of 80 districts from 2001-2008. This study also found that FMD outbreaks had no patterns and changed with time and regions, were associated with dry seasons and were higher in sub-counties

adjacent to national parks. However, in the bid to improve cattle production, research on infectious cattle production should not only focus on FMD, but also other important diseases.

Goats and sheep make an important contribution to the subsistence subsector of the economy of Uganda. The last livestock census of 2008 reported goat and sheep population of 12.4 and 3.4 million, respectively. The goats have almost equal distribution in all regions except Karamoja region (North Eastern) which has the highest goat population. However, most regions of Uganda do not rare a lot of sheep except Karamoja region that rear approximately half of the sheep population in Uganda. The major constraint to goat and sheep rearing is contagious caprine pleuropneumonia (CCPP), a mycoplasma disease of goats with high mortality rates of up to 80%. This disease that was first confirmed in Uganda in July 2007 when it was estimated to have killed 0.5 Million goats. Since then, the disease has caused devastating loses in Karamoja in form of high mortality, reduced meat yield, high cost of treatment, and loses associated with imposition of trade restrictions through quarantine. Antibodies against CCPP have been detected in districts surrounding Karamoja, an indication that this disease could be spreading to other parts of the country. Other disease challenges in small ruminants include helminthosis, ectoparasites such as mange, and other diseases related to poor management.

The pig industry is fast growing in Uganda due to increasing consumption of pork. The 2008 livestock census recorded approximately 3.1 million pigs, 41% of which are reared in the more urbanized central region. The major constraints of the pig industry are African swine fever (ASF) and the availability of feeds (MAAIF, 2012). ASF is a highly contagious, disease of pigs caused by iridovirus and is common in most parts of Uganda. It affects pigs of all ages with mortality usually close to 100 percent, yet no vaccine is available. Frequent outbreaks occur throughout the country each year. Recently most outbreaks occurred in Gulu (a former war ravaged area). The frequent outbreaks have discouraged farmers from rearing pigs in large numbers because they might perish in a single attack. Research is being undertaken about ASF.

Like the pig industry, the poultry industry is also fast growing in Uganda. Chickens are the most important poultry reared. The 2008 livestock census recorded approximately 39.1 million poultry including chickens, ducks and turkeys of which about 70% are kept under local free-range management conditions. Although feed is a major constraint to poultry industry, diseases especially New Castle Disease (NCD) causes devastating losses to the farmers. The local free-ranging poultry suffer extensively from NCD causing about 60%-80% mortality per annum in Uganda.

General challenges afflicting livestock production in Uganda include diseases associated with management, nutritional shortages especially during the dry seasons, transportation of livestock, handling of food of animal origin, as well as grading and marketing of animal products. Despite the challenges surrounding livestock production, there are a lot of opportunities that exist to improve the productivity of these livestock. Most parts of the country are involved in livestock production and livestock production contributes immensely to food security and livelihoods of most households. Studies have shown that households that rear livestock have better livelihoods than those that depend on crops. The indigenous breeds that they rear have unique genetic attributes such as adaptation and tolerance to drought, heat, diseases and ability to utilize low-quality indigenous forages and other feeds. Thus, selective breeding through identification of production traits amongst these indigenous breed is required in order to multiply them to improve production in breeds that can survive well in Uganda. For farmers that can manage upgraded breeds, selective crossbreeding of livestock could be

done to help increase production. Crossbreeding has been done in cattle, goats, pigs and poultry, but crossing should have a basis as to what level of the "cross" is appropriate and possibly come up with special "Ugandan breeds".

The major cattle disease FMD is also intensively studied including risk factors and molecular characterization. A level 3 bio-safety laboratory is due to be established at COVAB, specifically for FMD research. After studying the important strains, the next step would be to produce a vaccine suitable for Ugandan livestock. Meanwhile socio-economic studies such as the effect of FMD on household income in agro-pastoral and pastoral areas of Uganda have also been conducted (Ademun, 2012). Another disease that is attracting much research interest is animal and human trypanosomiasis with the view of finding a vaccine to protect the livestock. An approach of controlling human trypanosimosis by controlling the disease in cattle (stump of sleeping sickness or SOS) has been performed by COVAB with great success. On the other hand research on tick-born diseases has continued to be conducted with focus on controlling the parasites and the vectors. A vaccine against ECF has been produced and used in East Africa (Mukhebi and Perry), but has not been very effective. However, the recent development of tick resistance to accaricides has brought in a new dimension of research regarding tick-born diseases. There is need to identify the practices that has caused this resistance and provide mitigation measures to reduce losses associated with tick bites.

Research on African swine fever (ASF) is mainly risk factors associated with the occurrence of outbreaks and persistence of the disease. Particular emphasis is being placed on the role of wild swine and ticks in the occurrence of ASF disease (Muhangi et al., 2012). In addition there is ongoing molecular characterization of ASF virus in Uganda as an effort towards vaccine production. Recently the researchers at College of Veterinary Medicine, Animal Resources and Biosecurity (COVAB) were able to isolate the ASF virus which is a step towards vaccine production. Other research on pigs includes post-weaning losses in piglets due to diarrheic diseases. In addition, extensive research on feeds and feeding of pigs using available feed resources is necessary to promote pig production.

Amongst poultry diseases, Newcastle disease (NCD) is the major research area. Current research has focused on molecular characterization of the NCD virus aiming at producing a vaccine including virus strains commonly associated with the disease in Uganda. Although a thermostable NCD vaccine has been produced in Uganda, more research is being conducted in this area to produce NCD vaccine suitable for the rural farmers that rear the majority of the poultry in Uganda. Recently researchers at COVAB have isolated the NCD virus as an important step towards vaccine production. In addition, in fear of the spread of the avian flu that has been devastating to both birds and humans, COVAB has established a level 3 bio-safety laboratory for surveillance and monitoring of avian flu. Meanwhile, poultry feeds and feeding also requires research to help promote poultry industry in Uganda.

In conclusion, the role of livestock in providing livelihoods and food security to Ugandans cannot be over-emphasized. The challenges the livestock production is facing are opportunities for research that will help in improving the productivity of the livestock industry in Uganda. The ongoing research under the Sida-Makerere bilateral research cooperation is yielding information that could guide polices in forging solutions to some of these challenges.

References

For references please contact the author

Improving pasture availability for dairy cows in pastoral production systems

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The agro-pastoralists in the rangelands of south-western Uganda depend entirely on natural pastures as the main feed resource for their livestock. However, during drought the quantity and quality of forage drop, and thus does not adequately supply the needed nutrients. The objectives of this project, including several studies, were to investigate the effect of seasonal availability of pasture, how changes in feed availability and nutrient quality during rainy and dry season affects production performance of cows and calves on agro-pastoral dairy farms. The information is planned to serve as a base for future feeding recommendations to ensure a steady milk production throughout the year and good growth performance of calves.

A cross-sectional survey was performed on 75 households in six subcounties of Kiruhura district. Preliminary analyses reveal that feed and water shortages in the dry season are major constraints in the area. Few farmers carry out supplementary feeding of cattle even in periods of pasture scarcity.

A further study has been carried out on ten dairy farms in the same area with crossbred animals of Ankole and Friesian breeds. Pasture yield, botanical composition and nutrient quality have been recorded. For animal performance, milk yield, body condition score, heart girth and calf growth were measured. Also, weather data, baseline data about animals and information about milking routines and rangeland management have been collected. Some preliminary findings showed that the average pasture yield ranged between 1600 kg DM/ha in the rainy season and 700 kg DM/ha in the dry season. The crude protein ranged from 5-9% with values below 6% during the dry season. The daily milk yields were between 4.6-7.8 and 3.9-7.4 l/cow during rainy and dry seasons, respectively. Farmers that milked twice per day got 3.3 l more milk per cow/day compared to farmers who milked only once a day. The growth of calves was 2.8 and 2.7 kg/week during the rainy and dry season respectively.

Another study evaluated the effect of protein supplementation on the growth performance of Ankole x Friesian crossbred calves grazed on natural pastures. A total of 45 weaned crossbred calves aged about six months from five farms were used in the study. Three treatments were tested:

1) grazing on the natural pasture only, 2) supplementation with 2 kg DM/head/day of a home mixed concentrate (HMC), 3) mixture of 2 kg DM/head/day of lablab hay and 0.3 kg DM/head/day of maize bran. Daily live weight gain of calves supplemented with HMC was higher ($P<0.01$) than that of calves that depended entirely on grazing. No significant differences were observed between calves that were supplemented with lablab hay and HMC.

Reproductive health in dairy herds in Uganda and its implications for herd profit

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Reproduction is a key parameter determining life-time productivity and profitability in a dairy herd. Low fertility leads to productivity losses which can be directly translated into heavy economic losses and is the major reason for involuntary culling of dairy cows. Artificial insemination (AI) combined with proper AI recording, is one technical option available for breeding dairy cows to enhanced production and productivity. Reproductive failure is however a big disappointment to dairy farmers wishing to maximize production through AI. Although AI service has been in use in Uganda since 1960, its influence on productivity has been dismal partly because of its inefficient application and other factors often beyond the control of the beneficiary farmers.

The project focuses on cows in the period around calving, a time associated with health disturbances decisive for the economy of dairy producers. Dairy farms around Kampala have been visited for gathering of data on management routines around calving. Newly calved cows were repeatedly examined for sexual health and resumption of reproductive functions. Milk progesterone hormone assay and ultrasound were used for the diagnosis of reproductive disorders. Further data was gathered through questionnaire and interviews from farm owners, technical service providers and semen vendors around Kampala with the aim of identifying technical factors associated with cow reproductive failure on dairy farms using AI.

It was found that 31% of the cows suffered from retained foetal membranes after calving and 19% of the cows delayed resumption of oestrous cyclicity and reproductive functions beyond 85 days after calving. Compromised uterine health and lack of ovarian activity resulted could cause prolonged calving intervals and consequently decreased herd productivity and profitability. In addition, preliminary results indicate an inadequate AI service delivery system with inconsistent liquid nitrogen and semen supply plus poor AI recording and infrastructure.

Suggested practical recommendations, adapted to prevailing conditions, will involve keeping the cows healthy through the calving process, during early lactation and the breeding period. This will optimize milk production and cow longevity, which will in turn lead to improved livelihood for the individual farmer and for food security in general.

Animal genetic resources for improved livestock productivity under harsh environmental conditions

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Indigenous livestock breeds are generally well adapted to harsh tropical environments. Some breeds are drought and disease tolerant - attributes important for adaptation to climate change. Due to inadequate selective breeding, indigenous breeds are often unproductive. Instead, cross- breeding with exotic breeds has been practiced, mostly indiscriminately and leading to disastrous final results. Consequently, some indigenous breeds are threatened with extinction. Development of breeding strategies for specific indigenous livestock populations is therefore urgently needed in order to conserve the desired genes, improve productivity and natural resource use efficiency. This requires long-term and holistically designed efforts. However, poor infrastructure, e.g. livestock recording, and staff trained to manage animal genetic resources, remain key constraints.

This project explores the opportunities for genetic improvement of two livestock populations that are important in Eastern Africa. Firstly, we studied variation in trypanotolerance among four indigenous cattle breeds kept in tsetse infested areas of Ethiopia. Trypanosomosis (sleeping sickness) is one of the most disastrous animal diseases in the tropics that hinders human inhabitation and significantly reduces livestock productivity. One of the breeds, Sheko, showed significant tolerance to trypanosomosis. What remains is assessing strategies for disseminating the trypanotolerant genes into the broader livestock population in the affected regions. Results have been shared with national stakeholders at a workshop in Addis Ababa and have been taken onboard by the Ministry of Agriculture for translation into practice, including action research in a proposal to be considered by IFAD.

The second case focuses on Red Maasai (RM) sheep in Kenya and its crosses with Dorper – a meat type breed imported from South Africa. Due to many years of indiscriminate crossbreeding of RM with Dorper, the RM population has declined drastically. However, recent recurrent severe droughts have indicated the survival ability of RM. This project has two objectives: *i)* gather performance, reproduction and survival data on the two breeds and their crosses under field conditions in two Maasai village areas by organizing a pilot sheep recording scheme; *ii)* assess breeding objectives and design strategies for conservation and improvement of RM. The project builds on previous work carried out on selective breeding the RM sheep at the ILRI Kapiti ranch alongside the Maasai pastoralist flocks. In this study RM has shown superior survival and Dorper better growth rate. Milk production was found to be surprisingly valuable. The importance of sheep production for women has been specifically recognized. Progress and results have been shared with farmers and stakeholders at three workshops and have led to new partnerships to upscale the activities with ILRI as an important actor in cooperation with ministry departments and NGOs. Further data collection, including carcass traits, are underway and results will inform design of appropriate breeding strategies for conservation and improvement of the Red Maasai.

Metagenomic studies on virus dynamics at the livestock/tick/wildlife interface, with special reference to African swine fever

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Pigs are among the most promising animals to rear for food consumption and for income at both small and large scales for the poor population of Uganda. The overall demand for pork is increasing and opens up for possible opportunities from poverty to a much better life. However, epidemic infectious diseases such as African swine fever (ASF) constitute a major constraint for pig rearing, both for pig health and economical aspects due to its severity. The ecology of the causative virus is complex and involves as natural hosts wild African suids (warthogs and bushpigs) and soft ticks *(Ornithodorus spp)*, with occasional spillover to domestic pigs. Once the virus is introduced to the domestic pig population, causing ASF with high mortality, the virus can be maintained without the natural hosts, being transmitted efficiently via infected animals or animal products. However, the dynamics of the virus in the interface between the natural wild hosts and the domestic pigs is poorly understood. As part of a larger project, viral metagenomics was utilised to increase the understanding of the ecology of ASFV. In addition, we investigated whether these wild and domestic animals carried other viruses, possibly of relevance for the pig health but also as models to study viral dynamics at the interface of wild and domestic animals. Viral metagenomics is a collection of methods used in order to detect all viral genomes in a given sample (the so-called virome). These include nucleic acid preparation, amplification, large-scale sequencing and bioinformatics. Using this methodology we were able to find several new viruses in the soft tick as well as in the wild and domestic suids. Taken together, viral metagenomics may be used to answer questions about viral ecology, including that of ASFV.

Urban and peri-urban animal production

Chair: Dr Ewa Wredle

The importance of the zoonotic bacterium *Brucella abortus* in the milk chain in Gulu and Soroti regions of Uganda

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With increasing urbanization in low-income countries the numbers of livestock introduced in urban and peri-urban areas is increasing. In these settings, livestock is essential to improving food security although diseases such as bovine brucellosis threaten efficient and safe food production. In the peri-urban areas of Gulu and Soroti, Uganda, conditions exist for the zoonotic transfer of diseases from cattle and other livestock to humans. The bacterium *Brucella abortus* is of special concern in Uganda as people may be infected through consumption of unpasteurized milk and milk products and through contact with infected animals. The disease most commonly causes abortions in livestock, and decreases milk production. This study aims to improve food security in the peri-urban regions of Gulu and Soroti, Uganda. Milk and serum samples have been collected in herds in the study areas and at milk collection centers in Gulu, boiling points in Soroti, and from informal milk sellers in both regions. In the samples we have determined the prevalence of antibodies to *B. abortus.* We also plan to confirm and quantify the bacteria in the milk value chain at animal- and bulk milk level at local milk collection centers and informal milk sellers. A herd level questionnaire was administered to illicit information on risk factors of brucellosis in cattle. An additional questionnaire targeting milk deliverers and sellers was administered and is being utilized to create a map of the milk value chain at the level of collection centers and informal milk sellers. A total of 1007 serum and 207 individual animal milk samples were collected from 166 herds in both Gulu and Soroti. The serological analyses gave an individual animal seroprevalence of 8% and herd seroprevalence of 27%. Preliminary results show that using hired workers, sharing of grazing grounds, outsourcing replacement stock and rearing mixed breeds predisposed cattle to exposure to *Brucella*. In Gulu, 11% out of 142 bulk milk samples had *B. abortus* antibodies, whereas in Soroti 35% out of 188 milk samples were seropositive. Epidemiological analyses to investigate differences between the two regions are ongoing. In early 2013 additional molecular analyses of *Brucella* in the milk samples will be conducted. Risk-reducing suggestions on the prevention of the spread of *Brucella* infection to humans through the handling and consumption of milk and milk products should be as useful, practical, affordable, and sustainable as possible, taking into account the realities of milk collection and distribution in peri-urban areas of Uganda. Results and suggestions will be shared with regional stakeholders in cooperation with local DVO offices and Makerere University. Excess milk samples will be stored for future analyses. In this way, this project can provide future benefit to the communities from which samples were collected.

Feed for livestock in urban and peri-urban production: the case of Kampala, Uganda

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Animal populations are increasing in major cities of developing countries. The increase is stimulated by the high demand for animal products, largely due to urbanization and income growth. However, a range of issues have attracted the attention of research, particularly feeds. This project aimed to identify, nutritionally characterize and examine availability of feeds used by livestock farmers in urban and peri-urban areas of Kampala.

Results show that livestock farmers in Kampala face several constraints of which feed scarcity, diseases, high feed cost and veterinary drugs, and space limitation were the top ranked. Several strategies for coping with feed scarcity have been adopted, such as: changing of feed resources based on availability and cost, purchasing of feed ingredients in bulk, using crop/food wastes, harvesting of natural forages in open access lands and reducing herd size. However, most of these strategies aim at dealing with the constraint on a day-by-day basis rather than in a long-term perspective. The constraint caused by high feed costs was ranked high by chicken farmers. Unlike cattle and pigs, chicken production depends on expensive concentrate feeds. As a cost-saving mechanism, many chicken farmers mix their own feeds. However, these feeds did not conform to the recommended nutrient levels. They were low in protein and energy, and high in fibre and ash.

Limited information is available on the nutritional quality of the feeds used. As a result, farmers have adopted indigenous criteria for assessing the nutritional quality. According to them, animals offered a feed resource of good nutritional quality are less susceptible to diseases, eat much of that feed, gain weight, exhibit smooth hair coats, do not produce too firm or watery faeces, produce large quantities of faeces and exhibit good performance. However, much importance is put on availability and cost as opposed to nutritional quality. This explains why banana peels were ranked as the most commonly used feed resource, despite being perceived to be of low quality.

All dairy cattle farmers used banana peels, as compared to 74.1% for elephant grass. The use of elephant grass is held back by the ever declining access to land, poor agronomic practices and the Napier stunt disease. Other feeds with considerable contribution were sweet potato vines, left-over food, brewer's waste and natural forages growing in open access lands. Left-over food is an important source of pig feed in Kampala, and farmers ranked it highly for nutritional quality. However, there are concerns about the risks of physical and microbial contaminants.

It is recommended that livestock farmers in Kampala should be encouraged to adopt coping strategies that can deal with the challenge of feed scarcity more sustainably. In addition, they should be sensitized on the importance of nutritional quality, and also trained in feed formulation to ensure better and more efficient utilization of available feed resources.

Manure management in Kampala – A potential golden egg

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Urban agriculture plays a vital role in feeding the ever-growing population of Kampala city, however crop yields are declining as a result of soil degradation. The animal urban agriculture being practiced in the city could play a vital role in addressing the soil degradation. However the amount of animal waste available for this purpose is not properly known. To address this problem, a study was carried out in Kampala City between March and August 2011 to map the location of the animal farms, determine the number and type of animals kept, establish the type of animal feeds used and the manure management practices. Data collected was the type and number of animals kept, type and origin of the animal feed used as well as the current usage of waste generated from the animals.

The results obtained show that animal farms are predominantly located on the periphery of the city; in total 1300 farms were found. Poultry are the dominant animals in the city followed by pigs, cattle, goats and sheep. Looking at the number of animals as animal units, there are equal numbers of cattle and chicken followed by pigs. A variety of feeds are used for animals in the city with the commonly used ones being food peelings and pasture; the manure generated is mainly discarded (60%) or used as fertilizer (32%). This shows that large volumes of organic waste is processed by the animals but the fertilizer potential in the produced manure is only little utilized.

The manure management together with the lack of management of the organic waste causes major environmental pollution, e.g. eutrophication of Lake Victoria, greenhouse gas emissions and disease transmission. The lack of manure management today can be approached by introducing a new source of income to the single farmer by waste generated protein production by vermicomposting.

The vermicomposting system can be managed at farm size level, even on a farm with few animals. The conversion of the manure to feed is close to 8% as the material can be degraded 60-80% and 10 kg of degraded dry mass result in approximately 1 kg dry mass of worms that can be used as high value animal feed. This kind of system can be operated on farm level, where the daily manure is fed to the system at a rate of approximately 30 kg of manure per m^3. When spreading the manure evenly over the surface the material is consumed fast by the worms and the mass grow is slow. Thereby, a system of 1.5 m in height can be fed for several months prior to harvest. Upon harvest some of the digested material and worms are used for starting a new reactor, the remaining material can be separated into animal feed fraction (worms) and a highly appreciated stable fertilizer, with less environmental impact than if discarded. This system can be a golden egg for the farmer, producing valuable animal protein-based feed and an appreciated fertilizer. However, if fed too much, conven–tional composting starts and the high temperatures kill the worms.

An assessment of potential disease transmission early in the food value chain

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With a fast growing population, urban animal farming is an important means to secure food for the urban population. However, there are many challenges with urban animal farming, for example livestock diseases, manure management and access to feed of high quality. These are factors that may jeopardize food security. Therefore, to gain more knowledge of how to secure food we need to take a holistic approach by studying the combined importance of manure and animal feed for transmission of animal diseases, including zoonoses.

Manure is not only a valuable source of nutrients for soil, but can also be used for production of animal feed where the manure is used as food source for earthworms (through vermicomposting) or black soldier fly larvae, which upon drying can be used as fodder for poultry, fish and swine. The dried worms/larvae are high in protein and have high commercial value. However, the risks of transmission of infectious pathogens through the use of manure and the produced fodder are yet to be established. There are several known infections, including zoonoses, commonly found in manure, e.g. *Salmonella spp*., *Cryptosporidium spp*. and *Ascaris spp*. Most likely there are also other infectious agents, yet to be described, in manure that may have a negative impact on the health of animals and on food security.

The aim of this project was to better understand how to recycle nutrients found in urban settings back to agriculture for increased food production without cycling the pathogens. The effect of vermicomposting on viruses and bacteria found in cow manure was investigated. A pilot vermicomposting unit was established at the Makerere research centre Maurik at Kabanyolo, just outside of the university. Both earthworms and compost material were collected from five layers of the compost. The concentration of *Salmonella spp*., *Entercoccus spp*. and coliphages was established for each layer and in worms found in three of the five layers. Additional bacteriological analyses are yet to be conducted. To describe the entire viral flora metagenomic analysis was carried out on the collected samples. Metagenomics is a culture and sequence independent technology that utilizes high-throughput sequencing to, in an unbiased manor, describe the complete microbial community of a sample. The sequence data from the high-throughput sequencing is currently under analysis but we expect that this will yield novel information of the presence of viruses in this material.

In conclusion, the results from this project will provide knowledge that can be used to improve food security at an early stage in the meat and milk value chain. This project, focusing on both manure and food waste management/security as well as on infectious agents, also shows the importance of joint efforts from different research disciplines to gain a broad and strong understanding into these complex questions.

Abstract not presented during the symposium

Peri-urban animal farming in Dushanbe, Tajikistan - for good and bad

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In several of the low-income former Soviet Union republics many of the large state or collective farms have been replaced by smaller family run units. This gives an opportunity for entrepreneurial families to generate income. Concomitantly the public or governmental veterinary services have weakened because of diminished funding which implies that the control and combat of contagious diseases has deteriorated. This means an increased risk for infectious diseases, including zoonoses, in small-scale animal farming threatening food security as well as public health. The overall aim of this project is to develop capacity among staff in the Tajik Agrarian University (TAU) and other stakeholders for a more risk-based control of infectious animal diseases and to provide new data on zoonotic diseases in peri-urban animal farming around Dushanbe, the capital of Tajikistan.

In the project there has been a 10-day course for 9 Tajik veterinarians at SLU about control of infectious diseases and two Tajik veterinarians have had an additional visit for two weeks at SLU for training in laboratory diagnostic techniques. The filed studies around Dushanbe have been performed at three occasions by mixed TAU-SLU teams. The diagnostic methodology has been transferred from SLU to TAU.

We have particularly studied the zoonotic infection brucellosis in dairy farming as well as in sheep and goat farming around Dushanbe with respect to serological evidence of prevalence and spatial distribution of the infection, as well as knowledge, attitude and practices (KAP) among the farmers in relation to brucellosis. In the KAP studies we have included a gender dimension (cf. Lindahl, Sattorov, Jonasson, Boqvist, Sattori and Magnusson: Zoonoses in peri-urban dairy farming – Brucella and milkmaids in Dushanbe, Tajikistan. Abstract presented at the Agri4D Conference, Uppsala, 2011). In total we have examined about 450 households with dairy cows and sampled more than 600 cows. We have visited more than 20 villages keeping sheep and goats and sampled close to 1000 of these animals.

Our preliminary data show that the Brucella infection is prevalent in dairy cows, sheep and goats in the peri-urban areas of Dushanbe and is associated with reproductive disorders there, implying production losses. Further, there seem to be practices and attitudes among the farmers that put themselves as well as the consumers of their animal products at risk. Recommendations about how to improve the animal health as well as reduce the risk for humans will be further elaborated on in the final stage of the project.

Scientific session 4

Sustainable agroecosystems

Chair: Prof Christina Dixelius

Water resources and agriculture in Ethiopia: Managing the seasonal variability

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Agriculture is the main livelihood for eighty-four percent of the Ethiopian population (81 million in 2010). Almost all of these people depend on subsistence agriculture, which in turn depends heavily on available water. Agriculture accounts for about 95% of the average annual water withdrawal in the country. On the other hand, Ethiopian water resources can be described as plentiful since the annual surface water runoff is 122 x 109 m^3 per year and the ground water potential is 20 x 109 m^3 per year. However, extreme hydrological variability and seasonality create bottlenecks for agricultural development. More than 80% of the annual precipitation falls in the four months between June and September, leaving the remaining two-thirds of the year with less available water. This seasonal variability of rainfall has brought both past recurrent droughts and massive soil erosion. Supplementary agricultural activities during the dry season period have been compromised because of less available water during dry season.

Water storage that can be used during the dry season is crucial for the communities heavily dependent on subsistence agriculture. Forests are believed to be one of the mechanisms to store water for the dry season in both the popular mind, and some policies. However, the question of how forests affect dry season is an issue that continues to be debated around. Scientific studies show that forests could affect dry season flow positively or negatively depending on specific environmental circumstances.

Based on this background, a study was conducted to understand the relationship between forests and dry season flow in the rivers of northwestern Ethiopia. This study looked at the changes in hydrology and forest cover over the last 45 years (1960-2004) in order to summarize the influence of forests on hydrology. The study used hydrological data from rivers gauged since 1960 and remote sensing imageries since 1957. The results showed that the trends of deforestation and afforestation are different between watersheds. They also suggested that the relationship between forest cover and dry season flow was not strong, and when there were patterns, they were watershed specific. For instance, eucalypt plantation was associated with reduction of dry season flow in one watershed, and deforestation of riverine forest was associated with an increment of dry season flow in another watershed. In a third watershed, a reduction of natural forest cover from 1600 km^2 to 800 km^2 over 42 years caused almost no change on the flow regime including dry season flows. So, there is a need to understand watershed specificity before investing in forest management as a water resource intervention. This study also helped to generate research ideas like the value of developing a network of long-term experimental watershed monitoring to study the impact of different forest management activities on the availability of dry season water, as well as to study impacts of climate variability and climate change on the availability of dry season water.

Multifunctionality of agroforestry systems

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Agricultural production in East Africa is stagnant or declining while population continues to increase thus leading to shortage of land and food insecurity. Increased pressure on natural re- sources, including deforestation, is also increasing the vulnerability of small holder farmers to climate change, often manifested as increased rainfall variability. Low input of mineral fertilizer and manure has led to nutrient mining and reduced soil fertility. In order to improve productivity and livelihoods in the long run, the declining trends in soil fertility and tree cover need to be reversed and the resilience of the farming systems to climate variability and other stress factors enhanced. More trees on farms and in agricultural landscapes are needed to produce firewood, timber, fodder, fruit, etc. and to deal with environmental problems caused by deforestation. There is an expressed interest in farming systems with intercropping of trees and crops, in combination with livestock for eggs, milk and meat, so called agroforestry systems. The main research question in this project is: Can integration of trees and crops, and often livestock, contribute to enhance agricultural productivity and resource utilization, and contribute to improved living conditions for smallholders? We are using a quantitative approach to assess the productivity and multifunctionality of agroforestry systems at different scales applying available modelling tools. The aim is to quantify the biomass production, carbon storage and nutrient flows at the field, farm and landscape scales in western Kenya. Five settlements with similar soil and climatic conditions and well documented land use history have been selected in the Kitale area. At field scale, the WaNuLCAS (the Water, Nutrient and Light Capture in Agroforestry Systems) model that includes competition between trees and crops for light, nutrients and water is applied. At farm scale the NUANCES framework (Nutrient Use in ANimal and Cropping systems - Efficiency and Scales) is being used to study flows of nutrients and other resources on farms of increasing complexity (crops, trees, livestock). At landscape level, the GIS-based Polyscape modelling tool will be used to study the contribution of trees to synergies and trade-offs between agricultural productivity and other ecosystem services (water and sediment flows, continuous habitat, development of carbon storage). The work builds on established partnerships. Good cooperation and communication has been established between research, education and extension that will ensure scientific as well as practically applicable outcomes.

Assessing multi-functionality and climate change adaptation capacity of agroforestry systems in Western Kenya

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Conversion of natural ecosystems to cropland is the largest land use change caused by humans and has had one of the biggest consequences for both the climate and the provision of eco-system services. The deforestation rate in East Africa is today four times higher than the world average. Agroforestry is one promoted land use system in this area that is thought to provide necessary goods and at the same time maintain supporting, regulating and cultural services from the agro- ecosystem. A PhD study has been initiated linked to the "Multi-functionality of agroforestry systems" project, with the overall aim to assess if more diversified farming systems including crops, trees and/or livestock will enhance agricultural productivity, resource utilisation and resilience in relation to climate change. Two specific objectives are to (i) determine which measures small- scale farmers use to adapt or cope with rainfall variability, score their efficiency, and explore the rationale for farmers' choice of measure, and to (ii) evaluate the role of trees and/or livestock in smallholder farms for different functions/ecosystem services. In addition, soil structure, tree species diversity, nutrient flows, food and firewood self-sufficiency are determined. Methods used include semi-structured interviews, farm surveys, and random systematic soil sampling. 80 farmers in 2 geographical areas were interviewed in the study of adaptation measures and 20 farms (0.5-2 acre) are followed during one year in the farming systems study (four farm types; few trees without cow; few trees with cow; many trees without cow and many trees with cow, in 5 blocks).

Results from the first study show that the most common adaptation measures were to carry out timely management e.g. irrigate only in morning and evening and to plough and plant early in the season. However, the measures observed to be most effective were to use an energy saving stove, to plant leguminous trees and to preserve/store food. The reasons for not carrying out measures were mainly due to lack of money or knowledge. Access to advisory services significantly contributed to improved adaptation potential, and through using agroforestry practices, the potential was further enhanced. The ongoing studies show that the highest food and firewood self-sufficiency is for farms with many trees without livestock. The least food and firewood self-sufficient farms were the ones with few trees with livestock. The reasons (in order of importance) why farmers have planted trees are to get fruit, firewood, timber, shade and medicine.

Further work will be carried out regarding carbon and nutrient flows and stocks (N, P, K) as well as applying the NUANCES framework on the farm types in order to see the long-term effects of different nutrient management strategies.

Impact of trees on water and nutrients dynamics in smallholder maize-based farming systems

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Growing trees is different from other farm enterprises because the tree exerts an influence at a considerable distance and depth away from where it is planted. Despite decreasing land size due to fragmentation, smallholder farmers continue introducing trees on their farms as a strategy to optimize farm productivity to meet their livelihood objectives. This has resulted in a number of agroforestry practices including different tree species, at varying age and density, which presumably have different effects on the agroecosystem in terms of competition, complementarity or balanced off overall effects on below and above ground resources necessary for crop growth and productivity. In order to understand these complex interactions a PhD study was initiated linked to the 'Multi-functionality of agroforestry systems' project in Kitale, Trans Nzoia district, Western Kenya. The overall objective is to assess local knowledge about tree attributes linked to soil fertility and assessment of water and nutrient dynamics in maize (Zea mays) intercropped with 6 selected tree species; *(Calliandra calothyrsus, Sesbania sesban, Grevillea robusta, Eucalyptus saligna, Croton macrostachyus* and *Markhamia lutea).* The specific objectives are to *i)* carry out a typology study of the presence and use of dominant tree species in selected smallholder farms, *ii)* evaluate the farmers' local knowledge on trees' contribution to soil water/nutrient availability and biological activity within the farm, *iii)* investigate the effect of dominant tree species of various ages, under various densities and spatial-temporal arrangements, on soil organic C, water and nutrient availability, and associated crop performance, *iv)* determine the effect of dominant tree species of various ages, under various densities and spatial-temporal arrangements on arbuscular mycorrhizal fungi (AMF) abundance, diversity and activity, and *v)* model the impacts of the dominant trees species, as modified by their age, density and spatial-temporal arrangements on soil organic C, water and nutrient availability, and maize productivity using the Water Nutrient Light Capture in Agroforestry Systems (WaNuLCAS) model. Measurements being conducted on farms with comparable agroforestry plots of different ages include maize grain yield, crop and tree biomass, AMF abundance, diversity and hyphal length, and abiotic conditions (soil nutrients, water and carbon). Simulations will be run using WaNuLCAS model to investigate the impact of different land uses and agroforestry practices on water and nutrient resources in the study area. Tree and crop parameterization will be done and hence a complete tree library of the six tree species will be developed and maize library updated. The study will aid farmers and policy makers in accurately predicting the period of viable intercropping with trees and their effects on soil resources. It will also support better decisions in consideration of anticipated increased tree-crop interaction, its effect on maize production, water, nutrient availability and AMF.

Soil carbon, water infiltration and root competition; implications for management in African cropping and agroforestry systems

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Increasing soil carbon and the possibility for water to infiltrate into the soil is key to improve agricultural productivity in degraded and erosion prone agricultural systems as in the Nyando basin. To understand competition and/or ameliorative effects/synergies between trees and crops are fundamental in management of integrated agroforestry systems. These issues are also very relevant in a regional and global perspective for e.g. carbon sequestration, climate change and water quality.

The project consists of two parts, both with the objective to better understand and improve agriculture and food production. Both are also continuations/extensions of other projects.

1. To study changes over time in soil carbon content and the infiltration rates of water in different rehabilitation and agroforestry measures (exclusion of grazers and planting along contours; woodlots planted on small farms; erosion control by terassing) in western Kenya.

2. To quantify competition between crops and trees in agroforestry systems through the analyses of isotope ratios of respired CO2 in Ethiopia and Kenya.

So far the results from the isotopic analyses are none. This is due to delayed delivery of the analyzing instrument, and that the instrument twice delivered never worked. This failure from the involved company's side is now handled by the legal department of SLU. However, in October-November 2012, sampling was done in Kenya with another methodology addressing the same research question. Some preparatory interviews/questionnaires for the same kind of sampling has been done in Ethiopia, showing that farmers are very aware of the effect of trees (although not always phrasing them in relation to soil fertility or food production).

The study of infiltration capacity and carbon sequestration has been successful and it shows both increase with time of tree growth and protection from grazing. The results from 4 years after planting/protecting was impressive, however, adding sampling after 6 years, enabled through the present project, proved that soil improvement continues, for some parameters dramatically, over time.

The research results communication was very educative and much appreciated by the farmers. Surprisingly, they had never been reached by research communications before, although they are in a "research intensive" area. This emphasizes the importance of research communication, not only within academia, but also to the "end users" of research results.

Innovative crop protection

Chair: Prof Eva Johansson and Prof Barbara Ekbom

Keynote introduction

Innovative crop protection approaches for Uganda's farming systems. The contribution of Makerere University

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Abstract

Although crop production is the main activity of Ugandan farmers, it is still very inefficient with most of the farmers not achieving the potential yield of their crops. This may be due to several reasons, but poor management system, poor soil fertility, low yielding varieties, and damage due to insect pests and diseases are among the cause of low yields at farm level. Damage due to insect pest on various crops is responsible for 10 -20% yield losses under field conditions and over 30% in storage. Therefore the need to reduce crop losses in the field and store is well known among modern farmers in developed economies. In Uganda the majority of farmers do not control the damage caused by both insect pests and diseases. The situation is further aggravated by weak extension services in the country.

One of the popular pest management approaches is the use of chemical pesticides. It is now common knowledge that this is associated with a number of environmental and health concerns. Consequently there is increasing demand for new and innovative pest management approaches that are both environmentally friendly and economically acceptable to the end users. This paper highlights the contribution of the College of Agricultural and Environmental Sciences together with its partners towards developing innovative approaches to pest management.

Introduction

Agriculture is the backbone of the economy of Uganda. The 2009/2010 agricultural Census report indicated that over 45% of the 14.4 million households were involved in crop production (Table 1).

The main crops grown in Uganda were traditionally characterized into cash and food crops. Among the most important cash crops are coffee, tea, sugarcane, cotton, and tobacco, while the food crops are banana, maize, beans, sweet potatoes, cassava, groundnuts, finger millet, rice, irish potatoes, simsim, sorghum, and horticultural crops. The demarcation between food and cash crops, however, has over time faded with most of the food crops also doubling as cash crops. The crops are produced under seven farming systems as characterised by the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) (Table 2).

Table 1: Percentage distribution of household members by main activity by region in Uganda

Main activity	Regions				Total Number
	Central	Eastern	Northern	Western	
Crop production	41.2	46.8	50.8	44.4	45.9
Livestock production	1.5	0.8	1.7	1.2	1.3
Fisheries	0.4	0.3	0.3	0.3	0.3
Forestry	0.1	0.1	0.2	0.2	0.1
Trader	3.1	1.2	1.0	2.3	1.8
Artisan	0.4	0.2	0.3	0.5	0.3
Agricultural paid job	0.6	0.2	0.2	0.7	0.4
Non-agricultural paid job	4.5	3.4	2.3	3.6	3.5
No activity; looking for job	0.9	0.5	0.5	0.9	0.7
No activity; not looking for job	1.6	1.3	4.2	1.1	1.9
Student	41.5	40.8	29.4	41.1	38.6
Household (domestic) work	4.1	4.3	8.8	3.7	5.1
Apiary	0.1	0.1	0.3	0.0	0.1
Total	100	100	100	100	100
Total Number of respondents (‘000)	2,577	4,453	3,108	4,264	14,402

Table 2: Uganda's agricultural systems and major crops

	District	Major crops
Banana/coffee system	Bundibugyo, Hoima, Iganga, Jinja, Kabarole, Kampala, Mpigi, Mubende, Mokono, Luwero, Rakai, Wakiso	Robusta coffee, banana, maize, beans, sweet potatoes, Cassava, horticultural crops, tea, and ground nuts
Banana/finger millet/cotton system	Bugiri, Busia, Kamuli, Luwero, Masindi, Pallisa, Tororo	Cotton, robusta coffee, beans and maize
Montane system	Bushenyi, Kabarole, Kabale, Kamwenge, Kapchorwa, Kasese, Kyenjojo, Mbale, Mbarara, Rukungiri	Arabica coffee, banana, cotton, maize beans, wheat, millet, rice, irish potatoes, and sweet potatoes
Northern system	Apac, Gulu, Kitgum, Lira, Pader	Cotton, tobacco, millet, and sweet potatoes, sorghum, cassava, and sunflower
Pastoral systems	Rakai, Masaka, Mbarara, Moroto	Millet, cassava, sorghum, beans and maize.
Teso system	Katakwi, Kumi, Soroti	Cotton, finger millet, sorghum, groundnut, simsim sweet potato and cassava
West Nile system	Arua, Moyo, Nebbi	Tobacco, cotton, Arabica coffee, simsim, millet, sorghum, cassava and groundnuts.

Irrespective of the farming system, the majority of the farmers practice mixed cropping (Table 3), a practice that is believed to be an insurance against a number of environmental stresses and ensures household food security.

Although crop production is the main activity of Ugandans, it is still very inefficient; most of the farmers do not achieve the potential yield of their crops (Table 3). This may be due to several reasons, but poor management system, poor soil fertility, low yielding varieties, and damage due to insect pests and diseases are among the cause of low yields at farm level.

While there are few studies that have been conducted to determine the yield losses due to insect pests per crop, it is generally agreed that damage due to insect pest on various crops is responsible for 10-20% yield losses under field conditions and over 30% in storage. Therefore the need to reduce crop

losses in the field and store is important.

In Uganda unfortunately the majority of farmers do not take much action to control the damage caused by insect or diseases. The situation is further aggravated by weak extension services. According to the 2010 agricultural census only 4% of the 3.6 mill households received extension service in crop protection and 48% received plant protection information from fellow farmers.

This raises a number of key questions; is it the unavailability of crop protection technologies, which forces NAADS not to interact with the farmers on pest management issues? Or is it because the existing technologies are in unavailable form to the end-users? Furthermore what type of crop protection information are farmers exchanging between themselves? The answer to the first two questions is both yes and no. Yes because it is true that in some cases there may be no well-validated pest management technologies, which extension agents can take to farmers; thus the need for researchers to avail the new technologies. Similarly it also true that the available pest management technologies are unavailable to the farmers in the form of articles in international journals, annual reports of research institutions and universities, in unpublished reports of PI to donors, in theses collected in the libraries, and in monographs. There is thus need for innovative approaches to avail pest management information to the end-users.

One of the popular pest management approaches, which most farmers share among themselves, is the use of chemical pesticides to control diseases and insect pests. While chemical pesticides are very effective in controlling both pests and diseases and the frequency of their use is increasing, the challenge has been the way farmers apply them. It is now common knowledge that use of pesticides is associated with a number of environmental and health concerns. Consequently there is increasing demand for new and innovative pest management approaches that are both environmentally friendly and economically acceptable to the end-users. This paper therefore highlights the contribution of the College of Agricultural and Environmental Sciences together with its partners towards developing innovative approaches to pest management.

Innovative approaches

In quest for alternative control approaches to chemical pesticides, scientists have explored different tactics for managing insect pests and diseases. These tactics include use of resistant varieties, use of microbial control agents, including endophyates, biological control, cultural control practices, ecological control including habitat management. Our scientists in the CAES have not be left behind in the search for environmentally friendly pest management approaches. Examples include:

Pest management on legumes

Through support of IPM CRSP the college has developed IPM packages for management of cowpeas pests in eastern Uganda that included reducing pesticide application by 50%, encouraging appropriate plant spacing, and scouting. On groundnut the college through farmer IPM field schools helped farmers control groundnut rosette through promotion of close spacing, resistant varieties and minimum application of pesticides. On soya bean, the college developed and released varieties that are resistant to soya bean rust that was threating the production.

Through Sida funding and in collaboration with SLU we are exploring the use of mulches and soil fertility amendment in the management of insect pests of beans, cabbages and cowpeas. So far we

have demonstrated that crop waste residue application may control certain pests of beans and cowpeas depending on how they are applied.

Table 3: Current average yield and yield potential of some of the major crops in Uganda

Crop	pure	Mixed	Total area	Total production (MT)	Yield mt/ha	Potential yield/ha
Maize	47.1	52.9	1,014,260	2,361,956	2.3	5-8
Finger millet	49.0	51.9	349,987	276,928	1.1	2.3-2.8
Sorghum	68	32	399,253	375,795	0.9	2.5-3.5
Rice	81.3	18.7	75,086	190,736	2.5	8-10
Beans	35.3	64.7	617,522	929,278	1.5	5- 7
Field peas	72	28	43,837	16,452	0.4	3-4
Cowpeas	74.7	25.3	23,817	11,057	0.5	2-2.5
Pigeonpeas	60.9	39.1	29,801	11,330	0.4	1.3-1.5
Groundnuts	47.9	52.1	345,232	244,684	0.7	3-3.5
Simsim	68.1	31.9	175,597	101,028	0.6	0.8-1
Soya beans	58.2	41.8	36,444	23,623	0.6	2.5
Banana (cooking)	39	61	806,626	4,017,986	5.0	
Cassava	61.2	38.8	871,389	2,894,311	3.3	
Sweet potato	83.4	16.6	440,256	1,818,769	4.1	

Pest management on cereals

Through collaboration with ICIPE, NARO and IPMCRSP the college released *Cotesia flavipes*, a parasitoid of *Chilo partellus,* one of the key pest of maize and sorghum in eastern Uganda. The parasitoid has since established and taking care of the stem borer. The college also worked on striga

management in eastern Uganda and one of the key findings was that the striga, a parasitic weed of maize and sorghum, started being a serious problem in eastern Uganda when farmers lost their cattle, and it could be controlled by a plant known as a striga chaser. These findings helped us develop an IPM package that included crop rotation and intercropping with striga chaser and nitrogen application.

Through funds by Sida and collaboration with SLU we are looking at effects of landscape ecology on pests of maize.

Pest management on horticulture crops

The college has been concentrating on reducing pesticide application on tomatoes, pepper and Irish potatoes. The scientists have developed a tomato variety resistant to tomato bacterial wilt, which is one of the most devastating diseases of tomato. The variety MT 56 will soon be officially released. This variety is the background for an IPM package of tomato, which includes mulching, staking and minimum pesticide application. In addition we are exploring the use of clean seedling, grafting and low tunnels in the management of tomato disease. These packages are being disseminated through farmer field schools. On scotch bonnet pepper our scientists are looking at ways of manipulating irrigation water levels to control soil-borne diseases. On Irish potato we are exploring hydroponics as fast and safe ways of rapidly producing disease free planting material.

Cassava and sweet potato

The college through Sida funding has concentrated on understanding the epidemiology of viral disease of cassava and sweet potatoes. As a result of this work we have developed diagnostic tools, which we are trying to incorporate in seed system. We believe that one of the key ways of reducing the impact of the cassava brown streak virus and sweet potato virus disease is production clean planting material.

How are we disseminating these innovative approaches to the farmers

By nature of our institutional arrangement the college has limited resources to enable it scale out some of these innovation. We are therefore following different avenues. The first approach has been involving farmers in the research through our modified farmer field schools which has allowed us to develop and validate the technologies with farmers. Since we started using this approach in 1993 through the PIPM CRSP project it has proved very effective.

Another approach we would like to try is involving our students on internship to disseminate the findings to the end-users. The challenge we are still facing is to find funding to implement well-structured and supervised internship programs. We would like to explore the possibility of using the demographic site that has been established by Sida-funding as internship centre.

Conclusion

Makerere University in general and its College of Agricultural and Environmental Sciences have the potential to act as an agent of agricultural transformation if it can find means to upscale some of these technologies and innovations.

Keynote introduction

Gene stewardship – Optimizing the use of host resistance

Dr. Gregory A. Forbes, International Potato Center (CIP), Lima, Peru, and Prof. Jonathan Yuen, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden*

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The concept of stewardship of natural resources has been long used for pesticides, pharmaceuticals or GMOs, and may refer to the responsible use of the technology to prolong its effectiveness or to reduce its potential negative effect on the environment. Here we focus on the responsible use of genetically modified host resistance in potato against the oomycete pathogen, *Phytophthora infestans*, the cause of potato late blight. This is generally considered the worst single disease of potato, infamous for its role in the Irish Famine, and causing billions of USD every year in direct yield loss or in fungicide use. The disease is also problematic in developing countries because it is routinely controlled with pesticides, using unsafe application practices.

Two phenotypic classes of resistance are known against this disease, one which provides high levels of resistance or even immunity but which, to date, has been easily overcome by pathogen evolution (i.e., the appearance of new, pathogenic strains of the pathogen), and another which provides partial resistance but which appears more broadly stable against diverse pathogen strains. The first resistance type is known as "R-gene" or "race-specific", while the second is known as "multi-gene" or "race non-specific". Stewardship applies more readily to the former, since efforts should be taken to prolong the utility of the resistance as long as possible.

Scientists have developed models for deploying race-specific resistance of disease, which may involve actions by researchers, state or private organizations and farmers. For example, stewardship may involve a close monitoring of the pathogen population to identify any breakdown in the resistance. This is a complicated endeavor that involves organizing researchers in different locations and standardizing techniques, such as pathogen sampling and identification and data management. Stewardship may also be seen broadly as employing the best theories known to science to preserve the resource in question. Applying that concept to late blight resistance, one model which appears promising for durability is the use of stacked resistance genes, which is at present only practical with genetic modification. The International Potato Center (CIP) and partners are currently involved in a project aimed at putting a cassette of three resistance genes into potato cultivars locally adapted to Eastern Africa. CIP and the Swedish University of Agricultural Sciences (SLU) have partnered in the pathogen surveillance activities. Materials containing the gene cassette will be closely monitored during the testing process and the pathogen isolated from any symptoms that may occur. The general pathogen population will also be monitored and screened for the presence of pathogenicity factors (effectors) that may indicate a breakdown of resistance.

These activities will be linked with initiatives in the region. For example, they will be integrated within a new Consortium Research Program on Roots, Tubers and Bananas (CRP–RTB), which is part of the Consultative Group on International Agricultural Research (CGIAR). The CRP–RTB has a

project on disease surveillance and risk assessment, which will provide generalized disease surveillance support for these crops and thereby make available important resources, such as methodologies for sampling and a general on-line platform for data storage, querying and visualization.

Taken broadly, the concept of stewardship may also be applied to ancillary activities in the cropping system. For example, potato, as a vegetatively propagated crop, is severely affected by seed degeneration, an accumulation of diseases in the seed tubers, which greatly reduce yield. Degeneration of a new cultivar with a late blight resistance cassette would also be a loss of an important resource. Degeneration of potato is managed in the industrialized world by providing clean (near disease-free) seed for farmers to purchase at a reasonable cost. These seed systems do not exist in developing countries so the alternative management strategies are to use host resistance to the degeneration diseases and/or on farm management (such as selection of symptom-free plants for seed production). Thus, management of degeneration with one or both of these strategies is an important component of stewardship of genetically modified resistance to late blight.

The importance of landscape and local structure for pest and natural enemy occurrence

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This project brings together participants from a large area of East Africa. The project includes cooperation and collaboration between the Swedish University for Agricultural Sciences (SLU), Makerere University, ICIPE (African Insect Science for Food and Health), and the Vi Agroforestry project in East Africa. Our goal has been to explore the importance of interactions between landscape context and management options for improving biological control of insect pests. The ultimate objective is to provide as much information as possible in helping farmers choose management options for increasing pest control and ensuring high yield levels.

Our study included two cropping systems, coffee and maize. We wished to have one perennial and one annual crop in our study as different landscape elements and management options can be studied in the two diverse systems. We had field sites in both Uganda and Kenya for both cropping systems. Landscape variables in coffee were distance to natural areas (which was also correlated to altitude) in Uganda and proportions of tree cover and semi-natural habitats in Kenya. The management option we explored was the level of shading, this in both countries. In Uganda, the coffee berry borer and the white stemborer were the pests investigated. In Kenya, foliage pests (lace bugs, leafminers, and aphids) were inventoried at different sites. The landscape parameter of interest for maize was proportion of area covered by grasslands near the surveyed fields. The management option of interest was mixed cropping or single cropping of maize. Insects of interest in maize were pests, stemborers, and their natural enemies (mostly parasitoids).

Some field work is still ongoing and not all data has been analyzed, especially for the maize cropping system. We have, however, reached some important conclusions for coffee pests. Lands- cape context interacting with shading does influence pest occurrence concerning coffee foliage pests. For instance, shaded sites had more aphids in landscapes with the highest proportions of tree cover; the opposite was true in sun-exposed sites (more aphids in landscapes with low pro- portions of tree cover). For the white stemborer sun-exposed sites had the lowest attack rate and this was particularly true for low elevation (far from natural areas). For coffee berry borers, pest populations were lowest in shaded areas; but the landscape context did not matter. Diversity of natural enemies in coffee was highest in shaded areas near to natural areas (high elevation).

Capacity building has been an important component in our research and four MSc students (two Swedish and two African) will be able to complete their MSc degrees as a result of this project.

Semio-ecological management of high value crops in East and South Africa

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High value crops present important socio-economic development opportunities particularly in smallholder farming. With women disproportionally engaged in these activities, cash crops strongly support core developmental needs such as education, health care and nutritional needs for children in particular. In this project we developed and supported research and capacity building in multilevel management of pests in high value crops.

The research focused on three target crops, selected on the basis of criteria such as severity of the insect pest problem, existing ongoing research links, and possibilities for sustainable solutions: 1) African invasive fruit fly, *Bactrocera invadens*, arguably the most important pest in fruit crops throughout Africa, 2) the potato tuber moth, a pest which recently shifted from potato to tomato in Ethiopia, and 3) the African sugarcane borer, a serious pest in sugarcane in large parts of Africa. Focal countries were Ethiopia (1 and 2), and South Africa (3).

The strong dispersive capabilities of *B. invadens* require regional action. We researched its biology and explored potential measures for AIF control in both smallholder and large-scale farming contexts. Besides, applied aspects, such as the effect of orchard management techniques (particularly sanitation), population dynamic factors (i.e., its dispersive range), and management using methyl eugenol, we studied the fly's chemical ecology. We identified compounds that elicited antennal responses from mango, orange, guava and banana, and formulated synthetic blends on the basis of compounds shared across fruits. Synthetic blends of banana were equally attractive to both female and male flies as banana extract. Further work will study slow release of blends for field testing. Blends attracting males and females have the potential of cross-attracting several species of fruit flies and would be important for future monitoring and control of fruit flies.

Project 2 and 3 are interconnected and concern moth pests which defy effective biological control. In both systems parasitoid effectively suppress pest populations in other crops or vegetation, but not inside a monoculture of the target crop. Research aims to identify the cause of the lack of parasitization, and how the cropping system can be altered to favor biological and sustainable control of these pests. We found that lack of parasitization in both tomato and sugarcane is because natural enemies are unable to recognize 'signals' emitted by both crops upon herbivory. Semio-ecological intervention, through intercropping, choice of variety, and/or intercropping with repellent (for the pest) and/or attractant (for the parasitoid) plants, and possibly using improving host recognition through application of semiochemicals are currently being investigated. Both projects share strong parallels with the maize/*Chilo partellus* system, for which the "push-pull" strategy was developed and which is spreading in farming communities in East Africa as a sustainable method in pest control.

New, dominating clones of *Phytophthora infestans* in East Africa

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Phytophthora infestans, the causal agent of potato late blight, survived as a clonal lineage (known as US1) in most of the world for most of the 20th century. Emigration of new genotypes from Mexico has introduced more aggressive genotypes of the pathogen in much of the world, along with sexual reproduction in some areas, notably the Nordic countries. Sub-Saharan Africa, until recently, was still dominated by the US-1 clonal lineage, with some reports of new genotypes, but the introduction of these new genotypes generally did not displace the US-1 clonal lineage in these areas. A collection from South Africa, Mozambique, Malawi, Tanzania, Burundi, Rwanda, Uganda, and Kenya, made in 2007 by researchers from South Africa, consisted primarily of the US-1 clonal lineage, although one lineage, designated KE-1, was found in two fields in Kenya. We are in the process of analyzing a collection of material from Ethiopia, Kenya, and Uganda, using DNA-based markers, primarily microsatellites and mitochondrial DNA haplotypes. Our results indicate that the US-1 clonal lineage (identified by the 1b mitochondrial DNA haplotype) cannot be found in Ethiopia or Kenya, indicating complete displacement of US-1 in those areas by newer genotypes characterized by the 1a mitochondrial DNA haplotype. In Uganda, collections from the eastern part of the country were also of the 1a haplotype, but in western Uganda, most fields sampled had the 1b haplotype (US-1), though the 1a haplotype was found in 6 fields, which is consistent with an on-going displacement process. The US-1 lineage was also found on tomato in Uganda, though the tomato samples from Ethiopia were the 1a haplotype. SSR fingerprinting indicated close relationship between the clones in parts of Ethiopia, Kenya, and eastern Uganda. Limited phenotype testing with living isolates has only revealed the A1 mating type, and thus we have no evidence of sexual reproduction in this region. These new clones of *P. infestans* are more aggressive than the older US-1 clonal lineage, since they have displaced this older population, and will probably cause increased difficulties in controlling potato late blight in this region.

The way forward – summary from breakout sessions and round-table discussion

The seminar included a breakout session, i.e. a time slot allocated for group discussions, the aim of which was to give the participants an opportunity to meet and discuss relevant and urgent issues in informal groupings. The format of these group discussions was open, and it was thus up to the participants themselves to form discipline specific or cross-disciplinary groups, and to identify the topics to discuss. The result was five largely discipline specific groups in the following areas:

1. Plant breeding
2. Sustainable agro-ecosystems and soil fertility
3. Urban and peri-urban animal management
4. Animal health and production including reproduction
5. Innovative crop protection

The groups were to take notes of their discussions and to share the main issues during a concluding round-table discussion. It is the organizers' hope that the outcomes of the group discussions will be of value for the researchers themselves, and SLU Global will also keep record of the groups' notes for future consideration and, when possible and relevant, implementation. Below is a list of some main issues of general interest that several or all of the groups considered important for the future.

- The importance of continuity, and broadening (i.e. development of more interdisciplinary work) of the collaborations already established and deepened thanks to the funding from the Swedish Ministry of Foreign Affairs and Sida. The need to include economic/socioeconomic/value chain aspects were brought up by several groups. However, the issue of future, *and more long-term, funding* was identified as critical.
- The problem of finding funding for work conducted by MSc and PhD students. The need for a format for *funding of MSc students* for studies at Swedish universities was particularly articulated.
- The need to get added value of individual projects by *linking* the work that has been conducted separately by different sub-projects on the same field sites.
- *Documentation of existing collaborations* should be done in order to allow for the detection of personal links on a researcher to researcher level. SLU Global should be the hub that makes available information about these collaborations, which could be helpful for the establishment of regional networks.
- There was a suggestion to get added value of the individual projects by linking them with *CGIAR centers and the CRPs* (Consortium Research Programs).
- It was considered important to more efficiently *share published documents* (e.g. MSc and PhD theses and scientific papers).
- It was suggested that *climate change* is a relatively new problem area in Africa, and as a consequence there was a capacity gap in MSc/PhD education. Collaboration in this field was therefore in great demand.
- *Lobbying to increase the awareness* of the need to combat food and nutrition insecurity was identified as important, and a task both for SLU and its partners.
  On the issue of *funding possibilities* other than Sida it was suggested that SLU Global should be a catalyst for joint proposals.

Appendices

Agenda

Day 1 (Tuesday 4 Dec)

Introductory session

8.00-9.00 **Registration**

9.00-9.15 **Opening and welcome.** *Prof Arvid Uggla, Director SLU Global*

9.15-9.20 **Welcome remarks.** *Prof Eli Katunguka, Director of Research and Graduate Training, Makerere University*

9.20-9.50 **Keynote presentation.** Building sustainable food systems in Africa: AGRA-Sweden partnership. *Dr Rufaro Madakadze, Program Officer Education and Training, Alliance for a Green Revolution in Africa (AGRA)*

9.50-10.00 Practical information *Kim Rock, Carolyn Glynn*

10.00-10.30 **Coffee/Tea**

Scientific session 1 – Crop breeding and genetics. *Chairperson: Prof Ingrid Öborn*

10.30-11.00 **Keynote introduction.** *Assoc Prof Patrick Okori, Dean School of Agricultural Sciences, Makerere University*

11.00-11.20 Disease breeding in sorghum. *C. Dixelius*

11.20-11.40 Exploring genetic diversity and variation in tuber composition of nutsedge – a potential crop for East Africa. *E. Too, B. Were, A. Onkware, Joyce Agalo, S. Gudu, A. Carlsson*

11.40-12.00 Plant breeding and genetic resources – Collaborations between SLU, South Africa and Southern Africa*. E. Johansson, E. Alexandersson, M. Labuschagne, D. Jacobson, M. Vivier, D. Nguni, C. Mujaju, S. Andersson, F. Hailu, N. Mkhatywa, E. Jönsson, A. Geiger, D. Weighill, A. van Biljon, M. Prieto Linde, H. Persson Hovmalm*

12.00-12.20 Genetic resources and plant breeding – Collaboration between SLU and Central Asia. *L. Gustavsson, T. Bryngelsson, S. Andersson, M. Rahmatov, M. Mahkamov, E. Torutaeva, A. Zborowska*

12.20-13.20 **Lunch**

Scientific session 2 – Animal health and production. *Chairperson: Prof Elly Sabiiti*

13.20-13.50 **Keynote introduction.** Livestock production in Uganda: The opportunities and challenges for food security *Assoc Prof David Owiny, Dean School of Biosecurity, Biotechnical and Laboratory Sciences, Makerere University*

13.50-14.10 Improving pasture availability for dairy cows in pastoral production systems. *D. Mpairwe, C. Johansson, M. Tibezinda, S. Katuromunda, E. Sabiiti, E. Wredle*

14.10-14.30 Reproductive health in dairy herds in Uganda and its implications for herd profit. *T. Ntallaris, B. Kanyima, R. Båge*

14.30-14.40 **Health break**

14.40-15.00 Animal genetic resources for improved livestock productivity under harsh environmental conditions. *J. Philipsson, E. Zonabend, J. Ojango, E. Strandberg*

15.00-15.20 Metagenomic studies on virus dynamics at the livestock/tick/wildlife interface with special reference to African swine fever. *M. Berg, C. Masembe, R. A. Okurut, P. Atimnedi, A. Fisher, R. Skilton, R. Bishop, A. Blomström, K. Ståhl*

15.20-15.50 **Coffee/Tea**

15.50-16.20 **Keynote presentation.** Challenges for the African tertiary agricultural education. *Prof Hamidou Boly, Coordinator Tertiary Education in Agriculture Mechanism (TEAM-Africa)*

16.20-17.20 **Panel discussion:** Future needs for research and education in food security and land use sciences, and possibilities for strengthening collaborations between SLU and African institutions. Reflections from the day's discussions. *Rufaro Madakadze* (AGRA), *Ingrid Öborn* (ICRAF), *Eli Katunguka* (Makerere University), *Adipala Ekwamo* (RUFORUM), *Hamidou Boly* (TEAM-Africa), *Katri Pohjolainen Yap* (Sida) and *Arvid Uggla* (SLU Global). *Chairman: Dr Inge Gerremo, SLU Global*

19.00-21.00+ **BBQ Dinner at Hotel Metropole hosted by SLU Global**

Day 2 (Wednesday 5 Dec)

9.00-9.15 Welcome to Day 2. *Arvid Uggla*

Scientific session 3 – Urban and peri-urban animal production. *Chairperson: Dr Ewa Wredle*

9.15-9.35 The importance of the zoonotic bacterium *Brucella abortus* in the milk chain in Gulu and Soroti regions of Uganda. *K. Rock, D. Mugizi, J. Erume, C. Waiswa, G. Nasinyama, K. Ståhl, U. Magnusson, S. Boqvist*

9.35-9.55 Feed for livestock in urban and peri-urban production: The case of Kampala, Uganda. *C. Katongole, R. Lumu, K. Lawrence, J. Nambi-Kasozi, F. Bereeba, M. Presto, E. Ivarsson, J. E. Lindberg*

9.55-10.15 Manure management in Kampala – a potential golden egg. *A. Komakech, B. Vinnerås*

10.15-10.35 An assessment of potential disease transmission at an early level in the food value chain. *A-L. Blomström, C. Lalander, Vinnerås, A. Komakech, J. E. Lindberg, S. Boqvist*

10.35-10.55 **Coffee/Tea**

Scientific session 4 – Sustainable agroecosystems. *Chairperson: Prof Christina Dixelius*

10.55- 11.15 Management of water resources in Ethiopian agriculture. *S. Gebreyohannis, W. Bewket, K. Bishop, T. Almirew, E. Karltun*

11.15-11.35 Multifunctionality of agroforestry systems. *I. Öborn, J. Nyaga, Y. Nyberg, E. Barrios, S. Dahlin, M. Jonsson, B. Lager, V. Matiru, C. W. Muthuri, F. L. Sinclair*

11.35-11.55 Assessing multifunctionality and climate change adaptation capacity of agroforestry systems in W Kenya. *Ylva Nyberg, I. Öborn, M. Jonsson, E. Lazlo Ambjörnsson, E. Barrios, F. L. Sinclair*

11.55-12.15 Impact of trees on water and nutrients dynamics in smallholder maize-based farming systems. *J. Nyaga, C. W. Muthuri, E. Barrios, I. Öborn, V. Matiru, F. L. Sinclair*

12.15-12.35 Farmers' perceptions of trees, soil rehabilitation and research communication. *G. Nyberg, B. Lemma*

12.35-13.35 **Lunch**

13.35-13.45 Introduction and instructions to breakout sessions. *Carolyn Glynn*

13.45-17.00 **Breakout sessions incl. coffee/tea**

Evening meal at participants' own discretion

Day 3 (Thursday 6 Dec)

9.00-9.15 Welcome to Day 3. *Arvid Uggla*

Scientific session 5 – Innovative crop protection I. *Chairperson: Prof Eva Johansson*

9.15-9.45 **Keynote introduction.** *Prof Samuel Kyamanywa, Principal College of Agricultural and Environmental Sciences, Makerere University*

9.45-10.15 The importance of landscape and local structure for pest and natural enemy occurrence. *B. Ekbom, M. Jonsson, C. Midega, S. Kyamanywa, J. Karungi, D. Gayi, A. Ijala, N. Backlund, L. Malmberg*

10.15-10.35 **Coffee/Tea**

Scientific session 6 – Innovative crop protection II. *Chairperson: Prof Barbara Ekbom*

10.35-11.05 **Keynote introduction.** Gene stewardship – Optimizing the use of host plant resistance. *Dr Gregory Forbes, International Potato Centre (CIP)*

11.05-11.30 Integrated insect pest management in high value crops in Ethiopia: fruit and tomato. *E. Seyoum, T. Dejene, M. Karlsson, M. Mulugeta, B. Mekonnen, M. Proffit, B. Aregay, T. Mulugeta, J. Axelsson, Y. Hillbur, T. Dekker*

11.30-11.45 Research on push pull control of the sugarcane borer in Southern Africa. *C. Okoth, D. Conlong, A. Juergens, S. Rutherford, Y. Hillbur, T. Dekker*

11.45-12.05 New, dominating clones of Phytophthora infestans in East Africa. *J. Yuen, A. Njoroge, D. Shimelash, G. Tusiime, G. Forbes*

12.05-12.30 General discussion of sessions 5 and 6

12.30-13.30 **Lunch**

13.30-15.30 **Breakout sessions incl. coffee/tea**

15.30-16.30 **Closing session. Round table discussion** on strategies and ways forward based on reports from breakout sessions.
Chairman: Inge Gerremo

16.30-16.45 **Concluding remarks.** *Arvid Uggla*

Evening meal at participants' own discretion

Day 4 (Friday 7 Dec)

9.00-12.00 **Makerere University visit** (optional)

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Total: 106 participants

Proceedings of the SLU Africa Food Security Research Symposium

In October 2010 the Swedish Ministry of Foreign Affairs allocated specific funding to the Swedish University of Agricultural Sciences (SLU) for work to support global food security. The allocation was done with the long-term aim to reduce hunger and malnutrition by supporting sustainably improving agricultural productivity through research and development. SLU's mission was to engage with institutions particularly in Africa, conduct high quality collaborative research and enhance the capacity development of partner institutions. Priority research areas included plant breeding, farming systems, animal health and disease control. Within the framework of this collaborative research program, a symposium was held in Kampala, Uganda, in December 2012. In these proceedings, data generated from projects within the program are presented.

The **Swedish Unversity of Agricultural Sciences (SLU)** has core competence within the agricultural sciences, including forestry and veterinary sciences. The areas of expertise cover urgent global issues such as food production, energy supply, climate change, biodiversity conservation and control of infectious diseases in animal and man.

To strengthen SLU's involvement in issues related to improving productivity in agriculture, food security and sustainable livelihood in low-income countries, the university has established the programme **Agricultural Sciences for Global Development, (SLU Global)**. The programme's mission is to coordinate and visualize SLU's competence in research, education and expert council within the frame of the Swedish Policy for Global Development.

www.slu.se/slu-global

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