Enhancing Food Security through Improved Seed Systems of Appropriate Varieties of Cassava, Potato and Sweetpotato Resilient to Climate Change in Eastern Africa

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2. Executive Summary

Food security is a key priority for the over 200 million people of Eastern Africa, and this population is envisaged to double by 2030. The need to feed this population puts increasing pressure on the fixed land for food production. This is further aggravated by the increasingly degraded environment and the uncertainties resulting from climate change. Such declining and variable environments require robust crops adapted to a wide range of agro-ecologies in the region. Cassava, potato and sweetpotao are choice crops for such situation and are major food staple crops in the Eastern Africa countries of Ethiopia, Kenya, Tanzania, Rwanda and Uganda. Their plasticity to environmental regimes and yield make them the best crops for food and nutrition security in the sub-region. To better harness the potential of these crops for food and nutrition security in the face of changing climates, there is need to develop and promote well suited cultivars supported by efficient seed multiplication and delivery systems. Until now this remains a challenge in the sub-region. Therefore, the goal of this project is to contribute to improved and sustainable cassava, potato and sweetpotato production. Key intervention areas will include i) screening appropriate cassava, potato and sweetpotato varieties for adaptation to diverse agro-ecologies and disease pressure, ii) developing protocols and guidelines for high throughput production of quality planting materials, iii) designing and testing potential models for quality seed multiplication, delivery and initiate their institutionalization, and iv) promoting proven technologies and practices for enhanced semi-intensive and commercial production of cassava, potato and sweetpotato in relevant agro-ecologies of Eastern Africa. The key intervention areas will be achieved through screening germplasm under simulated climate and natural field conditions, developing high throughput seed delivery system, and participatory evaluation, packaging and promotion of technologies. The project will be led by Makerere University (MAK) in collaboration with Kachwekano Zonal Agricultural Research and Development Institute (KAZARDI), Addis Ababa University (AAU), Kenya Agricultural Research Institute (KARI), Institut des Sciences Agronomiques du Rwanda (ISAR), and Mikocheni Agricultural Research Institute (MARI). Other cooperating institutions will include the International Potato Centre (CIP), the University of Agricultural Sciences, Uppsala (SLU), University of Helsinki (UoH), National Crops Resources Research Institute (NaCRRI), Ethiopian Institute of Agricultural Research (EIAR), Jomo Kenya University of Agriculture and Technology (JKUAT). The project implementation will also involve private organizations: UNSPPA (Uganda), Kisima Farm (Kenya), Red barna (Ethiopia), URUGAGA IMBARAGA (Rwanda), and GTIL (Tanzania). Key project outputs will include a selection of appropriate varieties evaluated across different agro-ecologies, efficient and high throughput seed delivery system, and increased awareness and adoption of improved technologies. Overall, the project will contribute to increased food security for resource poor farmers in Eastern Africa. This project will be implemented in a period of 3 years at an estimated investment value of USD 1,193,205.

3. Background and rationale for the proposed project

Improvement of the cassava (*Manihot esculenta*), potato (*Solanum tuberosum*) and sweetpotato (*Ipomoea batatas*) production system in sub-Saharan Africa (SSA), where the three crops are important cash and food crops, can be a pathway to food security and adaptation to climate change. Cassava plays a key role as food security and income generating crop. Described as “classic food security crop” this crop offers the advantage of a decent harvest amidst erratic rainfall and infertile soils. In the East African region, cassava production is on average 10 t/ha (9.8 t/ha in Tanzania, 10.6 t/ha in Kenya and 12 t/ha in Uganda). These yields are about half compared to yields in some South Asian countries: China (16.3 t/ha), Indonesia (16.2 t/ha), Thailand (22.9 t/ha) and India (31.4 t/ha) (FAO, 2007). The low average yields in Eastern Africa are caused by an array of factors including susceptibility of commonly grown varieties to major diseases and pests, and variability in climate patterns. Among the major diseases, viral diseases are the most important in tropical Africa. Cassava brown streak disease (CBSD) is the most damaging disease causing over 50% yield loss and threatening the livelihoods of farmers in the sub-region (Hillocks *et al*., 2001). This is further aggravated by the poor seed system that does not allow timely availability and replacement of quality planting materials. Previously many national and international programs have identified improved cassava lines. However, the system of multiplication and distribution of planting material is often inefficient or non-existent.

Potato is both a staple food and a major source of household income in the region. Despite its importance, farm yields are frequently below 10 t/ha in comparison to 40-50 t/ha achievable in good growth conditions. The low productivity is due to a number of constraints including late blight (LB) and bacterial wilt (BW) diseases caused by *Phytopthora infestans* and *Ralstonia solanacearum*, respectively, but also viruses namely *Potato leaf roll virus* (PLRV), *Potato virus Y* (PVY), *Potato virus X* (PVX), *Potato virus S* (PVS), *Potato virus A* (PVA) and *Potato virus M* (PVM). Variability in climate pattern presents another threat to potato production amongst the subsistence growers. The inadequate availability and use of inputs such as clean seed, fertilizers, pesticides, and poor marketing (Wagoire *et al*., 2002) also reduces potato productivity. Among the inputs, seed potato constitutes 40-50% of the total variable costs in potato production (Tindimubona *et al*., 2000) rendering it the most expensive and highly significant input. Despite various efforts by the National Agricultural Research Systems and other private sector partners, production of quality potato seed remain a problem, leading many farmers to resort to “farmer saved seed” which is already diseased and act as a source of inoculum for further disease spread (Kaganzi *et al.*, 2006). Therefore, low utilization of quality seed potato is considered a major cause of low productivity in the potato sub-sector.

Sweetpotato is the third most important tuber crop in the world and food staple in the East African region. Its productivity is greatly limited by sweetpotato virus disease complex (SPVD) that has been, in many cases, associated with the disappearance of the once elite cultivars (Gibson *et al*., 1997). This undermines previous and ongoing efforts in genetic improvement for yield and quality e.g. cultivars with increased starch content and vitamin A levels. Sweetpotato genotypes with moderate amounts of vitamin A have been reckoned as a potential means of saving thousands of children in Africa from going blind each year. Sweetpotato productivity problems are further compounded by the gross lack of virus-indexing protocols and clean seed systems; planting materials are the common source of virus inoculum. Our previous efforts, during the BIO-EARN programme, have improved knowledge on the molecular characteristics of the viruses and their interactions with the host plants, and diagnostic approaches (Mukasa, 2004; Tairo *et al*., 2005). The availability of accurate diagnostic techniques and use of indexed planting material are good starting steps in boosting sweetpotato production (Fugli *et al*., 1999).

Multiplication and deployment of improved varieties will necessitate development high throughput seed delivery systems for the three crops achieved through a participatory approach involving key stakeholders in a public-private partnership. This proposed project will also address the need for increased awareness creation and training in a bid to accelerate uptake and promotion. Hence, the proposed approach of a participatory variety evaluation and selection with the main stakeholders will have the highest chance of adoption of high yielding resilient varieties of cassava, potato and sweetpotato in the region. Among the prerequisites for establishment of a well organized seed system are: i) availability of improved seed (foundation seed, basic seed), (ii) protocols for rapid multiplication of disease free planting materials, (iii) protocols for cleaning planting materials, (iv) well trained personnel on rapid multiplication and their maintenance, and (v) perhaps most important, there must be a well defined and institutionalized private/public partnership that is self sustaining to maintain primary, and secondary nurseries and deliver the seed to the farmers.

4. Adding value to existing efforts (relevance and quality of content of the proposal):
The proposed research will build-on and complement on-going and completed research on cassava, potato and sweetpotato in the sub-region. These include: (i) ***Great Lakes Cassava Initiative (GLCI):*** focusing on the multiplication and distribution of existing Cassava mosaic disease (CMD) resistant varieties while taking care not to inadvertently distribute CBSD within planting materials. (ii) ***BIOEARN programme*****:** which worked a) developing new clones for resistance to SPVD, b) understanding the nature of CBSD, c) developing diagnostic tools for CBSV and sweetpotato viruses, d) developing protocols for virus elimination, and e) evaluation of cassava clones for production of different starches. (iii) ***The Mega cassava project:*** this is a regional project under the Staples Crops Programme of ASARECA and aims at generating baseline data on CBSD and its impact on the stakeholders. (iv) ***Cassava: Adding Value for Africa (C:AVA):*** this is a regional project supported under the Bill & Melinda Gates Foundation to increase incomes of small scale farmers by turning cassava into high-quality processed flour that can be sold at a premium price. (v) ***MSI CBSD Project***: this aims at understanding the diversity of CBSV, spread of CBSD in Uganda, genetics of resistance to CBSD and developing protocols for RNA silencing. (vi) ***Regional National Cassava, Potato and Sweetpotato Programs:*** have carried out needs assessment surveys to establishment the challenges to production of these crops. (vii) ***CIP Potato East Africa***: selected germplasm for potato for with traits such as heat tolerance, WUE, resistance to viruses and late blight resistance. (vii) CIP Sweetpotato East: is working on management of sweetpotato weevils particularly through use of Bt technology, germplasm introduction and evaluation. Furthermore, CIP in collaboration with Vitamin A for Africa (VITAA) project and various NARIs in the region have promoted the development and use of orange fleshed sweetpotato cultivars that are rich in vitamin A. (viii) ***SASHA Project***: is focusing on promotion and conventional multiplication of planting material of sweetpotato clones, and evaluating the yield trade-off of using virus free planting material. (ix) ***IITA***: is focusing on improved productivity of cassava with resistance to major pests and diseases, of acceptable quality attributes.

Therefore, the past and current research initiatives have laid a foundation for this project which aims at evaluating and deployment of varieties that are adapted to climate change in their respective agro-ecologies, and developing and institutionalising efficient seed multiplication and delivery system. This project is therefore very distinct from the cassava and sweetpotato initiatives by the Bill and Melinda Gate Foundations through CRS/GLCI and CIP/SASHA. The GLCI project is focussing on i) diagnostic systems for cassava viruses and ii) understanding molecular basis of resistance to CBSD and iii) developing transgenic technology for CBSD. CIP/SASHA project is focussing on a numbers thematic areas including sustainable sweetpotato seed system in Africa – developing and testing strategies for effective multiplication, dissemination and exchange of disease free sweetpotato planting material. However, our proposal is focussing a comprehensive system that targets three important crops in the region. We shall focus on institutionalisation of the seed delivery systems, unlike other projects in the region, with active participation of the private sector. The project will also empower the potential beneficiaries with tissue culture skills as well as supporting certification and policy initiatives. For each of the three crops, a full agronomic package will be disseminated to the end users to enhance productivity.

Overall, this project complies with the objectives and aspirations of the Comprehensive Africa Agriculture Development Program (CAADP) of NEPAD, notably: a) enhancing productivity and production of key crop commodities in fulfilment of Pillar 3 which focuses on improving food supply and reducing hunger across the region, b) increasing access to and sustainability of quality planting materials consistent with Pillar 4 aiming at improving agricultural research system in order to disseminate appropriate technology.

5. Potential for economic and social impact
Cassava is a very important starchy root crop in many parts of the tropics where it is a vital staple for over 200 million people in the sub-region. It is grown in several agro-ecological zones and plays significant roles in the farming and food systems in Eastern Africa. It stores well in soil as a famine reserve crop, has high productivity per unit area and performs relatively well in marginal soils, which makes it ideal for food security regardless of declining soil fertility in the region. Cassava appeals to low income earners because it offers the cheapest source of calories and is an important cash crop. It can also be easily processed to produce industrial

starch and is important in livestock feed production. Among the 5 countries that make up the greater eastern Africa region that are occupied by close to 131 million people with a mean annual growth rate of 2.91% (World bank, world development indicator, 2008) cassava is grown on more than 10.5% of the total cultivatable land (including land used to grow cash crops) and contributes more than 45% of the total food consumed in the region being grown by about 70 million small holder households in addition to a number of commercial growing initiatives (FAO, 2008). Because of its significance, cassava is a high priority crop in the research and development agenda of national agricultural research efforts in the Eastern African regional and Africa as a whole. This is due to its sustainability and guaranteed contribution towards the millennium development goals and regional economic goals.

The crop has been prioritized by NEPAD as one of the crops to combat poverty and, food and nutrition insecurity in Africa (NEPAD, 2004). It is one of the strategic crops to address the Comprehensive African Agriculture Development Program (CAADP) pillar 3 (i.e. increasing food supply). In addition, cassava has the potential to be transformed from a purely subsistence food crop to a commercial crop for the food, feed, starch, ethanol and biofuels industries as has been achieved in other countries like Brazil and Thailand. Because of its significance, cassava is a high priority commodity in the national research and development agenda. Similarly, sweetpotato is an important food security crop that matures in 4-6 months and well adapted to tropical ecological zones. In addition sweetpotato is increasingly becoming important as a fodder in the diary and piggery sub-sectors. Sweetpotato genotypes that have moderate amounts of vitamin A have been reckoned as a potential means of saving thousands of children in Africa from going blind each year.

Potato is a key food crop in the region mainly Rwanda, Kenya, Uganda, Ethiopia and Tanzania in decreasing order. In Rwanda annual consumption is 125 kg/capita/year compared to 5 kg/capital/year in Ethiopia. It is one of the fastest emerging foods in the sub-region especially in the urban areas. In Uganda the production tripled during the last 20 years and in Ethiopia potato is mainly considered as a food security crop when cereals fail.

The project is expected to generate new knowledge, technologies and products that will promote expanded production and utilization of cassava, potato and sweetpotato for food and nutrition security and economic development in the East African region. This effort will further the outputs of our recently concluded research on cassava and sweetpotato in which various technologies were developed (BIOEARN Cassava-Sweetpotato Project 02). Among these are high yielding varieties, biotechnologies for producing clean planting materials and IPM packages for various pests and diseases. It will also further the efforts of other research initiatives on potato in the sub-region including CIP potato varieties for the low lands and different agro-ecologies.

6. Regional and international collaboration

There are many small and fragmented investments at national level in several countries seeking to address common developmental challenges in the region. Challenges dealing with bio-resources including agricultural productivity constraints, market opportunities, environmental problems such as climate change are regional in nature and require regional and joint efforts. Collaborative and regional efforts can enhance complementarities and more efficient use of resources (financial, human and infrastructural). The regional approach has proven useful and is an effective way of building capacity for producing regional public goods by reducing transaction costs and enhancing economies of scale, scope and size. Regional integration and shared approaches are increasingly important factors in promoting development particularly in Africa. This is mainly reflected in areas such as natural resource management, innovation and environmental protection, where African governments, through their regional bodies have shouldered greater responsibility. Regional bodies, such as the African Union (AU), New Partnership for African Development (NEPAD), East African Community (EAC), and Southern African Development Community (SADC) are thus central actors in shaping regional collaborative agendas. The partner countries in the sub-region share development challenges that require collective regional action to maximize synergies and impact.

This project will constitute a consortium of stakeholders that includes the major universities, national agricultural research institutions, key international support R&D institutions and private sector actors in the region. Some of the cooperating institutions include the International Potato Centre (CIP), the University of Agricultural Sciences, Uppsala (SLU), University of Helsinki (UoH), National Crops Resources Research Institute (NaCRRI), Ethiopian Institute of Agricultural Research (EIAR), Jomo Kenyatta University of

Agriculture and Technology (JKUAT). The project implementation will also involve private organizations: Uganda National Seed Potato Producers Association (UNSPPA, Uganda), Kisima Farm (Kenya), Red Barna (Ethiopia), URUGAGA IMBARAGA (Rwanda), and Genetic Technologies International Ltd (GTIL - Tanzania).

7. Project Goal and Purpose

The goal of this project is to contribute to food and nutrition security, and income generation. This goal will be achieved through evaluation and deployment of varieties of cassava, potato and sweetpotato that are adapted to climate change in diverse agro-ecologies, and developing and institutionalising efficient seed multiplication and delivery system in Eastern Africa.

8. Objectives

The specific objectives of the project are:

1. To screen appropriate cassava, potato and sweetpotato varieties for adaptation to diverse agro-ecologies and disease pressure,
2. To develop protocols and guidelines for high throughput production of quality planting materials,
3. To design and test potential models for quality seed multiplication, delivery and initiate their institutionalization, and
4. To promote proven technologies and practices for enhanced semi-intensive and commercial production of cassava, potato and sweetpotato in relevant agro-ecologies of Eastern Africa.

9. Outputs

By the end of this project we expect to have outputs that will contribute to improved productivity of the three target crops under the different climatic condition in Eastern Africa. The specific expected outputs arising from each of the main objectives are outline below.

- 1.1 At least 3 varieties each of cassava, potato and sweetpotato adapted to drought and heat stress identified.
- 1.2 Knowledge on the effect of temperature on the biology of viral vectors generated, and effect of temperature and humidity on CBSD and SPVD development generated
- 1.3 Prevalence of A1 and A2 strains *P. infestans* mapped for better management of potato blight

- 2.1 At least 2 technicians per country trained on micro-propagation techniques
- 2.2 At least 20 extension personnel and 100 farmers trained and practicing rapid multiplication
- 2.3 A minimum of 5 primary, 20 secondary and 100 tertiary multiplication and distribution centres in member countries established and functioning
- 2.4 At least one low-cost tissue culture system for farm level production of quality planting materials developed and tested
- 2.5 Guidelines on agronomic practices for screenhouse/nursery handling and managing tissue culture plantlets develop
- 2.6 At least one private sector trained in aeroponics technology and one low cost facility established
- 2.7 A report on the socio-economic viability of the tissue culture derived seed systems for sweetpotato and cassava

- 3.1 An inventory of existing models for seed multiplication and delivery compiled
- 3.2 At least two design options for seed multiplication and delivery selected for further testing
- 3.3 A cost effective seed delivery model in a public-private partnerships identified
- 3.4 At least 3 policy briefs on certification, branding and regulation for seed delivery produced and shared with appropriate policy making organs.

- 4.1 At least 4 IPM packages for potato moth, potato blight, sweetpotato weevil, and SPVD validated and promoted
- 4.3 At least 1000 farmers exposed to improved technologies on cassava, potato or sweetpotato.
- 4.4 At least one cost effective and efficient distribution system for high quality seed developed
- 4.5 Effective mechanisms of engaging with different stakeholder segment groups developed.

4.6 At least one promotional workshop and conference on popularizing improved technologies and practices conducted.
4.7 At least five papers in refereed journals published, and over 1,000 copies of subject specific brochures, guidelines, and leaflets produced

10. Outcomes

The primary outcome will be increased production of cassava, potato and sweetpotato resulting from promotion of climate resilient varieties supported by respective efficient seed systems. The secondary outcomes would include increased public-private investment partnerships in the three commodity sub-sectors, and appropriate policy frameworks for seed systems of vegetatively propagated crops. Objective specific outcomes are indicated in section 20 (Log frame).

11. Methodology and description of project activities

1) To screen appropriate cassava, potato and sweetpotato varieties for adaptation to diverse agro-ecologies and disease pressure

Climate change poses a major threat to crop production and food security. Notably, drought, heat, floods and changes in disease and pest epidemics greatly impact on sustained food production. Fortunately, well-adapted cultivars coupled with poor crop management practices could serve as mitigation measures for climate change. The plasticity of cassava, potato and sweepotato to environmental stresses, and high yield potential make them the best crops for food and nutrition security in the face of changing climatic conditions. Designing appropriate mitigation measures requires understanding of the behaviour of major pathogens and insect pests affecting these crops in the changing climatic patterns. Therefore, under this objective we propose to undertake the activities below.

1.1 Farmer participatory screening cassava, potato and sweetpotato clones for adaptation to diverse agro-ecologies.

Crop varieties are variously adapted to drought and heat stress environments. Selection of varieties of cassava, potato and sweetpotato suited for various agroecologies are yet to be achieved in the region. Accessions of the three crops will be collected from different geographical growing regions and evaluated under different heat and drought conditions in replicated trials. Data on number of plants wilting, drying and tuber yield will be collected and subjected to statistical analysis to determine elite lines for subsequent adaptation and promotion. For potato, a total of 18 clones from two potato clone sets B3C1 and B3C2 that have been under evaluation for yield and response to pests and diseases in the region will be evaluated both on-station and on-farm in warmer (<1400 masl), transition (1400-<1800 masl) and cooler areas (>1800 masl) for response to heat and associated pests and diseases. Generation 1 (G1) minitubers of each clone will be accessed from CIP Nairobi, bulked for one season and the resultant G2 used for the trials. Six trails sets will be established in each of the above defined agro-ecological zone, in Uganda, Rwanda, Kenya and Ethiopia. The experiment will be repeated for at least three seasons for conclusive results. In addition, 60 potato clones will be accessed from CIP and screened under drought chamber conditions before downstream evaluation. Similar approach will be followed with representative clones of cassava and sweetpotato. A total of 100 clones each for cassava and sweetpotato will be evaluated.

Selected clones will be evaluated on-farm (Farmer participatory performance evaluation) using an existing guide for Participatory Variety Selection (PSV) i.e., jointly evaluation by both farmers and scientists for two seasons. Three agro ecological areas sharply varying climatically (temperature, rainfall and humidity) will be selected in each country for hosting the on-farm trials. In each agro-ecology, at least 30 promising clones will be evaluated in six sites. Specifically, the clones will be evaluated for their desirable agronomic (plant health, plant type, yield potential) and root quality (cyanogens, taste, mealyness, texture and aroma) traits. The data will be subjected to multivariate analysis.

1.2. Study the biology of the sweet potato virus disease (SPVD) and cassava brown streak virus disease vectors (aphids and whitefly species) under different temperature regimes

There are increasing reports on upsurge of diseases and pest outbreaks in traditionally disease/pest free zones. The new epidemics could be associated with changes in climate. There is, therefore need to understand the role of temperature and humidity on the biology of the causative agents. Life cycles, oviposition, vector ability, and other carefully selected variables of aphids and whitefly species *Bemisia tabaci* under different temperatures (20, 25, 30, 35, 40 45^{0}C) will be monitored in cages containing sweet potato and cassava in separate growth chambers and SPVD and CBSV infection and severity recorded over a period of 3 months. To study the effect of temperature on the development of SPVD and CBSD, a collection of varieties of sweetpotato and cassava will be exposed to different temperature at 20, 25, 30, 35, 40, 45^{0}C and disease expression monitored based on visual virus symptoms. Disease development will be related to virus accumulation in vivo determined using polymerase chain reaction to establish the viral load. Trials on transmission efficiency at different temperatures will be undertaken by exposing the whitefly species to infected plant materials and exposing them to clean planting materials at 20, 25, 30, 35 and 40^{0}C for periods ranging from 10, 15, 30, 60 minutes and 4 and 8 hours.

1.3 Prevalence of A1 and A2 strains P. infestans mapped for better management of potato blight
Potato Late blight, caused by *Phytophora. infestan*s, is an important disease causing between 10-100% yield loss. The severity of the disease is dependant on the strain and mating type of the pathogen. In East Africa only mating type A1 has been confirmed present. However, there is a threat that mating type A2 reported in Egypt, Morocco and South Africa may be present in East Africa. If so, the presence of two mating types allows sexual recombination which will lead to more aggressive and virulent strains that may build up resistance against chemical pesticides. Under this activity we shall collect one hundred leaf samples from different agro-ecological zones in Ethiopia, Kenya, Rwanda and Uganda. *P. infestans* will be isolated from the leaf samples and cultured on V8 juice medium in Petri-dishes. All *P. infestans* isolates from each country will be sent to UoH (Finland) laboratory for characterization. Reference *P. infestans* A1 mating type will be acquired for mating type characterization. Pathotype for each isolate will be determined using potato differential cultivars. Genotypic characterization will be done using molecular tools. All isolates will be conserved in test tubes at 4°C. To track changes in *P. infestans* population in the region, *P. infestans* isolation and characterization will be done once a year for three years.

Objective 2: To develop protocols and guidelines for high throughput production of quality planting materials
Production of tropical roots and tubers is usually hampered by the lack of disease free and quality planting material. This is caused by the fact that these crops are normally propagated asexually, which favours the accumulation of pests and pathogens, reducing yield and quality, as well as a reduction in the crop's genetic diversity. Currently, the seed system of cassava and sweetpotato is largely informal and characterized by free exchange of small quantities of cassava stakes and sweetpotato vines among local communities with few and/or non-existent commercial seed producers. This seed system has major limitations. Firstly, because it is characterized by no certification and/or indexing system, it exacerbates complex diseases like cassava brown streak disease (CBSD) and sweetpotato virus disease (SPVD) for cassava and sweetpotato, respectively from generation to generation and making their control very difficult. In fact it is the lack of a functional certification system that has accelerated the rapid spread of CBSD in the region. Secondly, the inherently low cassava and sweetpotato multiplication rates become visibly amplified with this scheme as it involves a few individuals growing cassava and sweetpotato for both food and seed purposes. Consequently, use of clean seed technologies can help to unlock the yield potential of these two crops. A number of procedures have been developed and described for the production of clean plantlets for vegetatively propagated crops. Meristem culture technique is well established and widely used for production of virus-free plants (Zhang *et al*., 2009).

In-vitro micropropagation of clonally propagated crops offers promise for rapid quality seed multiplication for sustained optimal agricultural productivity. The technique allows production of healthy plantlets even when climatic conditions are not favourable and/or when foundation seed is limited. There is fragmented information on the critical components of cassava, potato and sweetpotato seed systems. For example, a number of procedures have been developed and described for the production of clean plantlets for vegetatively propagated crops. Meristem culture technique is well established and widely used for production of virus-free plants (Gao *et al*., 2000; Zhang *et al*., 2009). Recently, cryotherapy of shoot tips has been found as an alternative method for efficient elimination of plant viruses (Wang *et al*., 2009; Wang and Valkonen, 2009). In our previous BIOEARN Cassava/Sweetpotato we optimized protocols for rapid multiplication of clean planting materials for sweet potato and cassava, and established molecular diagnostic tools for ensuring delivery of virus free planting materials. However, what has not been undertaken is integrating these components into an operational seed distribution system. In this activity we propose to develop guidelines and protocols supported by appropriate agronomic packages and policies for a sustainable cassava, potato and sweetpotato seed systems. The system we are proposing will involve private sector including NGOs and SMEs.

2.1 Developing low-cost tissue culture protocols for farm level production of quality planting materials

Tissue culture (TC) offers great opportunities for enhancing cassava and sweetpotato productivity because of its robustness in availing clean planting material. Due to increasing threats (from biotic stresses at farm-level) and opportunities for commercialisation, there is a need to establish low-cost TC facilities in the cassava and sweetpotato growing regions. Hence, we intend to establish and pilot low-cost TC facilities in the project countries. This activity has four components i) modifying/adapting laboratory basic TC requirements (conditioned space, growth room, culture media, tools and equipment and specialist workers) to suit local conditions, but ensuring that product quality is maintained as successfully experienced in Latin America. This activity will involve identifying interested entrepreneurs and customizing the TC technology for SMEs, ii) training of farmer groups and agricultural officers on tissue culture concepts. The training sessions will address: a) the role of tissue culture in agriculture, b) identification of local and or cheaply available materials and chemicals that can be used to establish a community TC facility, and c) participatory implementation of the TC facility; iii) participatory comparative analysis of TC cassava plantlets produced by farmers and from formal laboratories respectively, and iv) technical backstopping of the rural based TC facility by the NARS laboratories and partners in Sweden (SLU) and Finland (UoH) in terms of indexing capacity for endemic diseases.

2.2 Assess agronomic practices for screenhouse/nursery handling and managing tissue culture plantlets, and develop guidelines for optimum production of quality planting material

For optimum harnessing of the tissue culture in production of quality planting materials, there is need to develop agronomic packages for screenhouse/nursery handling of the plantlets. This will involve consideration for hardening and weaning of cassava and sweetpotato plantlets. This is the most delicate step constraining mass propagation of clean cassava and sweetpotato, because of the high mortality of the plantlets that is registered during this stage of transfer to soil. The extent of survival during acclimatization will be maximized to allow for high throughput system. Beyond weaning, procedures for delivery of hardened small micropropagated plants to nurseries and their establishment requirements will be examined. This will include developing low cost alternative substitutes, developing field level diagnostic tools and devising environment friendly and suitable packaging materials.

2.3 Adapt the aeroponics technology for pre-basic potato seed production with private sector

CIP has developed and successfully tested a "3G" seed strategy (funded by USAID) that enables very rapid multiplication of pre-basic seeds using the aeroponics technology, which reduces the number field generations from 6 to only 2. This reduces the cost of production, the impact of serious soil-borne disease constraints such as bacterial wilt as well as enabling a fast release and mass bulking of new varieties through that approach. Aeroponic units have been introduced at research level in Ethiopia, Kenya, Rwanda and Uganda at the respective NARS. Preliminary results are promising and there is need to promote the technology to involve the private sector. In Kenya, aeroponic units have been introduced to 3 private companies and they are operating successfully. Under this activity, we therefore propose to pilot the technology in Ethiopia, Rwanda and Uganda through result demonstration with adopting the technology.

2.4 To determine and demonstrate the socio-economic viability of the tissue culture derived seed systems for sweetpotato and cassava.

The profitability of tissue culture-derived seed systems will be achieved by obtaining cost schedules under four different treatments: altitude, season, scale of operation and gender. Similar data will be collected from farm-saved seed utilisation as a check. Input costs that vary across different treatments and those that cut across treatments will be obtained together with yield and price data both at farm gate and at the market. Partial budget analyses will be run along both the sweetpotato and cassava value chains. In addition, the study will establish labour productivity in tissue-culture seed systems and compare profitability across the systems and examine the efficiency of factors used in production of seed cassava and seed potato. This study will produce decision support tools (DST) for use in promoting the products.

3) To design and test potential models for quality seed multiplication, delivery and initiate their institutionalization

Accessibility to improved cassava, potato and sweetpotato planting material still remains a problem in most African countries. In Kenya, for example, only 7% of the smallholder farmers had access to improved crops such as sweetpotatoes in 2001 (Roy-Macauley, 2002). This is mainly attributed to the absence of an effective distribution system of improved crops, technical expertise, and funding (Roy-Macauley, 2002). Lack of well organized seed distribution system for vegetatively propagated crops in East Africa has contributed, partly, to the slow rate of dissemination of new improved varieties. New varieties are traditionally disseminated through farmer to farmer variety exchange and limited sale of cuttings in market at the onset of rains. Besides the slow rate of dissemination of new varieties, lack of well organized seed distribution systems also results in spread and intensification of viral diseases in vegetatively propagated plants.

3.1. Design models for seed multiplication and delivery systems

This objective aims at integrating key components of the seed system including appropriate agronomic practices into an efficient seed system for cassava, potato and sweetpotato. To achieve this goal, an inventory of existing models for seed multiplication and delivery of clonally propagated crops in the sub-region and beyond will be compiled and reviewed through a commissioned consultancy. Various supported initiatives including but not limited to SASHA, BMGF, BIOEARN, GLCI, US-3G will be evaluated. The system's strengths and weaknesses, coverage and stakeholders involved will be captured amongst other aspects. The lessons gained will be used to design five working models which will be presented to a multidisciplinary team including extension workers, researchers, policy makers, private sector for feasibility analysis. For each module, the required funds and financing mechanism well be analysed, key plays identified, and its capacity to produce quality seed analysed. Risks associated with each model will be analysed in a stakeholder's consultative meeting. The best three models will be selected piloted and tested for seed delivery, efficiency and effectiveness in a PPP mode. Although there have been attempts to multiply and distribute improved and pathogen free cassava and sweetpotato under the USAID supported project (Grant No. 690-G 9800234), the approach have not been sustained perhaps because of low involvement of the Private Sector. In this proposal, GTZ-PSDA, GTIL, IMBARAGA, UNSPPA, GTZ-ETH and SOLARGROW will be among the private sector groups to be considered. During the development process, the PPP mode will be blended with the product chain specialization approach to increase on the efficiency of the system. Altogether, the technical performance of the model will be tested and the key players will be trained variously. This activity will be backstopped by UoH (Prof Jari Valkonen), SLU (Dr Anders Kvarnheden) and CIP (Dr Elmar S).

3.2. Initiate institutionalization of promising seed delivery model(s)

Proven seed delivery models will be institutionalized to revolutionize the production of three commodities through improved seed systems. The critical steps in the process will involve;

- Soliciting for supportive policy framework and a strategy for its implementation
- Identifying and gazeting production centers and distribution agents
- Lobbying for appropriate financing mechanisms
- Developing effective regulatory and seed certification systems
- Devising mechanisms for seed quality control including standards.
- Pursuing appropriate branding and advising on acquisition process towards attaining tools of power/operation – Binding constitution, registration, etc

4) To promote proven technologies and practices in the relevant agro-ecologies

4.1. Validating and promoting IPM packages for sweetpotato weevil and SPVD

Sweetpotato weevil and sweetpotato virus disease (SPVD) are the major production constraints of the crop in the region. To off set the constraints a number of technologies and practices ranging from resistant varieties to cultural practices have been developed. Moreover, farmers have their own traditional knowledge of minimizing the effect of these biotic stresses. However, the efforts did not improve the production and productivity of sweetpotato to the level of enhancing food security at the household level. Regardless of the on-going efforts in the region by National Research Programs, Universities and NGOs for the management of the above mentioned constraints which are likely to aggravated by climate change, the productivity of sweetpotato is far below its potential. The available technologies and traditional knowledge are not packaged and validated in the form of integrated crop management at a wider scale in the region to boost sweetpotato production to. These challenges will be addressed through a) validating and promoting management practices for sweetpotato weevil in different agro-ecologies which include resistant variety, cultural practices (planting time, planting density, earthing up, and use of botanicals, Bt, Beauveria, and Neem), and use of predators and parasitoids, b) validating and promoting management practices of SPVD in major sweetpotato growing areas which include use of rouging, use of clean planting material versus infected planting material, vector management (bio-control agents - parasitoids, botanicals), c) evaluating and promoting sweetpotato varieties resistant to SPVD across agro-ecological zones; in Ethiopia, Kenya and Uganda.

Four highly resistant sweet potato varieties will be planted at four locations on station each in Ethiopia, Uganda and Kenya in a randomized complete block design in four replications. Cultural practices such as earthing up, crop rotation and timely harvesting will be tested against sweet potato weevil in replicated experiment in factorial arrangement in four locations each in Ethiopia, and Kenya. Data on weevil infestation and weevil density will be taken at vegetative, maturity and harvesting. Integrated pest management packages such as neem, Bt, Beauveria, predators and parasitoids will also be tested in Ethiopia, Uganda and Kenya against sweet potato weevil. The experiment will be laid in complete block design with four replications. The treatments will be neem, Bt, Beauveria and the untreated check; while, the predators and parasitoids will be superimposed. This experiment will be done in four locations in each country. Cultural practices (rouging), clean planting materials, vector management and resistant varieties will be tested in Ethiopia, Uganda and Kenya for the management of SPVD. In all cases, data will be subjected to statistical analysis to select the best variety and recommend for the region.

4.2. Farmers and private companies exposed to improved technologies on cassava, potato or sweetpotato.
Once the technologies have been validated in activities 1-4, they will be promoted through demonstrations and field days. At least 1000 farmers per country will be exposed to these technologies. In case of new varieties and cleaned planting materials, they will be packaged and distributed through result demonstrations. Furthermore, the most cost effective and efficient seed multiplication and delivery system will be promoted to private-public partnerships. The cassava seed delivery system will be promoted in Kenya, Tanzania and Uganda, while that of sweetpotao will be promoted in Ethiopia, Kenya, Rwanda and Uganda. The potato aeroponics technology and seed potato delivery system will be promoted in Ethiopia, Rwanda, Tanzania and Uganda.

4.3 Effective mechanisms of engaging with different stakeholder segment groups for dissemination of proven technologies.
One of the challenges of promoting technologies is the lack of efficient systems of engaging mass media and policy makers. We propose a communication strategy that puts into focus the stakeholders in cassava, potato and sweetpotato production, utilization and seed delivery, and continuously evaluates the information needs of the stakeholders. Under this activity we shall establish a platform for dialogue with mass media, parliament select committees and donors to advocate for the uptake of new technologies and institutionalization of the promising seed delivery models. Through this activity policy briefs will be produced and circulated. Project outputs shall also be disseminated through stakeholder training (farmers, potential private investors), promotion materials including brochures guidelines and leaflets. We shall also carry out promotional workshops and one conference to disseminate the outputs of this project.

12. **Pathway to impact, applicability of the results in practice, potential impact and dissemination**
We envisage our outputs to impact at four levels namely farmers, potential small business enterprises (SMEs), natural agricultural research systems and academia, and policy makers. The farmers will be the key beneficiaries of the project outputs. In order to ensure that our key target group receive the outputs, participatory approaches will be used in development and evaluation of the technologies. In addition farmers will directly benefit from using improved varieties and clean planting material. Through efficient seed delivery systems, farmers will be able to access quality planting material at affordable price, and enhance improving productivity and hence ensuring food security and better livelihood. This will directly address **MDG number 1**. The seed systems that will be developed will provide opportunities for SMEs to invest in this area that is

virgin in the region. This project will deliberately engage potential SMEs in its implementation. This would lead into a more sustainable seed delivery system for vegetatively propagated crops. The project is likely to generate new knowledge on the physiology of drought and heat stress and genes involved. This information will be important for plant breeding programmes in the region; and the information will be disseminated through peer reviewed publications and scientific conferences. Adoption of the seed systems that will be developed under this project will depend on appropriate institutional policy frameworks. Therefore, information from this project will guide policy formulation. Consequently, policy makers will be informed through policy briefs and promotional workshops.

13. **Quality and organization of the consortium**

The consortium consists of scientists from different disciplines including agronomy, entomology, pathology, biotechnology, virology and social scientists, who have proven experience in research and project implementation in the region. Details of the PI and Co-PIs are indicated in the attached brief CVs (see **Annex 2**). The roles and responsibility of key scientists and partners are indicated in **Table 1**. This consortium also brings on board reputable institution in the region and outside the region. Makerere University as a lead institution on this project has excellent capacity to undertake both basic and applied research. Similarly, the partner institutions have good capacity to undertake both analytical and adaptive research. Makerere University Faculty of Agriculture has previously supported and hosted regional/research initiatives. NaCRRI has a national mandate to conduct research on major crop commodities including cassava and sweetpotato in Uganda. On the research agenda for NaCRRI, climate change ranks high. KARI and MARI have similar mandates as NaCRRI for Kenya and Tanzania, respectively. AAU is the premier institute of higher learning and research in Ethiopia. It will play key role in leading activities in Ethiopia. ISAR is the apex body for coordinating all agricultural research in Rwanda. The mandate of CIP is to reduce poverty and achieve food security on a sustained basis in developing countries through scientific research and related activities on potato and sweetpotato. The UoH Department of Agriculture conducts research on plant production and technologies pertaining to plant production. UoH has great expertise that will be exploited in backstopping molecular diagnostic activities on this project. The new SLU BioCenter at the Ultuna campus is equipped with a new phytotron facilitating plant experiments under controlled conditions. The phytotron facilities will provide the opportunity to analyse varieties of cassava and sweetpotato for reactions to abiotic stress, including heat stress, and to eliminate virus infections in plant material by heat treatment of in vitro-cultures.

14. **Competence and skill track record of principal Investigator**

The PI, Prof Samuel Kyamanywa, has a long truck record of lead and implementing several research projects in the region. He has been PI for over 11 research projects valued between 50,000 and 1,200,000 USD. Recently, he successfully led the BIOEARN Cassava-Sweetpotato project 02 and currently he is coordinating two regional research programs; i) The East Africa Regional Integrated Pest Management Project under the Integrated Pest management Collaborative Research Support Programme (IPM CRSP), ii) Seed Health Improvement Programme under DANIDA. All these projects involved consortia scientists and institution from the East African countries. He is therefore versed with the institutional arrangements and their operation in the region, a key facet in leading the proposed project. The leadership skills and experiences of the Co-PI are indicated in their respective brief CVs (see **Annex 2A-F**).

15. Proposed consortium project management

The project team will be led by a Principal Investigator (PI) in collaboration with the Co-PIs and activity leaders in the applying institutions, who will undertake specific project activities based on comparative competence. Other regional and international institutes will be consulted on some activities. Every year there will be a planning meeting for all the partners to review progress and budgets. Funds will be distributed according to activities based on agreed upon work plans. To ensure that the project is implemented properly a logframe will be used as the key monitoring tool.

Two approaches will be used for monitoring and evaluation (M&E). The first one will be participatory in which progress and implementation of the activities will be evaluated through regional meetings; one meeting at the beginning of the year to plan for activities and set mile stones for the year, and also evaluate progress. The second M&E approach will involve visits The PI and one Co-PI will make at least one each year to all the participating institutions to monitor progress being made by member countries. Consultancies and backstop visits from backstopping institutions in program formulation, implementation and monitoring will be actively solicited to build NARS institutional capacities. These will be mechanisms for corrective actions and adaptation to new implementation challenges. Annual reports will be developed, discussed at project review meetings with stakeholders, revised and adopted before submission using the standard BioInnovate reporting formats. The Co-PIs will provide audited annual financial statements of income and expenditures related to the grant through their respective institutional Accounting systems.

During the implementation of the project, we propose to explore the opportunities of leveraging funds and taking advantage of on-going research programme through cost sharing and other synergies on project activities particularly on students and research equipments. In addition we shall explore ways of collaborating with exiting programmes to broaden areas of operation and impact. Examples of such programs e.g. the Rockefeller funded project on “Strengthening East African Resilience and climate change adaptation capacity through training research and policy intervention”, and cassava community breeders of practices. Through this approach we anticipate to raise 10% of the budget as matching funds.

The partner institutions on this project shall conduct and manage the project, and project technologies and information, in a manners that enables a) the knowledge gained to be promptly and broadly shared and disseminated, and b) the intended product or products to be made available at reasonable cost to end user (Global access). Materials intended for research shall be exchanged following Material transfer agreements (MTA) signed by all parties as appropriate. Finally, an inventory of background and foreground IP associated with project objectives will be identified and the project will only utilize technologies and research with clear background access with no conditions for foreground utilization to ensure public availability. Foreground IP will be joint ownership of developer(s), this project.

18. Project Activity Plans

Table 1. Project activity plans corresponding to the involved scientists/collaborating partners and timelines of the activities for three year.

Activity	**Year 1**		**Year 2**		**Year 3**		**Partner Scientist and Institution.**
	H1	**H2**	**H1**	**H2**	**H1**	**H2**	
1.1.1 Farmer participatory evaluation - Cassava							Dr Kullaya (MARI) Dr Baguma (NaCRRI + BecA)
1.1.2 Farmer participatory evaluation - Potato							AAU, KARI, ISAR, KaZARDI, CIP
1.1.3 Farmer participatory evaluation - Sweetpotato							AAU, KARI, MAK, ISAR MARI,
1.2 Study the effect of temperature and humidity on vectors and disease development							Prof Kyamanywa/Dr Mukasa (MAK), Dr Ateka (JKUAT c/o KARI), Dr Anders Kvarnheden (SLU)
1.3 Mapping the prevalence of A1 and A2 strains *P. infestans* for better management of potato blight							Dr Kashaija (KaZARDI), Dr Elmar (CIP), Mr Ntozi (ISAR) Prof Jari Valkonen
2.1 Developing low-cost tissue culture protocols for farm level production of quality planting materials							Dr Mukasa (MAK)
2.2 Assess agronomic practices for nursery handling/mgt of TC plantlets, and develop guidelines for optimum production							Dr Mukasa (MAK) Dr Baguma (NaCRRI) Dr Mneney (MARI), Dr Tileye (AAU)
2.3 Adapt the aeroponics technology for pre-basic potato seed production with private sector							Dr Kashaija (KaZARDI), Dr Elmar (CIP), Dr Gebremedhin (EAIR/AAU), Mr. Ntizo (ISAR)
2.4 Determine and demonstrate the socio-economic viability of the tissue culture derived seed systems for sweetpotato and cassava							MAK (Dr. J. Bonabana-Wabbi)) CIP (To find consultant)
3.1 Design and test models for seed multiplication and delivery							Country cluster groups lead by: Dr Kashaija (UG), Dr Kullaya (TZ), Dr Getu (ET), Mr Ntizo (RW).
3.2 Initiate the institutionalization of promising seed delivery model(s)							Country cluster groups lead by: Dr Baguma (UG), Dr Mneney (TZ), Dr Getu (ET), Mr Ntizo (RW)
4.1 Validating and promoting IPM packages for sweetpotato weevil and SPVD in Eastern Africa							Dr. Getu (AAU) Dr Amata (KARI)
4.2 Farmers and private companies exposed to improved technologies on cassava, potato or sweetpotato using demonstrations and field days.							Private sector/country teams led by: Prof Kyamanywa (UG), Dr T. Alemu (ET), Dr Amata (KE), Mr Ndirigue (RW), Dr Mneney (TZ)
4.3 Develop mechanisms for public engagement (i.e. mass media, parliamentary committee, donors) in dissemination of technologies							country teams led by: Prof Kyamanywa (UG), Dr Tesfaye Alemu (ET), Dr Amata (KE), Mr Ndirigue (RW), Dr Mneney (TZ)

N.B. Time frame for achieving milestones, by six monthly periods are indicated in the project activity plan. The Indicators of progress towards project results are indicated in project activity plan and in the logframe below.

19. Detailed and summary project budget (USD)

N.B.

i) The amounts are in thousand ('000) of USD

ii) The applying institutions are:
AAU = Addis Ababa University Department of Biology,
KARI = Kenya Agricultural Research Institute
ISAR = Institut des Sciences Agronomiques du Rwanda
MARI = Mikocheni Agricultural Research Institute
KaZARDI = Kachwekano Zonal Agricultural Research and Development Institute
MAK = Makerere University Faculty of Agriculture

iii) The cooperating institutions are:
NaCRRI = National Crops Resources Research Institute
CIP = International Potato Centre
SLU = Swedish University of Agricultural Sciences
UoH = University of Helsinki

iv) Indirect costs = administrative costs where the different institutions will charge between 5 and 10% of the institutional total budget.

Table 2. INSTITUTIONAL BUDGET TOTALS (YEAR 1-3): Cassava, Potato and Sweetpotato Innovation Consortium Budget Years in USD

YEAR 2011

Activity		**AAU**	**CIP**	**ISAR**	**KARI**	**KAZARDI**	**MARI**	**SLU**	**UoH**	**NaCRRI**	**MAK**	**Total**
A	Equipment	10,000	-	10,000	10,000	10,000	10,000	-	-	-	15,000	65,000
B	Consumables	15,000	-	8,000	12,000	11,000	10,000	3,000	3,000	10,000	15,000	87,000
C	Travel	6,300	2,100	6,300	2,100	6,300	2,100	3,300	3,300	4,200	6,300	42,300
D	Field Costs	40,950	9,950	18,150	30,800	39,150	20,700	2,400	2,400	31,100	46,200	241,800
E	Subsistence EA/outside EA	4,500	3,000	3,000	9,000	6,000	4,000	3,000	3,000	1,500	6,000	43,000
F	Management/coordination Costs	200	250	200	200	200	200	-	-	200	25,000	26,450
G	Overheads	3,848	1,530	2,283	3,205	3,633	2,350	1,170	1,170	2,350	5,675	27,213
	Total	**80,798**	**16,830**	**47,933**	**67,305**	**76,283**	**49,350**	**12,870**	**12,870**	**49,350**	**119,175**	**532,763**

YEAR 2012

Activity		AAU	CIP	ISAR	KARI	KAZARDI	MARI	SLU	UoH	NaCRRI	MAK	Total
A	Equipment	10,000	-	5,000	10,000	5,000	-	-	-	-	15,000	45,000
B	Consumables	13,000	1,500	9,000	10,000	9,000	7,000	3,000	3,000	10,000	9,000	74,500
C	Travel	6,300	2,100	6,300	2,100	6,300	2,100	3,300	3,300	4,200	6,300	42,300
D	Field Costs	33,900	8,550	18,100	30,500	39,600	27,500	2,400	2,400	25,900	38,200	227,050
E	Subsistence EA/outside EA	5,000	2,000	2,000	4,500	4,500	4,000	3,000	3,000	1,500	4,500	34,000
F	Management/coordination Costs	200	250	200	200	200	200	-	-	200	22,000	23,450
G	Overheads	3,420	1,440	2,030	2,865	3,230	2,040	1,170	1,170	2,090	4,750	24,205
	Total	**71,820**	**15,840**	**42,630**	**60,165**	**67,830**	**42,840**	**12,870**	**12,870**	**43,890**	**99,750**	**470,505**

YEAR 2013

Activity		AAU	CIP	ISAR	KARI	KAZARDI	MARI	SLU	UoH	NaCRRI	MAK	Total
A	Equipment	-	-	-	-	-	-	-	-	-	-	-
B	Consumables	5,600	1,500	2,000	3,000	4,000	2,000	-	-	3,000	6,000	27,100
C	Travel	2,500	1,050	3,550	1,050	3,550	1,050	2,100	2,100	1,050	3,550	21,550
D	Field Costs	15,350	2,500	8,000	14,050	13,500	11,400	1,500	1,500	10,450	22,450	100,700
E	Subsistence EA/outside EA	2,000	1,000	1,500	3,000	3,000	2,000	-	-	950	3,000	16,450
F	Management/coordination Costs	200	250	200	200	200	200	-	-	200	13,000	14,450
G	Overheads	1,283	630	763	1,065	1,213	833	360	360	783	2,400	9,688
	Total	**26,933**	**6,930**	**16,013**	**22,365**	**25,463**	**17,483**	**3,960**	**3,960**	**16,433**	**50,400**	**189,938**
	Total for year 1,2&3	**179,550**	**39,600**	**106,575**	**149,835**	**169,575**	**109,673**	**29,700**	**29,700**	**109,673**	**269,325**	**1,193,205**

Budget Notes:

Details of the budget for each institution for three years are shown in Annex 1.

Equipment: small but essential equipment required by the various institutions will be purchased. E.g. PCR machines, laminar flow hood, pH meter, aeroponics parts.

Consumable costs include: Laboratory consumables (i.e. Reagents/Chemicals, Laboratory Supplies), Field supplies (Fertilizers, Seeds, chemicals), Office supplies (e.g. Stationery, Catridges, Toner, File folders)

Fieldwork costs include: allowances/perdiems, fuel, vehicle maintenance, labour, field technician costs, research assistant costs, etc. Fieldwork: Extra labour will be required in cases of field work or activities requiring extra technical support in Eastern African Institutions.

Travel includes: regional and local travel and DSA as per the guidelines of host institution.

Basis for estimation of regional/local travel:
Day subsistence allowance (DSA): e.g. 50 US$ for local travel
Per diems (PDs) for project scientists for regional travel US$150
Fuel, vehicle maintenance (institutional vehicle), air-tickets of economy class.

Coordination costs include: office supplies, communication, research visits, workshops, research planning meetings, travel, salaries (staff time costs) for thematic leaders/Co-PIs at the host applying institutions.

Monitoring and evaluation activities will be supported through the coordination budget line item of the PI's institution (MAK).

Overhead costs: Administrative costs of 5 - 10% of the total activity budget at each applying and cooperating institution based on institutional rates.

20. Log frame for the Cassava, Potato and Sweetpotato Innovation Consortium Project

Goal of the Project: To contribute to food and nutrition security, and income generation through evaluation and deployment of varieties of cassava, potato and sweetpotato that are adapted to climate change in diverse agro-ecologies in Eastern Africa.

Outputs	Outcome	Performance Indicators	Data Source	Collection Method	Assumptions
Project Specific Objectives					
Objective #1. To screen appropriate cassava, potato and sweetpotato varieties for adaptation to diverse agro-ecologies and disease pressure					
1.1 At least 3 varieties each of cassava, potato and sweetpotato adapted to drought and heat stress identified. 1.2 Knowledge on the effect of temperature on the biology of viral vectors generated 1.3 Knowledge on the effect of temperature and humidity on CBSD and SPVD development generated 1.4 Prevalence of A1 and A2 strains P. infestans mapped for better management of potato blight	Increased production of cassava, potato and sweetpotato in EA Use of knowledge in breeding for drought and heat stress in EA	5-10% yield increase in cassava, potato and sweetpotato At least 3 improved varieties being grown by farmers	Project reports Publications	Library search Internet search	Timely availability of funds Social/political environment in EA remains conducive.
Objective #2. To develop protocols and guidelines for high throughput production of quality planting materials					
2.1 At least 2 technicians per country trained on micro-propagation techniques 2.2 At least 20 extension personnel and 100 farmers trained and practicing rapid multiplication 2.3 A minimum of 5 primary, 20 secondary and 100 tertiary multiplication and distribution centers in member countries established and functioning 2.4 At least one low-cost tissue culture system for farm level production of quality planting materials developed and tested 2.5 Guidelines on agronomic practices for screenhouse/nursery handling and managing tissue culture plantlets develop 2.6 At least one private sector trained in aeroponics technology and one low cost facility established	Increased knowledge and application of TC in generation of planting material for the three crops. Increased access to clean planting materials.	Number of people trained and using TC techniques.	Project reports Publications A report on the socio-economic viability of the tissue culture derived seed systems for sweetpotato and cassava	Surveys Internet search	Willing and committed people .
Objective #3. To design and test potential models for quality seed multiplication, delivery and initiate their institutionalization					
3.1 An inventory of existing models for seed multiplication and delivery compiled 3.2 At least two design options for seed multiplication and delivery selected for further testing 3.3 A cost effective seed delivery model in a public-private partnerships identified 3.4 At least 3 policy briefs on certification, branding and regulation for seed delivery produced and shared with appropriate policy making organs.	Institutionalised seed system. Increase private sector involvement in the seed system. Increase use of clean planting materials and other	At least 1 functional public-private partnership. At least five small and medium enterprises involved in seed distribution.	Memorandum of understanding. Project reports. Publications	Library search Internet search, Surveys	Private sector willing to commercial cassava, potato, and sweetpotato

	technologies.	Seed distribution policy in place.			
To promote proven technologies and practices for enhanced semi-intensive and commercial production of cassava, potato and sweetpotato in relevant agro-ecologies of Eastern Africa.					
4.1 At least 4 IPM packages for potato moth, potato blight, sweetpotato weevil, and SPVD validated and promoted 4.3 At least 600 farmers exposed to improved technologies on cassava, potato or sweetpotato. 4.4 At least one cost effective and efficient distribution system for high quality seed developed 4.5 Effective mechanisms of engaging with different stakeholder segment groups developed. 4.6 At least one promotional workshop and conference on popularizing improved technologies and practices conducted.	Reduced loses diseases and insect pests. Increased awareness and use of improved technologies	At least 5% increase in yield for each of cassava, potato and sweetpotato Proportion of farmers using IPM practices.	Project reports Publications		Demand for quality planting material maintained or raises. Other private companies are willing to uptake technologies.

Key References

Food and Agriculture Organisation. 2002. FAO production year book. Vol. 56. Food and Agricultural Organisation United Nations.

Fokar M., Nguyan T., Blum A. 1998. Heat tolerance in spring wheat II. Grain filling. Euphytica 104: 9-15.

Fugli, K.O., Zhang, L., Salazar, L. and Walker, T. 1999. Economic impact of virus-free sweet potato planting material in Shangdong province, China. Impact on a Changing World. CIP Program report 1997-1998. International Potato Center, Lima Peru. 249-254.

Gibson, R. W., Mwanga, R. O. M., Kasule, S., Mpembe, I., and Carey, E. E. 1997. Apparent absence of viruses in most symptomless field grown potato in Uganda. Annals of Applied Biology, **130**: 481-490.

Hillocks R.J and Jennings, D.L. 2003. Cassava brown streak disease: A review of the present knowledge and research needs. International Journal of Pest Management, 49: 225-234.

Mukasa S.B., Rubaihayo P.R., and Valkonen J.P.T. 2003a. Incidence of Viruses and Virus-Like Diseases of Sweetpotato in Uganda. Plant Disease, 87: 329-335.

Mukasa, S.B. 2004. Genetic variability and interactions of three sweetpotato infecting viruses. Ph.D Thesis, Swedish University of Agricultural Sciences, Uppsala. 496 pp.

Tairo, F., Mukasa, S.B., Jones, R.A.C., Kullaya, A., Rubaihayo, P.R. and Valkonen, J.P.T. 2005. Unravelling the genetic diversity of the three main viruses involved in Sweet Potato Virus Disease (SPVD), and its practical implications. Molecular Plant Pathology, 6: 199–211

Zhou, X., Liu, Y., Calvert, L., Munoz, C., Otim-Nape, G.W., Robinson, D.J. and Harrison, B.D. 1997. *Journal of General Virology* **78:** 2101-2111.

Wang, Q., Laamanen, J., Uosukainen M, Valkonen, J.P.T., 2005. Cryopreservation of in vitro-grown shoot tips of raspberry (Rubus idaeus L.) by encapsulation–vitrification and encapsulation–dehydration. Plant Cell Rep (2005) 24: 280–288

ANNEX 1: INSTITUTIONAL BUDGET BY YEAR: Cassava, Potato and Sweetpotato Innovation Consortium Budget Years in USD

1.1 BUDGET BREAKDOWN FOR ADDIS ABABA UNIVERSITY (AAU)

Budget Item		Year 1	Year 2	Year 3	TOTAL
A	Equipment	10,000	10,000	-	20,000
B	Consumables	15,000	13,000	5,600	33,600
C	Travel	6,300	6,300	2,500	15,100
D	Field Costs	40,950	33,900	15,350	90,200
E	Subsistence EA	4,500	5,000	2,000	11,500
F	Management/coordination Costs	200	200	200	600
G	Overheads (5%)	3,848	3,420	1,283	8,550
	Total	**80,798**	**71,820**	**26,933**	**179,550**

1.2 BUDGET BREAKDOWN FOR KENYA AGRIC RESEARCH INSITITUTE (KARI)

Budget Item		**Year 1**	**Year 2**	**Year 3**	**TOTAL**
A	Equipment	10,000	10,000	-	20,000
B	Consumables	12,000	10,000	3,000	25,000
C	Travel	2,100	2,100	1,050	5,250
D	Field Costs	30,800	30,500	14,050	75,350
E	Subsistence EA	9,000	4,500	3,000	16,500
F	Management/coordination Costs	200	200	200	600
G	Overheads-(5%)	3,205	2,865	1,065	7,135
	Total	**67,305**	**60,165**	**22,365**	**149,835**

1.3 BUDGET BREAKDOWN FOR INSTITUT DES SC. AGRON DU RWANDA (ISAR)

Budget Item		Year 1	Year 2	Year 3	TOTAL
A	Equipment	10,000	5,000	-	15,000
B	Consumables	8,000	9,000	2,000	19,000
C	Travel	6,300	6,300	3,550	16,150
D	Field Costs	18,150	18,100	8,000	44,250
E	Subsistence EA	3,000	2,000	1,500	6,500
F	Management/coordination Costs	200	200	200	600
G	Overheads-(5%)	2,283	2,030	763	5,075
	Total	**47,933**	**42,630**	**16,013**	**106,575**

1.4 BUDGET BREAKDOWN FOR MIKOCHENI AGRIC RES INSTITUTE (MARI)

Budget Item		Year 1	Year 2	Year 3	TOTAL
A	Equipment	10,000	-	-	10,000
B	Consumables	10,000	7,000	2,000	19,000
C	Travel	2,100	2,100	1,050	5,250
D	Field Costs	20,700	27,500	11,400	59,600
E	Subsistence EA	4,000	4,000	2,000	10,000
F	Management/coordination Costs	200	200	200	600
G	Overheads-(5%)	2,350	2,040	833	5,223
	Total	**49,350**	**42,840**	**17,483**	**109,673**

1.5 BUDGET BREAKDOWN FOR KaZARDI

Budget Item		Year 1	Year 2	Year 3	TOTAL
A	Equipment	10,000	5,000	-	15,000
B	Consumables	11,000	9,000	4,000	24,000
C	Travel	6,300	6,300	3,550	16,150
D	Field Costs	39,150	39,600	13,500	92,250
E	Subsistence EA	6,000	4,500	3,000	13,500
F	Management/coordination Costs	200	200	200	600
G	Overheads-(5%)	3,633	3,230	1,213	8,075
	Total	**76,283**	**67,830**	**25,463**	**169,575**

A1.6 BUDGET BREAKDOWN FOR MAKERERE UNIVERSITY (MAK)

Budget Item		Year 1	Year 2	Year 3	TOTAL
A	Equipment	15,000	15,000	-	30,000
B	Consumables	15,000	9,000	6,000	30,000
C	Travel	6,300	6,300	3,550	16,150
D	Field Costs	46,200	38,200	22,450	106,850
E	Subsistence EA	6,000	4,500	3,000	13,500
F	Management/coordination Costs	25,000	22,000	13,000	60,000
G	Overheads-(5%)	5,675	4,750	2,400	12,825
	Total	**119,175**	**99,750**	**50,400**	**269,325**

A1.7 BUDGET BREAKDOWN FOR NaCRRI

Budget Item		**Year 1**	**Year 2**	**Year 3**	**TOTAL**
A	Equipment	-	-	-	-
B	Consumables	10,000	10,000	3,000	23,000
C	Travel	4,200	4,200	1,050	9,450
D	Field Costs	31,100	25,900	10,450	67,450
E	Subsistence EA	1,500	1,500	950	3,950
F	Management/coordination Costs	200	200	200	600
G	Overheads-(5%)	2,350	2,090	783	5,223
	Total	**49,350**	**43,890**	**16,433**	**109,673**

A1.8 BUDGET BREAKDOWN FOR INTERNATIONAL POTATO CENTRE (CIP)

Budget Item		Year 1	Year 2	Year 3	TOTAL
A	Equipment	-	-	-	-
B	Consumables	-	1,500	1,500	3,000
C	Travel	2,100	2,100	1,050	5,250
D	Field Costs	9,950	8,550	2,500	21,000
E	Subsistence outside EA	3,000	2,000	1,000	6,000
F	Management/coordination Costs	250	250	250	750
G	Overheads-(10%)	1,530	1,440	630	3,600
	Total	**16,830**	**15,840**	**6,930**	**39,600**

A1.9 BUDGET BREAKDOWN FOR UNIVERSITY OF HELSINKI (UoH)

Budget Item		Year 1	Year 2	Year 3	TOTAL
A	Equipment	-	-	-	-
B	Consumables	3,000	3,000	-	6,000
C	Travel	3,300	3,300	2,100	8,700
D	Field Costs	2,400	2,400	1,500	6,300
E	Subsistence outside EA	3,000	3,000	-	6,000
F	Management/coordination Costs	-	-	-	-
G	Overheads-(10%)	1,170	1,170	360	2,700
	Total	**12,870**	**12,870**	**3,960**	**29,700**

A1.10 BUDGET BREAKDOWN FOR SWEDISH UNIV OF AGRIC SCIENCES (SLU)

Budget Item		Year 1	Year 2	Year 3	TOTAL
A	Equipment	-	-	-	-
B	Consumables	3,000	3,000	-	6,000
C	Travel	3,300	3,300	2,100	8,700
D	Field Costs	2,400	2,400	1,500	6,300
E	Subsistence outside EA	3,000	3,000	-	6,000
F	Management/coordination Costs	-	-	-	-
G	Overheads-(10%)	1,170	1,170	360	2,700
	Total	**12,870**	**12,870**	**3,960**	**29,700**

	YEAR 1	YEAR 2	YEAR 3	TOTAL
YEAR TOTALS	**532,672**	**470,505**	**189,938**	**1,193,205**

ANNEX 2A. Brief CV for Prof Samuel Kyamanywa (PI, MAK)

Name & Address: Samuel KYAMANYWA
Department of Crop Science, Faculty of Agriculture, Makerere University
P.O. Box 7062, Kampala UGANDA.
Tel (O): +256-414-533580; Tel (Mob): +256-772-220000
Email: skyamanywa@agric.mak.ac.ug

Academic qualifications and work profile:
Born 18th January 1958, Kyamanywa obtained a B. Sc. Agriculture (Honours: Second class Upper division) Makerere University in 1980, and Ph.D (Agricultural Entomology) degree of Makerere University in1987 under the African Regional Post graduate Programme in Insect Science (ARPPIS) at the International Centre of Insect Physiology and Ecology (ICIPE) – Nairobi Kenya. He was also a research scientist at ICIPE, Nairobi, Kenya. Currently a Professor of Pest Management and has 26 years expertise in Agricultural Entomology and Integrated Pest Management (IPM). He teaches Under- and Post-graduate courses including, Insect Ecology, Insect Taxonomy, Economic Entomology and Pest management. He has successfully supervised over 50 M.Sc. and 5 Ph.D students in the fields of IPM, Biological control, storage pest management and use of molecular techniques for managing pests of the above crops. He has been PI of 11 research projects. Currently, is a coordinator for three regional research programs; i) Towards Sustainable Cassava and Sweet potato Production in East Africa under the BIOEARN Programme, ii) The East Africa Regional Integrated Pest Management Project under the Integrated Pest management Collaborative Research Support Programme (IPM CRSP), iii) Seed Health Improvement Programme under DANIDA. These Programmes involve scientists from the three East African countries. He has published **50** papers in international refereed journals, and 69 conference proceedings. Contributed a chapter in a book entitled "Globalizing Integrated Pest Management" by Blackwell. He has travelled widely and has tremendous experience in International Pest management issues.

Key Publications
Otim, M., J. Legg, **S. Kyamanywa,** A. Polaszek and D. Gerling (2005). Occurrence and activity of Bemisia tabaci parasitoids on cassava in different agro-ecologies in Uganda. *BioControl*. 50: 87- 95

Munyuli, M.B.T, G.C. Luther and **S. Kyamanywa** (2006). Predation effectiveness of Syrphids (Dipetra: Syrphidae) on Aphis craccivora Koch (Homoptera: Aphididae) in Eastern Africa. *Indus Journal of Biological Sciences*, 3(1): 596 – 603.

Asiimwe, P., Ecaat J. S., Otim M., Gerling D., **Kyamanywa S**. and Legg J.P. (2007) Life-table analysis of mortality factors affecting populations of *Bemisia tabaci* on cassava in Uganda. *Entomologia Experimentalis et Applicata* **122**, 37-44.

Munyuli, M.B.T., **S. Kyamanywa** and G.C. Luther (2008) Effects of groundnut genotypes, cropping systems and insecticide application on the abundance of native arthropod predators from Uganda and Democratic Republic of Congo. *Bulletin of Insectology* 61(1): 11 – 19

Egonyu JP, **Kyamanywa S** and Ssekabembe C.K, 2009. Natural enemies of sesame webworm and the effect of additive intercropping on its incidence in Uganda. *Journal of Applied Biosciences* 18:1019-1025

Mbanzibwa, D.R., Tian, Y.P., Tugume, A.K., Mukasa, S.B., Tairo, F., **Kyamanywa, S**., Kullaya, A. and Valkonen, J.P.T. 2009. Genetically distinct strains of Cassava brown streak virus in the Lake Victoria basin and the Indian Ocean coastal area of East Africa. *Archives of Virology*, 154:353–359.

Referees:
1) Dr Mark Erbaugh, Director of International Programmes in Agriculture, Ohio State University,
113 Agriculture Administration Building, 2120 Fyffe Road Columbus, Ohio 43210
Tel: +1614292725; Email: erbaugh.1@osu.edu
2) Prof. Elly Sabiiti, Department of Crop Science, Makerere University, P.O. Box 7062 Kampala Uganda.
Tel: +256 772438010; Email: ensabiiti@agric.mak.ac.ug

ANNEX 2B. Brief CV for Dr Alois KULLAYA (Co-PI, MARI)

Name & Address: **Alois KULLAYA**
Mikocheni Agricultural Research Institute, Eastern Zone,
P.O. Box 6226, Dar es Salaam.
Tel: 255-22-2700552; Mob: 255-744-372-846; Fax: 255-22-2775549/2116504;
akkullaya@yahoo.co.uk and akullaya@mari.or.tz.

Dr. Alois Kullaya is Principal Agricultural Research Officer based at Mikocheni Agricultural Research Institute (MARI), which is responsible for promoting coconut research and development (R&D) as well as agricultural biotechnology in the country. He holds a PhD in Plant Breeding, which he obtained in 1988 from the Technical University, Berlin, Germany. He is a married Tanzanian national born on 05.05 1952 in Moshi Tanzania.

University Education

- 1985 - 1988: PhD in Plant Breeding at the Institute for Tropical Agriculture of the Technical University, W. Berlin, Germany.
- 1980: One year post-graduate Training in Agricultural Rural Development at the Centre for Agricultural Development of the Technical University, West Berlin, Germany
- 1974 - 1979: BSc. and MSc Agriculture with bias in plant breeding at the Institute for Tropical Agriculture of the Karl Marx University

Research Functions

1981 – 2004:	Head of coconut breeding and National coordinator of coconut research activities under the National Coconut Development Programme (NCDP). This project commenced in 1979/80 and was successfully completed on 30th November 2004. The NCDP established a strong coconut R&D foundation and made significant contribution in promoting coconut research, development and utilization in the country.
1992 – 2004:	Collaborated in three EU-funded projects on the application of biotechnology to coconut improvement. Though these projects different coconut germplasm were characterized using molecular markers, and the first coconut linkage map was established.
03/1996 – 12/2008	Director of Mikocheni Agricultural Research Institute. The mandate of the Institute is to promote coconut R&D and agricultural biotechnology in the country
1999 t0 2006:	Local supervisor of students trained under the Eastern African Regional Programme and Research Network for Biotechnology, Biosafety and Biotechnology Policy Development (BIO-EARN) funded by Sida/SAREC
2003 to 2006:	Coordinator of a project on “Molecular Marker-Assisted and Farmer Participatory Improvement of Cassava Germplasm for Farmer/Market Preferred Traits in Tanzania” funded by Rockefeller Foundation.
06/2006 to 06/2010:	Co-Principal Investigator of a project titled “Towards Sustainable Cassava and Sweetpotato Production in Eastern Africa” under the BIOEARN programme funded by Sida/SAREC.
10/2006 to 09/2009	Coordinator of a project on “Cassava Transformation for the Longevity of Cassava Virus Resistance in Tanzania” funded by Rockefeller Foundation.
Since 2008:	Country Coordinator of Water Efficient Maize for Africa (WEMA) Project. This is a regional project being implemented in Kenya, Uganda, Tanzania, Mozambique and South Africa, and its aim is to develop, using conventional and molecular breeding as well as modern biotechnology tools, drought tolerant maize varieties and deploy these royalty free to farmers.

ANNEX 2C. Brief CV for Dr Ruth AMATA (Co-PI, KARI).

Name & Address: Ruth AMATA
National Agricultural Research Laboratories (NARL).
P.O. Box 14733 - 00800, Nairobi, Kenya.
Email: amata_ruth@yahoo.com

Personal details: Date of birth: 29th. August 1965. Married with 3 children.
Gender: Female

Current Position:

Senior Research Officer/Plant Pathologist, National Agricultural Research Laboratories (NARL)
Kenya Agricultural Research Institute (KARI)

Education and professional qualifications

2001-2006: PhD in Agriculture – University of Sydney, Australia.
1989-1992: BSc. In Horticulture – EgertonUniversity, Njoro, Kenya.

Recent Research undertakings

Project Coordination: I am currently the KARI Project Coordinator for 2 projects; **a).** Biosafetrain Project (Phase 2). Funded by Danish Development Authority (DANIDA), December 2007 to November 2010. The Project Title is Capacity building for biosafety and ecological impact assessment of transgenic plants in East Africa. **b).** I have been the KARI Coordinator of a regional Bioearn Project funded by the Swedish Development Authority (SIDA), 2006- June 2010. Project Title: Towards Sustainable Cassava and Sweet Potato Production in Eastern Africa. **c).** I am also an Assistant Project Coordinator in Kenya, for an Integrated Pest Management Collaborative Research Support Program (IPM CRSP), on horticultural produce in East Africa. Funded by USAID.

Student supervision:

Currently supervising 1 PhD and 3 Msc students enrolled at Nairobi University, Kenyattta University and Jomo Kenyatta University of Agriculture and Technology respectively, in the areas of biosafety and Crop Protection.

Resourcefulness in Regional and International training courses:

Served as a resource person in 4 regional training workshops (2007-2009).
Diagnostic services and management strategies of Plant disease problems to farmers, and other clients in Kenya.

Publications:

Journal papers and book chapters: Author for 2 papers in peer reviewed journals and a co-author in 6 peer reviewed journal papers within the period 2008-2010.

Fellowships awarded: 1. Australian Aid Scholarship. Duration: 2001 - 2004. **2.** African Women in Agricultural Research and development. Duration: June 2010 - June 2012.

Linkages with other institutions: Makerere University, University of Nairobi, Jomo Kenyatta University of Agriculture and Technology, Kenyatta University, Egerton University, University of Dar es Salaam Aarhus University, University of Copenhagen and The Ohio State University, USA. Kenya Plant Health Inspectorate Service (KEPHIS).

ANNEX 2D. Brief CV for Dr Emana Getu Degaga (Co-PI, AAU).

1. Personal Data

Full Name	**Emana Getu Degaga (PhD)**		
Date of Birth	**26 May 1962**	Place of Birth	**Wellega-Arjo, Ethiopia**
Gender	**Male**		
Nationality	**Ethiopian**	Marital Status	**Married**

Institution & Address Department of Biology, Addis Ababa University
P O. Box 1176, Addis Ababa, Ethiopia
Tel. 251-0911-019166(mobile); 251-0111-239471 (Office)
Email emanag@bio.aau.edu.et, egetudegaga@yahoo.com

2. Educational Qualification

BSc Department of Plant Sciences, College of Agriculture, Alemaya (AAU) July 1982
MSc School of Graduate Studies, Alemaya University (AU) June 1994
PhD ICIPE/Kenyatta University Feb.2002

3. Academic Position Associate Professor

4. Occupation Teaching, Research and Extension

5. Employer Department of Biology, Addis Ababa University, P. O. Box 1176 Addis Ababa, Ethiopia; period of Employment October 2005 -to the present
August 1982 to September 2005 Ethiopian Institute of Agricultural Research (EIAR)

6. Academic Profile

Senior Researcher (2002 on ward) by EIAR
Assistant Professor (October 2005 to May 2010) AAU
Associate Professor May 2010 to the present AAU

7. Academic Experience/teaching and advising

Under Graduate: General Entomology (Biol. 326, Biol 327, Biol. 443) Lecture and Lab.
Postgraduate Several Entomology courses
PhD & Msc. Research Thesis, PhD &MSc Thesis Advising (Over 50 students)
Also guest lecture at Haramaya, Jimma and Wellega Universities

8. Selected Scientific Publications (Out of over 60 publications)

I published over 50 scientific articles and below will be few lists (for more information please visit web site using goggle either by log in Emana or Getu or Degaga)

1) **Emana Getu, W.A. Overholt, and E. Kairu. 2004.** Comparative studies on influence of relative humidity and temperature on life table parameters of two populations of Cotesia flavipes (Hymenoptera: Braconidae). Biocontrol Science and Technology 14:595-605.
2) **Emana Getu, W.A. Overholt, and E. Kairu. 2003.** Evidence of establishment of *Cotesia flavipes* Camoron and its host range expansion in Ethiopia. Bulletin of entomological Research 93:125-129.
3) **Emana Getu, W.A. Overholt and E. Kairu. 2002.** Predicting the distribution of *C. partellus* (Swinhoe) and *Cotesia flavipes* Cameron in Ethiopia using Geographic Information System and Step-Wise Regression. Insect Science and Its Application 22:523-529.
4) **Emana Getu, W.A. Overholt. 2001.** Distribution and species composition of stem borers and their natural enemies in Ethiopia. Insect Science and its Application 21: 353-359.
5) Delenasaw Yewhalaw, **Emana Getu** and Emiru Seyoum. 2008. Evaluation on Potential of wild hosts as trap plants for managing gramineous stemborers in maize based agro-ecosystem. Journal of Economic Entomology 101(1) 50-55

9. Project management- PI for over six international and 30 local projects.

Referee: Dr. Emiru Seyoum (emiruseyoum@yahoo.com), Dr. Teshome Soromessa (soromessa@yahoo.com and Dr. Seyoum Letta (letaseyoum@yahoo.com).

ANNEX 2F. Brief CV for Dr Dr. Imelda N. Kashaija (Co-PI, Uganda).

PERSONAL INFORMATION

Name	:	IMELDA NIGHT KASHAIJA
Sex	:	Female
Date & place of birth	:	1st May, 1960, Mbarara.

Academic qualifications:

Degree	***Year***	***Institution***	***Subject***
PhD	1996	University of Reading	Agriculture – Plant Nematology
MSc	1990	University of Reading	Technology of Crop Protection
BSc (Hons)	1985	Makerere University, Kampala	Zoology & Botany

Relevant Professional Training

1. Planning, Monitoring, Evaluation & Impact Assessment of R&D Investments in Agriculture. Offered by IFPRI, two weeks in 2006.
2. The technology of seed potato production. Offered by WUR, two weeks in 2005
3. Interdisciplinary team working and agricultural research for development procedure for solving rural development problems. Offered by ICRA, six months in 2004.
4. Basic tissue culture techniques for micro propagation of plantlets, University of Reading, 1.5 months in 1991.

Recent employment and research expertise:

- October 2000 – to date: Leader of Kachwekano Zonal Agricultural Research and Development Institute (KAZARDI). In this capacity I plan, administer, manage, and co-ordinate all aspects of research on potato, temperate fruits, highland cereals and other highland-based cropping systems; as well as guiding dissemination of the institute-developed technologies to up-take in the Southwestern and other highland areas of Uganda. I also ensure timely allocation and disbursement of funds for planned activities.
- July 1996 – September 2000: Plant Nematologist – National Banana Research Program, NARO. Major responsibilities included (a) development of general methodologies for, and implementation of, diagnostic survey studies of banana production systems in Uganda and (b) conducting specific research on the population dynamics of plant parasitic nematodes associated with tropical highland crops.
- July 2004 – to date: Leading and/or participating in several activities that require application of or training in the Integrated Agricultural Research for Development (IAR4D) approach, in Uganda and other countries in Africa.

Recent Publications

Muzira R.N., Uzatunga I, and **Kashaija I.** 2005. Analysis of potato yield response to inorganic fertilizer and farmyard manure. In: Tenywa J.S., Adipala E., Nampala. P., Tusiiime G., Okori P. and Kyamuhangire W. (eds). Proceedings of the Crop Science Conference, Volume 7 Part 3, 2005

Kakuhenzire R., C. Musoke, **I.N., Kashaija,** and J. Smith. (2005). Validation, Adaptation and Importance of Small Seed Plot Technology for Production of Healthy Seed Potato among Rural, Resource-limited Households in, Uganda. African Crop Science Society Conference Proceedings 7: 712-717.

Kashaija, I.N., McIntyre B.D., Ssali, H., Kizito, F. 2004. Spatial distribution of roots, nematode populations and root necrosis in highland banana in Uganda. *Nematology. 6 (1): 7-12.*

ANNEX 2F: Brief CV for Mr. Senkesha Ntizo (Co-PI, Rwanda)

Name & Address: Senkesha Ntizo
ISAR-Musanze Research Station,
Muhoza Sector, Musanze District,
Northern Province, Rwanda
Email: senkesha@yahoo.fr, Cell phone: (+250) 08610105

Personal Details: Date of birth: 08/05/1964, Nord Kivu / D.R.Congo. Married. Gender: Male

Educational qualifications

2004-2005: Msc, Plant Pathologist:, Agricultural University of Gembloux, Belgium.
1997 : Ingénieur Agronome in Agriculture, Crop Production: – National University of Rwanda.
1990 : Gradué en Sciences Agronomiques : Agronomie Générale, Institut Facultaire des Sciences Agronomiques de Yangambi/DRC,

Work Experience:

I have been the head of several programmes/projects which include; 1998-2003 and from October 2005 - up to now Head, Potato Research Program/ISAR (Institut des Sciences Agronomiques du Rwanda)/ Rwanda; Project Manager at ISAR level of CIP-USAID-3G Potato Project. This project is promoting the production of potato minitubers using the aeroponic technology system; Project Manager at ISAR level of Roots and Tubers Project/ Potato crop Component. The aim of this project at ISAR level the production of in vitro plantlets in the tissue culture lab, minitubers production in greenhouse and Pre-basic seed production in open field; Since 2008, I am involved in FARA-SSA-Challenge Programme Lake Kivu Pilot Site activities as Taskforce 1 member (Crop productivity); I am also a member of the Taskforce of the Rwanda National Plant protection Service. In 2002, I did consultancy for USAID/Rwanda Pesticide evaluation and safer use action plan for Rwanda crop protection and commodity protection; 1998-2003 Head, Ruhengeri Research station, ISAR, Rwanda: June 2001-2003 and from October 2005 – up to now In charge of the potato tissue culture laboratory and screenhouses for potato clean seeds production, ISAR Musanze:

Summary of Publication Record

1. Pule B.B., Meitz J., Thompson A., Fry W.E., Myers K.L., Wakahiu M., **Senkesha N.** and McLeod A., 2008: Characterization of Phytopthora infestans populations from selected central, eastern and southern Africa. Third International Late Blight Conference Beijing. International Potato Center, Lima, Peru.

2. Sallah, P.Y.K, Njeru, R.W., Akinyemi,S.O.S., Nyirigira,A., **Senkesha,N**., Gashabuka,E., Kabayiza,E. And Nyombayire, A., 2007: Diagnostic survey of the farming systems in Rusogo watershed in Nyabihu district of Rwanda: Cropping systems and Challenges. ISAR Proceeding conference held in Kigali,Rwanda 26-29 March, 2007 pp 82-91.

3. **Senkesha N**., Jijakli H. M. And Busogoro J. P., 2005: Caractérisation des souches rwandaises de Phytophthora infestans (Mont.) de Bary, agent pathogène du mildiou de la pomme de terre. Thesis for Msc degree, Agriculture University of Gembloux,Belgium.

4. Nabahungu L.N., Ruganzu V., Mukuralinda A., Zaongo C., **Senkesha N**., 2005: Différentes sources du phosphore inorganique, fumier et chaux sur l'amélioration des sols acides du Rwanda. African Crop Science Conference Proceedings, Kampala, 5-9 December. Vol. 7 pp. 1103-1108

5. Tsedeke A., **Senkesha N**., Muyango S. 2002. Pesticide evaluation report and safer use action plan for Rwanda crop protection and commodity protection. Prepared for USAID/Rwanda. Report, Kigali/Rwanda.