Bio-enhanced seeds and seedlings for East Africa

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International Livestock Research Institute (ILRI)

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Duration: **3 Years**

Amount: **US $ 502,028**

2. EXECUTIVE SUMMARY

The lead applicant: Jomo Kenyatta University of Agriculture and Technology (JKUAT), Kenya

Project title: Bio-enhanced seeds and seedlings for East Africa

Budget requested from Bio-Innovate and project duration: 502,028 USD for three years (2011-2014)

Project description:

Goal: to improve the livelihoods of and generate income for farmers in Kenya, Uganda and Tanzania by reducing yield losses and increasing crop sustainability

Purpose: to develop bio-enhanced seeds and seedlings within a regional, commercial setting to reduce the impact of biotic and abiotic production constraints in crops, for the ultimate benefit of resource-poor farmers

Geographical focus: Kenya, Tanzania, Uganda

Project objectives:

1. to develop bio-enhanced vegetable seeds and seedlings
2. to develop bio-enhanced cereal seeds
3. to facilitate regional harmonisation of bio-pesticides registration and promote bio-enhancement of seeds and seedlings

Principal project partners:

- International Institute of Tropical Agriculture (IITA), Uganda
- The REALIPM Company Ltd (RealIPM), Kenya
- Alpha Seed Company Ltd (Alpha Seed), Tanzania

Project summary and justification:

Peri-urban agriculture constitutes one of the fastest growing markets in the humid tropics, edging towards a vital cash crop economy, supplying income to producers and food to the urban population. Pests and diseases are of particular concern, and chemical inputs are regularly being used by farmers with ill effects on producers, consumers and the environment. Bananas are essential staple crops in East Africa, and their role for food security will grow due to population growth and climate change. Contrary to vegetables grown in peri-urban conditions, these crops receive little agricultural inputs.

Microbial biological control offers a much-needed alternative to pesticide abuse in vegetable crops, and can play an essential role in protecting banana crops from pests and diseases. Unfortunately, biological control is not yet used to its fullest potential in East Africa, despite its potential for vegetable and cereal crops grown especially by smallholder farmers. Bio-pesticides, if applied the same way as conventional chemical pesticides, face several hurdles that hamper their commercial use. The fragmented policy environment constitutes another major hurdle.

This project primarily aims to realise the potential of vegetables and cereals for farmers in Eastern Africa, by enhancing them with bio-pesticides in a harmonized regional policy environment, so that these seeds and seedlings are adapted to the conditions encountered in farmers' fields in the region. The project will build on bio-enhancement of banana tissue culture, previously funded through the Eastern African Programme and Research Network for Biotechnology, Biosafety and Biotechnology Policy Development (BIO-EARN) and conducted by the same principal partners.

Bio-pesticide adoption barriers can be drastically reduced by:

- *Innovation incubation and promotion of targeted value chains (thematic area 3)*: By applying bio-pesticides to cereal and vegetable seeds and seedlings instead of the crops in the field, and within the setting of seed companies/seedling nurseries and prior to sale to farmers, hurdles related to farmers' adoption of bio-pesticides are removed, creating a "pull".

- *Bio-resource innovation policy and sustainability analysis (thematic area 4)*: By simplifying and harmonizing national registration protocols for bio-pesticides, hurdles related to their availability in Eastern Africa are removed, creating a "push".

3. BACKGROUND AND RATIONALE FOR THE PROPOSED PROJECT

Vegetable production in peri-urban areas: unsustainable pesticide abuse

With the rapid rise in urbanization in the developing world, food demand for urban centres escalates, while available peri-urban land becomes more intensely cultivated. A critical problem, therefore, relates to the sustainable increase in agricultural production proportional to this demand. Many growers intensively cultivate small land areas, which facilitates the build up of pests and diseases. Researchers consequently need to reconcile competing demands: to protect the environment on the one hand and enhance agricultural productivity on the other (McPherson 2008).

These competing demands are nowhere as juxtaposed as in the rapidly growing market of vegetable production, especially the intensive, high input peri-urban systems such as those for tomato and eggplant. Peri-urban agriculture constitutes one of the fastest growing markets in the humid tropics, edging towards a vital cash crop economy, supplying income to producers and food for the urban population. Tomato is the most important vegetable crop in East Africa, with annual production levels over 1 million ton. Kenya and Tanzania are the biggest tomato producers in East Africa, and production levels of tomato in 2009 increased with 31% and 19% in Kenya and Tanzania, respectively (FAO 2011). Tomato is equally the most important vegetable crop in Uganda, produced mainly in peri-urban areas for supply of the fresh market (Akemn et al. 1999). Traditionally, African vegetables have been overlooked in preference to exotic ones such as cabbage, carrot and tomato. With increasing food prices at local markets, demand for endogenous vegetables is expanding. In Tanzania, demand for African eggplant (*Solanum aethiopicum*) is booming because of its economic and nutritional value, and the crop has big commercial potential (Odhimabo 2008, Agbicodo 2011). African eggplant has many uses, from using fruits in stews and as medicines, to using leaves for cooking. Smallholder growers account for at least 80% of total eggplant production in East Africa. Eggplant is currently the most popular vegetable in the Kampala market, while increasingly being offered on the shelves of large supermarkets in surrounding countries (Chadha and Mndiga 2007).

Pests and diseases are of particular concern for vegetable crop production systems, and constitute a key obstacle to increased yields. Outdated, ineffective and highly toxic chemical inputs are regularly used by peri-urban farmers with ill effects on producers, consumers and the environment. Due to climate change, altered weather conditions increases plants vulnerability to diseases, insect pests and weeds (Rosenzweig et al. 2001). Implementing safe pest and crop management strategies are a critical impetus for peri-urban agriculture markets to flourish and for farmers to access the global peri-urban value chain. With promotion of non-pesticide alternatives, vegetable productivity and market access will rise, along with human and environmental health, through reduced pesticide residue of crop products and contamination of the environment, including water sources (Erenstein 2006, UNCTAD 2009). Tomato is plagued by a large number of pests and diseases, many of which are borne on seedlings. Major diseases include early and late blights (*Alternaria solani* and *Phytophthora infestans*), and bacterial wilt (*Ralstonia solanacearum*). Major pests include root-knot nematodes (*Meloidogyne* spp.), thrips, aphids, mites (*Frankliniella* spp.), and American bollworm (*Helicoperva armigera*). In East Africa, farmers depend on excessive use of pesticides to control these pests and diseases, and currently farmers are routinely spraying pesticides twice a week throughout the tomato growing season (Akemn et al. 1999, Agbicodo 2011). On eggplant, the most serious pests and diseases are equally soil-borne, and include bacterial wilt (*Ralstonia solanacearum*), collar rot (*Sclerotium rolfsii*) and wilting (*Verticillium dahliae*), and root-knot nematodes (*Meloidogyne* spp.) (PROTA 2011).

Cereal staple crops: suboptimal production due to lack of pest and disease control

Cereal (maize) crops play an essential part in providing food for millions in East Africa, and their role for food security will undoubtedly grow due to population growth and climate change. Maize is among the most important staple crops in East Africa, accounting for almost one third of caloric intake of its population. In Kenya and Tanzania, maize is the most important cereal crop, while in Uganda 1.2 million ton is produced per year (FAO 2011).

Grown mostly in subsistence conditions, and contrary to vegetables grown in peri-urban conditions, cereal crops receive little agricultural inputs. As a result, pests and diseases are major factors affecting their productivity. For example, over 17 species of stem borers limit attainable maize yield in Africa (Friesen and Palmer 2004). Rice production losses due to pests are estimated to amount to 37% (Oerke 2006).

Biological control: a much needed alternative that has not yet fully reached sub-Saharan Africa

Microbial biological control offers a much-needed alternative to pesticide abuse in vegetable crops and can play an essential role in protecting cereal crops from pests and diseases. Microbial biological control is the use of naturally occurring microorganisms, often formulated as bio-pesticides, against pests and diseases. Unlike chemical pesticides, such products are environmentally safe, non-toxic to humans and animals due to their high specificity, and, because they are living organisms, cause much less pesticide resistance. *Bacillus thuringiensis*, the most widely used bio-control agent in the developing world, has been used in over 1 million ha in China, Cuba and Brazil against various insect pests, and has spurred the development of genetically modified crops in the developed world (Jeffrey and Lord 2005). To safeguard human and environmental health, and continue to produce and protect crops sustainably, biological crop protection has become a necessity. In the Netherlands, because of consumer and government concerns about pesticide residues, > 90% of pest and disease control on some crops is currently through biological control (Pilkington et al. 2010). North America accounts for 40% of global bio-pesticide production, while Europe and Oceanic countries account for 20% each. The North American and European bio-pesticide market is valued at 340 million USD annually, and is growing at 15% per year, a rate that is five times higher than that of conventional, chemical pesticides (Müller et al. 2004).

Much of the bio-pesticide revolution has not yet reached sub-Saharan Africa. However, bio-pesticides are now being produced commercially by several small- and medium-sized commercial companies in sub-Saharan Africa (Kenya, South Africa and Senegal) and sold into several thousand ha of a range of both protected and field crops, for large and small-scale growers. They have successfully replaced pesticides as foliar applications as well as soil drenches because they are less harmful than chemical pesticides and even provide better control. Several important pests in sub-Saharan Africa have been successfully combated using government-sponsored biological control programs. The estimated benefit-cost ratios for biological control are 200:1 to 740:1 for the cassava mealybug and 145:1 for mango mealybug, amounting to net ` of 1.7 billion USD for Nigeria, 383 million USD for Ghana, and 74 million USD for Benin (Alene et al. 2007). However, small-scale farmers have not yet been a target market for bio-pesticides.

Seed and seedling treatment with bio-pesticides: an ideal application method

Bio-pesticides have been formulated for application through conventional spray equipment and irrigation systems. However, bio-pesticides, if applied the same way as conventional chemical pesticides, face several hurdles that hamper their commercial use: (1) costs and quantities involved for mass production are problematic; (2) their application is logistically and economically less feasible for farmers; (3) abiotic factors greatly reduce field performance; and (4) they are topical, and do not attack the pests inside the plant (Dubois 2006, Akello et al. 2007).

To overcome these hurdles, seed treatment with bio-pesticides is now practiced commercially in Europe, USA and Israel, with several products developed for seed and seedling treatment against nematodes, insects and diseases (Bennet and Whipps 2008, AgraQuest 2010). However, little use has been made of this technology in sub-Saharan Africa in spite of its great potential to have an immediate low-cost impact on crop establishment and plant growth enhancement. Existing use on high value crops and commercial trials clearly demonstrate the benefits of bio-enhanced seeds and seedlings through soil drenches and seed treatments.

Registration of bio-pesticides: a hurdle in sub-Saharan Africa

The policy environment constitutes another major hurdle why biological control is not being implemented in sub-Saharan Africa on a large scale. In order to apply bio-pesticides commercially, applicants are required to "register" the product with regulatory authorities of individual sub-Saharan countries, prior to use. Registration follows the evaluation of comprehensive scientific data, in the form of a lengthy and costly dossier, comprised of two parts: an ecological-toxicological study (the

'eco-tox' dossier) and a large-scale, controlled field experiment (the 'registration field trial'). Often, this dossier is modelled on or even identical to requirements for registration of chemical pesticides. The full potential of bio-pesticides for smallholder farmers has yet to be realised, because of the prohibitive cost of registration efficacy trials ('extension of labels'). Bio-pesticide companies in sub-Saharan Africa have only invested in registration of high value export crops such as roses and field lettuce. Support for registration of bio-pesticides for seeds and seedlings important to smallholder and subsistence farmers would have an immediate and widespread impact on crop production.

However, many countries outside of sub-Saharan Africa have long realized that regulatory requirements for biological control organisms should be much less than for conventional chemicals, and have implemented separate, highly simplified registration requirements for bio-pesticides. Many of the regulations for conventional chemicals simply do not apply to bio-pesticides. Secondly, the funds expended to conduct needless studies are a hurdle to their development, thereby perpetuating the use of older, toxic chemicals. Thirdly, regulatory agencies such as the United States Department of Agriculture (USDA) consider it a waste of their resources having to review studies that were not really needed to complete a risk assessment. Finally, most bio-pesticides involve ingredients to which man is commonly exposed, and therefore there is a known history of exposure without any adverse impact (Michael Braverman, USDA, pers comm). In addition to unnecessary bureaucratic processes, bio-pesticide registration is a strictly national affair, with no harmonization across countries. As such, applicants are forced to repeat registration for each country afresh, gathering different data for different registration dossiers, while the same pest or disease can be controlled by the same bio-pesticide.

Fit of the project within Bio-Innovate priority areas

We strongly believe that these barriers to bio-pesticide adoption can be drastically reduced by combining both an innovation (Bio-Innovate priority area 3) and policy (Bio-innovate priority area 4) component.

- *Innovation incubation and promotion of targeted value chains (priority area 3)*: By applying bio-pesticides to vegetable and cereal seeds and seedlings instead of the crops in the field, and within the setting of seed/seedling companies/nurseries and prior to sale to farmers, hurdles related to farmers' adoption of bio-pesticides are removed, creating a "pull".
- *Bio-resource innovation policy and sustainability analysis (priority area 4)*: By publishing guidelines and best practices for bio-pesticides registration and bio-enhancements of seeds and seedlings, we hope that this information will help the pest control and product boards of the three countries harmonise bio-pesticide registration in the eastern Africa region.

This project aligns with the Bio-Innovate priority areas 1 and 2 as follows:

- *Climate change adaptability, productivity and improvement for food and nutrition security (priority area 1)*: Vegetables are essential for income generation of smallholder farmers and a nutritionally balanced diet of consumers, while cereals comprise essential staple crops. Unfortunately, these crops are highly susceptible to soil born pests and diseases, whose levels and geographical ranges are set to increase due to climate change. As such, bio-enhancement of seeds and seedlings will be an essential tool to ensure healthy crop production, especially in light of the increased onslaught of pests and diseases due to climate change.
- *Waste treatment, bio-energy for renewable bio-resources, and securing freshwater resources (priority area 2):* Unlike other commodities grown in East Africa, pest and diseases of vegetables are increasingly controlled through the often repeated and indiscriminate use of chemical pesticides. These chemicals contaminate soils and freshwater resources, a problem that is aggravated in urban and peri-urban areas where such crops are often grown. Providing a viable alternative to pests and disease control, through bio-protection, will help secure freshwater resources.

4. ADDING VALUE TO EXISTING EFFORTS

Since relatively recent, seed and seedling treatment using bio-pesticides is a highly researched innovation in biological control because it allows bio-pesticides to compete with conventional chemical pesticides. Because quantities required to enhance seeds and seedlings with bio-pesticides

are much lower compared to field application, the cost of application of bio-pesticides through this innovative application is greatly reduced. Secondly, seeds and seedlings can be coated during their initial production by the seed company or seedling nursery, removing the need for farmers to have to apply the products themselves. In other words, the seeds or plantlets come "ready-armed" when sold to the farmer. Microbial control agents are highly sensitive to abiotic factors in the field, especially UV and drought, which has necessitated their protection with expensive formulations. However, by applying the bio-pesticides inside the seeds or seedlings, they become protected from such abiotic factors inside the plants. Finally, many pests of vegetables and cereals have their damaging stages inside the plant, where they are difficult to reach. Traditional application of bio-pesticides relies on topical field applications, which do not directly target the damaging stages. By coating seeds or seedlings with bio-pesticides early on, they can colonize the plants in the rhizosphere or as endophytes, providing protection "inside-out" (Dubois 2006, Akello et al. 2007).

Numerous studies are available that have investigated bio-enhancement of seeds and seedlings with a variety of biological control agents. For example, bio-enhancement of carrot seeds with *Clonostachys rosea*, a biological control agent under development, virtually eliminates damping-off, caused by seed-borne *Alternaria* spp. (Jensen et al. 2004). Seed treatment of tomato with *Trichoderma harzianum*, a commercially available bio-pesticide, alleviates a wide variety of biotic, abiotic and physiological stresses, drastically increasing seedling growth (Mastouri et al. 2010). Other crops such as rice seed treatment with bacterial bio-pesticides reduces leaf blast (*Pyracularia grisea*) severity by up to 80% in the Philippines (Gnanamanickam and Mew 1990). It should come as no surprise that several biological control agents are already registered and commercialized as seed and seedling treatments to take advantage of this innovation (e.g. by Koppert, Monsanto, AgriQuest, etc.) (Jeffrey and Lord 2005, Backman et al. 2008). For example, a bio-pesticide based on *Bacillus subtili*s has been registered for seed treatment in Europe and the USA for suppression of root diseases caused by *Rhizoctonia* spp., *Fusarium* spp. and *Aspergillus* spp., which are some of the main soil-borne diseases of eggplant and tomato (Bayer 2011).

In sub-Saharan Africa, the innovate technology of bio-enhancement of seeds and seedlings is barely taken advantage of. In South Africa, seed treatment of *Trichoderma* sp. is used for control of Fusarium wilt in peas, and promising data have also been obtained using seed treatment of wheat and maize with *Trichoderma asperellum*. In Kenya, seed treatment of maize with a South African *Trichoderma* sp. strain increased yield with 50%, whereas seedling treatment of sprout and celery with a Kenyan *Trichoderma asperellum* strain doubled yield (RealIPM 2011a,b). In Kenya, inoculation of banana tissue culture seedlings with *Fusarium oxysporum* reduced nematode population densities by > 45% and damage by > 20% over one growth cycle (Waithira 2009). In Kenya, coating tomato seeds with *Trichoderma harziunum* increase germination rate by 82 % (Okoth et al. 2011). Isolates of *Trichoderma harzianum* are reported to significantly reduce the severity of seedling wilt in tomatoes cause by *Fusarium oxysporum* f. sp. *Lycopersici* (Mwangi et al. 2009). However strain of bacteria bio-control agents such as *Bacillus subtilis* are shown to produce antibiotic activity that suppress damping-off diseases in tomatoes caused by *R. solani* (Asaka and Shoda 1996).

Our commercial partner, RealIPM, is ideally suited to help bring this technology to sub-Saharan Africa. RealIPM has three bio-pesticides that are being registered for commercial use in a wide variety of crops and against a wide variety of pests. Registrations are currently being sought in Kenya for *Trichoderma asperellum* against root knot nematodes on fine beans, *Metarhizium anisopliae* against mealybug in pineapples, and *Bacillus subtilis* against powdery mildew on roses and peas; and against rust on a range of crops. In Ethiopia, *Trichoderma asperellum* is being registered against root knot nematodes in melon, passionfruit, rose and pepper; *Bacillus subtilis* is being registered against powdery mildew in rose, pepper, melon, and against rust in beans. Demonstrating their wide-ranging potential in sub-Saharan Africa, the products are even being registered for commercial use as far as Ghana, namely against mealybug on pawpaw (*Metarhizium anisopliae*), against *Phytophthora* in pineapples, against black pod in cocoa and oil palm, and against leaf miner in oil palm (*Trichoderma asperellum*). Based on the availability of these bio-pesticides and the huge potential of seed and seedling treatment, which has been proved in the field in Eastern Africa, we consider the potential for success as very high.

In the last fifteen years, increasing efforts have addressed the harmonization of pesticide regulatory requirements and processes in the EU, Sahel region (CILLS), Andean Community, North American

Free Trade Agreement (NAFTA), Association of South East Asian Nations (ASEAN) and MERCOSUR (the Southern Common Market). Unfortunately, no simplified regional registration protocols exist in East Africa for bio-pesticides. The FAO International Code of Conduct on the Distribution and Use of Pesticides (FAO 2003), which serves as a global framework for the judicious use of pesticides, has been applied for SADC member states of Southern Africa (SADC 2009). These regulations, however, merely act as guiding principles and are not followed. More importantly, no distinction is made between bio-pesticides and chemical control methods, risking to further antagonize the use of bio-pesticides as safe alternatives to chemical ones.

Regional harmonisation has the advantage that information can be shared, harmonized registration requirements can be set, trade can be facilitated, available expertise and facilities can be optimally utilized and shared, and data collection can be reduced. Only in West Africa, a regional registration protocol specifically for bio-pesticides has been implemented under the Comité permanent Inter-Etats de Lutte contre la Sécheresse (CILLS), comprising the Sahelian countries Burkina Faso, Cape Verde, Gambia, Guinea Bissau, Mali, Mauritania, Niger, Senegal and Tchad. The existence of such protocols has lead to rapid and facilitated registration of a bio-pesticide based on *Metarhizium anisopliae* for control of the desert locust.

So far the registration of bio-pesticides is very tedious and ill-comprehended, including in countries like Kenya where bio-pesticide technology is advanced. The registration process is hardly understood by scientists and the bio-pesticide industry. The project intends to study bio-pesticide registration procedures in Kenya, Uganda and Tanzania, and document, publish and disseminate the information to all stakeholders in a workshop. The project will link with organizations such as COMESA and USDA-FAS, which have realized the urgent need for regional harmonization of bio-pesticide registration, and we are confident we will spearhead their initiatives using practical solutions, based on private sector involvement. IITA is already actively involved as technical expert in the COMESA and USDA-FAS initiatives, and together with their links to CILLS, will be a valuable asset to facilitation of bio-pesticide registration.

5. POTENTIAL FOR ECONOMIC AND SOCIAL IMPACT

Substantial pest and disease infection of vegetable and cereal seeds and seedlings occurs in the seed companies and seedling nurseries, which are then transferred to the field, already infected with insect pests, nematodes, and bacterial, viral and fungal pathogens. The earlier that plants become infected, the greater the degree of loss or damage. Preventing crop infection in the first instance is perhaps the single most important strategy to avoid or limit crop losses in terms of quality and yield. Limiting the use of chemical pesticides constitutes a priority for safeguarding the environment and consumer health, although conventional use of bio-pesticides is ill-equipped to compete with the use of chemical pesticides. Bio-enhancement of seeds and seedling is thus an ideally placed and essential innovation for a healthy, sustainable vegetable and cereal sector in Eastern Africa.

This project entails strong cooperation with the private sector, who already considers the innovation economically viable based on commercial experiences outside East Africa. They could act as motors to further stimulation of agro-businesses, especially small-scale seed producers and seedling nurseries. Table 1 illustrates an economic analysis of likely returns to the individual farmer using bio-enhancement with bio-pesticides. In the project, some activities will explicitly calculate the cost-benefit ratios of the innovation.

Table 1. An economic analysis of likely returns to the individual farmer using bio-enhancement with bio-pesticides.

Crop	Current yield (kg/ha)	Bio-pesticide cost (USD/ha)	Yield gain (kg/ha)	Increased return (USD/ha)	Economic gain (USD/ha)
Tomato	4,000	25	400	160	135
Maize	2,000	15	200	60	45

Tomato and maize prices are estimated at 0.4 and 0.3 USD/kg, respectively. The amount of tomatoes and maize required to break-even and pay for the extra cost of the bio-pesticide are 62.5 kg of tomatoes/ha and 50.0 kg of maize/ha (source: RealIPM).

Increased quality of seeds and seedlings is a main focus of the project. We also anticipate increased production through increased yields, and reduction of pest and disease losses. However, this logic might turn to be false, as climate change is set to greatly increase pest and disease pressure; hence,

bio-enhanced seeds and seedlings might merely be a necessary requirement to maintain a status quo of current production levels. In any case, the growing demand of the ever increasing urban centres in East Africa will offset increased production of especially vegetables, whereas increased production of cereals will serve to ameliorate food security for the rural population. In addition, producers of vegetables with lower levels of pesticide residues will finally be able to link to high-quality, high-premium markets (e.g. EU, organic agriculture, and supply of the large tourism industry in Kenya and Tanzania).

Dissemination and development costs are intrinsically build into the outputs. Furthermore, these tasks will be carried by the private sector (bio-pesticide company and seed company), guaranteeing their dissemination. It is important to note that the project also includes gender aspects. Peri-urban vegetable production systems are especially an important income generator for women.

The justification for addressing the different crops and bio-pesticide

The selected crops; Tomatoes and Maize are the vegetable and cereal of economic importance in the eastern Africa region and the larger Sub-Saharan Africa. In east Africa maize is the primary staple crop and a fundamental part of people's livelihood systems, in some communities in the region, maize is culturally and politically important. Tomato is the highly consumed vegetable in the world while eggplant is an upcoming crop. The production of these crops has been limited by a number of pest and disease. The increase in incidences of these pests and diseases has resulted in prophalytic use of chemical pesticide that led to pesticide residues in food especially on freshly eaten vegetables. Control of the insect pest and pathogens can easily be achieved by use of bio-pesticides particularly those that target pests which affect the nursery stage of the seedling. Coating seeds with biopesticides will ensure that healthy seeds are planted which will boost seedling vigour in the initial stages of growth. This will ensure that common damping of diseases caused by pathogens such as *Pythium, Rhizoctonia* and *Phytophthora* are controlled. *Trichoderma asperellum* is known to control these pathogens which this project will test against. The *Bacillus subtilis* is known to control soil borne bacteria and induce systemic acquired resistance which we shall test against serious bacterial diseases such as *Ralstonia solenacearum. Metarhizium anisopliae* is known to control common nursery insect pest such as cutworms and thrips soil dwelling stages. *Bacillus subtilis* and *Trichoderma asperellum* have been reported to have marked bio-fertiliser effects which we anticipate to confer increase in seedling vigour.

6. REGIONAL AND INTERNATIONAL COLLABORATION

The purpose of the project is explicitly regional in scope, with one of the objectives to help harmonize registration protocols across national boundaries. Seed and seedling treatment with conventional bio-pesticides has wide-ranging implications for the whole seed sector in sub-Saharan Africa. For example, RealIPM is already fostering commercial links with large seed producers in Mozambique for seed enhancement of rice, wheat, barley, peas and beans.

The scope of the project will be focused on three of BIO-EARN's target countries: Kenya, Tanzania and Uganda. However, outputs of the project will undoubtedly be transferable to other target countries, where seeds and seedling systems are developed. The project includes IITA as co-PI, Africa's leading research partner for finding solutions for hunger, malnutrition and poverty, and whose network across sub-Saharan Africa will be used to disseminate and communicate outputs and outcomes. Other sub-Saharan networks, such as COMESA, also have a scope beyond the original target countries. Through IITA, the project will link with the BeCA hub; with regional networks such as ASARECA; and with regional trading blocks such as COMESA.

The relationships between partners

The role of the public research institution in seed production chain is to improve crops through breeding or seed enhancement while the role of commercial private companies is to take up the improved seed, multiply and market through seed dealer or distributors.

The role of JKUAT and IITA as public research institutions is therefore to develop commercialisation protocols for enhancing seed/seedlings with bio control agents and not commercialisation. The private companies would use the researched protocols to commercialise the process and distribute the bio enhanced seeds to farmers through seed dealers and stockists. The East African farmers are used to

this model. However, JKUAT will utilise their existing tissue culture (TC) banana nursery network to reach farmers in rural parts of Kenya.The public institution will train the nursery owners and vegetable growers on the best practices in handling the bio-enhanced seeds and seedlings using participatory approach. JKUAT and IITA have extensive knowledge on basic research on endophytic fungi as bio control agents of banana pests. All tomatoes and eggpant seeds used in East Africa are hybrids and farmers have to purchase them from seed dealers every planting season. This project will bio enhances vegetable seed already popular with farmers. Likewise all farmers plant hybrid maize seed especially in Kenya.

Alpha Seeds bring seed technology to the project as they are experienced in seed production, seed treatments, and marketing of seeds to growers in East Africa. They provide an important link in the value chain for this project. They provide a pathway for dissemination of this technology to farmers in Tanzania.

RealIPM provides the biocontrol component to the project. They have skills and knowledge in biopesticides production, handling and quality control and commercialisation. They are also knowledgeable in the legal framework on the authorization necessary for using biocontrols in East Africa. They have experiences in pesticide registration procedures in Kenya and will be of importance in development of dossiers for bio-pesticides registration in the region.

This project will develop protocols for bio pesticide registration and use that will be placed in the public domain. JKUAT will subsequently incorporate this knowledge in their teaching and human capacity development. This project is about "proof of concept" and as such other seed companies and biocontrol producers can adopt this technology freely. (More information on the roles of partners' is in Annex 5b)

7. PROJECT GOAL AND PURPOSE

Project goal and purpose

Goal: to improve the livelihoods of and generate income for farmers in Kenya, Uganda and Tanzania by reducing yield losses and increasing crop sustainability
Purpose: to develop bio-enhanced seeds and seedlings within a regional, commercial setting to reduce the impact of biotic and abiotic production constraints in crops, for the ultimate benefit of resource-poor farmers

Objectives, outputs and outcomes

Objective 1: to develop bio-enhanced vegetable seeds and seedlings

Outputs	Outcomes
1.1. commercial protocols developed for vegetable seed/seedling bio-enhancement	seed companies incorporate protocols for vegetable seed/seedling bio-enhancement; bio-enhanced vegetable seeds/seedlings commercially available to nurseries and farmers
1.2. growth increase, and pest and disease resistance demonstrated for vegetable seed/seedling bio-enhancement	vegetable farmers experience increased yields, and better protection against pest and diseases; vegetable farmers reduce pesticide use
1.3. cost/benefit ratio for vegetable seed/seedling bio-enhancement established	market demand exists by nurseries and farmers for bio-enhanced vegetable seeds/seedlings
1.4. synergistic effects between bio-enhancement and fertilizer input established for vegetable seeds/seedlings	seed companies/nurseries combine use of fertilizer together with bio-enhancement of vegetable seeds/seedlings to maximize yield
1.5. bio-pesticides registered for vegetable seed/seedling bio-enhancement in Tanzania and Uganda	bio-pesticides are available and widely known for commercial use as bio-enhancers of vegetable seeds/seedlings in Uganda and Tanzania
1.6. extension-of-label obtained for bio-pesticide use on vegetable seeds/seedlings in Kenya	bio-pesticides are available and widely known for commercial use as bio-enhancers of vegetable seeds/seedlings in Kenya

Objective 2: to develop bio-enhanced maize seeds

Outputs	Outcomes
2.1. commercial protocols developed for maize seed bio-enhancement	seed companies incorporate protocols for maize seed bio-enhancement; bio-enhanced maize seeds commercially available to nurseries and farmers
2.2 growth increase, and pest and disease resistance demonstrated for maize seed bio-enhancement	maize farmers experience increased yields, and better protection against pest and diseases
2.3. cost/benefit ratio for maize seed bio-enhancement established	market demand exists by nurseries and farmers for bio-enhanced maize seeds
2.4. synergistic effects between bio-enhancement and fertilizer input established for maize seeds	seed companies/nurseries combine use of fertilizer together with bio-enhancement of maize seeds to maximize yield
2.5. bio-pesticides registered for maize seed bio-enhancement in Tanzania and Uganda	bio-pesticides are available and widely known for commercial use as bio-enhancers of maize seeds in Uganda and Tanzania
2.6. extension-of-label obtained for bio-pesticide use on maize seeds in Kenya	bio-pesticides are available and widely known for commercial use as bio-enhancers of maize seeds in Kenya

Objective 3: to facilitate regional harmonisation of bio-pesticides registration and promote bio-enhancement of seeds and seedlings

Outputs	Outcomes
3.1. information and best practices shared on bio-pesticide registration and bio-enhancement	regional registration of bio-pesticides is facilitated and complements the ACTESA and COMESA initiatives, and bio-enhancement of seeds and seedlings is promoted
3.2. guidelines published for bio-pesticide registration in the region (Kenya, Uganda and Tanzania), and merits of bio-enhancement of seeds and seedlings	registration of bio-pesticides, and bio-enhancement of seeds and seedlings are explained and promoted

8. METHODOLOGY AND DESCRIPTION OF PROJECT ACTIVITIES

As mentioned under '13. Institutional support', some laboratory infrastructure, scientific equipment and vehicles are present at JKUAT, IITA, RealIPM and Alpha Seed, and will be made available for the current project. Some infrastructure and equipment and chemicals will need to be purchased at the beginning of the project, partly to replace outdated ones. These are outlined in '19. Detailed and summary project budget (USD)'. Many of the outputs of objectives (1) and (2), which are laboratory-, screenhouse- and field-based, will also require purchase of equipment and chemicals.

An initial planning meeting of all stakeholders, possibly including complementary Bio-Innovate projects and representative farmer groups linked to the seed companies/seedling nurseries and complementary projects, will be deemed essential. During the project, yearly planning meetings among key partners will ensure timely delivery of outputs and allow for changes in the milestones or even outputs if necessary. Periodical meetings in the respectively countries will be carried to sensitize stakeholders on the guidelines for pesticides registration. At the end of the project, a final stakeholder meeting will be held for communication of outputs and, if possible, early outcomes. Specifically, the final-year stakeholder meeting aims to group all stakeholders involved in bio-pesticide research, application and legislation, to disseminate lessons learnt during the project related to bio-pesticide registration and bio-enhancement of seeds and seedlings. During the final-year stakeholder meeting, a published guideline booklet will be disseminated. This final-year stakeholder meeting will also serve as a final evaluation meeting against the quantified outputs and milestones.

Formal capacity building, through training of MSc students registered at local universities, is important in the project. These students will be allowed to conduct their research within the project. If incorporated, students will be recruited at the beginning of the project to ensure timely submission of their dissertations.

The value chain for bio-enhanced seeds and seedlings consists of: (1) applied research, (2) regulatory services, (3) bio-pesticide companies, (4) private seed sector, and (5) farmers and consumers. PIs and co-PIs represent (1), (3) and (4). Development, promotion and delivery partners represent (1) and (2).

(5) will be reached through links with (4) and complementary projects discussed in '12. Matching funds and commitment from host institution'.

Experiments will be conducted to maximize colonization in maize, tomatoes and eggplant (with high colonization as a function of pest habitat). This will be performed in the screenhouse through controlled repeated experiments, and then in the lab using selective isolation media. Plant growth will also be assessed. At first, we will test major inoculation methods (drip, drench, seed coating etc), after which we will conduct several experiments for fine tuning dose response, and time for inoculation.

The best methodologies for inoculation on target pests will be tested: this will be done in the screenhouse using repeated experiments by first inoculating plants with biopesticides, and then subsequently artificially inoculating plants with pests. The damage caused by the pathogen and growth parameters will be assessed.

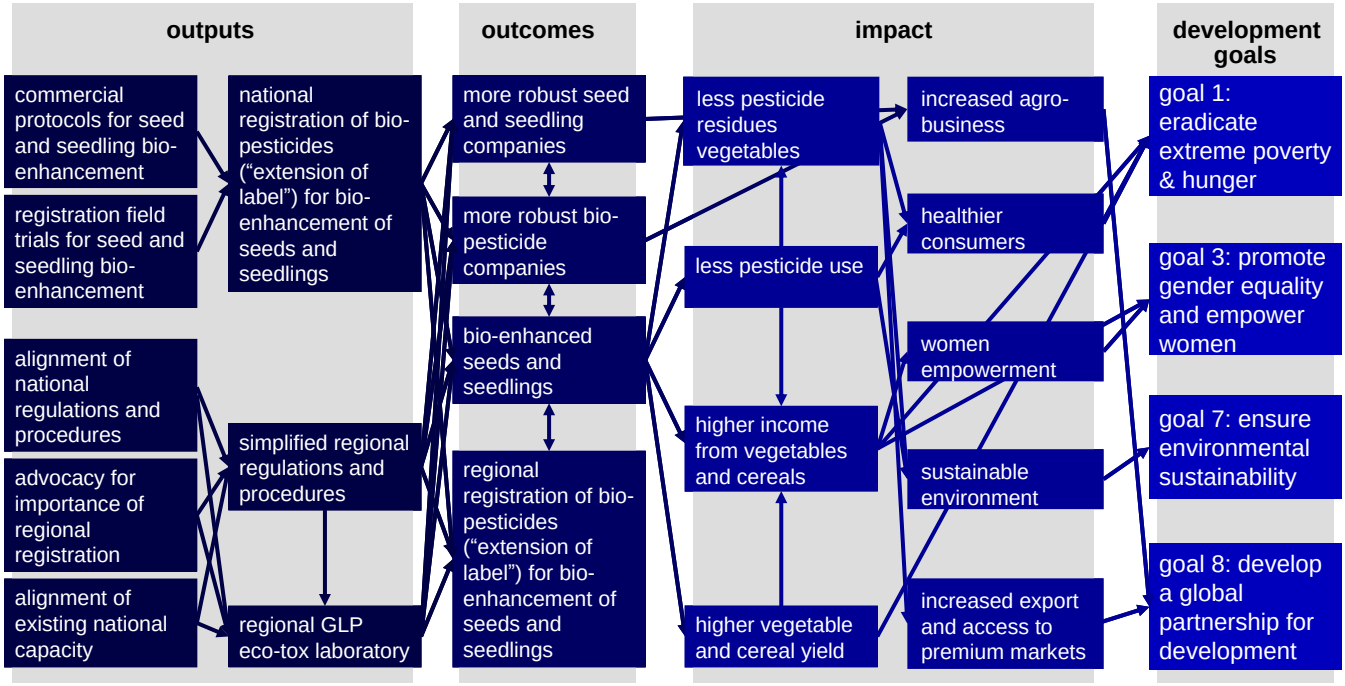
The best inoculation method(s) will be used to test bio pesticide- enhanced plants in the field, using repeated experiments and negative and positive (pesticides) controls. Parameters such as pest incidence, plant growth and yield will be assessed. Pest populations will be either artificially introduced or natural (highly infected fields or high pest pressure). Using the best inoculation method, testing of biopesticide-enhanced plants in the field as a multifactor experiment will be carried out with and without fertilizer. The performance of the plants in natural growth conditions and high disease pressure will be determined.

9. PATHWAY TO IMPACT (COMMERCIALIZATION AND OR USE)

Research products constitute technology, know-how and commercialization of bio-enhancement of vegetable and cereal seeds and seedlings. Bio-pesticides will be scaled up by RealIPM, while Alpha Seed will scale up the production of bio-enhanced seeds and seedlings for vegetable and cereal crops. For vegetables, the innovation will result in less use of conventional chemical pesticides, leading to more sustainable agri-businesses, empowerment of smallholder peri-urban producers, reduction in environmental pollution, and increased farmer and human health. For vegetables and cereals, the innovation will lead to a reduction in pests and diseases, an increase in yield, and ultimately a reduction in poverty and increase of income.

The UN Millennium Development goals to which this project will contribute are primarily: 'eradicate extreme poverty & hunger' (goal 1); 'ensure environmental sustainability' (goal 7); and 'develop a global partnership for development' (goal 8). The project also indirectly contributes to 'promote gender equality and empower rural women' (goal 3). Anticipated economic gains could be as a result of yield gains and as a result of reduced chemical pesticide input.

The figure below illustrates a full pathway for utilization of the innovation, for both commercial use and the public good. It includes the main linkages along the innovation chain to ensure delivery, ultimately contributing to the Millenium Development Goals.



10. TEAM LEADERSHIP, COMPOSITION AND ROLES OF PARTNERS

Team leadership

Strong track records of the PIs (Esther Kahangi, Losenge Turoop) and co-PIs (Daniel Coyne, Thomas Dubois, Henry Wainwright, Hussein Omari Mongi) are detailed in Annex 5b, based on one-page curriculum vitaes. All PIs and co-PIs have substantial experience in project management and team leadership in a regional context, and have jointly executed and led the research that serves as the basis to this proposal, including BIO-EARN.

Team composition and roles of various partners

The team is comprised of 4 partners (JKUAT, IITA, RealIPM and Alpha Seed), comprising 2 PIs and 4 co-PIs. Two of the 4 partners are private sector. In addition, the project will strengthen links with at least 3 development/promotion/delivery partners. The JKUAT team will lead the project activities.

Principal investigator/s

- *Esther Kahangi, Vice-Chancellor, JKUAT, Nairobi, Kenya*: 1) Director of BIO-EARN from 2006-2007, 2) member of the board of 7 national/regional/international organizations and internationally awarded; referees: N Kamaum, Dean of Agriculture, JKUAT, Box 62000, Nairobi, Kenya, k_ngamau@yahoo.com, dean@agr.jkuat.ac.ke; MA Onyango, Professor, JKUAT, Box 62000, Nairobi, Kenya, mabukutsa@yahoo.com
- *Losenge Turoop, Senior Lecturer, JKUAT, Nairobi, Kenya*: 1) manager of semi-commercial JKUAT tissue culture company, with a staff of 20 workers and students for one year, 2) coordinator of projects related to commercialization of endophytes at JKUAT; referees: B Hau, University of Hannover, D -30419 Hannover, Germany, +49 5117623503, hau@mbox.ipp.uni-hannover.de; JE Faust, Department of Horticulture, Clemson University, E-143 P&A Bldg, Clemson, SC 29634, USA, +1 8646564966, jfaust@exchange.clemson.edu

Co-principal investigators at partner organizations

- *(co-PI) Daniel Coyne, Scientist (Nematologist), IITA, Dar-es-Salaam, Tanzania:* Coyne has 10+ years experience in endophyte research in East Africa, with a wealth of experience on integrated pest management in a variety of crops grown in East Africa
- *(co-PI) Thomas Dubois, Scientist (Bio-control Specialist), IITA, Kampala, Uganda:* Dubois has 8+ years experience in endophyte research in East Africa and regional registration protocols for bio-pesticides
- *(co-PI) Henry Wainwright, Director, REALIPM, Nairobi, Kenya:* Wainright is the director of the most successful bio-pesticide company in East Africa, with commercial experience on several crops and against several target species

- *(co-PI) Hussein Omari Mongi, Director of Research, Alpha Seed Company Limited, Moshi, Tanzania*: Mongi has over 40 years of experience in public and private seed companies in Africa

Participating development, promotion and delivery partners

- *Martha Byanyima, CAADP Coordinator, COMESA, Lusaka, Zambia*: COMESA has prioritized regional registration protocols for bio-pesticides within their program. Linking with COMESA will be essential.
- The project will partner with other seed/seedling companies/nurseries in Kenya (e.g. *KARI Seed Unit*, *Kenya Seed Company*) and Uganda (e.g. *NASECO*, *Victoria Seeds*), and farmer groups linked to those seed/seedling companies/nurseries.

11. COMPETENCE AND SKILL TRACK RECORD OF PRINCIPAL INVESTIGATOR

Esther Kahangi, the PI, is currently the Deputy Vice-Chancellor in charge of research, production and extension in JKUAT. All university- and donor-funded research projects at JKUAT falls under her supervision. She was previously the coordinator of BIO-EARN. At JKUAT, she established and headed the Institute of Biotechnology Research. She has previously headed various positions in the university and is also UNESCO's Chair in Biotechnology. She spearheaded the banana tissue culture laboratory in JKUAT until it attained sustainability, and the laboratory is now a commercial venture. Kahangi has been a PI for many regional projects, including endophyte technology projects funded by the German Federal Ministry of Economic Cooperation and Development. She is adequately trained in project management, and all the projects she has led were completed on time and on budget, and delivered outputs as required. She has the required experience to lead the proposed project, which furthermore fits very well within her core mandate at the university. In addition, Dr. Losenge Turoop will be responsible for day-to-day implementation and oversight of all the project activities. Examples of previous team management experience, as well as referees, are highlighted under '10. Team leadership, composition and roles of partners' are in Annex 5b.

JKUAT, the lead institution, has experience in managing collaborative projects, having participated in > 150 international projects over the last five years. In addition, for the last 3 years, JKUAT has been coordinating major regional projects such as the project "*Regional Programme in research methods*", funded by the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) (2009-2011; 3,404,000 USD).

Knowledge on which the proposed project is intended to build on

The project is based on the use of non-chemical pest management. JKUAT, IITA and RealIPM have worked as a team in previous projects that employed endophytic fungi in control banana weevils and nematodes. This project was carried out by a multi-national consortia involving university researchers in Germany, South Africa, Kenya and Uganda for over seven years Isolation and inoculation procedures were optimised, mode of action and persistence using molecular markers was studied. The efficacy of selected isolates in both *in vitro* and field conditions were studied. A dossier for registration as biopesticides was developed and submitted to the Pest control and produce board for registration. JKUAT network of nursery owners were trained on good nursery management practices on endophyte enhanced banana seedling.

. This project therefore borrows heavily on the knowledge and skills acquire in these studies.

12. MATCHING FUNDS AND COMMITMENT FROM HOST INSTITUTION

The project will be highly complementary to the proposal "*Vegetable value chain: improved productivity and safety for greater marketability to benefit poor farmers in the humid tropics*", funded by the Federal Ministry of Economic Cooperation and Development (BMZ) (PI: IITA, 2012-2015, ~1.2 million USD) (acceptance pending). The aim of the above mentioned project is to enhance the affordability, availability and safety of nutritionally beneficial vegetables by identifying multiple pest- and disease-resistant vegetables, and incorporate them within a sustainable production chain, bolstered by a high quality seedling system and better market linkages in the humid tropics. A large output will be focused on enhancing seedlings of vegetables with bio-pesticides and biological growth promoters, directly linking into the present proposal.

The project will also be complementary to the proposal "*Development and commercialization of biological control of aflatoxins to improve public health, increase trade, augment smallholder income, and enhance food security in Nigeria and Kenya*", funded by the Bill & Melinda Gates Foundation (PI: IITA, 2012-2015, ~1 million USD). Aflatoxins, produced by toxigenic strains of *Aspergillus* spp., are an immense threat to human health by contaminating maize, cassava and other staple crops in East Africa. A bio-pesticide that controls aflatoxin-producing strains of *Aspergillus* spp. has been registered in Nigeria, where it will be used commercially. Within this project, a bio-pesticide will be developed in Kenya, using strains adapted to the Kenyan ecosystem. Several of the key partners in this proposal will be involved.

The project will benefit from the projects "*Improvement of rice production in Kenya*", funded by the National council of science and technology (NCST) (PI: JKUAT, 2010-2013, 175,000 USD) and "*Use of biocontrol technologies to control pest and disease in banana*", funded by the Japanese International Cooperation Agency (JICA) and the African Institute for Capacity Development (AICAD) (PI: JKUAT, 2010-2012, 50,000 USD).

Matching funds from private companies

The two private companies involved in this project are Small and Medium Enterprises (SME) thus have limited resources and are operating on a regional basis. The two companies have limited resources for research and Development. They are also significant local employers, for instance REALIPM employs three times as more people in Kenya than the multinational company Syngenta E.A..

Other costs that have not been included as contributions by the private sector companies include:
The registration costs of three biopesticides (no biopesticide can be used or sold commercial without the regulators' approval. This requires per bio-pesticide the costs indicated below:

Contribution	**Amount USD**
PCPB fee	1,000
Independent eco and toxicological testing	7,000
Independent field efficacy testing	3,000
Total cost for three biopesticides	33,000

In 2010 REALIPM spent over 500,000 US$ building a biopesticide production, packaging and quality control facility in Kenya. This project would not be possible without this investment that has been made outside the scope of this project. This facility will be avail for the proposed project for production of the Biopesticide. RealIPM will offer Additional Greenhouse space for experimentation.

There is still very little involvement African seed companies in the use of bio-pesticides. The financial state of most African seed companies is very low but ALFA Seeds will be willing to invest in the use of bio-pesticides as a means of supporting small scale farmers. Indeed, the Alpha Seed Company will have to adjust its programme of activities in order to make available some of the facilities for the project.

Alpha Seed Company is willing to assist the project to access eight of its contract farmers in order to respond to the query on the involvement of small scale farmers as beneficiaries. Participation of farmers will imply that the company will have to meet the following costs per farmer each of them cultivating one acre for the project.

Expenditure per farmer (one acre)	**Cost (USD)**
Fertilizer N	30
Fertilizer Compound	37
Insecticide	44
Fungicides	29
Micronutrients	7

Land rent and water	134
Advance for labour and Nursery	201
Processing	60
Supervision	27
Total	**570**

Alfa seed will also engage the regulatory institutions such as the Tropical Pesticides Research Institute (TPRI) and the Tanzania Food and Drug Administration (TFDA). Their involvement will attract additional costs including research on efficacy and eco-toxicology which Alfa seeds will meet the cost. ALFA Seed Company has also offered to spend cash amounting to 55,000 USD as follows:

	Alpha Seed Company	**USD**
1	Final year workshop	100
2	Project management travel	200
3	Technical staff travel	200
4	Technical staff	11,520
5	Casual labor	4,320
6	Daily allowances	1,800
7	Fuel and maintenance	8,300
8	Farmer inputs package	13,680
9	Guidelines	250
10	Laboratory & screen house renting	15,000
TOTAL		**55,370**

Difference and similarities with current and pending projects;

The project on "*Development and commercialization of biological control of aflatoxins to improve publichealth, increase trade, augment smallholder income, and enhance food security in Nigeria and Kenya"* funded by bill and Melinda gates is similar in that atoxigenic strains of the fungus Aspergillus are used as Bio-logical control agents of the aflatoxin is producing strains. In both cases a fungi is used as a control agent. Another BMGF funded project is on the control of striga. The difference is that approaches used and diseases targeted are different. Though these are dealing both with biocontrols, they have different targets, different problems and not on vegetables crops.

The project on "*Improvement of rice production in Kenya*", funded by (NCST) mainly aims at breeding rice for resistance with and aspect of use of bio-fertilisers i.e. nitrogen fixing bacterials to enhance rice production. The propose project will supplement these activities by ensuring pests and diseases in nursery and early stages of the crop are managed.

The JICA and AICAD funded project on "*Use of bio-control technologies to control pest and disease in banana*", complements the activities of the current project. Knowledge on inoculation procedures developed for banana seedling will be useful in inoculation of seeds and seedling for the proposed projects. Although the banana project targeted mainly banana pests i.e. banana nematodes and weevils, the current project will address damage caused by both the insects pests and diseases.

In our proposed project the biopesticides are targeting 1) root diseases (Fusarium, Rhizoctonia, Pithium, etc), 2) nematodes and 3) soil pests (e.g. cut worms, slugs and snails).

JKUAT incubation centre

JKUAT has production units that scale up technologies developed in the University for Purposes of commercialisation. This project will strengthen and add JKUAT capacity for training and developing enterprises in agro-technology (seed and bio-control technology). JKUAT recently won a UNIBRAIN sponsorship for a development of an incubation centre which would therefore be used to incubate the technologies proposed in this project.

13. INSTITUTIONAL SUPPORT (LETTER OF COMMITMENT)

Laboratory infrastructure, scientific equipment, vehicles and some chemicals (for preparation of bio-pesticides, field trials, etc.) is present at IITA, JKUAT, RealIPM and Alpha Seed from previous projects, including BIO-EARN. This infrastructure, scientific equipment, vehicles and chemicals will be made available for the current project, highly reducing capital cost at the beginning of the project. The two private companies will donate their products (bio-pesticides and seedlings) for use in the project. In addition, production facilities from the two companies will also be used at the experimental stages of the project.

Extensive direct contributions can be expected from the projects detailed under '12. Matching funds and commitment from host institutions' because of broad complementarities (e.g. further equipment, etc.). A large contribution from these complementary projects will be of time required for some of the scientists involved in the project, which will be available at a highly reduced cost. In addition, it is expected that the costs of planning meetings can reduced, because these costs will be shared with the two other complementary projects.

Partner support letters are attached to this application. Under '19. Detailed and summary project budget (USD)', all in-kind contributions, which equal 416,239 USD, are detailed.

14. MONITORING AND EVALUATION, DISSEMINATION AND COMMUNICATION PLANS

JKUAT will be the primary implementing organisation, responsible for coordinating activities with the partners. The JKUAT project managers will provide technical guidance and remain in close collaboration with each of the partners. Sub-agreements will be signed with all partners, which will allow for close monitoring and supervision of activities and expenditure. JKUAT has previously worked with most of the partners and is sure of their ability to deliver. Project financial records will be maintained according to JKUAT strict accounting standards and in line with Bio-Innovate guidelines, including internal and external auditing procedures.

Milestones are described in '16. Milestones and time frame', while indicators and procedures used for project monitoring, implementation and evaluation are described in '8. Methodology and description of project activities' and '17. Indicators of progress towards results'.

Project outputs will be defined as international public goods (IPGs). Research will be conducted using methods that allow for peer-reviewed publication in international journals. Information will be disseminated through numerous channels. A major emphasis will be placed on channels that target (1) seed and seedling companies; (2) policy makers and regulators; (3) smallholder farmers in the target countries. Ultimately, all information obtained through the project will be disseminated through extensive media networks (e.g. through IITA) and close linkages with national/regional stakeholders using the annual workshops, publications, dissertations and websites. Of major importance will be the final-year stakeholder meeting, during which guidelines for registration of the bio-pesticides and bio-enhancement of seeds and seedlings will communicated and discussed.

15. INTELLECTUAL PROPERTY AND OTHER POLICY ISSUES

The microbial organisms (*Trichoderma asperellum*, *Metarhizium anisopliae* and *Bacillus subtilis*), which constitute the active ingredients in the bio-pesticides and on which the project is founded, are registered/on the verge of being registered with Kenyan authorities (PCPB). *Trichoderma asperellum* and *Bacillus subtilis* are property of RealIPM, whilst *Metarhizium anisopliae* was isolated by ICIPE (International Centre for Insect Physiology and Ecology, Kenya) and RealIPM has an agreement to produce this organism under licence. A copy of this licence is attached to the application. RealIPM will develop distribution agreements with appropriate partners in other sub-Saharan Africa to commercialize the bio-pesticides. RealIPM already has experience in this in South Africa, Ghana and Tanzania, and could easily develop sustainable partnerships with distributors throughout the region.

Intellectual property rights related to technologies developed in the project (e.g. protocols) will be adhered to according to the IP regulations of JKUAT and IITA. As a fundamental principle, all intellectual property developed during the project will be defined as an international public good. JKUAT recognizes that teaching, research and innovation/invention involve complex relationships among several parties such as individual innovators/inventors, external research sponsors and various

departments. As a member of CGIAR, IITA and other partners will adheres to the principles contained in the Convention on Biological Diversity, the FAO-CGIAR Agreement on Genetic Resources, and the International Treaty on Plant Genetic Resources for Food and Agriculture. Existing national laws are always respected by the project partners.

No genetically engineered or potential hazardous organisms are involved in the project. Microbes used in the project occur naturally at high densities and frequencies in cultivated plants and are classified as non-toxic (CAST 2003).

16. MILESTONES AND TIME FRAME

Milestones to assess progress towards achieving outputs and time frame are presented in Annex 1.

17. INDICATORS OF PROGRESS TOWARDS RESULTS

Annual indicators to assess progress are presented in Annex 2.

18. PROJECT ACTIVITY PLANS

Activity plans according to the partners are presented in Annex 2. All activities have primary implementing partner(s) and secondary backstopping partner(s). However individual activity plans and time frame are as indicated in annex 5a.

JKUAT and Alpha Seed will develop commercially viable bio-enhancement protocols for tomato and eggplant, and evaluate seedling growth and tolerance/resistance to pests and diseases. IITA and RealIPM will develop commercially viable bio-enhancement protocols for maize, and evaluate seedling growth and tolerance/resistance to pests and diseases. IITA will implement a cost-benefit analysis for the technology. RealIPM will be charged with the responsibility of the extension-of-label of the bio-pesticides for use on tomatoes, eggplant, and maize in Kenya. IITA will take the lead in registration of the bio-pesticides in Uganda and Tanzania. JKUAT will be in charge of annual and final-year workshops, and provide information on regional registration of bio-pesticides and bio-enhancement, using the guidelines developed by RealIPM.

19. A SUMMARY PROJECT BUDGET (USD)

	YEAR 1	JKUAT	IITA	RealIPM	Alpha Seed Company	Total
A	Materials and supplies	57,350	23,150	11,050	10,000	**101,550**
B	Travel	7,900	8,000	0	0	**15,900**
C	Field work related research costs	21,230	17,766	8,310	8,310	**55,616**
D	General project expenses	13,200	10,000	1,800	1,800	**26,800**
E	Others (overhead)	9,968	11,371	0	0	**21,339**
	Total year 1	**109,648**	**70,287**	**21,160**	**20,110**	**221,205**
	YEAR 2	**JKUAT**	**IITA**	**RealIPM**	**Alpha Seed Company**	**Total**
A	Materials and supplies	11,250	8,250	2,650	2,500	**24,650**
B	Travel	16,100	6,500	2,500	2,500	**27,600**
C	Field work related research costs	21,718	17,862	8,646	8,646	**56,872**
D	General project expenses	14,200	9,700	1,800	1,700	**27,400**
E	Others (overhead)	6,327	8,166	0	0	**14,493**
	Total year 2	**69,595**	**50,478**	**15,596**	**15,346**	**151,015**
	YEAR 3	**JKUAT**	**IITA**	**RealIPM**	**Alpha Seed Company**	**Total**
A	Materials and supplies	0	500	2,000	1,500	**4,000**
B	Travel	3,600	0	0	0	**36,000**
C	Field work related research costs	54,328	18,458	5,232	5,232	**83,250**
D	General project expenses	12,800	10,500	1,400	1,500	**26,200**
E	Others (overhead)	7,073	5,685	0	0	**12,758**
	Total year 3	**77,801**	**35,143**	**8,632**	**8,232**	**129,808**
	Total over 3 years	**257,044**	**155,908**	**45,388**	**43,688**	**502,028**

A detailed project budget, per partner and including in kind contributions, is presented in Annex 3. Likely but not guaranteed future financial support from complementary sources is outlined in '12. Matching funds and commitment from host institution' and amount to ~2.5 million USD.
Funds disbursement has been budgeted in the following proportions 44% Yr1, 30% Yr2, and 26% Yr3.

20. LOG FRAME FOR THE PROJECT

A log frame is attached in Annex 4.

A list of references used in this proposal is presented in Annex 6.

ANNEX 1. MILESTONES AND TIME FRAME

Output	year 1		year 2		year 3	
	semester 1	semester 2	semester 1	semester 2	semester 1	semester 2
Objective 1: to develop bio-enhanced vegetable seeds and seedlings						
1.1. commercial protocols developed for vegetable seed/seedling bio-enhancement	initiation of protocol development for seed/seedling bio-enhancement of tomato and eggplant (using the most popular cultivar(s)/country)	completion of protocol development for seed/seedling bio-enhancement of tomato and eggplant (using the most popular cultivar(s)/country)				
1.2. growth increase, and pest and disease resistance demonstrated for vegetable seed/seedling bio-enhancement			initiation of on-station performance testing of bio-enhanced tomato and eggplant (using the most popular cultivar(s)/country)	completion of on-station performance testing of bio-enhanced tomato and eggplant (using the most popular cultivar(s)/country)		
1.3. cost/benefit ratio for vegetable seed/seedling bio-enhancement established					ex-ante cost benefit established for bio-enhanced tomato and eggplant seeds/seedlings with seed companies, nurseries and farmers	
1.4. synergistic effects between bio-enhancement and fertilizer input established for vegetable seeds/seedlings					initiation of on-station performance testing of bio-enhanced tomato and eggplant combined with selected fertilizer treatments (using the most popular cultivar(s)/country)	completion of on-station performance testing of bio-enhanced tomato and eggplant combined with selected fertilizer treatments (using the most popular cultivar(s)/country)
1.5. bio-pesticides registered for vegetable seed/seedling bio-enhancement in Tanzania and Uganda				initiation of registration of at least 1 bio-pesticide each on tomato and eggplant against at least 1 pest or disease/crop (in Tanzania and Uganda)	on-going registration of at least 1 bio-pesticide each on tomato and eggplant against at least 1 pest or disease/crop (in Tanzania and Uganda)	completion of registration of at least 1 bio-pesticide each on tomato and eggplant against at least 1 pest or disease/crop (in Tanzania and Uganda)
1.6. extension-of-label obtained for bio-pesticide use on vegetable seeds/seedlings in Kenya				initiation of extension-of-label of at least 1 bio-pesticide each on tomato and eggplant against at least 1 pest or disease/crop in Kenya	on-going extension-of-label of at least 1 bio-pesticide each on tomato and eggplant against at least 1 pest or disease/crop in Kenya	completion of extension-of-label of at least 1 bio-pesticide each on tomato and eggplant against at least 1 pest or disease/crop in Kenya

Objective 2: to develop bio-enhanced seeds of maize						
2.1. commercial protocols developed for maize seed bio-enhancement	initiation of protocol development for seed bio-enhancement of (using the most popular cultivar(s)/country)	completion of protocol development for seed bio-enhancement of (using the most popular cultivar(s)/country)				
2.2 growth increase, and pest and disease resistance demonstrated for maizeseed bio-enhancement			initiation of on-station performance testing of bio-enhanced maize (using the most popular cultivar(s)/country)	completion of on-station performance testing of bio-enhanced maize (using the most popular cultivar(s)/country)		
2.3. cost/benefit ratio for maize seed bio-enhancement established					ex-ante cost benefit established for bio-enhanced maize seeds with seed companies, nurseries and farmers	
2.4. synergistic effects between bio-enhancement and fertilizer input established for maize seeds					initiation of on-station performance testing of bio-enhanced maize combined with selected fertilizer treatments (using the most popular cultivar(s)/country)	completion of on-station performance testing of bio-enhanced maize combined with selected fertilizer treatments (using the most popular cultivar(s)/country)
2.5. bio-pesticides registered for maize seed bio-enhancement in Tanzania and Uganda				initiation of registration of at least 1 bio-pesticide each on maize against at least 1 pest or disease (in Tanzania and Uganda)	on-going registration of at least 1 bio-pesticide on maize against at least 1 pest or disease (in Tanzania and Uganda)	completion of registration of at least 1 bio-pesticide each on maize against at least 1 pest or disease (in Tanzania and Uganda)
2.6. extension-of-label obtained for bio-pesticide use on maize seeds in Kenya				initiation of extension-of-label of at least 1 bio-pesticide each on maize against at least 1 pest or disease in Kenya	on-going extension-of-label of at least 1 bio-pesticide each on maize against at least 1 pest or disease in Kenya	completion of extension-of-label of at least 1 bio-pesticide each on maize against at least 1 pest or disease in Kenya

Objective 3: to facilitate regional harmonisation of bio-pesticide registration and promote bio-enhancement of seeds and seedlings						
3.1. information and best practices shared on bio-pesticide registration and bio-enhancement						conduct a workshop on bio-pesticide registration procedures in Kenya, Uganda and Tanzania, and bio-enhancement of seeds and seedlings
3.2. guidelines published for bio-pesticide registration in the region (Kenya, Uganda and Tanzania), and merits of bio-enhancement of seeds and seedlings		compare and document procedures for bio-pesticide registration in Kenya, Tanzania and Uganda			write and publish guidelines for bio-pesticide registration in the region (Kenya, Uganda and Tanzania), and merits of bio-enhancement of seeds and seedlings	

ANNEX 2. INDICATORS OF PROGRESS TOWARDS RESULTS, AND PROJECT ACTIVITY PLANS

outputs	primary partner	secondary partner	indicators		
			year 1	year 2	year 3
Objective 1: to develop bio-enhanced vegetable seeds and seedlings					
1.1. commercial protocols developed for vegetable seed/seedling bio-enhancement	JKUAT, Alpha Seed	IITA, RealIPM	protocol for seed/seedling bio-enhancement of tomato and eggplant for at least 1 bio-pesticide/crop		
1.2. growth increase, and pest and disease resistance demonstrated for vegetable seed/seedling bio-enhancement	JKUAT, Alpha Seed	IITA, RealIPM		tomato and eggplant growth enhanced by at least 20% and 50% reduction of at least 1 pest or disease/crop	
1.3. cost/benefit ratio for vegetable seed/seedling bio-enhancement established	IITA	JKUAT, RealIPM, Alpha Seed		increased profit of at least 10% established for tomato and eggplant farmers	
1.4. synergistic effects between bio-enhancement and fertilizer input established for vegetable seeds/seedlings	JKUAT, Alpha Seed	IITA, RealIPM		synergistic effects of combining bio-enhancement with fertilizer use quantified for tomato for at least 1 bio-pesticide	synergistic effects of combining bio-enhancement with fertilizer use quantified for eggplant for at least 1 bio-pesticide
1.5. bio-pesticides registered for vegetable seed/seedling bio-enhancement in Tanzania and Uganda	IITA, Alpha seed	RealIPM			registration of at least 1 bio-pesticide each on tomato and eggplant against at least 1 pest or disease/crop (in Tanzania and Uganda)
1.6. extension-of-label obtained for bio-pesticide use on vegetable seeds/seedlings in Kenya	RealIPM	JKUAT			extension-of-label of at least 1 bio-pesticide each on tomato and eggplant against at least 1 pest or disease/crop in Kenya
Objective 2: to develop bio-enhanced seeds of maize					
2.1. commercial protocols developed for maize seed bio-enhancement	IITA, RealIPM	JKUAT, Alpha Seed	protocol for seed bio-enhancement of maize for at least 1 bio-pesticide		
2.2 growth increase, and pest and disease resistance demonstrated for maize seed bio-enhancement	IITA, RealIPM	JKUAT, Alpha Seed		maize growth enhanced by at least 20% and 50% reduction of at least 1 pest or disease/crop	
2.3. cost/benefit ratio for maize seed bio-enhancement established	IITA	JKUAT, RealIPM, Alpha Seed		increased profit of at least 10% established for maize farmers	
2.4. synergistic effects between bio-enhancement and	IITA, RealIPM	JKUAT, Alpha Seed		synergistic effects of combining bio-enhancement with fertilizer	synergistic effects of combining bio-enhancement with fertilizer

fertilizer input established for maize seeds				use quantified for maize for at least 1 bio-pesticide	
2.5. bio-pesticides registered for maize seed bio-enhancement in Tanzania and Uganda	IITA, Alpha seed	RealIPM			registration of at least 1 bio-pesticide each on maize against at least 1 pest or disease (in Tanzania and Uganda)
2.6. extension-of-label obtained for bio-pesticide use on maize seeds in Kenya	RealIPM	JKUAT			extension-of-label of at least 1 bio-pesticide each on maize against at least 1 pest or disease in Kenya
Objective 3: to facilitate regional harmonisation of bio-pesticide registration and promote bio-enhancement of seeds and seedlings					
3.1. information and best practices shared on bio-pesticide registration and bio-enhancement	JKUAT	IITA, RealIPM, Alpha Seed			workshop proceedings on bio-pesticide registration, and bio-enhancement of seeds and seedlings published
3.2. guidelines published for bio-pesticide registration in the region (Kenya, Uganda and Tanzania), and merits of bio-enhancement of seeds and seedlings	RealIPM	JKUAT, IITA, Alpha Seed			guidelines on bio-pesticide registration, and bio-enhancement of seeds and seedlings published

ANNEX 4. LOG FRAME

output	outcome	performance indicator of outcome	data source	collection method	assumptions - assessment of progress/achievements
Objective 1: to develop bio-enhanced vegetable seeds and seedlings					
1.1. commercial protocols developed for vegetable seed/seedling bio-enhancement	seed companies incorporate protocols for vegetable seed/seedling bio-enhancement; bio-enhanced vegetable seeds/seedlings commercially available to nurseries and farmers	at least one seed company per country (Kenya, Tanzania, Uganda) incorporates bio-enhancement of vegetable seeds/seedlings in production line	▪ sales records from seed companies ▪ protocols ▪ project reports ▪ student theses ▪ peer-reviewed publications ▪ laboratory notebooks	▪ laboratory and screenhouse experiments	▪ timely import and export approvals ▪ continued interest of the private sector ▪ commercial viability of bio-enhancement technology ▪ willingness of farmers to participate and buy bio-enhanced vegetable seeds/seedlings
1.2. growth increase, and pest and disease resistance demonstrated for vegetable seed/seedling bio-enhancement	vegetable farmers experience increased yields, and better protection against pest and diseases; vegetable farmers reduce pesticide use	farmers using bio-enhanced vegetable seeds/seedlings increase yield by at least 10%; farmers using bio-enhanced vegetable seeds/seedlings reduce use of pesticides by at least 15%	▪ yield data and sales records from farmers ▪ project reports ▪ student theses ▪ peer-reviewed publications ▪ laboratory notebooks	▪ screenhouse and field experiments ▪ farmer field data collection	▪ continued interest of the private sector ▪ willingness of farmers to participate and buy bio-enhanced vegetable seeds/seedlings
1.3. cost/benefit ratio for vegetable seed/seedling bio-enhancement established	market demand exists by nurseries and farmers for bio-enhanced vegetable seeds/seedlings	at least one seed company per country (Kenya, Tanzania, Uganda) increases profit from selling bio-enhanced vegetable seed/seedlings to farmers; farmers using bio-enhanced vegetable seeds/seedlings increase profit by at least 10%	▪ costs and sales records from seed companies ▪ project reports ▪ peer-reviewed publications	▪ seed company, nursery and farmer questionnaires ▪ economic data collection and analysis	▪ continued interest of the private sector ▪ commercial viability of bio-enhancement technology ▪ willingness of farmers to participate and buy bio-enhanced vegetable seeds/seedlings
1.4. synergistic effects between bio-enhancement and fertilizer input established for vegetable seeds/seedlings	seed companies/nurseries combine use of fertilizer together with bio-enhancement of vegetable seeds/seedlings to maximize yield	at least one seed company and nursery combine use of fertilizer together with bio-enhancement of vegetable seeds/seedlings	▪ costs and sales records from seed companies and nurseries ▪ project reports ▪ student theses ▪ peer-reviewed publications	▪ laboratory and screenhouse experiments	▪ continued interest of the private sector ▪ commercial viability of bio-enhancement technology ▪ willingness of farmers to participate and buy bio-enhanced vegetable

					seeds/seedlings
1.5. bio-pesticides registered for vegetable seed/seedling bio-enhancement in Tanzania and Uganda	bio-pesticides are available and widely known for commercial use as bio-enhancers of vegetable seeds/seedlings in Uganda and Tanzania	registration of at least one bio-pesticide for use as bio-enhancer of vegetable seeds/seedlings in Uganda and Tanzania	▪ registration dossiers ▪ registration permits ▪ project reports	▪ bio-pesticide eco-tox dossiers ▪ government-approved registration field trials	▪ clear governments procedures and cooperation in Uganda and Tanzania ▪ timely application of registration with relevant Tanzanian and Ugandan bodies (PCPB)
1.6. extension-of-label obtained for bio-pesticide use on vegetable seeds/seedlings in Kenya	bio-pesticides are available and widely known for commercial use as bio-enhancers of vegetable seeds/seedlings in Kenya	registration of at least one bio-pesticide for use as bio-enhancer of vegetable seeds/seedlings in Kenya	▪ registration dossiers ▪ registration permits ▪ project reports	▪ bio-pesticide eco-tox dossiers ▪ government-approved registration field trials	▪ government cooperation ▪ timely application of registration with relevant Kenyan bodies (PCPB)
Objective 2: to develop bio-enhanced seeds maize					
2.1. commercial protocols developed for maize seed bio-enhancement	seed companies incorporate protocols for maize seed bio-enhancement; bio-enhanced maize seeds commercially available to nurseries and farmers	at least one seed company per country (Kenya, Tanzania, Uganda) incorporates bio-enhancement of maize seeds in production line	▪ sales records from seed companies ▪ protocols ▪ project reports ▪ student theses ▪ peer-reviewed publications ▪ laboratory notebooks	▪ laboratory and screenhouse experiments	▪ timely import and export approvals ▪ continued interest of the private sector ▪ commercial viability of bio-enhancement technology ▪ willingness of farmers to participate and buy bio-enhanced maize seeds
2.2 growth increase, and pest and disease resistance demonstrated for maize seed bio-enhancement	maize farmers experience increased yields, and better protection against pest and diseases	farmers using bio-enhanced maize seeds increase yield by at least 10%	▪ yield data and sales records from farmers ▪ project reports ▪ student theses ▪ peer-reviewed publications ▪ laboratory notebooks	▪ screenhouse and field experiments ▪ farmer field data collection	▪ continued interest of the private sector ▪ willingness of farmers to participate and buy bio-enhanced maize seeds
2.3. cost/benefit ratio for maize seed bio-enhancement established	market demand exists by nurseries and farmers for bio-enhanced maize seeds	at least one seed company per country (Kenya, Tanzania, Uganda) increases profit from selling bio-enhanced maize seeds to farmers; farmers using bio-enhanced maize seeds increase profit by at least 10%	▪ costs and sales records from seed companies ▪ project reports ▪ peer-reviewed publications	▪ seed company, nursery and farmer questionnaires ▪ economic data collection and analysis	▪ continued interest of the private sector ▪ commercial viability of bio-enhancement technology ▪ willingness of farmers to participate and buy bio-enhanced maize seeds

2.4. synergistic effects between bio-enhancement and fertilizer input established for maize seeds	seed companies/nurseries combine use of fertilizer together with bio-enhancement of maize seeds to maximize yield	at least one seed company and nursery combine use of fertilizer together with bio-enhancement of maize seeds	▪ costs and sales records from seed companies and nurseries ▪ project reports ▪ student theses ▪ peer-reviewed publications	▪ laboratory and screenhouse experiments	▪ continued interest of the private sector ▪ commercial viability of bio-enhancement technology ▪ willingness of farmers to participate and buy bio-enhanced vegetable seeds/seedlings
2.5. bio-pesticides registered for maize seed bio-enhancement in Tanzania and Uganda	bio-pesticides are available and widely known for commercial use as bio-enhancers of maize seeds in Uganda and Tanzania	registration of at least one bio-pesticide for use as bio-enhancer of vegetable seeds/seedlings in Uganda and Tanzania	▪ registration dossiers ▪ registration permits; ▪ project reports	▪ bio-pesticide eco-tox dossiers ▪ government-approved registration field trials	▪ clear governments procedures and cooperation in Uganda and Tanzania ▪ timely application of registration with relevant Tanzanian and Ugandan bodies (PCPB)
2.6. extension-of-label obtained for bio-pesticide use on maize seeds in Kenya	bio-pesticides are available and widely known for commercial use as bio-enhancers of maize seeds in Kenya	registration of at least one bio-pesticide for use as bio-enhancer of maize seeds in Kenya	▪ registration dossiers ▪ registration permits ▪ project reports	▪ bio-pesticide eco-tox dossiers ▪ government-approved registration field trials	▪ government cooperation ▪ timely application of registration with relevant Kenyan bodies (PCPB)
Objective 3: to facilitate regional harmonisation of bio-pesticide registration and promote bio-enhancement of seeds and seedlings					
3.1. information and best practices shared on bio-pesticide registration and bio-enhancement	regional registration of bio-pesticides is facilitated and complements the ACTESA and COMESA initiatives, and bio-enhancement of seeds and seedlings is promoted	increased number of registered bio-pesticides, facilitated regional registration of bio-pesticides, and awareness of bio-enhancement of seeds and seedlings	▪ bio-pesticide company sales records ▪ official list of registered products of with Kenyan authorities (PCPB) and equivalent bodies in Tanzania and Uganda	▪ attendance list at third year workshop; evaluation reports by workshop participants; cooperation with and interest from regional bodies; project review; own data collected during project	▪ clear governments procedures and cooperation in Kenya, Uganda and Tanzania ▪ interest of the private sector (bio-pesticide companies and seed companies)
3.2. guidelines published for bio-pesticide registration in the region (Kenya, Uganda and Tanzania), and merits of bio-enhancement of seeds and seedlings	registration of bio-pesticides, and bio-enhancement of seeds and seedlings are explained and promoted	increased number of registered bio-pesticides and awareness of bio-enhancement of seeds and seedlings	▪ bio-pesticide company sales records ▪ official list of registered products of with Kenyan authorities (PCPB) and equivalent bodies in Tanzania and Uganda	▪ cooperation with and interest from regional bodies; project review; own data collected during project	▪ clear governments procedures and cooperation in Kenya, Uganda and Tanzania ▪ interest of the private sector (bio-pesticide companies and seed companies)

ANNEX 5a. Project Activity Plan

Objective 1: to develop bio-enhanced vegetable seeds and seedlings		Year 1		Year 2		Year 3	
Activity	Involved Partner and scientists	H1	H2	H1	H2	H1	H2
1.1. To develop protocols for vegetable seed/seedling bio-enhancement	JKUAT and Alpha seeds						
1.2. To assess growth and pest and disease resistance for vegetable seed/seedling bio-enhancement	JKUAT and Alpha seeds						
1.3. To undertake a cost/benefit ratio analysis for vegetable seed/seedling bio-enhancement established	JKUAT and Alpha seeds						
1.4. to assess synergistic effects between bio-enhancement and fertilizer input established for vegetable seeds/seedlings	JKUAT and Alpha seeds						
1.5. to register biopesticides for vegetable seed/seedling bio-enhancement in Tanzania and Uganda	Real IPM and Alpha seeds						
1.6. to undertake extension-of-label obtained for bio-pesticide use on vegetable seeds/seedlings in Kenya	Real IPM and JKUAT						
Objective 2: to develop bio-enhanced seeds of maize							
2.1. To develop protocols for maize seed/seedling bio-enhancement	IITA and RealIPM						
2.2. To assess growth and pest and disease resistance for maize seed/seedling bio-enhancement	IITA and RealIPM						
2.3. To undertake a cost/benefit ratio analysis for maize seed/seedling bio-enhancement established	IITA						
2.4. to assess synergistic effects between bio-enhancement and fertilizer input established for maize seeds/seedlings	IITA and RealIPM						
2.5. to register biopesticides for maize seed/seedling bio-enhancement in Tanzania and Uganda	IITA and ALFA seeds						
2.6. to undertake extension-of-label obtained for bio-pesticide use on maize seeds/seedlings in Kenya	RealIPM						
Objective 3: to facilitate regional harmonisation of bio-pesticide registration and promote bio-enhancement of seeds and seedlings							
3.1. to share information and best practices on bio-pesticide registration and bio-enhancement	JKUAT						
3.2. to publish guidelines for bio-pesticide registration in the region (Kenya, Uganda and Tanzania), and merits of bio-enhancement of seeds and seedlings	IITA and RealIPM						

Annex 5b

Description of project Activities

PARTNER INSTITUTIONS: JKUAT

Activity 1.1 developing commercial protocols for vegetable seed/seedling bio-enhancement
This activity involves development of protocol for bio-enhancement of tomato and eggplant seed/seedling for at least 1 bio-pesticide/crop. This activity will start in Year one. This will involve testing for best methods of inoculation and optimisation of spore concentration. JKUAT will deal with the tomato and eggplant seedlings which will be replicated in Tanzania by Alfa seeds.

Activity 1.2 Assessing growth and pest and disease resistance for vegetable seed/seedling bio-enhancement
This activity involves growing inoculated seedling and assessing their tolerance to disease and pest. This will involve designing screenhouse experiment where inoculated plants will be tested for tolerance to pest and diseases. Plants will be inoculated and at various stages the effects of disease is monitored and quantified.

Activity 1.3 Undertaking a cost/benefit ratio analysis for vegetable seed/seedling bio-enhancement established
This activity will involve determining the cost of inoculating plants and compare them with contemporary TC plants. This will ascertain the profitability of enhanced seeds and seedlings. Value of inputs involved in seed enhancement will be determine and compared with cost of raising seedlings the field and yield of the full crop could also be assessed.

Activity 1.4 Establishing synergistic effects between bio-enhancement and fertilizer input for vegetable seeds/seedlings
The JKUAT and Alfa seeds will grow bio-enhanced seeds and seedlings and determine the effects of fertilisers or the colonisation of the seedling and the effects of fertiliser on the bio-pesticides and their combined effect on pest and disease management and plant growth. This activity will be carried out in the third year.

Activity 1.6 Undertaking extension-of-labels obtained for bio-pesticide use on vegetable seeds/seedlings in Kenya
This activity will involve extending registration of label for registered bio-pesticides on other crops to tomatoes and eggplant. This will involve the application of registration of label through the control bodies such PCPB in Kenya. JKUAT will work with RealIPM in developing the required documentation and submitted to PCPB. The consortium hope that since the bio-pesticide are already registered for use on other crops on in Kenya, documentation and time required will be shorter and the efficacy trials as well as eco-toxicological test may not be necessary.

Activity 3.1 sharing information and best practices on bio-pesticide registration and bio-enhancement
JKUAT will organise seminars and meetings with relevant stake holders authorities involved in the process of bio-pesticide enhancement. This activity will be conducted in when sufficient information has been collected.

PARTNER INSTITUTIONS: IITA

Activity 2.1 developing protocols for maize seed/seedling bio-enhancement
This activity involves production of protocol for seed/seedling bio-enhancement of maize for at least 1 bio-pesticide. This activity will start in Year one. This will involve testing for best methods of inoculation and optimisation of spore concentration. IITA will deal with the maize protocols development in Uganda and RealIPM will assist.

Activity 2.2 assessing growth and pest and disease resistance for bio-enhancement maize seed/seedling

This activity involves growing inoculated seedling and assessing their tolerance to disease and pest. This will involve designing screenhouse experiment where inoculated seeds will be tested for tolerance to pest and diseases. Inoculated seedlings will be tested for tolerance to insect pest and diseases at the germination and seedling stage. Thereafter growth will be assessed.

Activity 2.3 Undertaking a cost/benefit ratio analysis for maize seed/seedling bio-enhancement established

This activity will involve determining the cost of inoculating plants and compare with non-inoculating maize seedlings. This will ascertain the profitability of enhanced seeds and seedlings. Value of inputs involved in seed enhancement will be determined and compared with cost of non-enhanced seedlings the field and yield of the full crop could also be assessed.

Activity 2.4 Assessing synergistic effects between bio-enhancement and fertilizer input established for maize seeds/seedling

The IITA will grow bio-enhanced maize seeds and seedlings and determine the effects of fertilisers or the colonisation of the seedling and the effects of fertiliser on the bio-pesticides and their combined effect on pest and disease management and plant growth. IITA will also try to determine the effects of seed dressing chemicals on the bio-pesticide.

Activity 2.5 registering bio-pesticides for maize seed/seedling bio-enhancement in Tanzania and Uganda

IITA together with RealIPM will develop protocols and apply for bio-pesticide registration. Dossier for registration of these bio-pesticides will be developed and procedures applicable for Uganda will be adhered to. Efficacy trial and ecotoxicology test will be conducted.

Activity 3.2 publishing guidelines for bio-pesticide registration in the region (Kenya, Uganda and Tanzania), and merits of bio-enhancement of seeds and seedlings

This activity involved harmonising the bio-pesticide registration process in the region; IITA will ensure that best practices for Bio-pesticides registration will be undertaken. Guidelines applicable for the region will be published to ensure ease of pesticides registration.

PARTNER INSTITUTIONS: REALIPM

Activity 1.5 registering bio-pesticides for vegetable seed/seedling bio-enhancement in Tanzania and Uganda

In this activity RealIPM will use her experience in bio-pesticide registration for assisting IITA and ALFA seeds to register Bio-pesticides in the respective countries. This activity involves development of ecotoxicological dossiers, efficacy data and control boards applications.

Activity 1.6 Undertaking extension-of-labels obtained for bio-pesticide use on vegetable seeds/seedlings in Kenya

This activity will involve extending registration of label for registered bio-pesticides on other crops to tomatoes and eggplant. This will involve the application of registration of label through the control bodies such PCPB in Kenya. RealIPM will develop the required documentation and submitted to PCPB. The consortium hope that since the bio-pesticide are already registered for use on other crops on in Kenya, documentation and time required is not much and the efficacy trials as well as eco-toxicological test.

Activity 2.1 developing protocols for maize seed/seedling bio-enhancement

This activity involves production of protocol for seed/seedling bio-enhancement of maize for at least 1 bio-pesticide. This activity will start in Year one. This will involve testing for best methods of inoculation and optimisation of spore concentration. IITA will deal with the maize protocols development in Uganda and RealIPM.

Activity 2.2 assessing growth and pest and disease resistance for bio-enhancement maize seed/seedling

This activity involves growing inoculated seedling and assessing their tolerance to disease and pest. This will involve designing screenhouse experiment where inoculated seeds will be tested for tolerance to pest and diseases. Inoculated seedlings will be tested for tolerance to insect pest and diseases at the germination and seedling stage. Thereafter growth will be assessed.

Activity 2.4 Assessing synergistic effects between bio-enhancement and fertilizer input established for maize seeds/seedling

The RealIPM and IITA will grow bio-enhanced maize seeds and seedlings and determine the effects of fertilisers or the colonisation of the seedling and the effects of fertiliser on the bio-pesticides and their combined effect on pest and disease management and plant growth. RealIPM will determine the effects of chemically dressed maize seeds to the efficacy of the bio-pesticide.

Activity 3.2 publishing guidelines for bio-pesticide registration in the region (Kenya, Uganda and Tanzania), and merits of bio-enhancement of seeds and seedlings

RealIPM will bring verse experience in registration of bio-pesticides in the region. Together With IITA, RealIPM will compile all the guidelines for the three countries in the region that we hope will enable harmonisation of guidelines for bio-pesticides registration. This activity involved harmonising the bio-pesticide registration process in the region; IITA will ensure that best practices for Bio-pesticides registration will be undertaken. Guidelines applicable for the three countries will be published to ensure ease of pesticides registration.

PARTNER INSTITUTIONS: ALFA SEEDS

Activity 1.1 developing commercial protocols for vegetable seed/seedling bio-enhancement

This activity involves production of protocol for seed/seedling bio-enhancement of tomato and eggplant for at least 1 bio-pesticide/crop. This activity will start in Year one. This will involve testing for best methods of inoculation and optimisation of spore concentration. Alfa seeds will work with JKUAT for the tomato and eggplant seedling.

Activity 1.2
2 Assessing growth and pest and disease resistance for vegetable seed/seedling bio-enhancement

This activity involves growing inoculated seedling and assessing their tolerance to disease and pest. This will involve designing screenhouse experiment where inoculated plants will be tested for tolerance to pest and diseases. Plants will be inoculated and at various stages the effects of disease is monitored and quantified.

Activity 1.3 Undertaking a cost/benefit ratio analysis for vegetable seed/seedling bio-enhancement established

This activity will involve determining the cost of inoculating plants and compare them with contemporary TC plants. This will ascertain the profitability of enhanced seeds and seedlings. Value of inputs involved in seed enhancement will be determine and compared with cost of raising seedlings the field and yield of the full crop could also be assessed.

Activity 1.4 Establishing synergistic effects between bio-enhancement and fertilizer input for vegetable seeds/seedlings

The JKUAT and Alfa seeds will grow bio-enhanced seeds and seedlings and determine the effects of fertilisers or the colonisation of the seedling and the effects of fertiliser on the bio-pesticides and their combined effect on pest and disease management and plant growth. This activity will be carried out in the third year.

Activity 1.5 registering bio-pesticides for vegetable seed/seedling bio-enhancement in Tanzania and Uganda

ALFA SEEDS will work with other partners on registration of Bio-pesticides in the Tanzania. This activity involves development of ecotoxicological dossiers, efficacy data and control boards applications in Tanzania

Activity 2.5 registering bio-pesticides for maize seed/seedling bio-enhancement in Tanzania and Uganda

ALFA seeds will develop protocols and apply for bio-pesticide registration in Tanzania. Dossier for registration of these bio-pesticides will be developed and procedures applicable for Tanzania will be adhered to. Efficacy trial and ecotoxicology test will be conducted. With Inputs from other partners ALFA SEEDS will lead the registration process in Tanzania. They will

ANNEX 5c. CURRICULUM VITAES OF PIs AND CO-PIs

Name **Prof. Esther Murugi Kahangi (PhD)**

Professional preparation

Degree	Major, Year, and Institution
BSc Horticulture	Horticulture, 1976 Weihenstephan, Germany
MSc Plant Science	Plant Science- 1979 , University of Nairobi, Kenya
PhD Plant Sciences	Plant Sciences. 1994, University of Nairobi, Kenya

Appointments

Full Professor	2007 to date. Jomo Kenyatta University of Agric and Tech Council
Associate Professor	1996 - 2006. JKUAT Council
Senior Lecturer	1992 - 1996. University College Council
Lecturer	University College Council, JKUAT
Deputy Vice Chancellor-JKUAT	May 2007 to date. DVC- In charge of Research Production and Extension- Principle assistant and advisor to the Vice Chancellor
Director, BIO-EARN	May 2006 - May 2007: Director of east African regional program and network on Biotechnology, Biosafety and Bio policy (BIOEARN); three year program with a budget of USD 10,000,000 (research grant for SIDA)
Director, IBR JKUAT	1991 - 2004. Director, Institute for Biotechnology Research at JKUAT- Established the institute from scratch
Dean, Faculty of Agriculture	1985 - 1990. Dean Faculty of Agriculture
Chairman, Dept. of Horticulture	1982 - 1991. Initiated the Department of Horticulture
Head of Section	1976 – 1981. Head of Vegetable Seed Production Section at National Horticultural research Station, and also in charge of country's research in vegetable seed production

Selected publications

Okumu, M.O., Van Asten, P.J.A.,. **Kahangi, E.M.**, Okech, S.H., Jefwa, J., Vanlauwe, B. 2011. Production gradients in smallholder banana (cv. Giant Cavendish) farms in Central Kenya. Scientia Horticulturae.

Makobe, M.N., Misra, A.N., Imbuga, M.O., **Kahangi E.M**. 2007. Field evaluation of tissue cultured-regenerated sorghum (*Sorghum bicolor* L) Moench for development of salinity tolerance. East African Journal of Botany.

Kuria, P., Demo, P., Nyende, A.B., **Kahangi, E.M**. 2007. Cassava starch as an alternative cheap gelling agent for in in-vitro micropropagation of potato. African Journal for Biotechnology.

Ongoso, J., **Kahangi, E.M**., Ndiritu, D., Miizutani, F. 2004. Genetic characterization of cultivated bananas and plantains in Kenya by RAPD markers. Scientia Horticulturae.

Synergistic activities

September, 2008: Hired by Sida, Sweden to evaluate a regional project proposal involving 9 East African countries. The proposal was on plant genetic resource conservation / establishment of regional genebanks

February, 2006.Consultancy to conduct research on technological & policy issues constraining farmers from establishing viable micro- and small food processing enterprises in Machakos and Muranga

January, 2006. Member of team of consultants contracted by NEMA to review an environmental impact assessment report by PharmEng Technology (cfr. establishment of a research facility at ILRI for Biosciences for Eastern and Central Africa (BecA))

Current membership in national/regional/international Boards

Member of KARI board of directors; Trustee board member, Kenya Horticultural Association; Commonwealth Director; Member of Kilimo Trust Board (A Regional Trust supported by Gatby, UK); Member of the Executive Board of Generation Challenge Programme (international research Consortium supported by various donor agencies); Member of the International Society of Horticultural Science

Research grants (total Amount: USD 4,012,880)

2008-2011: German Ministry of Foreign Affairs (BMZ) & BIOEARN: tissue culture market pathways
2009: Bill & Melinda Gates Foundation: 6th Conference of Global Consortium of Higher Education & Research for Agriculture (GCHERA)
2005-2008: German Ministry of Foreign Affairs (BMZ): endophytes
2004-2007: Rockefeller Foundation: nutrients limiting banana production in Kenya and Uganda
2001: UNESCO: Chair in Biotechnology

International and local recognition

2005: Presidential recognition. Elder of Burning Spear (EBS)
2005: Rated among the top 50 women in East Africa by Oakland Publishers

2002: Awarded UNESCO Chair in Biotechnology

Name	**Losenge Turoop**
Date of birth	December 28, 1971, Suguta Marmar, Samburu District, Kenya.
Citizenship	Kenyan
Sex	Male
Profession	Phytopathologist
Education	PhD (Phytopathology), MSc Horticulture; Major in Phytopathology and Entomology BSc (Horticulture)
Languages	English, Kiswahili and German
Professional Membership	Member, the American Phytopathological Society Member, the Kenya Horticultural Association
Contact details	Department of Horticulture JKUAT Box 62000 Nairobi, Kenya Email: losenge@yahoo.com Tel: +254 0735 248 436

EDUCATION

April 2008 - Feb 2010	Visiting scholar at the Department of Horticulture Clemson University, South Carolina USA
2006 – 2007	Short course in Project cycle management, Humbodt, University, Germany Postdoctoral Fellow, University of Hannover, Germany
2001- 2005	PhD Jomo Kenyatta University of Agriculture and Technology, Kenya
1998 - 1999	MSc in Horticulture; Major in Phytopathology and Entomology (University of Hannover, Germany)
1992 - 1995	BSc in Horticulture second class honours upper division (JKUAT, Kenya)

WORK EXPERIENCE

April 2010 -	Senior Lecturer JKUAT
2005 - 2010	Lecturer Department of Horticulture, Jomo Kenyatta University of Agriculture and Technology
2000 - 2005	Tutorial Fellow at the Department of Horticulture, Jomo Kenyatta University of Agriculture and Technology

Jan - April 1994	Worked as supervisor in production of green beans on attachment basis for four months in Homegrown Kenya LTD
1993	Attached to the Ministry of Agriculture as a field extension officer for three months
1992	Worked in a community child help project as a social worker for four months in Lerroki Child Programme affiliated to Christian Children Fund

SELECTED PUBLICATIONS

Mwaura P., Dubois T., Losenge T., Coyne D. and Kahangi E. 2010. Effect of endophytic *Fusarium oxysporum* on paralysis and mortality of *Pratylenchus goodeyi.* African Journal of Biotechnology 9: 1130-1134.

Turoop L., James F.E . and Simon S.W. 2009. Transmission and management of tobacco mosaic virus in a greenhouse environment. Phytopathology, 99: S131-S131.

Mbaka J.N., Wamocho L.S., Turoop L. and Waiganjo M.M. 2009. In vitro growth inhibition of Kenyan *Phytophthora cinnamomi* isolates by different fungicide formulations. Journal of Applied Biosciences 20: 1159-1165.

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Mbaka J.N., Losenge T., Waiganjo M.M. and Wamocho L.S 2010**.** Phenotypic variation in three *Phytophthora cinnamomi* populations from macadamia growing areas in Kenya. Journal of Animal & Plant Sciences 1: 900- 911.

CURRICULUM VITAE

Engr. Thomas DUBOIS, Ph.*D.*

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Email: t.dubois@cgiar.org

EDUCATION

PhD entomology 2003 — **Cornell University**, USA
- Concentration: invertebrate pathology - GPA 3.81
- Includes 4 years of field work in China

BSc and MSc bioengineering 1997 — **University of Gent**, Belgium
- Graduated with Great Distinction (represents top 5% of class), with agriculture as specialization

PROFESSIONAL EXPERIENCE

Employment

- 2003 – present: Scientist, International Institute of Tropical Agriculture (IITA)
- 1998: Junior Research Expert, Flemish Association for Development, Cooperation and Technical Assistance (VVOB), Nigeria

Project management

- Responsible for total portfolio of 4.56 million USD, including monitoring and implementation, management of human resources, budgets, procurement
- streamlined private sector networks, enhanced distribution channels, initiated farmer cooperatives, formed contract farming systems, developed training modules in production, credit, marketing, business operations and group formation (Burundi, Kenya, Tanzania, Uganda)
- implemented project continuum from upstream (molecular) to downstream research (on-farm), stimulated public-private partnerships (Burundi, Kenya, South Africa, Uganda)
- Research published in >150 articles/press items, of which 34 peer-reviewed articles

Awards / consultancies

- 2006 World Bank Young Promising Scientist Award
- Member of Expert Committee on FAO's 2011 background study "Effect of climate change on microbial genetic resources"
- Member of Steering Committee of UNCTAD's annual flagship innovation reports; reviewer of 2010 report "Technology and innovation: enhancing food security in Africa through science, technology and innovation"
- Chair of session "Policy coherence in biotechnology at the national and regional level" during FAO Annual Technical Conference 2010

Banana2008

- Chair of Organizing Committee of first pan-African banana conference (Mombasa, Kenya, 5 - 9 Oct 2008)
- Organized by consortium of 21 institutions/organizations/private companies/donors
- Attended by >350 participants from >60 countries, incl. Ministers of Agriculture from Kenya, Rwanda and Uganda; Undersecretary-General UN; policy makers; large and small private sector; government representatives; large contingent of journalists

Capacity building

- Supervised and trained 6 PhD, 19 MSc and 4 BSc university students, and numerous research technicians and associates in 7 countries
- Formal and informal training of private sector, farmers and farmer groups

Partnerships

- Coordination of research and forming linkages between actors in 7 countries
- Partners include universities, private sector, farmer groups, NGOs, governmental organizations and international organizations, with special emphasis on public-private sector partnerships

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CURRICULUM VITAE

DANNY COYNE

CONTACT: International Institute of Tropical Agriculture c/o IITA, Carolyn House,
26 Dingwall Road, Croydon CR9 3EE England
Tel: + 256 (0)752787802; +255 (0)767500442; e-mail: d.coyne@cgiar.org

SPECIALISM: Agricultural research; tropical agriculture; integrated pest management; training and extension; plant nematology; smallholder farming; project management

LANGUAGES: English (mother tongue), French, Kiswahili

KEY EXPERTISE AND EXPERIENCE

Primarily a plant nematologist with twenty years experience in agricultural research and extension in tropical cropping systems across Africa and in UK agrochemical field trials co-ordination. In-depth knowledge of tropical crop systems through involvement in, and management of, crop protection extension and pest management projects within African National programmes and at International Agricultural Research Centres. Project management and team leadership within a regional context necessitating co-ordination of staff and activities over distance, across national programmes and facilitating the integration of activities into national programmes. Experience in the development of project proposals, implementation, monitoring and evaluation of projects/activities, training of regional agricultural staff and financial accountability. Expertise in design and management of research projects, extension methodologies, IPM, team leadership, training, crop protection, participatory survey methodologies, collaboration within multidisciplinary projects, presentation of research findings, computer & data analysis.

PhD STUDENT SUPERVISER/PROMOTER
11 students, finalized or in progress at various universities

MSc STUDENT SUPERVISER/PROMOTER
Numerous

GRANTS
Numerous grants awarded since 2001 as lead or co-lead investigator or contributor

PUBLICATIONS: **Books:** 3 as primary editor
Book Chapters: 7 as co-author
Scientific Journal Articles: 101 articles
Extension material/articles: numerous

PROFESSIONAL MEMBERSHIPS:
International Society for Horticultural Science; Tropical Agricultural Association; European Society of Nematologists; Nematology Society of South Africa; Afro-Asian Society of Nematologists; Nigerian Society for Plant Protection; Organisation of Nematologists of Tropical America

CURRICULUM VITAE

Name:	Henry Wainwright
Qualifications:	BSc (Nottingham), PhD (Bath), PGCE (Leeds)
Organisation:	The REALIPM Company (K) Ltd
Address and contacts:	P O Box 4001, Madaraka, Thika – 01002, Kenya, Tel. +254 722 655983 wainwright@realipm.com www.realipm.com
Awards:	Fellow of the Institute of Horticulture (FIOH)
Current position:	Director and joint owner

Experience relevant to this project:

Dr Wainwright has been a resident in Kenya since 2000 and has worked in the Horticulture/Agriculture sector all his life. From 1987–1993 he worked with ODNRI (now NRI) and has considerable experience in project identification, implementation and management. At the end of 2003, he and his co-director/owner formed The REALIPM Company in Kenya and have undertaken training, consultancy and produced and sold biological control agents. The company currently employs 115 staff including nine graduates and has invested over 500,000 USD in developing biopesticide production and quality control facilities in the last 18 months.

The REALIPM Company is primarily a company that specialises in crop protection and trains on both conventional and biological control measures. REALIPM has implemented a range of externally funded projects including those funded by the Pesticide Initiative Programme (PIP), an EU funded project managed by COLEACP, and other projects/consultancies funded by USAID, DFID, World Bank, BMGF and UNDP. REALIPM staff has, in the last two years worked in Kenya, Tanzania, Ethiopia, Uganda, Rwanda, Zambia, Mozambique, Madagascar, Zimbabwe, South Africa and Ghana.

REALIPM has a biopesticide production facility and is already producing *Trichoderma asperellum*, *Bacillus subtilis*, *Beauveria bassiana* and *Metarhizium anisopliae*, all of which have or are in various stages of registration with the Kenyan, South African, Ethiopian and Ghanaian authorities. REALIPM has a full time MSc graduate that co-ordinates their registration activities.

Dr Wainwright has published over 120 technical papers and is an associate editor of The Journal of Horticultural Science and Biotechnology for over 20 years.

Dr Wainwright has also been an external examiner for the BSc and MSc courses at the Jomo Kenyatta University of Agriculture and Technology for four years (2006 – 2010).

CURRICULUM VITAE

MONGI Hussein Omari
Tanzanian

EDUCATION:

From	To	University	Degrees(s) or diplomas obtained
Jul 1959	Mar 1962	Makerere University, Kampala, Uganda	BSc Agriculture
Aug 1964	Nov 1995	West Virginia University, Morgantown, USA	MSc Agronomy & Soil Fertility Minor: Horticulture, Rural economy/Marketing
Feb 1972	Oct 1974	University of Dar es Salaam, Dar es Salaam, Tanzania	PhD (Agronomy/Soil Fertility Management)

PRESENT POSITIONS:

2000 to date: Director, Research and Development, Alpha Seed Company, Arusha, Tanzania

General planning; company programme development; liaison with research institutions and seed companies on variety development and/or trials; attendance to all matters concerning the seed industry in Tanzania, East Africa and SADC countries; selection and testing of seed varieties crops for adaptation field trials and customer acceptance; assist the Managing Director in all matters affecting the company, on funds' sourcing, field production, packaging and market research; liaison with Government on seed matters, including membership of the National Seed Committee.

2004 to date: CEO Mbegu Technologies Limited, Tanga, Tanzania

A limited agribusiness company specializing in seed technology (as one of its three Directors); Company has 5,000 acres of land in Tanga region, Tanzania.

KEY QUALIFICATIONS:

Chairman of Tanzania Coffee Board (TCB); **Member of TaCRI R&D Advisory Panel**; grower of coffee seedlings; manager of own small coffee holdings; **leadership of various government parastatal bodies during and after public employment**; experience in **ICRAF, FAO as leader or team member of project preparation, operation and field implementation, management of out-posted project staff**; recruitment and fielding of programme/project preparation missions for national, bilateral and multilateral supports; project monitoring, evaluation, review and revision over a 20-year period with international civil service (FAO, ICRAF, others); **development and leadership of the first viable private sector seed company (Alpha Seed Company, Tanzania) under the PPP modality; working smoothly with actors in international support programmes**; awareness of needs and **approaches for realizing credible changes in agriculture and rural development, partly gained in working with international experts in evolving OAU's agriculture and rural development strategies and programmes, such as CADAAP, etc.**

SPECIFIC EXPERIENCE IN AFRICA:

Experiences cover wide activities in R&D, education and training, as well as programme/project preparation, operation/implementation for the complex of crop production approaches/technologies within various farming systems, including agroforestry, suburban agriculture, aspects of plantation crops and the floriculture industry; direction/management of parastatal and quasi-private (semi-autonomous) institutions, serving as Chairperson or member of Boards of Directors, under centrally controlled and free market economies both within Tanzania and while serving as FAO-CPO (and Associate CPO) for eastern and southern African countries (**Kenya, Malawi, Zambia, Zimbabwe, Lesotho, Botswana, Mozambique, Eritrea, Ethiopia, Uganda, Tanzania, Namibia; and Research Project Manager in Somalia)**. Most relevant experience is involvement in coffee production matters all my life as I was born and raised on a smallholder coffee farm in the immediate vicinity of large scale commercial coffee farms in Kilimanjaro and the involvements in directing Tanzania's Coffee Board as Chairman of its BoD while at the same time fully involved in supporting TaCRI's R&D activities as a member of its Technical Advisory Committee, the unit that strongly advised strongly on the revision/updating of TaCRI's SAP and extension of financial and other supports for the revised SAP's implementation from the donor community and the Government of Tanzania.

PUBLICATIONS:

Numerous articles, working and conference papers, MSc and PhD theses, programmes and projects, written for research, training and extension offices of the Ministry of Agriculture, the University of Dar es Salaam, UN HQ (as consultant), ICRAF, UNDP, UNHCR, and FAO; prepared a review/analysis of fate of donor-funded projects for UN HQ in 1997 (as consultant) by virtue of my position then as Managing Director of the Nordic-Tanzania Agricultural Project, Uyole (Mbeya), Tanzania.

ANNEX 6. LITERATURE

Agbicodo E. 2011. Breeding hybrid vegetables in Africa for the African market: case of African eggplant, tomato and chinense pepper. Book of abstracts. 2011 International Conference on Solanaceae Resistance Breeding. 17-19 February 2011. Chiang Mai, Thailand.

AgraQuest 2010. Monsanto and AgraQuest to collaborate on development of new seed treatments research to focus on controlling nematodes, insects and disease. 13 September 2010. Press release. www.agraquest.com

Akello J., Dubois T., Gold C.S., Nakavuma J. and Paparu P. 2007. *Beauveria bassiana* Balsamo (Vuillemin) as a potential endophyte in tissue culture banana (*Musa* spp.). Journal of Invertebrate Pathology 96: 34-42.

Akemn M.C., Kyamanywa S., Luther G., Ssekyewa, C., Erbaugh J.M. and Warren H. 1999. Developing IPM systems for tomato in Central and Eastern Uganda. IPM CRSP Annual Report 6:117-121.

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Asaka O. and Shoda M. 1996. Biocontrol of *Rhizoctonia solani* Damping-Off of Tomato with *Bacillus subtilis* RB14. APPLIED AND ENVIRONMENTAL MICROBIOLOGY, 62: 4081–4085.

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Gnanamanickam S.S. and Mew T.W. 1990. Biological control of rice diseases (blast and sheath blight) with bacterial antagonists: an alternate strategy for disease management. Proceedings of the Conference on Pest Management in Rice. Society of Chemical Industry, London, UK.

Jeffrey C. and Lord J.C. 2005. From Metchnikoff to Monsanto and beyond: the path of microbial control. Journal of Invertebrate Pathology 89:19-29.

Jensen B., Knudsen I.M.B., Madsen M. and Jensen D.F. 2004. Biopriming of infected carrot seed with an antagonist, *Clonostachys rosea*, selected for control of seedborne *Alternaria* spp. Biological Control 94:551-560.

Kim H.Y., Choi G.J., Lee H.B., Lee S.W., Lim H.K., Jang K.S., Son S.W. , Lee S.O., Cho K.Y., Sung N.D. and Kim J.-C. 2007. Some fungal endophytes from vegetable crops and their anti-oomycete activities against tomato late blight. Letters in Applied Microbiology 44:332-337.

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Ref.:

29 July 2011

Letter of Support for Project on Bio-enhanced seeds and seedlings for East Africa

Alpha Seed Company (ALSEED) expresses its interest and support to participate and implement the project titled: "**Bio-enhanced seeds and seedlings for East Africa**" submitted by JKUAT in partnership with IITA and RealIPM to Bio-resources Innovations Network for Eastern Africa Development (BioInnovate) Program.

ALSEED is Tanzania's first local privately-owned enterprise in the seed sector established on 11 June 1993 and registered in Tanzania. ALSEED's mission is to acquire, develop, produce and deliver high quality vegetable seeds to the Tanzania farming community. The Company continuously addresses farmers' constraints through close partnerships with them and with relevant institutions. The Company believes that quality seed production with small scale farmers is sustainable since it gives them an opportunity to see and do farming as a business which in turn creates the need to seek for new knowledge, technology and market information.

Therefore, the objectives of the project will auger well with the company plans and activities. The project will further open up new avenues for the company to serve farmers by ensuring that have healthy seeds and seedlings to start off their farming and contribute to reduction of cost of inputs (particularly pesticides) as well as labour for crop production.

We look forward to working in a team to the success of the project.

Yours faithfully,

Hussein Mongi, PhD
CEO and Director of R&D
ALPHA SEED COMPANY LIMITED