IITA

Research to Nourish Africa

# R4D Review

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*Researcher inspecting soybean seeds for pathogen cultures.* Photo by J. Oliver, IITA.

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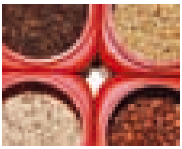

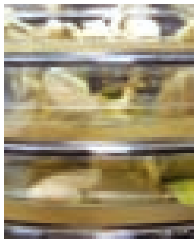



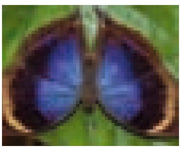



## 36 BEST PRACTICE

# EDITOR'S NOTE

## Plant health matters

Efforts by national and international research systems during the last two decades have contributed to nearly doubling the production of major staple foods including cassava, maize, yam, and banana in Africa. Most of these gains, however, have come about as a result of an expansion of the planted area, but crop production per unit area of the land is lower than anywhere else in the world.

Yet the continent is expected to improve food production dramatically, doubling or tripling the existing capacity, to feed over 200 million undernourished people[1]. Although new varieties have contributed to improve crop production, productivity, and quality, their performance has been constrained by suboptimal conditions, such as declining soil fertility, drought, attacks by pests and diseases, and lack of good quality planting material.

The current approach—expanding the area under agriculture to increase food production—is unsustainable and results in significant ecological damage. This realization worldwide is driving the search for newer options to intensify agriculture within the existing area.

We believe that ensuring plant health is pivotal to increase productivity and the strategy of sustainable agriculture intensification[2]. The compelling reason for this is that biological threats, such as diseases, pests, and weeds are directly responsible for reducing crop yields by at least one-third[3], and at least half of these losses could easily be averted using simple and affordable technologies and practices that prevent diseases and pests from affecting plants and produce. Ensuring plant health, therefore, is one of IITA's most important R4D strategies to improve agricultural productivity and food security and reduce poverty.

This issue highlights some of the technologies and strategies developed and promoted by IITA and its partners for plant health protection.

The value of plant health management cannot be underestimated given the precarious nature of agricultural systems in Africa with the evolution, establishment, and quick spread of pests and diseases, such as fruit flies, cassava brown streak and banana bacterial wilt.

Although plant health protection measures are relatively easy to adopt, considerable training, awareness creation, and financial support are required to improve skills and infrastructure in national systems to foster the technology transfer to farms where plant health matters.

*"True national defense is a huge offensive force against biological threats to food systems."*

*- Hartmann, Director General, IITA*

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[1] FAO. 2010. The State of Food Insecurity in the World 2010. FAO, Rome.
[2] www.bis.gsi.gov.uk/foresight
[3] Oerke EC. 2006. J. Ag. Sci. 144: 31–43.

*To ensure food security in Africa, plant health matters need to be given immediate attention*. Photo by J. Oliver, IITA.

# NEWS

## Nigeria gets improved cassava

The Nigerian government has released four improved cassava varieties that are a product of about a decade-old conventional breeding research. These include NR 01/0004, CR 41-10, TMS 00/0203, and TMS 01/0040.

TMS 00/0203 and TMS 01/0040 were bred by IITA scientists, while NR 01/0004 was bred by the Umudike, Nigeria-based National Root Crops Research Institute, and CR 41-10 by the Colombia-based International Center for Tropical Agriculture (CIAT).

On-farm prerelease trials involving local farmers in eight states of the country show that the improved varieties outperformed local checks with an average yield of about 31 t/ha compared with 26 t/ha recorded by the local varieties.

Farmers love the varieties for their excellent culinary qualities, high yield, and resistance to pests and diseases.

The new varieties seek to strengthen Nigeria's lead in cassava production, increase farmers' incomes, and guarantee food security.

## Better soybean

Two African nations—Malawi and Nigeria—have released three improved soybean varieties that can enhance the productivity of the crop and offer farmers better opportunities.

The varieties are TGx1740-2F, TGx1987-10F, and TGx1987-62F. TGx1740-2F was developed by IITA in collaboration with the Department of Agricultural Research Services (DARS) in Malawi. Varieties TGx1987-10F and TGx1987-62F were developed by IITA in collaboration with Nigeria's NCRI.

The Malawi Agricultural Technology Clearing Committee officially approved the release of TGx1740-2F in January 2011 while the Nigeria Varietal Release Committee released TGx1987-10F and TGx1987-62F in December 2010.

The varieties outperformed the standard and local checks grown in the two countries, with high grain yield in multiple locations under on-station and on-farm trials.

Many farmers preferred the varieties because they smother weeds and reduce the cost of weeding. Farmers that participated in the on-farm trials of the varieties last year said they preferred them especially for their golden color at maturity.

In Malawi, TGx1740-2F gave the highest mean grain yield of 2.5 t/ha. It exceeded the yield of checks, grain variety Nasoko by 10% and the widely grown promiscuous variety Magoye by 32% during the two-year multilocation on-station trials.

The variety performed equally well during on-farm participatory variety selection trials in four districts of central Malawi. In the 2009/10 season, it outyielded all the new types of soybean varieties under testing with 2.2 t/ha. It also surpassed Nasoko by 15% and Magoye by 38%.

High in nutritive value, soybean is fast gaining appeal in Africa, offering a cheap source of protein. The crop is also emerging as an important feed, food, and raw material for producing high-quality protein products. For smallholder farmers it is an important cash crop and also improves soil fertility because of its ability to fix high amounts of atmospheric nitrogen.

## Conference on humid tropics

The Consortium for Improving Agriculture-based Livelihoods in Central Africa (CIALCA) and the CGIAR Consortium Research Program (CRP) on the Humid Tropics led by IITA will convene an international conference on 'Challenges and Opportunities for Agricultural Intensification of the Humid-Highland Systems of sub-Saharan Africa', in Kigali, Rwanda, on 24-27 October 2011.

The humid highlands in sub-Saharan Africa are characterized by high population densities and require intensification. Unfortunately, many communities lack easy access to the means to achieve this.

The conference aims to take stock of the state-of the art in agricultural intensification in the highlands of sub-Sahraran Africa, and to chart the way forward for agricultural research for development in the humid highlands, through keynote presentations, oral and poster presentations, and strategic panel discussions.

## UPoCA gives farmers a lifeline

Cassava value addition is helping African farmers increase their income, and improve livelihoods and food security through a USAID-funded project called Unleashing the Power of Cassava (UPoCA).

Implemented in seven African countries—Nigeria, DR Congo, Ghana, Malawi, Mozambique, Tanzania, and Sierra Leone—by IITA, the project has benefited thousands of farmers in these countries.

In Sierra Leone, the Tongea Women farmers in Sandeyalu community formed the Tongea women's development association comprised of 54 women and 4 men.

Through the IITA-UPoCA project, a cassava microprocessing center was subsequently inaugurated, providing farmers with a financial window of opportunity. Incomes from USAID projects such as UPoCA have helped the people of Sandeyalu in rebuilding their community after years of civil unrest.

This success story echoes across other countries such as Nigeria, DR Congo, Ghana, Malawi, Mozambique, and Tanzania where UPoCA is being implemented.

In Malawi, UPoCA helped revive a moribund starch factory—the first in that country. Thousands of farmers benefited from improved cassava cuttings, training, and capacity building for processors.

*Happy cassava woman farmer.* Photo by IITA.

In Nigeria the project linked up processors to farmers for steady production/supply of cassava roots, provided improved cuttings and training, and also helped build the capacities of farmers and processors.

Farmers in Ido community, Oyo State, Nigeria, have more than doubled the yield of cassava from an average of 10 t/ha to more than 20 t/ha. Other states that benefited from the UPoCA project were Osun, Ondo, Ekiti, Kogi, Nasarawa, and Benue states.

Farmers say the project has increased the production of cassava with the availability of improved cassava stems, making food more secure and generating wealth.

Apart from boosting the productivity of cassava in the project areas and maximizing the use of the root crop, the project is also promoting food security and improving the incomes of women farmers and processors in particular, and African farmers in general.

## Liberia and Ghana to develop agriculture

The governments of Ghana and the Republic of Liberia have officially agreed to jointly develop, promote, and implement research activities to improve their agricultural sectors.

A memorandum of understanding was signed by representatives of Ghana and Liberia, with the assistance of IITA's Sustainable Tree Crops Program (STCP), in collaboration with the Ghana Cocoa Board. IITA/STCP works in both countries.

The agreement was signed by the Minister of Finance and Economic Planning, Kwabena Duffuor, and the Chief Executive of COCOBOD, Anthony Fofie, for Ghana, and by the Minister of Agriculture, Florence Chenoweth, and the Deputy Director General of the Central Agricultural Research Institute (CARI), Abugarshall Kai on behalf of Liberia.

Under the MoU, the Cocoa Research Institute of Ghana and Liberia's CARI will exchange expertise, knowledge, and genetic resources (seeds and nursery development) to develop and improve the tree crops sector in Liberia. Specifically, the national research institutions of both countries will facilitate the provision of planting material as requested by either countries, make available research and training facilities and materials to visiting scientists from either institution, and provide technical expertise for the successful implementation of mutually-agreed projects.

# Climate change & plant health

Irmgard Hoeschle-Zeledon*, i.zeledon@cgiar.org or sp-ipm@cgiar.org

The discussion on the impact of climate change (CC) on agriculture has often focused on how changes in temperature, rainfall, and $CO_2$ concentrations will affect the suitability of temperate regions for crop production and how crops will react in terms of yields. The effects of climate change on biotic factors in the tropics, such as weeds, pests, and pathogens (hereafter referred to as pests), have not received much attention.

Empirical data exist, however, to show that these biotic factors have major effects in determining productivity in the tropics. For instance, during the 1997 El Niño phenomenon, the mean temperature on the Peruvian coast increased by about 5 °C above the annual average, causing a decrease in potato infestation by the leafminer fly *Liriomyza hydobrensis*, which otherwise was a major pest. However, the abundance and infestation severity of all other pests increased in all crops, including potato (Kroschel et al. 2010). The complex consequences of CC particularly on pests and pathogens are still only imperfectly understood (Gregory et al. 2009).

### CGIAR's work on climate change

What are IITA and the other centers of the Consultative Group on International Agricultural Research (CGIAR) doing to mitigate the impacts and adapt to the effects of CC on pests? Historically, CGIAR centers have a broad R4D focus; centers have been developing knowledge (e.g., pest profiles), products (e.g., new crop varieties, biocontrol agents against invasive pests), and technologies (e.g., predictive models, diagnostic tools) that are suitable for diverse agroecologies including the tropics, wet, humid, semiarid, and dry, and to some extent the temperate zones as well. The broad knowledge and experience of centers provide an unprecedented advantage to assess the products and technologies in different agroecologies and weather settings and to determine their resilience and ability to cope in altered climatic situations.

Several programs directly focus on managing pests. For instance, the breeding of crop varieties for resistance to pests and pathogens has always been a focus of the CGIAR. With the uncertainties of CC, this work has become more relevant. Breeding for resistance to drought and waterlogging, although not the primary objectives, also aim at making varieties better able to tolerate biotic threats, since drought and excess water in the soil both increase the plants' vulnerability to these factors.

A good example is the effort to develop drought-resistant maize cultivars by CIMMYT and IITA. These will not only allow the expansion of maize production into areas with less reliable rainfalls but also ensure the continued production in regions that are prone to future water scarcity. Drought-tolerant cultivars also reduce the risk of aflatoxin contamination in the field. Additional characters are incorporated into the drought-tolerant maize, such as resistance to maize streak disease which is endemic in Africa. Similar programs are ongoing to develop drought-resilient

*Coordinator of the CGIAR Systemwide Program on Integrated Pest Management (SP-IPM) convened by IITA.

cassava and cowpea, and yam with tolerance for major pests.

The CGIAR centers are also working towards the development of cropping systems with greater intra- and interspecific diversity to increase resilience to CC-induced threats from biotic factors. For example, IITA is promoting maize–cowpea intercropping to reduce the pest pressure on cowpea.

Bioversity International is exploring how intra-specific crop genetic diversity on-farm not only reduces current crop losses to pests and pathogens, but also decreases the risk of genetic vulnerability and the potential of future crop damage, thus enhancing the impact of other IPM strategies and providing farmers with increased adaptive capacity to buffer against climatic changes.

CIP developed a temperature-driven phenology model for the potato tuber moth, *Phthorimaea operculella* that provides good predictions for the population in areas where the pest exists at present (Kroschel et al. 2010). Linked with geographic information systems (GIS) and atmospheric temperature, the model allows the simulation of risk indices on a worldwide scale to predict future changes in the distribution of the species due to increasing temperatures. The approach can also be used for other insect species. Hence, CIP created the Insect Life Cycle Modeling software (ILCYM) to facilitate the development of other insect phenology models. With its support, the phenology model can be implemented and allows for spatial simulation of insect activities.

Many centers support the collection and conservation of plant genetic diversity that can be built into new cultivars to enhance their resistance to biotic stresses. Diagnostics capacity is continuously augmented for the accurate and timely recognition of endemic pests, new variants, and invasive pests. Crop biodiversity—landraces and wild relatives that are the reservoirs of genes for abiotic and biotic factors—is conserved ex situ to protect the species from erosion by CC-induced changes.

In a collaborative effort, CIP, IITA, *icipe*, and partners in Germany and Africa are implementing a project to understand the effects of rising temperatures on the distribution and severity of major insect pests on main food crops. ILCYM will be further improved and adapted to cover a wide range of insect species. The results will contribute to filling the knowledge

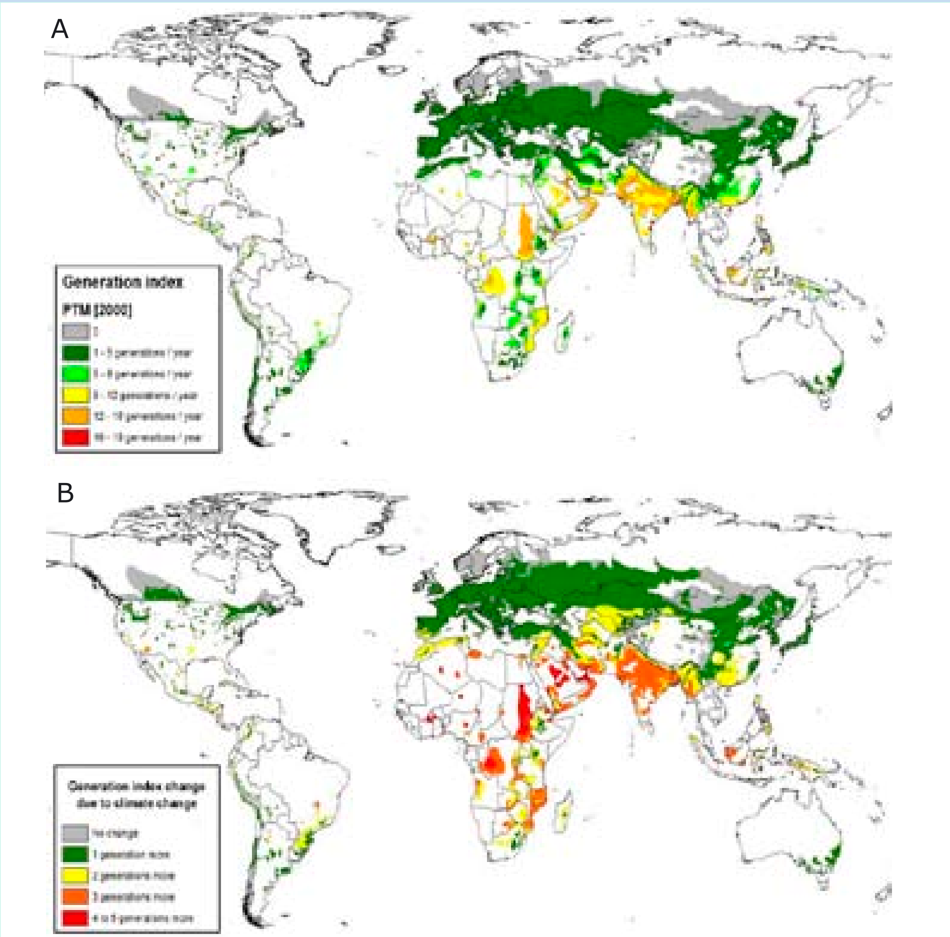
*Diverse crop production system.* Photo by IITA.

gap about CC effects on economically important insect herbivores and their natural enemies.

IITA is planning to research the effect of changes in temperature on the invasion potential of major biotic threats in the Great Lakes region of East Africa and elsewhere: Banana bunchy top virus (BBTV), Banana Xanthomonas Wilt (BXW), and Panama Disease–Tropical Race 4, cassava brown streak virus disease, cassava mosaic disease, maize streak, soybean rust, and pod borer pests, among others.

As whiteflies and aphids are considered to become more problematic with increased temperatures, IITA is also preparing research on the biocontrol of different whitefly and aphid species in vegetables and staple crops.

A project has been proposed on the bio-enhancement of seeds and seedlings of cereals and vegetables




*Climate change scenarios for the potato tuber moth,* Phthorimaea operculella*: (A) Generation index (generations/year) under present temperature conditions, and (B) Change in numbers of generations/year by 2050 using the atmospheric general circulation model (Govindasamy et al. 2003).*

for East Africa to stimulate the plants' defense mechanisms against pests and pathogens expected to increase in number, frequency, and severity. This project also addresses the registration of biopesticides and the availability of endophytes to the tissue culture industry.

### CGIAR research programs

Under the new CGIAR Research Programs (CRPs), centers are addressing CC-induced crop health issues in various ways. Breeding for resistance to predicted biotic stresses continues to be a major focus in CRP3 (roots, tubers, banana) and its subcomponents. This component, coordinated by CIP, specifically recognizes CC and agricultural intensification as drivers for higher pressure from pests. Hence, this program aims at developing management strategies for priority biotic threats to these crops. These include the development of improved detection and monitoring tools, and surveillance methods for detecting and mapping existing, emerging, and resurgent molecular pests and pathogens. It will look into increasing general plant and root health through the enhancement of the natural disease suppressing potential of soils, and the antagonistic pest and disease potential of the aboveground agroecosystems.

The CRP on Integrated Systems for the Humid Tropics, led by IITA, will have a substantial focus on CC, its impact on pests, and plans for mitigation. For example, research will establish the relationship between CC and key cassava pests to develop integrated pest management (IPM) strategies including those for whitefly, African root and tuber scale, termite, green mite, aphid, and mealybug.

Phenology models for insect and mite pests and their antagonists on several crops will be developed and validated and their potential for changes in warming will be determined.

In collaboration with CABI, community surveillance for pests and diseases will take place through the expansion of the mobile plant clinic network.

Knowledge and decision support tools for the management of potato and sweetpotato pests (diseases and insects) will be developed and assessed in relation to the expected intensification of the agroecosystems in the humid and subhumid tropics.

Sustainable management of cassava virus disease in the cassava-based system will also be studied, and the vulnerabilities of these systems to CC-induced pest and disease problems will be determined.

The CIAT-coordinated CRP on CC, Agriculture, and Food Security began operations this year. It will continue the activities initiated by the CGIAR Challenge Program on CC. This CRP aims at mainstreaming strategies that address the management of CC-induced pest and disease threats among international and national agencies. It will identify and test innovations that enable communities to better manage and adapt to climate-related risks from biotic factors.

### Recommendations

A lot of surprise shifts in ecosystems could come. It is therefore important that research capacity and knowledge bases are maintained to understand and rapidly react to mitigate any debilitating impacts (Shaw and Osborne 2011).

To accomplish this, it is necessary to establish good baseline data on current pest status in agroecosystems. This knowledge base will serve as a reference point to measure the fluctuations and the effectiveness of interventions.

It is important to determine the key weather variables that could change as a consequence of CC and their influence on agroecosystems and pests, and establish preemptive coping strategies.

*Larva of the noctuid moth feeding on the pistil of cowpea.* Photo by S. Muranaka, IITA.

Available CC models could be handy for predicting CC factors.

A diverse scientific base including specialists in pathology, entomology, ecology, taxonomy, and epidemiology is required. They should work together to ensure that the outcomes of their research are linked to existing knowledge, economic forces, and common understanding (Shaw and Osborne 2011).

As it generally takes more than 10 years to breed a new resistant cultivar of a crop, breeding programs must start well in advance of the serious risk of a biotic threat  Breeders need to be informed on the problems which might become important in the future (Chakraborty et al. 1998 in Juroszek and Tiedemann 2011).

Crops being bred for abiotic threats such as drought, waterlogging, and salinity should be prepared for the pests that could flourish under these conditions and select varieties that can tolerate pests as well.

Changes in occurrence, prevalence, and severity of infections and infestations will also affect crop health management (CHM) practices. There is a need to effectively disseminate and use those techniques that are currently underused (Juroszek and Tiedemann 2011).

Significant contributions could be made in improved field monitoring of pests and diseases, and better delivery systems for pest control products (Strand 2000 in Juroszek and Tiedemann 2011). Preventive crop protection measures may become more relevant under CC to reduce the risks (Juroszek and Tiedemann 2011).

CC is a global problem that affects all countries. Hence, global cooperation is required. However, given the nature of plant pests and pathogens, more local or regional strategies need to be put in place that define potential risks and measures to tackle expected threats. Investments in early detection systems, including border controls to monitor the migration of pests through plants, plant products, and other goods, will be the key to avoid the spread of invasive pests and reduce high management and eradication costs (FAO).

New farming practices, different crops, and IPM technologies must be developed to control the established pests and prevent the spread of new ones (FAO).

Governments should consider developing country-specific strategies to cope with CC-induced changes and put in place favorable policies for the introduction and promotion of new technologies for CHM.

It is also crucial to create and augment awareness about the effects of CC among policymakers and other officials involved in developing agricultural strategies.

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# Climate change is everyone's responsibility

Climate change (CC) is a long-term change in the statistical distribution of global weather patterns over periods of time that range from decades to millions of years. Several factors, known as climate forcers, usually natural events such as volcanic eruptions, earthquakes, solar radiation, and ocean currents shape climate change.

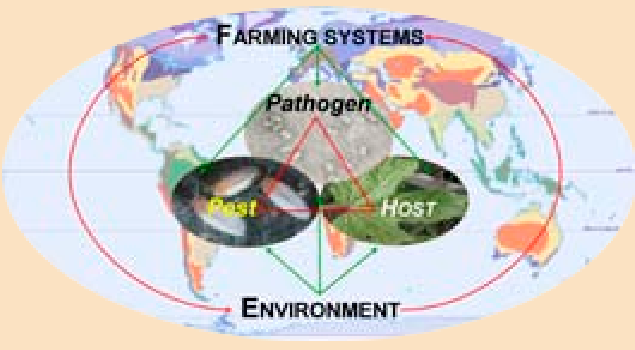
However, the climate forcer of the 21st century CC—carbon dioxide ($CO_2$)—is mainly human-induced and attributed to the burning of fossil fuels and tropical deforestation. The property of $CO_2$ to trap heat within the earth's atmosphere is contributing to global warming. Thus, a rise in $CO_2$ levels increases the warming effect. Trapped heat in the atmosphere warms oceans, melts ice caps, raises sea levels, and increases average surface temperature, all of which are affecting normal weather patterns.

Some of the abnormal changes experienced over the last two decades include severe and prolonged droughts, extreme storms and prolonged rainfall pattern, high temperatures, and heat waves. These sudden and extreme variations in weather patterns due to 'global warming' have profound effects on living organisms on earth. The altered conditions create risks as well as opportunities favoring certain living beings over others and contribute to shifts in niches. In addition, it could lead to long-term variations in climate (e.g., permanent increase in average temperature) that might irreversibly affect biodiversity in a given region.

In the context of agriculture, sudden and abnormal changes in weather could change the suitability of a given environment for cultivation of crops. This could be due to abiotic factors such as drought, heat (cold), or excessive water directly linked to weather or simply due to increased pests and diseases that would severely impede performance of the crops. Since crops, diseases (pathogens), and pests (including vectors) are intimately associated and influenced by the environment, any shift in these factors will alter the balance, and could have a positive impact (e.g., decreased pest pressure) or negative impact (e.g., increased pest pressure) on overall crop performance.

Using simulation models, attempts the world over are being made to determine the impact of CC on agroecosystems to establish appropriate coping strategies, particularly for the negative impacts. Although this appears simple, it is the most complex issue confronting researchers, policymakers, governments, and entrepreneurs worldwide.

Communities are working together to bridge the gaps and establish global coordination networks to mitigate the impact of CC. IITA and other CGIAR centers, together with national and international organizations, are contributing to these endeavors with a primary focus on conserving biodiversity and improving the resilience of smallholder agriculture in the developing countries in Africa, Asia, and Latin America.




*Life on earth is a dynamic process and intimately connected to the biotic forms in cohabitation, farming systems, and environment. A shift in one parameter alters the delicate balance in an interconnected world.*

Source: L. Kumar, IITA.

# Towards a healthy banana TC industry in East Africa

Thomas Dubois, t.dubois@cgiar.org

## Tissue culture banana

Banana in smallholder farmer systems is traditionally propagated by means of suckers. These contain soil-borne pests and diseases, and by using them, farmers unknowingly distribute and perpetuate pest and disease problems.

Plants produced by tissue culture (TC), because they are produced axenically in the laboratory, are material that is free from pests and diseases with the exception of fastidious bacteria and viruses.

There are many added benefits to using TC plants: (1) they are more vigorous, allowing for faster and superior yields; (2) more uniform, allowing for better marketing; and (3) can be produced in huge quantities in short periods of time, allowing for faster and better distribution of existing and new cultivars, including genetically modified banana. In other words, the TC technology can help banana farmers to make the transition from subsistence to income generation.

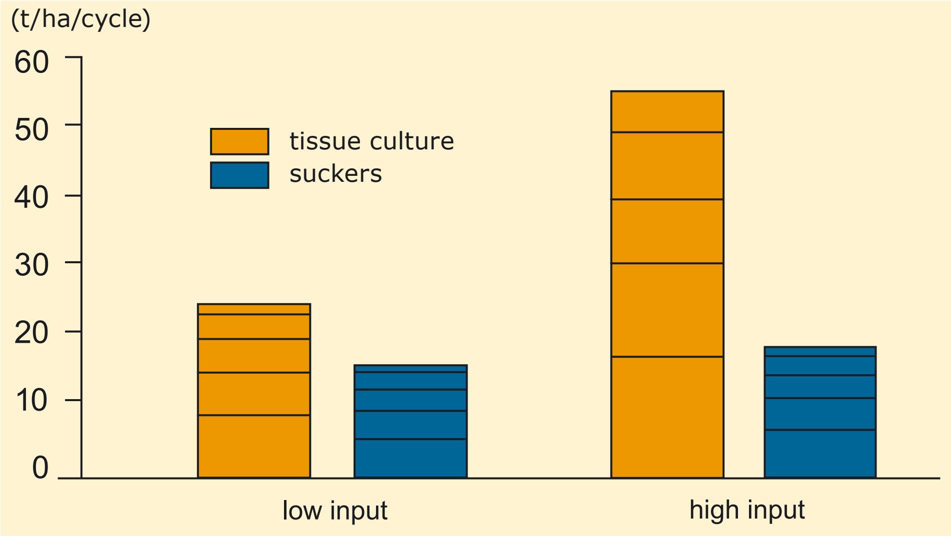
However, TC plantlets are relatively fragile and require appropriate management practices to fully harness their potential, especially during the initial growth stages shortly after being transplanted to the field. In East Africa, TC plantlets are often planted in fields burdened with biotic pest pressures and abiotic constraints.

## A SWOT analysis

*The importance of the private sector*

The adoption of TC technology is still relatively low in East Africa. In Kenya, coverage of TC banana is estimated at 5–7% of the total banana acreage; adoption rates are significantly lower in countries such as Uganda, Burundi, and Tanzania, although reliable data do not exist.

*Young tissue culture plantation in Nairobi, Kenya.* Photo by T. Dubois, IITA.




*Cumulative yield (t/ha/cycle) of a plantation derived from tissue culture (orange bars) compared to one derived from conventional planting material (blue bars), over 5 cropping cycles and under two management regimes (low input and high input). Every little block represents one crop cycle. Data based on 1,600 plants total.*

In East Africa, the technology is booming under the impetus from the private sector. At least 10 commercial private laboratories have sprung up in the last decade in Burundi, Kenya, Uganda, and Tanzania. Collectively, they produce at least 2 million plants/year, although exact numbers seem to fluctuate widely and are hard to come by. Most of these companies manage the entire production chain, from sourcing the mother plants to weaning the TC plantlets. Despite the steep entry barrier, the TC business is very lucrative for the entrepreneur who engages in plantlet production. In some countries, universities and research organizations are also involved in the commercial production of TC banana.

*Lack of quality standards and virus indexing*

One of the biggest dangers for sustainable commercial production of TC plants is the lack of several essentials: (1) standards for quality management during the production process, (2) plant health certification, and (3) regulatory procedures. Such conditions are especially important to avoid spread of viruses, which are easily transmitted through TC plantlets.

For instance, *Banana bunchy top virus* (BBTV) is on the list of the 100 most dangerous invasive species worldwide. It is widely distributed in Central Africa and also in Burundi and Rwanda in East Africa, yet implementation of virus indexing schemes is largely absent in East Africa. It is important to put in place standard procedures for ensuring the production and distribution of high-quality, virus-free planting material, and to establish independent agencies that set and implement standards and improve the skills of personnel. In East Africa, certification schemes need to be regionally harmonized, especially with the transnational movement of plants between the countries, so that there is no weak link in the region.

*Unregulation—a potential danger to the spread of diseases*

At present, the commercial production of TC banana plantlets is largely unregulated. Not only are TC banana plantlets being moved in very large quantities across borders; uncertified mother material is also crossing borders. This practice is potentially risky, and could perpetuate infected sources and cause new outbreaks of disease.

In the ideal situation, there need to be certification standards for the quality and health of TC plants and the monitoring of TC producer operations. These are largely ignored because of poor awareness, and the lack of capacity and regulations required for the implementation of such standards. To transform the system, governments and/or the TC industry could consider common facilities to implement certification schemes. For instance, an accredited governmental or independent virus indexing laboratory, established as a commercial service for TC operators, would leverage costs and improve TC standards.

*Plantain for sale in market.* Photo by IITA.

Another important requirement for TC producers is sustainable access to virus-free and true-to-type mother plants and this is currently lacking. The establishment of certified mother plant gardens as a common resource, either by governmental agencies or a consortium of commercial TC producers, would provide this essential requirement.

Contrary to a general perception, especially among donors, it is not merely the standards themselves that are a constraint, but also a lack of knowledge on how procedures are actually implemented along the value chain, through certification schemes. The equipment for virus indexing has become relatively cheap and technical skills are quite easily acquired. Their costs can be offset, e.g., through a service-based fee to private sector stakeholders.

Also, emphasis could equally be placed on certifying general operational procedures in a private TC laboratory. Currently, the quality of TC plantlets varies significantly, and several producers are struggling with off-types and accidental mixtures of varieties that become apparent only after being planted in the field, resulting in negative perceptions about TC.

Certification schemes need to be implemented in such a way that they do not become burdensome to producers or create bureaucratic barriers. Several quality certification schemes used for clonal crops, including banana, from other regions can be considered to develop an appropriate scheme for East Africa. Ultimately, it is not only the commercial sector that should self-regulate; governmental bodies need to take responsibility.

*Nurseries*

Nurseries for TC plants are essential, as they act as a distribution hub connecting producers to the farmers. They also act as focus centers for farmers and farmers' groups, and are therefore an easily approachable venue for training and other interventions. The survey by IITA and University of Hohenheim of all TC nurseries in Burundi, Kenya, and Uganda, found that nurseries in East Africa face an array of problems. Relationships between producers and nurseries, especially those related to timing, quality, and quantity of plantlet supply, are often suboptimal.

At the nursery level, there are three main operational issues: access to water, credit, and the transport of plantlets. The location of the nurseries is also crucial. Nurseries need to be close to the producer and to the market, otherwise they might fail. Clear drivers for the success of a nursery are good agricultural practices and, interestingly, a diversification into crops outside banana.

In TC banana value chains, nurseries have different roles across countries in East Africa. In Uganda, nurseries are run as businesses independent of the TC operators and of the farmers. In Burundi, the nurseries are owned and managed by the producers. In Kenya, nurseries are run as entities separate from the producers, and most of them are owned by farmers' groups that act as the customers for these nurseries. The business model in Kenya seems to hold the secret for a sustainable and vigorous link between producers and farmers.

*Distorted value chains*
One danger for a healthy commercial TC sector is the lack of sustainable market pathways to deliver the plants to the farmers. Especially in Burundi and Uganda, outlet markets for TC plantlets are mainly governmental and nongovernmental organizations, a situation which seems unsustainable in the long term.

The sustainability of the banana TC industry is especially worrisome in Burundi, where the entire value chain is subsidized. Virtually all TC plantlets are being bought by developmental agencies, which then pass on these plantlets to often untrained farmers, free of charge, and without embedding this transfer in an encompassing training program or input package (e.g., fertilizers).

**Test tubes to farms: how it's done**

Tissue culture plantlets are made in specialized laboratories, and the technology consists of a few basic steps: (1) the apical meristem is isolated from the mother plant and induced to form shoots, (2) the shoots are multiplied, (3) when plants are needed, the multiplied shoots are put on a root-inducing medium, (4) the young plants are transferred to a screenhouse for hardening, and (5) the plants are planted in farmers' fields.

*Empowerment of farmers in the value chain through farmers' groups*
Organizing banana farmers into groups has long been considered advantageous, because of increased buying and selling power, reduced economic and social risk, increased economies of scale, and improved access to credit and inputs by formally certified groups.

The study by IITA and the University of Hohenheim of the farmer-to-market linkage in Uganda demonstrated that farmers in marketing groups obtain higher prices than their ungrouped colleagues. The certification of farmers' groups implemented by IITA's national partners, ISABU (L'Institut des Sciences Agronomiques du Burundi) in Burundi and VEDCO (Volunteer Efforts and Development Concerns) in Uganda, has made them eligible for savings and credit schemes. Some have even engaged in other commercial activities, such as the start-up of a catering service.

*Training of farmers' group in business skills in Uganda.* Photo by Moses Lule.

*The importance of a training package*
In East Africa, the distribution of superior planting material alone will not ensure a good crop. Commercial farmers are skilled in juggling the inputs and effort needed to produce crops and make a profit but smallholder farmers are constrained by factors such as a lack of land and capital, access to technology, and a good marketing infrastructure. Therefore, efficient distribution systems will be needed to deliver the TC plants as part of a package, including training and access to microcredit.

IITA and its national partners, ISABU, JKUAT (Jomo Kenyatta University of Agriculture and Technology), and VEDCO, have been implementing hands-on, comprehensive training schemes for farmers as well as the operators of TC banana nurseries. Training schemes encompass modules in agronomy, marketing, business and financing, and for farmers, group formation and group dynamics. Participants were followed for over a year, and their ability to implement the skills learned during the training program was monitored. So far, a total of 851 separate training events have been implemented in Burundi, Kenya, and Uganda, and through the partnership, 10 new farmers' groups and 5 new nurseries have been established.

*Location, location, location*
TC banana plantlets come at a cost, and might not be economically beneficial throughout all banana-producing areas in East Africa. Location is everything.

IITA, in collaboration with Makerere University, conducted a cost-benefit analysis of the technology based on a comprehensive quantitative questionnaire with 240 farmers across four districts in Uganda, and compared it with the use of conventional planting material.

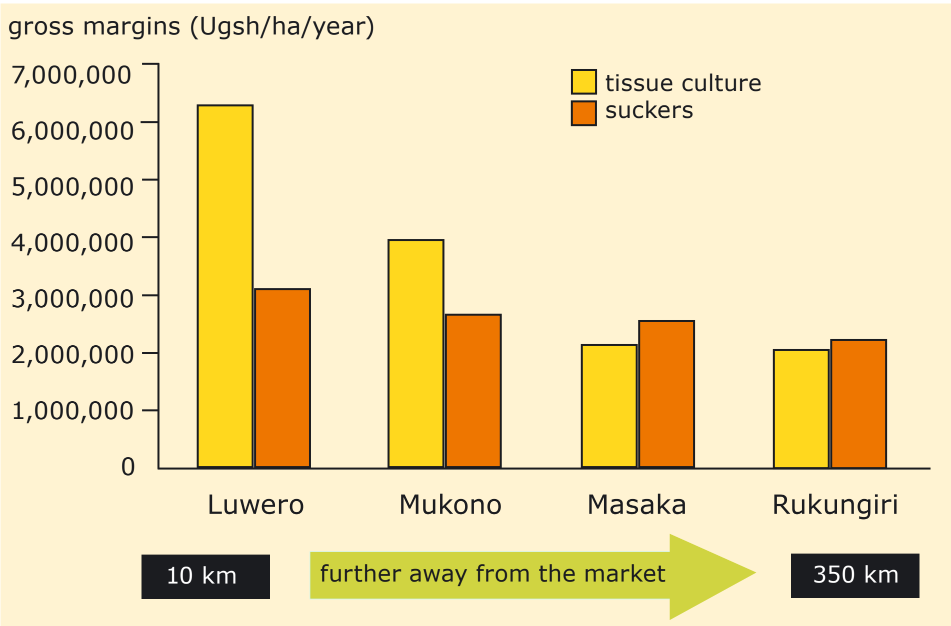
Both production costs and revenues were consistently higher for TC-derived material than for suckers. However, banana prices varied greatly with district and declined significantly with increasing distance from the main market (see graph). Also, production costs decreased significantly the further away the farms were from Kampala due to better agroecological conditions and the much reduced pressure from pests and diseases. As a result, although both TC plantlets and suckers were profitable to the farmer, TC material was more profitable than suckers closer to the main banana market.

In districts with low banana prices and at a greater distance from the main banana market, farmers could receive similar gains by planting suckers rather than TC plants. For a farmer in Uganda, it makes economical sense to grow TC banana close to the main urban market.

*An objective* ex-post *assessment*
Despite a booming commercial sector, there is only anecdotal evidence that farmers who have adopted TC banana benefit tremendously in terms of higher yields and household incomes.

Sound socioeconomic analyses are crucial to guide policy strategies, learn from successes already achieved, and identify important constraints for a wider dissemination of TC banana in the region.

Earlier studies on the impacts of TC banana in the region have either employed *ex ante* methods before any meaningful adoption was actually observable, or they have used relatively simple and ad hoc qualitative methodological tools, which do not allow robust and representative statements. The large body of subjective 'gray' literature, sometimes unconditionally and unilaterally promoting the benefits of TC banana, without considering the quality of the plant material, input package, and market access, risks having an adverse effect on the adoption of the technology in the long term.




*Gross margins (in Ugandan shillings)/ha/year of banana plantations derived from tissue culture (yellow bars) compared to conventional planting material (orange bars) in Uganda, the further away from the main banana market (Kampala).*

The University of Göttingen, in collaboration with IITA, is currently answering the following main research questions: (1) What are the determinants of TC banana adoption among farmers? (2) What are the impacts of this technology on on-farm productivity, household income and income distribution, and poverty and food security? (3) How do institutional factors in technology delivery and product marketing influence adoption and impact?

Some of these research questions have been answered. In Kenya, a substantial share of the population has heard about TC banana and is, therefore, generally aware of the technology's existence, although only a few have had a chance to fully understand its performance and requirements. This study finds that farmers' education, access to agricultural information, knowledge of the location of a TC nursery within a reasonable distance, and affiliation to social groups significantly increase the likelihood of the TC technology being adopted.

This study also highlights the positive role of access to credit and of gender in the adoption of TC material. Farmers with access to credit and female-headed households are more likely to adopt TC plants. The latter finding is particularly interesting from a policy perspective, because it shows that, when there is an equal chance for both men and women to acquire sufficient knowledge about an innovation, women are more likely to adopt it.

*Banana market in Ikire, Nigeria.* Photo by O. Adebayo, IITA.

# GHU: Gateway for the safe exchange of germplasm

Lava Kumar, l.kumar@cgiar.org

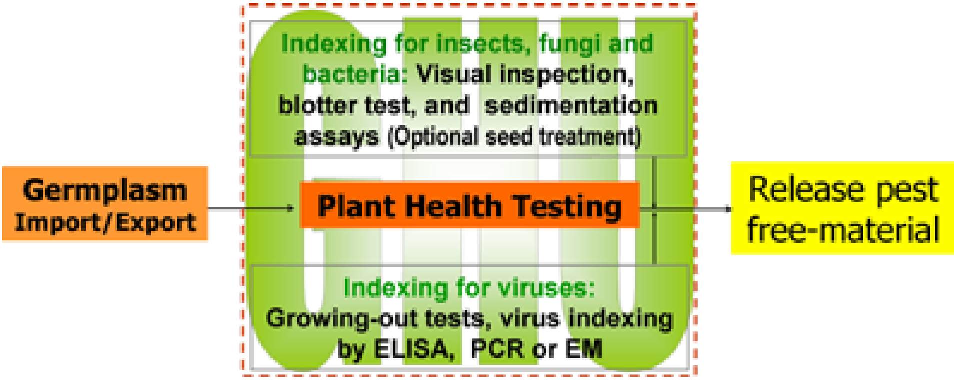
### International exchange of germplasm: an essential step for sharing international public goods

Since its inception in 1967, IITA has been actively involved in the collection, conservation, and use of the plant genetic resources of important crops, such as banana and plantain, cassava, cowpea, maize, soybean, and yam, and their wild relatives from Africa and other parts of the world. Using this germplasm, IITA's crop improvement programs, based in several locations in sub-Saharan Africa, have been developing high-yielding, nutritionally

*Seed testing.* Photo by IITA.

## Germplasm exchange: benefits and risks

Crop germplasm—seeds, plants, or plant parts suitable for propagation—is a high-value commodity very frequently exchanged for agricultural research, crop diversification, food production, and commerce. International exchanges of useful germplasm have been the major factor in the diversification and improvement of global agriculture. For instance, about 30% of the world's food production is derived from crops originating in other countries. Cassava, first introduced from Latin America by the Portuguese in 1558, has been established as one of the major food staples in sub-Saharan Africa. Germplasm exchange, however, has an inherent risk of introducing exotic plant pathogens (viruses, fungi, bacteria, phytoplasma, and other pathogenic microbes), weeds, insects, and nematodes (pests). Due to a lack of competition and resistance, introduced pests often result in devastating epidemics in territories in which they did not exist before, leading to severe economic losses. The cassava green mite, *Mononychellus tanajoa*, a native of Latin America, was accidentally introduced into Africa in the 1970s and spread to almost all the cassava-producing regions, reducing yields by 30–50%. This pest was controlled through the introduction of a natural enemy from Latin America, *Typhlodromalus aripo,* in 1993. The accidental introduction of the *Banana bunchy top virus* in Malawi has affected banana production in over 3000 ha and completely wiped out production in Nkhota Khota and Nkhatabay. In addition, pests associated with the germplasm may reduce its longevity during storage and may have negative effects on crop performance (e.g., nematodes in yam tubers). Therefore, several safeguards have been established to prevent the spread of pests through the movement of germplasm from one area to another. These quarantine or phytosanitary measures are enforced through national and international legislation.




*Scheme for phytosanitary management of germplasm.* Source: L. Kumar, IITA.

superior crop varieties resistant to pests, diseases, and drought.

These are regularly exchanged with national and international programs for crop improvement and agriculture development.

## Germplasm safety matters

As part of the measures to prevent the inadvertent spread of pests through exchange activities, IITA has established a Germplasm Health Unit (GHU). The GHU is responsible for the production, maintenance, and exchange of healthy (pest-free) germplasm in accordance with the international requirements on plant protection. These are covered by the International Plant Protection Convention (IPPC) under the auspices of FAO, and those set up by the Inter-African Phytosanitary Council (IAPSC) and National Plant Protection Organizations (NPPOs) to safeguard agriculture and natural resources from the risks associated with the entry, establishment, or spread of plant pests.

GHU (a) facilitates germplasm exchange in support of IITA's international crop improvement programs; (b) inspects for pests and certifies the health status of germplasm; (c) ensures compliance with the national regulations on plant introductions and exports; (d) guards against the introduction of exotic pests into countries where they do not occur; (e) ensures phytosanitary management of plant genetic resources conserved in the IITA genebank; and (f) provides capacity building and awareness creation on phytosanitary measures.

GHU operates within the framework of the procedures for the introduction and export of germplasm established by the government of the host country in which IITA's operations are based. For instance, all the exchange operations of IITA's activities in Nigeria are organized in accordance with the legislation of the Nigerian Agriculture Quarantine Service (NAQS) of the Federal Department of Agriculture, Nigeria.

## Ensuring exchange of clean germplasm

Crops researched at IITA comprise those propagated through botanical seeds or true seeds (maize, soybean, cowpea, and other legumes of importance to African farming) and crops that are propagated through vegetative propagules, including stems (e.g., cassava), tubers (e.g., yam), and *in vitro* plants (e.g., banana and plantain, cassava, and yam).

Each type of germplasm demands a unique set of procedures for assessing the health status of the material. At

IITA, this work goes on from production to postharvest to the point when the material is dispatched.

Plant material generated for international exchange is inspected with the technical officers of NPPO during the active growth stage in the field or screenhouse to ensure the selection of pest-free material. The sorted materials (seeds or vegetative propagules) are then brought to the GHU laboratories for critical inspection for the presence of pests. Detection methods used for this purpose include visual inspection of dry seeds, seed washing, agar and blotter tests, seed soaking, and seedling symptom tests which aid in identifying any pest-infested material. Additional techniques are used for pest identification including culturing techniques, microscopy, and biochemical analyses of samples by enzyme-linked immunosorbent assay (ELISA), polymerase chain reaction

## Seeds as vehicles of pests

True seeds (botanical seeds) offer the safest form in which to exchange germplasm. Despite their ability to serve as potential vehicles for the spread of pests, it is relatively easy to sort out contaminated seeds from healthy seeds. Furthermore, seeds can be treated with chemicals (e.g., Mancozeb at 2 g $kg^{-1}$) to eliminate several types of fungi and bacteria. Only a small fraction (about 10%) of the >1000 plant-infecting virus species is capable of being spread through seeds (e.g.. *Cowpea aphid-borne mosaic virus* in cowpea is seed transmitted, but not *Cowpea golden mosaic virus*). Virus infesting seeds can be eliminated by grow-out tests, and seeds harvested from uninfected plants offer the safest approach.

In contrast, almost all the pests present in the vegetative tissues (stems, tubers, roots, suckers, *in vitro* plants) are spread through planting material. Therefore, exchanging planting material in the form of stem cuttings (e.g., cassava and sweetpotato), tubers (e.g., yam and Irish potato), or suckers (e.g., banana and plantain) poses the maximum risk of spreading pests. As a general rule, quarantine regulations prohibit the exchange of vegetative propagules unless stocks are derived from plants certified as pest-free. Micropropagation or the *in vitro* propagation of plants using modern tissue culture methods offers the safest option for exchanging vegetatively propagated crops. Procedures employed during *in vitro* propagation result in the elimination of all pests, but not viruses and some fastidious microbes. Special procedures are used to eliminate viruses from in vitro plants. Therefore, where possible, IITA exchanges only *in vitro* planting material (tissue culture) produced under aseptic conditions.

**Seeds pose less risk than clonally propagated materials**

**Less risk**
-Scope for phytosanitation
-Only few viruses can be transmitted through seed

**High risk**
-Phytosanitation is difficult and demands special process
-All types of pathogens spread

(PCR), and genomic sequencing. Only materials that are free of the regulated and unregulated quarantine pests are released for international exchange.

GHU also monitors for genetically modified organisms (GMO) to comply with the Cartagena biosafety protocol, also under the regulation of NPPOs. This is done mainly by seeking an additional declaration from the exporting parties on the GMO status of the planting material as stipulated in the conditions of the import permit issued by the NPPO. Diagnostic capacity exists to monitor germplasm for traces of GMOs by PCR assays, targeting constitutive elements of transgene constructs, such as promoters of *Agrobacterium tumefaciens* or Cauliflower mosaic virus 35S gene, that are widely used for generating transgenic plants.

### Complying with regulations

Germplasm exchange activity commences with the application of a permit from a host country for germplasm import (for use in IITA's R4D programs) or germplasm export (to partners, collaborators and other stakeholders, including IITA's missions in other countries). This is an essential process under the Convention of Biological Diversity (CBD) treaty that regards biodiversity as a national treasure, and requires authorization from the respective governments for free exchanges. Every country has a nodal agency tasked with issuing permits for the movement of germplasm.

In addition, GHU applies for phytosanitary certificates (PC) for the export of material. The PC is issued by NPPO after the condition has been satisfied that the material being exported meets the phytosanitary standards of the IPPC and the importing country. GHU invariably complies with national regulations in obtaining these two documents for all seeds or plant materials sent or received. Similarly,

## Categorization of pests

Pests are classified into (a) regulated pests and (b) unregulated pests. Regulated pests are further classified into quarantine pests and regulated nonquarantine pests.

Pests whose introduction into an area can result in severe destruction are classified as quarantine pests. Territories can be free of quarantine pests (e.g., *Fusarium oxysporum* f. *cubense* Race 4 present in some parts of Asia but not in Africa) or present but not widely distributed (Cassava brown streak viruses, *Xanthomonas campestris* pv. *musacearum* responsible for banana bacterial wilt, and *Banana bunchy top virus* occur in Africa, but are restricted to certain regions).

**Quarantine pests** are rigorously controlled through official monitoring measures. **Regulated nonquarantine pests** are widely distributed and their presence in germplasm causes a loss of planting material or initiates a new disease cycle (e.g., *Cucumber mosaic virus* infects a range of hosts, including banana, and is widely distributed). Regulated quarantine pests are monitored by specific procedures. In general, all programs for the production of clean planting materials, including those meant for international exchanges, ensure freedom from quarantine pests and regulated nonquarantine pests.

The categorization of pests is usually country-specific. For instance, NAQS classifies pests under three categories:

*Category A*: Pathogens which are not present in Nigeria and/or in any country in West Africa

*Category B*: Pathogens which are of restricted local distribution in Nigeria and/or West Africa against which field inspection and or/seed health testing methods can provide adequate protection

*Category C*: Internationally widespread pathogens which affect seed quality.

Pest lists and pest categorization are often updated.

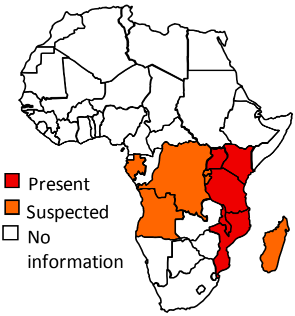
## Dangerous pathogens on the move

The following pathogens provide the greatest threat to food security in sub-Saharan Africa.

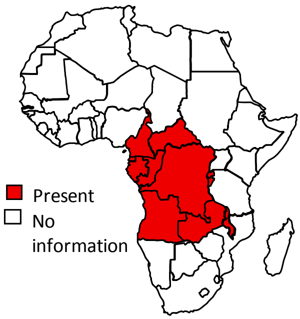
**Cassava brown streak viruses**
-Emerging virus disease of cassava
-Destroy tuberous roots
-Occurs in Kenya, Uganda, Tanzania, Malawi, and Mozambique
-Suspected in DRC, Congo, Burundi, Rwanda, Gabon, and Madagascar

**Banana bunchy top disease**
-BBTV-infected plants become unproductive
-Major constraint to fruit production and the production and distribution of quality planting material
-Widespread in Central Africa

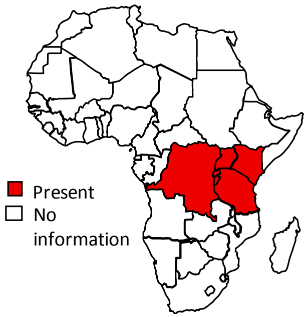
**Banana bacterial wilt (BXW)**
-BXW affects fruit production and quality, and kills the plant
-Widespread in East Africa




Cassava brown streak




Banana bunchy top




Banana bacterial wilt

when material is imported it is subjected to post-entry inspection to ensure its compliance with the conditions specified in the import permit. Depending on the need, material is held in the post-entry isolation facility until the necessary clearances are obtained. Material that satisfies all the conditions is released for IITA's use.

From 2005 to 2010, GHU, from IITA's Ibadan Station in Nigeria in liaison with NAQS, has facilitated about 492 exchanges, 157 imports, and 335 exports of crop and other plant material to 69 countries, 34 of which are in Africa (Fig. 1). USA, India, Colombia, Mexico, and Japan are among the top 5 non-African countries. Within Africa, the top 5 countries with which IITA has exchanged germplasm are Bénin, Ghana, Cameroon, Kenya, and South Africa. Each of these countries has specific legislation. However, procedures for health monitoring have the same underlying principle, i.e., *the exclusion of pests and the prevention of pests from spreading.*

### Phytosanitary protection of genetic resources

GHU ensures the phytosanitary management of the germplasm of food crops (about 27,000 accessions) conserved in the IITA genebank and also in the *in situ* germplasm collections of breeding programs. Germplasm conserved in the genebank is systematically evaluated for its health status and clean germplasm

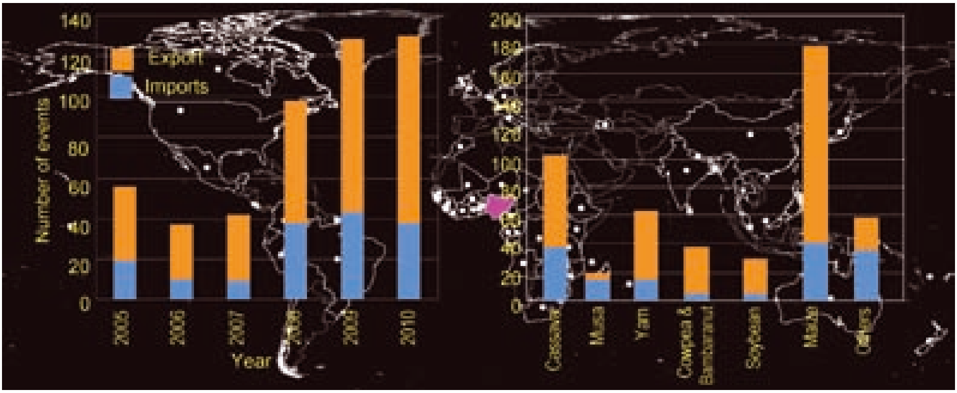



*Fig. 1. Germplasm export and import events facilitated by GHU to various countries around the world.* Source: L. Kumar, IITA.

*Information dissemination through exhibits and hands-on demos, IITA Open Day.* Photo by L. Kumar, IITA.

is conserved for distribution by IITA's Genetic Resources Center (GRC).

## Contributing to phytosanitary capacity development in SSA

Together with the Virology and Molecular Diagnostic Unit and GRC at IITA, Ibadan, GHU augments diagnostic procedures for monitoring pests in germplasm; develops a reference pest collection and DNA bank to use as controls; establishes DNA barcode databases of the pests of African food crops; and augments procedures for salvaging clean germplasm.

GHU plays an active role in developing the skills of NPPOs in the testing for germplasm health and the production of pest-free germplasm via training courses and short-term assignments. It also creates awareness on quarantine pests, quality standards for planting material, and the sanitary and phytosanitary (SPS) measures.

Knowledge and technologies developed are disseminated through training programs, the publication of protocol manuals, information flyers and a website (http://www.iita.org/germplasm-health). The unit also collaborates with NPPOs and IAPSC as a technical partner to develop phytosanitary capacity in Africa.

## Dangers of unknowns

Certain basic knowledge on pests is necessary to implement phytosanitary measures. Examples are the characteristics of the pest and its variants, its effect on the host (symptoms), geographic distribution, alternative hosts, modes of spread, vectors, and the availability of diagnostic tools. Insufficient information compromises the phytosanitary inspection and demands very stringent measures on the production of planting material.

For instance, frog skin disease (FSD), a virus-like disease of cassava prevalent in certain parts of Latin America, is difficult to diagnose due to insufficient knowledge on its etiology and the lack of reliable diagnostic tools. Moreover, FSD does not induce characteristic symptoms in the aboveground parts of the plant further complicating the detection of infected sources. To avoid the risk of spreading FSD, *in vitro* plantlets generated from cassava plants produced in FSD-free fields are moved. However, only a few organizations are capable of producing plants in this manner. To obtain useful germplasm from any agencies that are incapable of producing planting material under stringent phytosanitary conditions, the material from the source requires that it be sent to a third party capable of producing FSD-free plants. This procedure severely delays the exchange of material.

Similarly, the etiology of cassava brown streak disease (CBSD) was unraveled in the late 1990s and succeeded by the development of diagnostic tests for cassava brown streak viruses (CBSVs) that cause this disease. But CBSD had been known to occur in coastal zones of southern Africa for nearly a century. Like FSD, aboveground symptoms of CBSD are cryptic and difficult to recognize. Due to insufficient knowledge on CBSD and poor awareness, it is conceivable that cassava was moved, albeit inadvertently, from CBSD-affected areas to other cassava-producing regions in Africa contributing to the virus spread in the continent.

These two examples depict the limitations of phytosanitary monitoring and the potential risk for pest escape if adequate precautions are not taken. To circumvent the limitations in diagnosis of uncharacterized, not-so-well-characterized, and cryptic pests, monitoring programs are increasingly relying on broad-spectrum diagnostic tools, including deep sequencing, which identify a range of related species in the same genus, family, or order.

Although these approaches reduce the risk of potential pest escape, they are expensive, laborious, and detect every species including benign endosymbionts and pose challenges to decisions on germplasm exchange. Another approach depends on the production of “clean” planting material using sources from pest-free areas. GHU adopts both these approaches to increase confidence in germplasm health and safety.

# Conservation of germfree-germplasm

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Plant genetic resources (germplasm) are the foundation for sustainable agriculture and global food security. They possess genes that offer resistance to pests and diseases and resilience to abiotic stresses, such as drought tolerance, soil erosion, and other constraints.

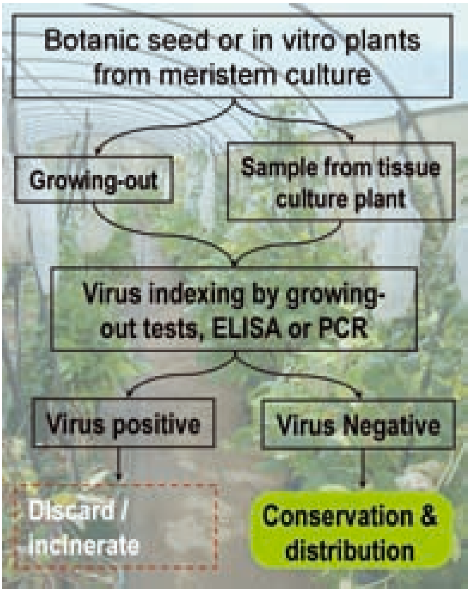
However, genetic resources are eroding at unprecedented rates as a result of the loss of habitat, outbreaks of pests and diseases, and abiotic stresses. Therefore, it has become imperative to conserve genetic resources for agricultural sustainability and the preservation of global biodiversity.

*Seeds of important grain legumes are conserved in IITA's Genetic Resources Center.* Photo by IITA.

In the mid-1970s, IITA has initiated an *ex situ* conservation of germplasm of important African food crops which are held in trust on behalf of humanity under the auspices of the United Nations. To date, IITA's Genetic Resources Center (GRC) conserves over 27,000 accessions of six main collections of African staple crops, namely, cowpea and other *Vigna*, soybean, maize, cassava, banana, and yam. Germplasm is distributed worldwide for use in research for food and agriculture. Depending on the species' reproductive biology and mode of dissemination, collections are stored in field, seed, or *in vitro* genebanks.

However, germplasm (seeds or vegetative propagules) infested with pathogens such as, viruses, fungi, bacteria, and nematodes, insects, mites and even weeds (hereafter all referred to as pests) can spread along with the planting materials. Because of this risk, planting materials are traditionally sourced from healthy-looking plants and as an additional safety measure they are treated with chemicals to eliminate bacteria, fungi, nematodes, insects and other pests. However, viral pathogens are difficult to detect and pose challenges to "clean" (pest-free) planting material production procedures. IITA's collections were sourced over 35 years from several countries in Africa and other parts of the world.

Knowledge on viruses infecting crops conserved in the IITA genebank and the means for their detection and production of clean planting material have dramatically improved over the past two decades. To ensure that




*Conservation of virus-free germplasm.*

germplasm conserved is free of pests, particularly viruses, a systematic approach was taken to assess the health status of every accession in the genebank and produce clean planting materials for conservation.

For seed-propagated crops (maize and legumes), clean seed production requires planting accessions in contained screenhouses. Emerging plants are monitored for symptoms and each plant is tested using diagnostic tools for all known seed-transmitted viruses occurring in the territory where they were last grown. Plants that test positive for virus and/or showing virus-like symptoms are destroyed. Seeds are harvested from the virus-negative, healthy-looking plants. Clean seeds are then deposited in the germplasm collections. This work started in 2008, and so far over 4000 accessions of legumes have been evaluated and clean seed material produced have been conserved in the genebank.

For clonally propagated crops (cassava, yam and banana), production of clean planting material involves *in vitro* procedures using meristem culture. In cassava, source plants are subjected to thermotherapy (exposing plants to 27-30 °C) from 1 to 3 weeks prior to meristem excision and *in vitro* propagation. *In vitro* plants are indexed for viruses and plants that test positive are discarded while virus-negative plants are further propagated for conservation in the *in vitro* genebank. So far, over 2000 accessions of clonal crops have been subjected to this process to derive virus-free plants.

Production and conservation of "clean" planting material is expensive; however it improves the turn-around time for processing germplasm for exchange and dramatically improves its use. In addition, clean germplasm improves the viability of the material conserved in the genebank and prevents the risk of the accidental spread of pests from one region to another through the planting materials.

*Researcher in genebank.* Photo by IITA.

# In Kanti Rawal's footsteps: wild cowpea from Nigeria

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*Cowpea: dietary protein for millions in West Africa.* Photo by IITA.

Cowpea, *Vigna unguiculata* (L.) Walp. is the major legume crop in the African lowlands. It is the main protein supply of half of the population in sub-Saharan Africa.

Nigeria is the most populous country in West Africa, and also produces the largest amount of cowpea. Its urban population is growing in leaps and bounds, and thus, it is also importing a lot of cowpea from all its neighbors.

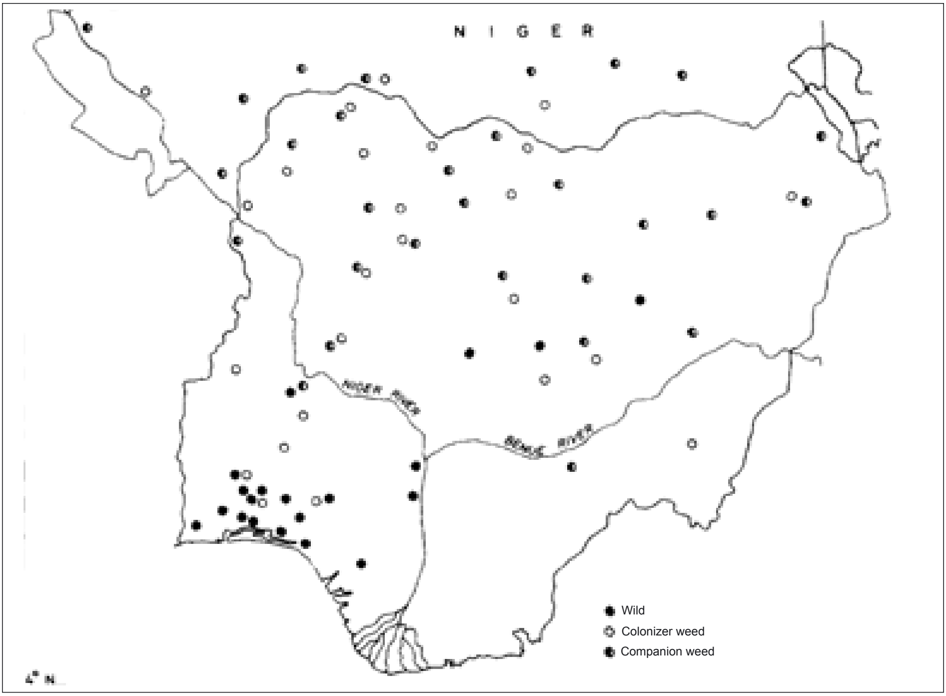
Cowpea is considered by several authors as having been domesticated in Nigeria or within a larger area including Nigeria (i.e., Vaillancourt and Weeden 1992). In addition, the first wild cowpea accession was collected in northern Nigeria by J.M. Dalziel, a British botanist, and this led Piper (1913) to propose the African origin of cowpea[1].

To some extent, this partly explains why Nigeria was the first country surveyed for cowpea accessions by IITA's then Genetic Resources Unit. Between 1970 and 1973, Kanti Rawal traveled 38,000 km around Nigeria and Niger. He collected wild cowpea accessions as well as numerous accessions of domesticated cowpea.

According to his map (see next page), he collected wild cowpea in 68 places (Rawal 1975). Unfortunately, over the years, the passport data of these accessions were lost and, today, the place of collection is known for only four out of the 40 accessions still maintained at IITA.

Regarding Nigeria, Rawal (1975) wrote in the abstract of his paper: "As in the case with many cultivated species, *Vigna unguiculata* (L.) Walp. has a wild form growing in secondary forests and derived savannahs and a companion weed form adapted to disturbed habitats such as roadside ditches and fields. Evidence of introgressive hybridization between weedy and cultivated forms has been presented. The

[1]The African origin of cowpea was proposed 50 years earlier, when authors were split between those supporting an African origin and those supporting an Indian origin. Piper, while successfully crossing a domesticated cowpea and a wild plant from Nigeria, definitely proved the African origin of cowpea. After 1913, the African origin of cowpea was not challenged anymore and definitely accepted.




*Geographic distribution of the wild, the colonizer weed, and the companion weed forms of* V. unguiculata *in Nigeria and Niger. The cowpeas are cultivated commercially in areas between latitudes 8°N and 15°N* (Rawal 1975).

zone of extensive natural hybridization corresponds to the cultivation area of northern Nigeria and Niger and may well extend to Upper Volta (now Burkina Faso) and Senegal."

Rawal gave very good descriptions of what he called the wild and weed forms. His wild forms were samples of subsp. *baoulensis* (A.Chev.) Pasquet; the weed forms were samples of subsp. *unguiculata* var. *spontanea* (Schweinf.) Pasquet. We (Pasquet and Padulosi in press) believe that the first subspecies belongs to the secondary gene pool of cowpea and the second to the primary gene pool. However, since Rawal's material is mostly lost[2], the assessment of the diversity of wild cowpea from Nigeria is impossible in the absence of new collection missions in the country.

In addition, factors such as climate change, increased incidence of pests and diseases, cultural change, or the adoption of improved lines are also likely to affect the diversity of cowpea and wild *Vigna* in the near future. To avoid the irreversible loss of *Vigna* and to secure highly viable *Vigna* diversity, the Global Crop Diversity Trust in association with IITA and Nigeria's National Centre for Genetic Resources and Biotechnology (NACGRAB) organized a collecting mission for wild *Vigna* germplasm in 2010. The mission covered 27,000 km in Nigeria between 14 October and 7 December and collected 260 accessions (242 of var. *spontanea* and 18 of

[2]IITA still holds 40 accessions, but this could be only one-third of the original number.

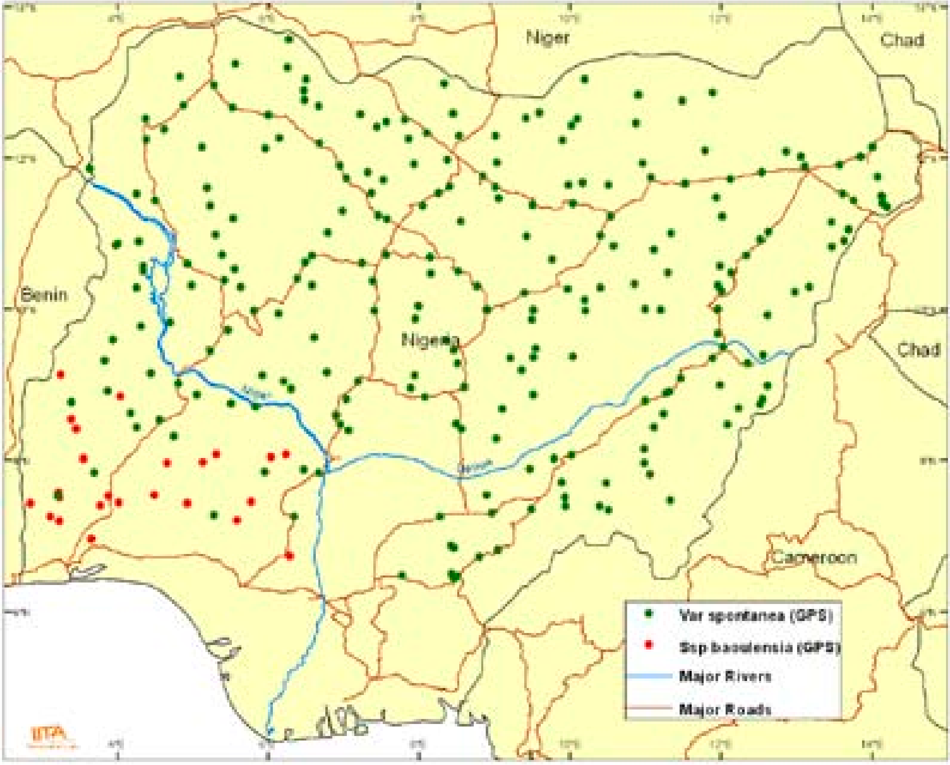


*Fig. 1. Localities where subsp.* baoulensis *(red dots) and var.* spontanea *(green dots) were observed.*

subsp. *baoulensis* (Fig. 1). In addition, 13 populations were sampled for further population genetic analysis.

In comparison with the Rawal missions that took place in 1971–73, we surveyed more localities within a shorter time. Unlike Rawal, we focused on wild cowpea only and benefited from a much better road network, especially in northern Nigeria where we were driving more than 600 km/day. In the end, there is a general agreement between the results of Rawal's survey and our own in terms of geographical distribution of both subspecies.

In the northern ranges, we often encountered wild cowpea in fields or at roadsides. Wild cowpea plants are easy to spot in the field, as they twine 2–3 m above soil level on sorghum or pearl millet stems (Fig. 2). Domesticated cowpea are prostrate or short and erect but usually not twining.

Based on the ecological definition of a weed, which is "an uncultivated plant taxon that benefits from human impacts or 'disturbance'," var. *spontanea* is a weed mainly encountered in disturbed places, such as in fields and gardens, at roadsides, and sometimes within towns (sewage ditches, grassy places); it was not observed within Yankari National Park. However, to some extent, var. *spontanea* is also a weed in the economic sense of the word since it is usually pulled out from the fields by farmers. It usually appears as isolated plants or isolated patches of fewer than 20 plants or as a few plants forgotten by the farmer while weeding.

In some places, we found fields with as many wild cowpea as domesticated cowpea (SP 815, Katsina State, for example). We suspect that, in these places, farmers were primarily interested in fodder. Var. *spontanea* is obviously a good fodder plant and farmers primarily cultivating cowpea for fodder would not choose to lose time weeding wild cowpea.

Since experiments have proved pollen flow between wild and domesticated cowpea at over 30 m distances (Fatokun and Ng 2007), we checked if domesticated cowpea was grown within 30 m of the collecting sites for wild cowpea (Fig. 3). This occurred frequently (70%) in the northern part of the range which is also the main cowpea production area. Our survey confirms Rawal's (1975) conclusion. There are numerous situations in Nigeria in which domesticated cowpea and wild cowpea exchange genes. Therefore, its diversity may not be much higher than that of the domesticated gene pool. An evaluation of diversity among the collected material would help confirm or disprove this assumption.

*Fig. 2. Wild cowpea (var.* spontanea*) twining on pearl millet (SP 916, Kano State, left) and sorgum (SP 913, Kaduna State, right) stems.* Source: R. Pasquet, *icipe.*

*Fig. 3. Domesticated cowpea close to var.* spontanea *(arrow). SP 949 (Borno State).* Source: R. Pasquet, *icipe.*

The potential hybridization between wild and cultivated forms has implications for the transgenic Bt cowpea which are presently under confined field trials in Nigeria (www.aatf-africa.org/userfiles/Cowpea-Project-brief.pdf). If the Bt gene could move through the pollen from transformed to wild plants, further careful studies need to evaluate the advantage given by the Bt gene to a wild cowpea plant and whether Bt cowpea poses any risk to biodiversity.

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## **New book:** Nature Conservation in West Africa: Red List for Benin

A new book, titled *Protection de la Nature en Afrique de l'Ouest: Une Liste Rouge pour le Bénin* (Nature Conservation in West Africa: Red List for Benin), published by IITA and partners, has just come off the press.


The 365-page volume is bilingual (French and English) and was edited by IITA Scientist Emeritus Peter Neuenschwander, Professor and Vice-Chancellor Brice Sinsin (Université d'Abomey-Calavi, Benin), and Biosystematist Georg Goergen (IITA). The book, for the first time, presents information on the status of rare and threatened species, such as plants, animals, fish, among others.

The publication consists of 33 chapters written by about 40 scientists and conservationists that cover an evaluation of 550 species based on the IUCN (International Union for Conservation of Nature, http://www.iucn.org/) criteria.

The book is of interest to those working in nature conservation, including schools, NGOs, government agencies, policymakers, as well as tourists.

The book was produced with the generous support of the following partners: Swiss Agency for Development and Cooperation (SDC), Leventis Foundation, Netherlands Embassy (Benin), and Helvetas (Switzerland).

Copies are available for sale from IITA. To get a copy, please contact Peter Neuenschwander, IITA-Benin, at p.neuenschwander@cgiar.org or Katherine Lopez, IITA, Ibadan, Nigeria, at k.lopez@cgiar.org.

# Restoring the IITA Forest

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In 2010, the *International Year of Biodiversity*, a new project began at IITA to enhance biodiversity and restore IITA's Forest. Coincidentally, the United Nations (UN) declared 2011 as the *International Year of Forests*, and the IITA–Leventis Project is preparing to plant over 30,000 saplings of indigenous tree species this year to restore native forests.

## Background

The IITA campus (1000 ha) in Ibadan, Nigeria, now largely within the city limits of Ibadan, was acquired in 1965. The land was mostly bush, interspersed with field crops and 26 villages, whose occupants were relocated. After campus construction and the allocation of fields for crop research, about a third of the site—some 350 ha—was left untouched. In 1987, campus residents created pathways through this regenerating post-abandonment secondary forest, resulting in the Forest Trails we still enjoy today. After more than 45 years as a reserve, and with continuing loss of forest in southwest Nigeria, this area has become an increasingly important refuge for many plants and animals that were once widespread. Together with an artificial lake at the west margin, the IITA Forest shelters a wealth of animal and plant species and provides a habitat for biodiversity in Nigeria.

## Objectives

The IITA–Leventis Forest Restoration Project aims to:

- Restore the existing forest by removing invasive exotic species, such as *Chromolaena odorata, Delonix regia, Gliricidia sepium, Leucaena leucocephala,* and *Tithonia diversifolia,* and replanting the area with indigenous species from seeds, wildlings, and cuttings.
- Protect the IITA Forest against disturbance and theft, in particular, against hunting for bush meat and the collection of medicinal plant parts.
- Catalog the biodiversity of the forested areas, mainly in terms of birds, butterflies, and medicinal plants, and monitor changes.
- Replant the east bank of the lake with indigenous tree species and carry out research into reforestation techniques.
- Engage in conservation educational activities, especially with young people,

### Year of Forests 2011

Forests provide a shelter to people and a habitat to biodiversity. They are a source of food, medicine, and clean water and play a vital role in maintaining a stable global climate and environment. All of these elements taken together reinforce the message that forests are vital to the survival and well-being of people and life everywhere. The United Nations General Assembly declared 2011 the *International Year of Forests* to raise awareness on the sustainable management, conservation, and development of all types of forests. For more information: www.un.org/en/events/iyof2011/.

*Junonia cymodoce basking in the sun.*
Photo by Sz. Safian

to raise awareness of the need to protect forests.

- Form local, regional, and international partnerships in tropical forest conservation, research, and education activities.

### Activities

The team of rangers and nursery workers from the IITA–Leventis Project is led by Project Coordinator John Peacock, Medicinal Plant Expert Deni Bown, and Nursery Manager Olukunle Olasupo. In the first year, over 21,000 seedlings of more than 40 indigenous tree species were propagated. Experimental plots were established to record the effects of different ground treatments on the growth of 10 species. Reforesting the east bank was also started by planting trees grown in their first Tree Seed Project by the International School at IITA and by the Institute's staff.

In addition to the School's Tree Seed Project, a Garden Club was started to show children how to grow, propagate, harvest, and value edible and medicinal plants. There are regular activities to engage children in observing wildlife and appreciating the forest. Moves are also under way to found a Youth Explorers' branch of the Nigerian Field Society which will use the resources and expertise at the IITA campus. Educational displays of medicinal plants, butterflies, and photo archives of birds were exhibited at events, and information, both printed and electronic, is provided for the numerous visitors.

Together with the Security Unit at IITA, the team also improved the protection of the Forest.

*Catalogue of forest resources*

The IITA Forest is an internationally acclaimed Important Bird Area (IBA). Since March 2010, over 200 bird species have been identified during surveys by Shiiwua Manu, Phil Hall, John Peacock, Adeniyi Taiye, and Matt Stephens. Similar baseline surveys were carried out for butterflies by Szabolcs Sáfián, Robert Warren, and Oskar Brattström, and brought the total identified in the IITA Forest to 220. Deni Bown has to date recorded 431 plant species at IITA; of these, 382 have medicinal uses.

*Flagship species*

For many people, the Forest is a place of mystery and beauty but something they may not know much about. By targeting conservation efforts on spectacular species, their interest can be focused. The Project has three flagship species: the Ibadan malimbe, *Malimbus ibadanensis,* an endangered bird found only in the Ibadan area; the iroko, *Milicia excelsa,* one of Nigeria's most important timber trees; and the "PG plant", *Pararistolochia goldieana,* a liana (a woody vine) that produces the largest flower in Africa.

The Iroko is of major economic importance but cannot be grown successfully in plantations. The only place where it is now safe from being felled is within the IITA campus.

Likewise the Ibadan malimbe and PG plant are totally dependent on the IITA Forest for survival.

Over the past 50 decades, the loss of tropical forests in Nigeria has been catastrophic, giving this fragment in IITA considerable importance. Increasing its extent and biodiversity is part of IITA's new initiative to conserve biodiversity and create an African Science Park or Innovation Africa™. These are valuable resources for local interests and the wider scientific community.

*Flagship species in the IITA Forest: (left) Ibadan malimbe,* Malimbus ibadanensis, (Source: Leventis Foundation) *and (right)* Pararistolochia goldieana*, a woody vine that produces the largest flower in Africa.* Photo by O. Adebayo, IITA.

## Why do tropical forests matter?

Tropical rainforests support the greatest complexity and numbers of living organisms on earth. In pristine forests, tree species alone may exceed 100/ha—whereas in temperate forests, there are fewer than 10/ha—and each has at least 15 other organisms dependent on it. The destruction of tropical forests, therefore, has a devastating impact on biodiversity. Since 1995, Nigeria has lost over 56% (>6 million ha) of its rainforests and deforestation continues at a world-record rate of 3.5% every year. Currently only 9.6 million ha remain, which is less than 10% of the total land area—the lowest percentage in West Africa. Traditionally, forests provide local employment and are sustainably harvested for fibers, foods, beverage ingredients, medicines, fodder, colorants, tannins, latex, oils, resins, and waxes, as well as for timber. Nationally, they are a source of tourist revenue and carbon credits. Internationally, they protect watersheds and globally, they mitigate the effects of climate change. Their loss has complex knock-on effects that are only now being quantified in terms of environmental, climatic, and socioeconomic change. Environmental degradation is increasingly seen as an economic loss that developing countries can ill afford. Now that the real cost of overexploiting this apparently inexhaustible "free" supply of wild plants and animals has become apparent, goals are being established by the United Nations via the Convention on Biological Diversity (CBD) and incentives for **R**educing **E**missions from **D**eforestation and Forest **D**egradation (REDD) to protect the remaining forests, reforest degraded areas, and promote sustainable development.

# BEST PRACTICE

## Investing in aflasafe™

aflasafe™ is a cost-effective, safe, and natural method for preventing the formation of aflatoxin in maize and other susceptible commodities in the field and also in postharvest storage and processing. It is providing hope for African farmers and opening doors for entrepreneurs looking to invest on a winning formula in the agricultural sector.

Scientific studies suggest that investment in aflasafe™ in Africa is viable, not only for profit but also to improve people's health. For instance, the study of Wu and Khlangwiset (2010) estimated that the cost-effectiveness ratio (CER; gross domestic product multiplied by disability-adjusted life years saved per unit cost) for aflatoxin biocontrol in Nigerian maize ranged from 5.10 to 24.8. According to the guidelines from the World Health Organization (WHO 2001), any intervention with a CER >1 is considered to be "very cost-effective".

**About aflatoxins**

Produced by the fungi *Aspergillus* spp., aflatoxins are highly toxic fungal substances that suppress the immune system, and cause growth retardation, liver cancer, and even death in humans and domestic animals.

Aflatoxins also affect the rate of recovery from protein malnutrition and Kwashiorkor, and exert severe nutritional interference, including in protein synthesis, the modification of micronutrients, and the uptake of vitamins A and D.

Exposure in animals reduces milk and egg yields. The contamination of milk and meat is passed on to humans after consumption of these products. Aflatoxins affect cereals, oilseeds, spices, tree nuts, milk, meat, and dried fruits. Maize and groundnut are major sources of human exposure because of their higher susceptibility to contamination and frequent consumption.

The toxins are most prevalent within developing countries in tropical regions and the problem is expected to be further exacerbated by climate change.

The high incidence of aflatoxin throughout sub-Saharan Africa aggravates an already food-insecure situation. Agricultural productivity is hampered by contamination, compromising food availability, access, and utilization. Unless

*Maize farmers receive aflasafe™ from IITA.* Photo by IITA.

aflatoxins in crops and livestock are effectively managed, marketable production and food safety cannot improve. Thus, the economic benefits of increased trade cannot be achieved.

Aflatoxins cost farmers and countries hundreds of millions of dollars annually. These losses have caused crops to be moved out of regions, companies to go bankrupt, and entire agricultural communities to lose stability.

**aflasafe™ to the rescue**
An innovative scientific solution in the form of biocontrol has been developed by the US Department of Agriculture's Agricultural Research Service (USDA-ARS). This breakthrough technology,already widely used in the United States, reduces aflatoxins during both crop development and postharvest storage, and throughout the value chain.

IITA and USDA-ARS have been collaborating since 2003 to adapt the biocontrol for Africa. They achieved significant breakthroughs that resulted in the development of an indigenous aflatoxin technology in Nigeria, now called aflasafe™. aflasafe™ contains four native atoxigenic strains of *Aspergillus flavus* that outcompetes and replaces the toxin-producing strains, thus reducing aflatoxin accumulation.

IITA and partners conducted trials in Nigeria. Native atoxigenic strains reduced contamination by up to 99%. The National Agency for Food and Drugs Administration and Control (NAFDAC) gave IITA provisional registration to begin testing of the inoculum of a mixture of four strains under the trade name aflasafe™. In 2009 and 2010, maize farmers who applied aflasafe™ achieved, on average, a reduction of >80% in aflatoxin contamination at harvest and 90% after storage.

Groundnut farmers also achieved more than 90% reduction in Nigeria and Senegal using a version of aflasafe™ with native atoxigenic strains from Senegal.

**In the future**
The success recorded so far in the control of aflatoxin comes from aflasafe™ produced in the lab. Consequently, to meet the demands of farmers in sub-Saharan Africa, large-scale production is needed.

In Nigeria, for instance, nearly 30% of harvested maize has high levels of aflatoxins and is prone to being rejected by the feed industry. In Kenya, last year because of aflatoxin contamination, more than two million bags of maize were declared unfit for human consumption in the Eastern and the Coast provinces.

*IITA staff producing aflasafe™ in the lab.* Photo by IITA.

Some countries, such as Senegal, have lost groundnut export market to the European Union due to aflatoxin contamination.

Commercial production of aflasafe™ would allow easy and widespread availability of a simple solution to the most recalcitrant problem affecting farmers and consumers. The monetized value of lives saved, quality of life gained, and improved trade by reducing aflatoxin far exceeds the cost of aflasafe™ production.

**Reference**
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# Clean seed systems

## Sustainable production and distribution of clean banana and plantain

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Banana (*Musa* spp.) including the plantain type are among Africa's most important staple food and cash crops. Nearly 30 million t of banana are produced yearly in Africa, mostly by smallholders and consumed locally.

The major edible types are parthenocarpic (produces fruit without fertilization) and seedless. They are propagated traditionally by planting corms and suckers (daughter plants that grow from the rhizomes at the base of mother plants).

However, propagation material derived from the infected mother stocks results in perpetuation of diseases (e.g., viruses such as banana bunchy top, banana streak) and pests (e.g., nematodes and weevils) leading to low yields and poor quality fruits.

Due to the unavailability of disease- and pest-free or clean planting materials, farmers in sub-Saharan Africa traditionally plant suckers derived from their own plantations, most of which are affected with pests and diseases.

IITA has been using three approaches to generate clean planting material of farmer-favored banana cultivars:

**Boiling water treatment of suckers:** Suckers are submerged in boiling water for 30 seconds to kill nematodes and weevils. This method is efficient and easy for farmers, but it has low output and is laborious.

**Macropropagation using the PIF technique:** Through the technique known as PIF (plantes Issues de Fragments de tige) tens of good quality plantlets are produced within two months at relatively low costs. In this approach, the primary buds of entire suckers or fragments of corms are destroyed and axillary buds are exposed to high humidity to induce sprouts which are then harvested, hardened, and distributed. This approach can be implemented in remote rural areas near farmers' fields or by NGOs in direct contact with farmers for training and the distribution of good planting materials. This procedure is simple to replicate using locally made humidity chambers (Fig. 1).

**Micropropagation:** Also known as *in vitro* production of tissue culture (TC) material this is the most efficient approach to the production of clean planting material in terms of throughput and germplasm exchanges across international borders. *In vitro* plantlets are micropropagated in the TC laboratory of IITA in Ibadan, Nigeria, and hardened first in the acclimatizing rooms, then in screenhouses before being distributed to farmers. Planting materials from preferred landraces and improved hybrids are propagated through TC, and hardened for use or maintained in a conservation cold room where each genotype is replicated several times from the initial meristem for future use (Fig. 2).

Combining the TC pipeline with the macropropagation through PIF, IITA regularly distributes thousands of seedlings to NARS, NGOs, and farmers in West and Central Africa. Besides the preferred local varieties, the most

*Fig. 1. IITA's Emmanuel Njukwe, Paula Bramel, and Bi Irie Vroh visit the Fritz Jakob Foundation, an NGO collaborator in Cameroon to look at humidity chambers under shade and planting materials obtained by the NGO.* Source: B. Vroh, IITA.

*Fig. 2. IITA's Delphine Amah holding racks of TC plants in a growth room.*
Source: B. Vroh, IITA.

distributed improved materials include the plantain hybrids PITA 14, PITA 21, and PITA 23 and the cooking banana hybrid BITA 3. These hybrids express a higher level of tolerance for black Sigatoka diseases compared with local varieties.

IITA trains farmers in applying boiling water treatment of suckers and macropropagation by PIF to produce clean planting material. However, IITA primarily uses micropropagation as the method of choice for conservation, propagation, and distribution of germplasm, and also to support its breeding programs. IITA also provides training programs on TC operations for NARS. For IITA's projects in West Africa, clean planting materials are produced by TC or by PIF, hardened and raised in screenhouses, and then transferred to specific project sites (Fig. 3).

In rural communities, IITA emphasizes training for farmers and rural entrepreneurs so they can produce clean planting materials in their own communities. These various efforts enhance the farmers' access to clean planting materials and also encourage involvement of commercial operators in distribution of planting materials. The improvement of the capacity of NARS and the involvement of the private sector are needed to scale up the technologies for the sustainable production of clean planting materials of banana and plantain.

*Fig. 3. Hardening of clean planting materials produced by TC and PIF methods in a screenhouse at IITA.* Source: B. Vroh, IITA.

# Developing clean seed systems for cassava in East and Central Africa

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Cassava is one of those crops that uses part of the plant for propagation. It is very convenient to use vegetative material from a previous crop to plant a new one. This is one of the beauties of vegetatively propagated crops. However, this convenience comes at a price. The use of planting material from a previous generation to establish the next provides an easy way for disease-causing pathogens, particularly viruses, to pass directly from one plant generation to another. So, while they offer convenience, vegetatively-propagated crops are often more widely affected by pathogens than those planted in the form of true seeds.

In Africa, cassava is the most widely cultivated of the vegetatively-propagated crops, being grown on more than 12 million ha across the continent. The exotic pest introductions, cassava mealybug and cassava green mite, caused great damage to Africa's cassava crop in the 1980s and 1990s, but both have been effectively managed through the implementation of a classical biological control program.

The fungal diseases, cassava bacterial blight (*Xanthomonas axonopodis* pv. *manihotis*) and cassava anthracnose (*Colletotrichum gloeosporioides* f. sp. *manihotis*) are locally important. The greatest current constraints to cassava production, however, are the virus diseases, cassava mosaic disease (CMD) caused by cassava mosaic geminiviruses (CMGs) and cassava brown streak disease (CBSD) caused by cassava brown streak viruses (CBSVs), which together cause crop losses worth more than US$1 billion annually.

One of the most important approaches to controlling these virus diseases, as well as other pathogens of cassava, is through the avoidance of infection. This can be achieved by starting out with pathogen-tested plants, and then bulking the planting material through a series of quality controlled multiplication steps. Although it sounds very simple, this can be difficult to achieve in practice.

Pathogen testing requires well-equipped laboratories run by adequately trained staff. Quality management in the field requires extensive grassroots knowledge of disease symptoms and the involvement of an appropriately trained and resourced national plant protection organization. In many parts of sub-Saharan Africa, capacity for these

*Cassava stems for future crop.*
Photo by L.Kumar, IITA.

functions remains insufficient to meet the demands.

IITA and its partners have made significant progress in developing and implementing new systems to maintain the health of cassava through seed systems. For instance, through the Great Lakes Cassava Initiative (GLCI), a multi-partnered project implemented from 2007 to the present in Burundi, Democratic Republic of Congo, Kenya, Rwanda, Tanzania, and Uganda, a rigorous system has been put in place to assure the health of cassava planting material. This has been particularly important in view of the rapid recent spread of a devastating pandemic of CBSD in East Africa.

The key components of the quality and health management system are as follows: Primary (centralized seed production sites) managed by researchers or qualified seed producers, secondary, and tertiary multiplication sites (usually in farmers' fields) are all assessed, at least once in a year, using the Quality Management Protocol (QMP). This sets out quality levels, primarily in terms of disease and pest incidence and material quality that must be met if the field is to "pass".

The QMP standards for CMD and CBSD incidences ascertained by diagnostic tests are <10% for primary and secondary sites and <20% for tertiary sites in endemic areas. Planting materials from fields that fail to meet QMP standards are not distributed or used for further multiplication, although the tuberous roots can be used by the growers for consumption. Fields that meet the QMP standard and test negative for CBSVs are approved for more widespread dissemination.


*Healthy cassava plant.*
Photo by IITA.

This is the first time that this level of rigor has been applied to maintaining the health of cassava through multiplication programs in sub-Saharan Africa. It has been invaluable in assuring the health of the planting material provided to more than half a million beneficiaries in six countries, and provides an important model for other current and future cassava development programs.

Much remains to be done before such an approach can be used in a more sustainable way. Most importantly, basic capacity needs to be strengthened in most countries. Key elements of this include the laboratory and human capacity for virus indexing, as well as the knowledge of QMP and the capacity of the national plant quarantine organization to monitor cassava seed systems.

In addition, the management of cassava diseases could be greatly enhanced by the establishment of isolated nuclear multiplication sites planted with virus-tested cassava plantlets derived from tissue culture, as well as by raising awareness among growers about the importance of establishing the next crop with healthy planting material.

A long-term goal, as the commercial value of cassava increases, will be to provide a mechanism through which planting material certified through the QMP attracts a price premium. Creating added value is certain to be the key to the future development of clean seed systems for cassava in Africa. IITA and its partners are strongly committed to reaching this goal.

# Clean yam tubers from vine cuttings

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*Yam market vendor.* Photo by IITA.

Production of yam seed tubers using vine cuttings and in vitro micropropagation is quick, cost-effective, and results in clean planting material. This new propagation system for yam developed by IITA uses vine cuttings grown on carbonized rice husks combined with in vitro micropropagation (tissue culture) (Fig.1).

The traditional system uses tubers as seeds, is inefficient and costly. High production costs are attributed to the use of seed yam tubers, which account for about 30% of the total yield and as much as 63% of the total variable cost incurred per season of cultivation. The multiplication rate in the field using the traditional system is also very low (1:5 to 1:10) compared, for instance, with some cereals (1:300). Low quality seed yam containing pests (nematodes) and

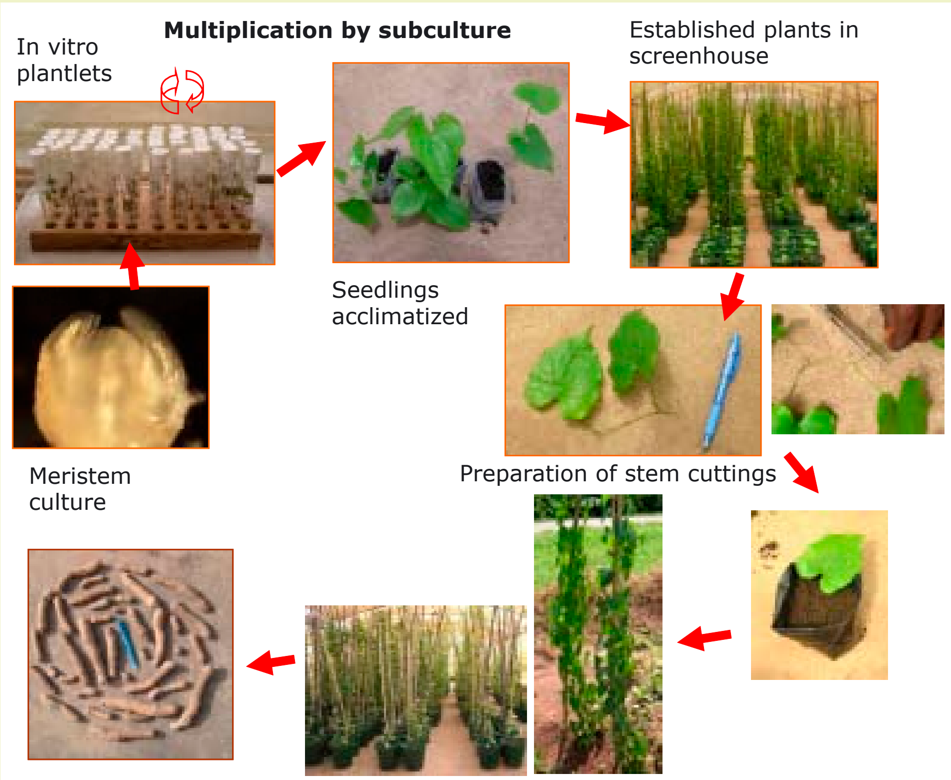



*Fig. 1. Clean seed tuber production system using vine propagation in combination with tissue culture techniques.* Source: H Kikuno, IITA.

pathogens (viruses) also result in a poor yield of ware yam tubers.

The use of vine cuttings as a planting material gives a higher multiplication rate that is about 20−50 times more than the traditional system. It also significantly lowers the risk of nematode infestation and promotes faster multiplication and better and more uniform crop quality. Although viruses are difficult to eliminate, planting materials (seedlings or tubers) produced by this approach are relatively clean compared with those from other propagation methods used in the open field.

An experiment conducted from 2009 to 2010 using seed tubers produced by vine propagation and planted at 25 cm × 1 m spacing resulted in the production of tubers both large (200−400 g) and small (<10−30 g). Large tubers are suitable for use as seed yam for planting in the field, whereas small tubers are resown to obtain appropriately sized seed yam (about 200−400 g) (Table 1).

Attempts are also being made to standardize the procedure for the direct use of vine cuttings as planting material using cv. TDr 95/18544. The success of this approach could change the way in which yam is propagated in the future and eliminate the dependence on seed yam for planting needs. It would also boost the availability of yam by ~30% (Table 1 and Fig. 2).

Another trial conducted to understand the appropriate time to excise vine cuttings established from tissue culture materials revealed that the best time for vine cutting is before the rapid tuberization stage. Vine cuttings taken after tuberization were poorly established (Fig. 3, Kikuno et al. 2010).

**Table 1. Yield of tubers harvested from yam (white yam: TDr 95/18544) with different sizes of seed tubers produced by vine propagation.**

| Size of seed yam and mini-setts | Fresh weight of tubers (g/plant) | Estimated yield (t/ha) |
|---|---|---|
| <10 g (SHM) | 427.6ab | 17.2 |
| <10 g (FM) | 325.6b | 13.2 |
| 10–30 g (SHM) | 570.0a | 22.8 |
| 10–30 g (FM) | 555.8a | 22.4 |
| 25–30 g sett (Control) | 391.6b | 15.6 |
| Mean | 454.1±105.9 | 18.2±4.2 |

SHM: Plants originating from tissue culture materials cultured in the screenhouse.
FM: Plants originating from mini-setts from tubers and cultured in the open field.

*Fig. 2. Tubers harvested from plants grown from seed tubers propagated by vine cuttings.* Source: H. Kikuno, IITA.

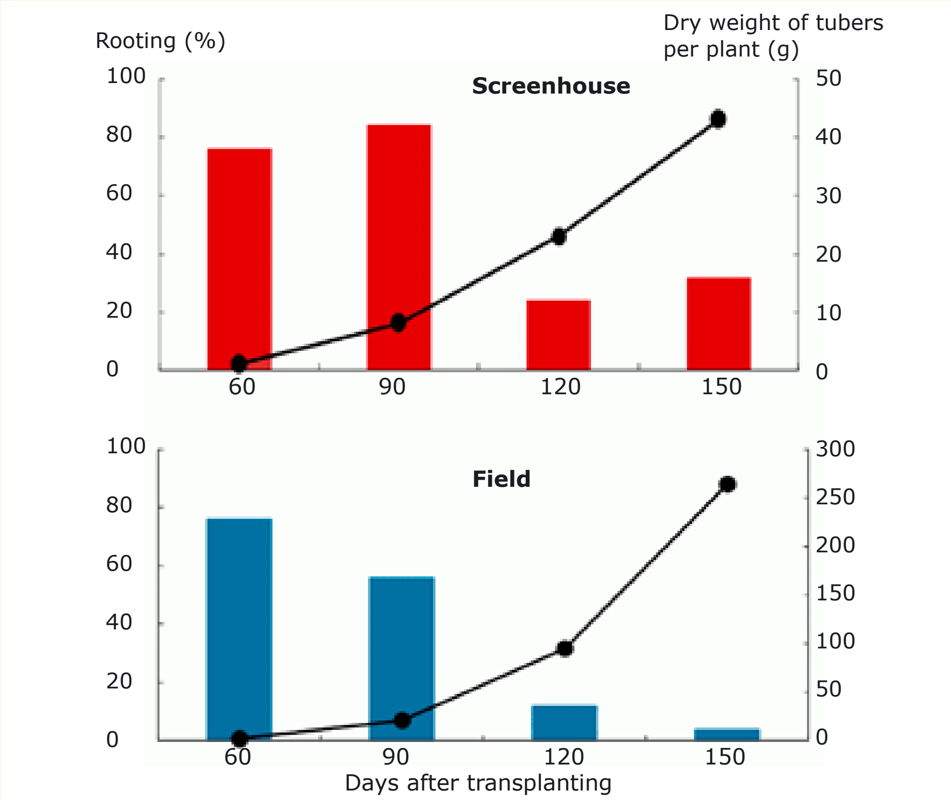



*Fig. 3. Correlation between rooting of vine cuttings and dry weight of tubers formed on mother plants. Time course of rooting of vine cuttings and growth of tubers of mother plants on yam (*D. alata *cv. TDa 95/00361). Bars in each figure indicate % of vine cuttings with rooting.*

This new technology offers a rapid solution for a high-output production of seed yam or yam planting material. At the same time, it addresses the need for large numbers and the quick distribution of improved varieties to farmers. This knowledge would be useful for NARES, CSOs, and farmers involved in producing and distributing seed yam, and in maintaining and multiplying breeder and foundation seeds. The technologies can also be used as a research tool by scientists.

The project was funded by the Japanese Government (Ministry of Foreign Affairs), Sasakawa Africa Association, Tokyo University of Agriculture, and International Cooperation Center for Agricultural Education at Nagoya University in Japan under the Ministry of Agriculture, Forestry and Fisheries funded the project. Partners include the Tokyo University of Agriculture; National Root Crops Research Institute at Umudike, Nigeria; Crop Research Institute, Ghana; and Institute of Agricultural Research for Development, Cameroon.

**Reference**

Kikuno H, Matsumoto R, Shiwachi H, Toyohara H, and Asiedu R. 2007. Comparative effects of explants sources and age of plant on rooting, shooting and tuber formation of vine cuttings from yams (*Dioscorea* spp.). Japanese Journal of Tropical Agriculture 51, Extra issue 2.

# A **hot** bath for the suckers!

*An effective treatment against nematode and weevil pests of banana and plantain*

Banana and plantain (*Musa* spp.) are important food crops for millions of people all over the world. The banana is the most popular fruit in the world and number one in international trade. The FAO estimates that over 100 million t of banana and plantain were produced worldwide in 2007. In sub-Saharan Africa (SSA), over 70 million smallholder farmers depend on the two crops for their food and income.

Banana and plantain production is greatly constrained by pests and diseases that lead to annual losses of millions of US dollars. The most important pests are nematodes (several species) and weevils (*Cosmopolites sordidus*) that are found in the soil and roots.

*Farmers dipping peeled suckers in boiling water.* Source: D. Coyne, IITA.

Nematodes attack the roots, hampering the uptake of nutrients from the soil and drastically reducing yield. In severe cases, they topple the whole plant. Weevils, on the other hand, attack the plant's underground corm, weakening the plant and causing stem breakage. Average production losses from nematodes are estimated at 30% of the harvests of highland banana in East Africa and can exceed 60% for plantain in West Africa.

These two pests are spread from one farm to another through the planting of infested suckers. Farmers can avoid infesting their farms by ensuring that they plant disease- and pest-free suckers, such as those derived from tissue culture. These are, however, out of reach for the millions of small-scale farmers in sub-Saharan Africa.

Research has shown that peeling and treating the suckers in hot water, at 50 °C, can effectively remove both nematodes and weevils and their eggs. This method has worked successfully for commercial farms and organized cooperatives but not for small-scale farmers. This is because a thermometer must be used to ensure precision and the right temperature and this is not readily accessible to the farmers in SSA.

IITA's scientists Danny Coyne and Stefan Hauser have developed an easier method that is just as effective by simply immersing the peeled or unpeeled suckers in boiling water for 20–30 seconds.

**The counting**

The duration of 20–30 seconds can be achieved by simply counting from 1 to 30. Farmers can also use small objects, such as pebbles, to mark the time:

*Plantain plant with three sword suckers, field trial on IITA Campus, Ibadan, Nigeria.*
Photo by A. zumFelde, IITA.

picking the pebbles one by one and placing them in a small container. The counting takes about 1 second/item but farmers can check the time for more accuracy.

This technique has proven to be friendly to small-scale farmers and is better than the hot water treatment at 50 °C as the time taken to treat a sucker is reduced and the measurement of the temperature and timing is simplified. It effectively disinfects suckers of various sizes without affecting their germination

The method is radical and requires skill and care when it is promoted to farmers who may be sceptical at first. The scientists recommend the use of a demonstration plot to introduce the technology and convince farmers to adopt it. They must keep within 30 seconds as otherwise they risk damaging the suckers, especially those that are small-sized.

Although the technology requires a fuel/ energy source and the process has to be followed precisely, it is definitely a much easier method to use than the hot water treatment.

Using boiling water to treat the suckers has the potential to improve banana and plantain productivity by eliminating the two pests.

*Plantain field planted with suckers treated in boiling water, IITA Campus, Ibadan.*
Photo by A. zumFelde, IITA.

# DEWN: a novel surveillance system for cassava disease

Innocent Ndyetabula*, indyetabura@yahoo.com and James Legg, j.legg@cgiar.org

*Researchers inspect cassava plan st for disease incidence.* Photo by IITA.

Pandemics of cassava mosaic disease (CMD) and cassava brown streak disease (CBSD) are the most important biotic constraints to cassava production in East and Central Africa.

For several years, researchers have tracked these two diseases and monitored patterns of pandemic expansion. However, costs have been high, and the visits made once a year have barely kept pace with the rate of disease spread.

Hence, researchers working to control these problems resolved to explore other monitoring options. During early discussions, two themes were frequently highlighted: community participation and new technology. Could both of these be incorporated into an alternative approach to monitoring disease spread in such a way that the system would provide an early warning of new outbreaks?

The result was the Digital Early Warning Network or DEWN. After extensive consultation, a plan was developed for its pilot-level implementation. This system works with six farmers' groups in each of 10 disease-threatened districts of northwestern Tanzania, and provides them with a system based on the use of the mobile phone for reporting incidences of CMD and CBSD in their farms. By communicating monthly with farmers' groups, it was expected that new outbreaks would be identified quickly, allowing the timely implementation of control measures.

**Partnerships**
The pilot phase of DEWN has been primarily implemented by the Lake Zone Agricultural Research Institute

*Contact address: Maruku Agricultural Research Institute, PO Box 127, Bukoba, Tanzania.

(LZARDI), under the IITA-coordinated Disease Objective of the Great Lakes Cassava Initiative (GLCI). GLCI is funded by the Bill and Melinda Gates Foundation (BMGF) and is led by the Catholic Relief Services (CRS). The partners of GLCI in the DEWN target districts included several local NGOs (TAHEA, MRHP, KUMKUMAKA, RUDDO, and TCRS) as well as the local government agricultural advisory system.

**Training**
At the outset, it was essential to train all participating farmers' groups to recognize the symptoms of the two virus diseases, and introduce the SMS-based communication system. A total of 1281 farmers were trained in the 60 groups, and district partners were provided with a GPS unit and digital camera to record field locations and any unusual disease symptoms.

Each of the farmers' groups was provided with a basic GSM phone and SIM card and introduced to the simple texting system for sending monthly disease reports. A straightforward text format was used for the farmers' groups to provide information on how many farmers had observed each of the two diseases in their fields that month, and for how many farmers each disease had become more severe, less severe, or stayed the same. Once reports had been compiled at the farmers' group level, they were sent as a single text to the LZARDI modem.

**Outcomes**
**Validation visit**. A follow-up visit was made after 6 months to validate farmers' reports. A refresher course was provided, but the farmers generally indicated a good knowledge of the main symptoms of both diseases. Partly as a consequence of their new understanding of the significance of CMD and CBSD, there was a strong demand from participating farmers for improved varieties.

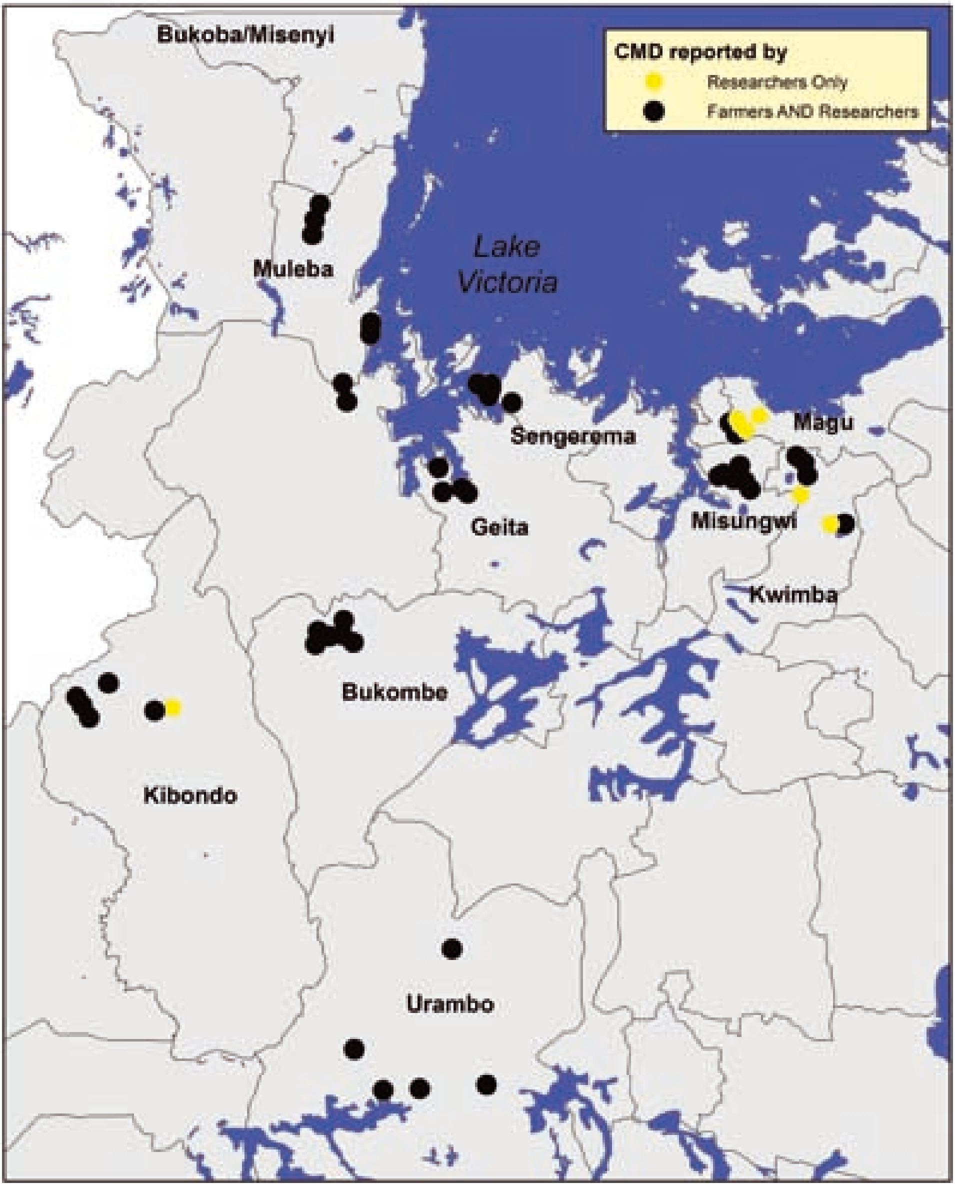
**Voice of the Farmer reports**. Participating farmers were linked to the Voice of the Farmer project (VOF). This is a project that is executed by Synovate and financed by BMGF. It aims to use a network of call centers to provide monitoring and evaluation support to existing BMGF programs.

DEWN provided a means for VOF to communicate directly with many of the participating farmers. This enabled VOF to conduct two surveys to assess the effectiveness of DEWN's training program on the identification and management of cassava pests and diseases. Participating farmers were called directly by VOF call center staff and were asked a series of short questions in Swahili. Although farmers' responses indicated a good general knowledge of CMD and CBSD, some confusion about symptoms was evident, highlighting the need for further training support. The VOF–DEWN reports are available online at www.vof.synovate.co.ke.

**Mapping new disease outbreaks**. Information obtained from the DEWN reports received from farmers' groups was used to generate maps. One of the most significant findings was that CBSD, reported by farmers via SMS, was then confirmed by researchers' visits in two districts (Bukombe and Urambo) in which CBSD had not previously been reported. This has allowed project teams to focus extra disease mitigation efforts on these areas.

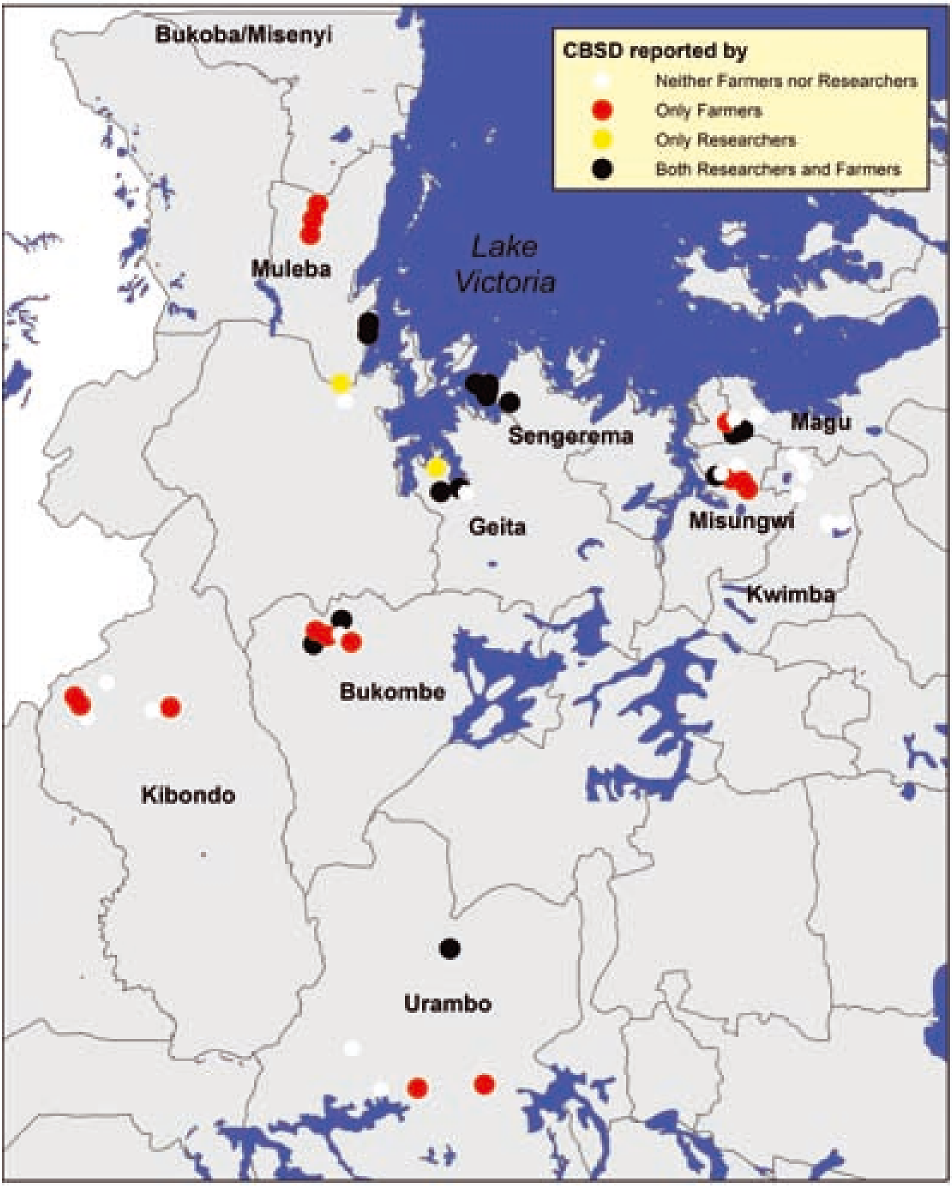
**Extending DEWN**. Recognizing the potential value of DEWN for providing communities with a means of doing their own monitoring of crop disease, the GLCI cassava team in Rwanda decided to start a similar scheme. Farmers' representatives from Rwanda visited DEWN partners in Tanzania in October 2010 and were introduced to the approach and given training in recognizing CBSD and CMD. The Rwanda team will initiate its own DEWN program in 2011.

DEWN has provided an innovative, informative, and relatively cheap means for involving communities in monitoring the health of their own crops. Farmers' participation has been enthusiastic, and some important practical outcomes have been achieved. Two of the greatest challenges which remain, however, are the accurate diagnosis of CBSD, which has cryptic or unrecognized symptoms and the regular provision of feedback to participating communities.




*Map based on farmers and researchers' reports of CMD occurrence in Lake Zone districts of Tanzania.* Source: J. Legg, IITA.

Plans are already being developed to address these problems. As these difficulties are overcome and as connectivity in rural areas continues to expand, it seems certain that there is great potential for the more widespread use of digital networks such as DEWN for the community-based monitoring of crop diseases.




*Map based on farmers and researchers' reports of CBSD occurrence in Lake Zone districts of Tanzania.* Source: J. Legg, IITA.

# Combating the threat of CBSD

Cassava brown streak disease (CBSD) is a virus disease that has emerged as a serious threat to production in Eastern and Southern Africa.

Two virus species, *Cassava brown streak virus* and *Cassava brown streak Uganda virus*, the cassava brown streak viruses or CBSVs, have been recognized to cause CBSD. The infection results in mosaic symptoms on leaves, brown streaks on stems, and a corky necrosis in tuberous roots.

Root necrosis has the most damaging effects on the use and marketability of the tubers and thus affects the livelihoods of cassava farmers. It can make susceptible varieties unusable if the roots are left in the ground for over 9 months.

CBSVs are spread through the planting of infected stem cuttings and also by a vector, a whitefly, *Bemisia tabaci*. The foliar symptoms of CBSD are less conspicuous and farmers are often unaware of the problem until they harvest the roots and the corky, yellow-brown necrotic rot becomes evident.

*Brown streak-affected cassava.* Photo by L. Kumar, IITA.

There is no cure for the disease. Once plants become infected, the only option for growers is to uproot and destroy them. The use of virus-free planting material and the cultivation of resistant varieties are the only options for the control of CBSD.

## Where is it and where is it heading?

CBSD is endemic in Kenya, Malawi, Mozambique, Tanzania, and Uganda and its occurrence is suspected in Burundi, Gabon, Madagascar, DRC, and Rwanda. Available evidence suggests a westward spread of the disease.

## What is IITA doing about it?

IITA has adopted a multipronged strategy to tackle CBSD, to reduce the effects on cassava in epidemic areas, and prevent a further spread of the disease. Its efforts begin with informing governments about the threat. The four technical pillars of this strategy are as follows.

- Monitor disease spread and assess its impact: Key outputs include (a) the development of disease distribution maps, (b) estimates of yield loss, and (c) identification of targets for development.
- Understand disease etiology and epidemiology; develop tools for monitoring and forewarning: Key outputs include (a) understanding the effects of the viruses in cassava, (b) examining the characteristics of virus spread, (c) creating diagnostic tools for CBSVs, and (d) using digital-enabled field surveillance tools for real time reporting and a monitoring network.
- Develop and disseminate durable CBSD-resistant cassava cultivars: Key outputs include (a) screening and selecting over 40 elite cassava cultivars with

dual resistance/tolerance to CBSD and cassava mosaic disease (CMD) appropriate for various countries, (b) deploying tolerant varieties for farmers to cultivate in East Africa, (c) developing molecular markers and modern molecular breeding tools for the accelerated development of CBSD-resistant varieties, (d) pre-breeding in areas currently not affected by the viruses, and (e) developing clean seed systems for the multiplication and dissemination of virus-free planting material.

- Capacity building through the transfer of knowledge, technology, and products to stakeholders: IITA has (a) built a coalition of international teams to combat CBSD, (b) trained scientists, extension workers, and plant quarantine officials in disease recognition, monitoring, and diagnostics, (c) established regional diagnostic labs, (d) created awareness through the use of the mass media, and (e) provided technical backstopping to national efforts in combating CBSD.

A suite of knowledge, technologies, and products derived so far from IITA's R4D efforts is playing a vital role in checking the spread of the disease and has contributed to reviving cassava production in areas affected by the epidemic. However, complete recovery and the prevention of any further spread of CBSD are still a long way off. They require a strong commitment from national and international communities to sustain the ongoing and emerging research and development efforts that are devising effective and eco-friendly technologies for sub-Saharan Africa.

### Advice to stakeholders

In countries where CBSD is already established, IITA recommends that governments require the use of available CBSD control programs, including the adoption of promising CBSD-resistant cultivars, and the production and distribution of clean cassava planting material.

Countries not yet affected need to increase their vigilance and develop the capacity to recognize CBSD and deploy eradication programs; establish plans for preemptive action to reduce the risk of CBSD spreading from affected regions; and put in place programs to produce and distribute clean planting material.

*Prof Mike Thresh, Scientist Emeritus, Natural Resources Institute, UK (right), during his visit to IITA-Ibadan, teaching students how to recognize diseases in the field.* Photo by L. Kumar, IITA.

All the cassava-producing countries in Africa should:

- Organize large-scale awareness creation programs to inform farmers, extension workers, CSOs, and national research entities about CBSD, the eradication of infected plants, and the steps for disease control.

- Strengthen the monitoring capacity of the national quarantine authorities and other relevant bodies including the establishment of communication systems for a rapid response to prevent disease and eradicate infections where they are identified.

- Develop resistant varieties most urgently, through breeding, using both conventional and transgenic approaches.

- Put in place a strategy for the production and distribution of clean cassava planting material, and adopt improved varieties with resistance to CBSD and CMD.

- Affirm financial and political support for collaboration, cooperation, and coordination to prevent the further spread of CBSD in tropical Africa.

# David Chikoye:

## Think of the big picture: look at the end users

*David Chikoye is the IITA Director for R4D responsible for managing the southern African hub and two programs—the Cereals and Legumes (CLP), and the Horticulture and Tree Crops Programs.*

**Why did IITA choose Zambia as the hub for the southern African region?**
From a historical perspective, IITA has been operating in southern Africa for over 25 years. In fact, we operated in 12 out of 13 countries in southern Africa. We were looking at each country in terms of the contribution to agriculture vis-à-vis policies, the ease of doing work, i.e., the social amenities, and (more importantly), the availability of partners. Zambia was centrally located, and the Government's policies over time have been pro-agriculture. In Zambia, there is easy access to private farms and also to the NARES.

**How crucial is southern Africa to IITA's mandate?**
IITA serves the needs of sub-Saharan Africa. In West Africa, we have made significant progress, especially in Nigeria where the headquarters is located. For instance, in soybean, when we started, Nigeria was not near the countries that were high producers of the crop but now, it is the highest producer in Africa, with about 600,000 ha planted to the crop. What this means is that it is now important for us to start transferring some of the knowledge from the west to the other parts of Africa. The southern African region has challenges similar to those in West Africa, therefore the successes we have made in the west can be transferred to the south with little modification. This has been our strategy.

**What is going on in the hub?**
Our strategy has been to collect and also interact with our colleagues in southern Africa and use the knowledge which has been generated over time to start testing in southern Africa. Some of the things we have been doing include testing varieties, management and agronomic and postharvest practices, as well as cross-cutting activities such as the training of NARES partners.

**Do you see any radical change in the way IITA does its work because of the CG reforms?**
In the short run, nothing will radically change. What has happened is that the CG reforms have split some of our programs. For instance, the CLP has been split into two—maize goes into the maize consortium research program (CRP) and legumes go to the legume component of the CRP. Also some of our programs have been consolidated. For example, roots and tubers have been consolidated with banana and plantain, making the program bigger. The

Opportunities and Threats program fits very well with the Markets CRP. These to me are minor modifications in the short run. So when you look at the way we manage our programs at IITA, I don't think anything significant will change although in the long run we might need to make some adjustments. The CG reforms will entail that we do full cost recovery. That means that the way we do business has to change. In summary, the CG reforms have their advantages and disadvantages but generally, they are for the good of the institute.

### What would you consider the most significant achievement of the CLP?

The CLP has really made a lot of progress in terms of developing high-yielding varieties together with crop management practices. We have also developed several postharvest technologies. In addition, there has been a wide adoption of these technologies and to me, those are significant developments.

For instance, *Striga* is a major problem for cereals—maize, rice, sorghum, etc. It has been estimated that *Striga* alone causes annual losses of about US$7 billion. That negatively affects more than 100 million people. We have been able to develop *Striga*-resistant or tolerant maize varieties. In cowpea, we have been able to develop varieties that are tolerant of pests and diseases. Significant achievements have been made in this program.

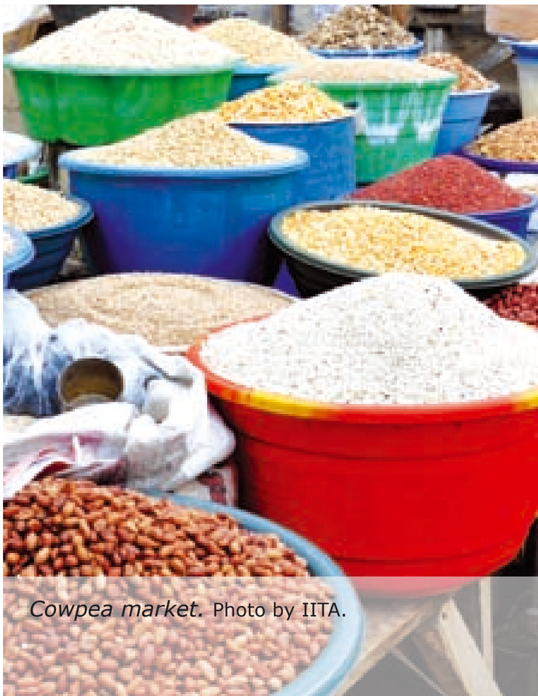
### What makes it difficult for cowpea to attract the private sector?

Let us look at it this way: cowpea is an African crop compared with maize and soybean that came from other continents. Those crops, by their nature, have attracted a lot of commercial interest. For instance, in maize, the commercial sector is very much interested in marketing seeds—hybrids—but not for cowpea. For soybean, there is a lot of commercial interest in the poultry sector.

Cowpea is a traditional crop—grow it, harvest it, and eat it. It offers a lot of benefits, of which we may not be sufficiently aware. For us to move the crop forward, we need to go into serious advocacy. Again if you look at most programs, they have biases for cereal crops. If you look at maize in most countries, there is some subsidy in terms of input supplies, fertilizer, etc. Nothing like this exists for cowpea but cowpea is relatively easier to grow.

### What role can cowpea play in southern Africa?

Over the last 10–15 years, we have had this problem of drought, so I see cowpea diversifying the maize-based system, especially in years when drought will become more pronounced. Southern Africa is again hit by HIV and AIDS. Those people that are affected need nutritious foods. Cowpea, being a protein food, can help to provide some of the nutritional needs. Lastly, livestock production in the region is also significant. Therefore the dual-purpose cowpea will have a significant role to play by providing fodder for livestock. Looking at the bigger picture, cowpea can have a big role to play in solving poverty in Africa.



*Cowpea market.* Photo by IITA.

### How can IITA work better with partners?

IITA can contribute to solving poverty but our efforts alone are not enough. We need to look at our comparative advantage; that is in upstream and strategic research. Where we don't have the comparative advantage, we should look for partners. Traditionally, we work with the NARES but now with the CG reforms, we need to tap into and strengthen our linkages with the private sector. Let's take advantage of the skills the private sector has, especially in marketing technologies. These guys are good in marketing and they have existing channels which they use in promoting their technologies.

### How can scientists become better communicators?

Scientists are good communicators especially in communicating among peers, e.g., in seminars and conferences and publishing in scientific journals. This is so because they all speak the same language. But this is only one component. We need to talk to donors, policymakers, and other people.
The question is: can these groups understand our jargon? The answer is usually, no, they can't. Most scientists need to be retrained on communicating their science to the layperson. This is one of the issues about which IITA's Director General Hartmann had been reminding scientists—if you work in the lab, think of the big picture. We need to work with the Communication Office and the media to train scientists in communicating effectively to end users.

### Any words of wisdom for colleagues?

I don't think I am qualified to pass words of wisdom. What I want to reemphasize is that the challenges in Africa are many: poverty, malnutrition, etc. IITA is a means that we can use to resolve some of these problems. So as we work for IITA, let's not forget the big picture—let's think about the end users.

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# Jim Gockowski:

## Sustainable intensification of agriculture is an alternative to deforestation

*Jim Gockowski is an agricultural economist with the Sustainable Tree Crops Program (STCP) based in IITA-Ghana.*

*About 15 years ago, the Rockefeller Science Foundation offered Jim the opportunity to work in any five of CGIAR centers. His wife's passion for Africa and Cameroon in particular made the family to choose IITA. In this interview with Atser Godwin, Gockowski shares his experience as he works in Africa for Africa.*

*IITA-STCP works with partners to improve the livelihoods of households in cocoa-based production systems in West Africa. In photo: Red-podded cocoa tree.* Photo by S. David, IITA.

### Tell us about your work.

When I first started with IITA in 1995, I was involved in the Alternative to Slash and Burn Program. This was a system-wide program looking at issues of deforestation along the forest margins and trying to come up with alternatives to extensive agriculture that uses the forest as an input in the production system. Also, beginning in 2000, we got involved with STCP, which is a public-private partnership between the global chocolate industry and USAID that is focused on the cocoa belt of West Africa and is working on sustainable improvement of livelihoods of cocoa-producing households.

### What has been its impact?

We do lots of evaluation, and we try and do some policy work with our studies and findings.

The impact of the social sciences in the STCP and the Alternative to Slash and Burn Program has been on two levels: One is on policy levels that is providing information and evidence, and the impact of policies or in some cases the lack of policies on livelihoods, outcomes, and the environment.

The other impact is in helping to transfer developed products—basically knowledge on natural resources management—to farmers. We have done this through development of curriculums for farmers' field schools. We are also involved with some of the climate negotiations around the Reducing Emissions from Deforestation and Forest Degradation (REDD) initiative.

### What have been the impacts of STCP?

We have trained over 120,000 farmers in five countries of West Africa. We have also worked with farmer organizations to strengthen their efforts through collective marketing with probably over 40,000 households being affected. These are probably two major impacts with the STCP. Farmers from the field school training have seen returns increased by between 40 and 43%.

### What is REDD all about?

REDD is a means of reducing carbon emissions into the atmosphere. It was a coalition of rainforest countries that got together in 2007 at the conference of the parties of the Kyoto protocol. They put their REDD agenda on the negotiating table in terms of the climate negotiation. The basic concept is that as developing countries, they need to provide jobs for their people and one way that is historical is to convert the rainforest into production agriculture or other forms of earning livelihoods.

The REDD idea is the concept of economic compensation to countries with tropical rainforests for their foregone opportunities of not deforesting the rainforest.

### What is the IITA project called Fertilizers-for-Forest (f4F)?

What we know in West and Central Africa is that agriculture is the principal driving force for deforestation and in particular the practice of slash and burn. When this happens, you get wood ash that is loaded with potassium and some trace amounts of nitrogen. The wood ash improves the soil but it is not a sustainable practice.

The idea of Fertilizers-for-Forest is really about sustainable intensification led by policy changes that would offer farmers an alternative to cutting down the forest and burning to get wood ash. The alternative is that instead of cutting the forest to get the biomass, let's use fertilizers.

We believe that this type of intensification is necessary for preserving what is being left of the West African forest which is 18% of what it used to be. It is also one way that we can conserve the Congo basin rainforest.

### How do you see IITA playing a role in mitigating the effects of climate change?

There are two ways that we can play a role. One is to support policy-led intensification projects by working with NARES partners and better soil fertility management options. This will take away pressure on the rainforest and help in reducing global warming. This is on the mitigation side. Again, we know that climate is getting warmer, with predictions that in the next 70 years, temperatures could rise by more than three degrees. We also know that agricultural productivity doesn't respond positively to warmer temperatures hence there will be a reduction in yields. So we need to be focused on the climate response of our major production systems as it proceeds. It will be a gradual thing but we need to be strategic about it. We need to strategize.

On the adaptation side, we need to be working on drought-tolerant crops. We need to do adaptive research that would allow the African smallholder farmers to deal with a change in climate.

Another area is that of institutions. We have problems with our credit markets, crop insurance, and input markets. We need to strengthen these institutions and a government policy that favors the private sector approach that doesn't distort markets.

### What are some of the positive changes that you are seeing in Africa?

From a rural perspective, I have seen a lot of self-empowerment. I think this is happening because democracy is playing its role by giving the rural majority a voice and that voice is starting to be heard. Again, I don't think it will be business as usual because the population is growing quite fast and we need to feed these teeming millions. We need to modernize agriculture and African farmers are beginning to demand those from their public servants.

### What makes your work successful?

If I have made any success, it is due to diligence. If you work hard, I guess good things result. We have a wonderful institute with a lot of good scientists and all that I can say is that I have been fortunate to work with very good scientists.

# NAQS: IITA contributes to our effectiveness

*Olufunke Awosusi is a Senior Plant Quarantine Officer with the Nigeria Agricultural Quarantine Service (NAQS) in the Federal Ministry of Agriculture and Rural Development. NAQS is charged with the responsibility of protecting the Nigerian agricultural economy from the attacks of pests, especially "foreign" pests, and also enhancing agricultural trade through export inspection and certification. Below are excerpts from an interview with Godwin Atser on the role of the NAQS and the collaboration with IITA.*

### What is the role of NAQS?

The NAQS evolved from the former Plant Quarantine Service. It was established in recognition of the fact that agricultural quarantine is the control of the introduction and spread of pests and diseases by means of legislation and as a result of the country's problems within a decade before independence with the introduction of cocoa and maize pests. The cocoa industry almost collapsed; plantations were destroyed; and disease-resistant cocoa varieties were handed to farmers for replanting. This cost the Government a colossal amount. For maize, it took the concerted efforts of several West African nations coming together to revive production in the region.

NAQS was created to harmonize the quarantine of plant, veterinary, and aquatic (fisheries) resources in Nigeria to promote and regulate sanitary (animal and fisheries health) and phytosanitary (plant health) measures in connection with the import and export of agricultural products with a view to minimizing the risk to the agricultural economy, food safety, and the environment.

The main objective of NAQS is to prevent the introduction, establishment, and spread of animal and zoonotic diseases and pests of plants and fisheries including their products. NAQS also undertakes emergency protocol to control or manage new pest incursion or diseases outbreak in collaboration with key stakeholders.

### What is the situation with NAQS today?

The standards have improved drastically. Today NAQS has improved personnel who are more skillful and trained in pest diagnosis stationed in the entry and exit points in the country. We have had improvements in diagnostic facilities and this is perhaps one of the reasons why some of the exotic pests have been kept outside our borders.

### What is your assessment of quarantine in Africa?

Africa has witnessed improvement in the quarantine system. The Inter-Africa Phytosanitary Council (IAPSC) has been playing a tremendous role in harmonizing phytosanitary regulations within the continent, training phytosanitary inspectors, and coming up with pest lists to guide nations, revision of phytosanitary legislation and regulation, and implementation of phytosanitary standards, among others.

### Any challenges in carrying out your task?

The problem faced by NAQS is the lack of political will concerning the quarantine system itself. Again, the role of the quarantine service is not very much appreciated, especially in food security. A lot of attention has been focused on how to improve production. The attention placed on plant protection is not as much as that given to plant improvement. But, however successful the improvement program, once you allow pests to come in, they would destroy the crops/gains. This understanding hasn't been appreciated and it is partly why the sector is given low funding.

Also, the public is not properly being informed about what plant quarantine stands for. Therefore, having voluntary compliance with the regulations is a bit difficult. Another problem is the lack of emergency funds and preparedness to contain the immediate outbreak of pests.

### In recent times, what are some of the pests you find challenging?

Recently, we have noticed the introduction of fruitflies that are fast devastating fruits in our country. But we need a regional approach to tackle this problem, because the insect involved is a strong flier. We are also faced with the threats of more pests. On cassava, we have *Cassava mosaic virus* (Ugandan strain) which is ravaging crops in East Africa. Another is the *Cassava brown streak virus*, which affects cassava leaves and roots. We also have threats of banana bunchy top and banana bacterial wilt. We need to inform people so that they don't bring

*Keeping out pests from national borders is a key role of the quarantine service.* Photo by S. Muranaka, IITA.

planting materials into the country from East Africa. There is the need to put preemptive action in place so that new diseases don't get to Nigeria and West Africa.

### What measures are being put in place to contain the spread of these pests?

For fruitflies, we held a sensitization workshop in 2009 where different stakeholders participated. The FAO is coming up with a regional control measure for the West African bloc to harmonize and adopt. Again, scientists are looking for ways to control these pests. For cassava brown streak disease or CBSD, we have stepped up quarantine efforts aimed at curtailing/ scrutinizing the entrance of planting materials from those endemic regions. In the future, we are thinking of training our officers on new tools that aid the inspection of imported planting materials.

### Why is the response to crop pests especially slow when compared with the response to animal pests?

When new crop pests come in, the impact for the first few years is not so obvious. This is not the case with the invasion of animal pests when you see the deaths of animals. Perhaps this is the reason why crop pests don't catch the attention of the Government immediately. We could be talking about fruitflies but people are saying, "Mangoes and oranges are still on the streets." When the devastation arising from pest establishment, spread, and destruction becomes much serious and farmers start crying, that is the time we get an official response, especially in terms of funding for control measures.

### What kind of support would you ask for specifically?

Capacity building to enhance pest interception and diagnosis is very important for us. If you don't have knowledge about the biology of the pests, you may have problems. The quarantine inspectors/officers need to be trained and the training needs to be continuous. Secondly, a country like Nigeria has a very diverse culture and the climatic conditions to grow crops all year round, so there is a need for us to conduct pest surveillance so that we know the pest status in the country.

There is an ongoing pest survey and this is being done on a crop by crop basis. Scientists from universities, national agricultural research institutes, and international organizations are involved and we hope it will be on a continuous basis with support from the government and stakeholders.

### How good an option is biocontrol?

Biocontrol is a good strategy. Everybody wants to deemphasize the use of pesticides because of the effect of chemical residues and there is a lot of emphasis now on food safety. Also there is concern about preserving biodiversity. Now the emphasis is on integrated pest management. The more often you can eliminate the use of pesticides, the better.

### How is the collaboration with IITA?

We have a very good and strong relationship with IITA. IITA is our major stakeholder when it comes to germplasm exchange.

IITA has been assisting us in the training of our officers—upgrading their skills—especially in the area of pest diagnosis.

Sometimes when we are handicapped by inadequate facilities IITA steps in. Also IITA is good in the area of information dissemination which had been beneficial to us.

The collaboration with IITA is quite strong and mutually beneficial. Sometimes IITA assists us to attend international workshops and seminars that are relevant for job improvement.

The institute has contributed to our effectiveness in the country.

# COMESA: Ensuring sanitary and phytosanitary standards in the region

*Martha Byanyima is a food science and trade expert from Uganda. She has worked in the region on sanitary and phytosanitary (SPS) and agricultural trade programs, supporting countries to carry out the necessary policy and legal reforms and strengthening private sector/industry systems.*

*Currently, she is the Regional Process and Partnerships Facilitator of the Comprehensive Africa Agriculture Development Program (CAADP) at the COMESA Secretariat. CAADP is the Africa Union Commission and the NEPAD Coordinating Agency (AUC/NPCA) continental program aimed at increasing agricultural productivity in Africa.*

*She supports development of the regional CAADP process and establishes partnerships for regional investments in key areas prioritized to address the challenges of food security and poverty in the Common Market for East and Southern Africa (COMESA) region. She also leads COMESA's SPS work program.*

## What is COMESA all about?

COMESA is a regional economic community (REC) of 19 countries. Our mandate is to create a vibrant and dynamic common market in which business will thrive and expand regionally. We improve the competitiveness of the farmers, entrepreneurs, and traders. In this regard, compliance with international standards, particularly SPS measures, which are a prerequisite for agriculture and agro-industry competitiveness and access to regional and global markets, becomes very important to us.

## Why are SPS measures important?

SPS measures are mandatory requirements instituted by governments to protect human, animal, and plant health. These commonly take the form of legislation, inspection, and testing requirements and border controls. Measures similar to SPS had been in place for several decades; however, they became more important under the World Trade Organization (WTO) Agreement in 1995, which recognized the right to protect the agricultural sector and biodiversity. These measures ensure that products produced domestically or imported conform with the regulations and standards of the territory.

The SPS agreement of WTO encourages countries to use common standards, guidelines, and recommendations as developed by the International Plant Protection Convention for plant protection, the Codex Alimentarius

Commission for food safety, and the World Organization for Animal Health for pests and animal diseases and zoonoses.

### How can compliance with SPS standards facilitate trading and marketing of agricultural goods?

Compliance with SPS standards promotes economic development and trade. SPS is a very important area as we deepen regional integration to reduce barriers to transacting business and to free the movement of agricultural and food products among member countries. COMESA has slowly progressed from a Preferential Trade Area with lower duties charged on goods originating from member countries to a Free Trade Area (FTA) in 2000 where no duty is charged on goods from member countries as long as they comply with the rules of origin and to a full Customs Union in 2009 where a common external tariff is applied to goods imported from outside the region.

### How do you promote these standards?

While such a progression is based on tariff reduction and/or elimination to reduce the cost of transacting business, SPS barriers constitute an added cost to business that is not easily quantified, requiring scientific and technical capacity that is often lacking. In this regard, strengthening SPS infrastructure, such as laboratories, and the harmonization of SPS laws, regulations, procedures, and standards are essential for intra-regional trade and successful regional integration.

### What is the Green Pass system?

It is the harmonization of SPS measures across COMESA countries and the establishment of equivalence through common certification schemes. The Green Pass system is intended to restore confidence among trade partners and remove SPS barriers to facilitate trade and the marketing of food and agricultural products within the region.

### How can Green Pass help trade and markets in East and Southern Africa?

Since SPS is an important area for effective markets in the context of regional integration, COMESA has a regional work program aimed at mobilizing resources to address the critical gaps in the SPS systems of regional member countries.
The work program has four result areas: (a) common certification schemes (standards), (b) monitoring, surveillance, and preparedness for emergencies, (c) improved exchange of SPS information between the public and private sectors, and (d) improved regional leadership and coordination.

Our activities include encouraging the adoption of regional standards, establishing regional SPS databases and information systems, establishing modalities and piloting mutually agreed certification schemes such as the Green Pass, awareness and training workshops, and strengthening SPS infrastructure, such as laboratories.

### How are you implementing the Green Pass system?

The first step in creating awareness and motivating countries to step

*Food supplies being loaded on trucks for transportation to urban centers.* Photo by IITA.

*Enforcing phytosanitary policies and regulations in the region would benefit trade and commerce, and ultimately the farmers and consumers.* Photo by IITA.

up harmonization efforts is the establishment of the SPS legal framework to guide countries on the necessary policy and legal reforms. At the heart of the legal framework is the Green Pass system.

### What can international organizations or networks do to help promote standards and the Green Pass system?

Currently we are developing proposals to pilot commercially driven Green Pass certification schemes. For example, we will support the member countries to develop common protocols to address the problem of fruitflies in banana, passion fruit, and avocado, or aflatoxins in maize. Such protocols, developed and piloted by the private sector and governments, with support from COMESA, will constitute the science to inform the Green Pass certification scheme. The protocols and related infrastructure, such as reference laboratories, are regional public goods that serve both the private and public sectors.

### Who are your partners in implementing the system?

In piloting the Green Pass certification scheme, we envisage partnerships with the private sector, regional institutions with relevant expertise, such as IITA and governments. The decision to implement the Green Pass was endorsed by ministers of agriculture in July 2010, and thus all countries will be involved to the extent that the Green Pass is the viable option to resolve the existing SPS problem.

### What are some of your challenges?

The greatest challenge is to create a common understanding of the Green Pass concept; there are variations in the way it is understood by experts, governments, the private sector, and other stakeholders.

Another challenge is traditional certification schemes that are based on international standards but may not respond to intraregional trade challenges. For example, South Africa (SA) demands a certificate of origin from Zambia honey exporters in addition to the animal health certificate issued by the Government. The Zambia market, however, has lots of food imports from China which treats bees with antibiotics. SA regulations restrict antibiotic residues in honey. Therefore, SA demands full proof that the honey originates from Zambia and not China, where the honey is not organic. In this case the Green Pass would come in handy to establish a certification scheme that includes traceability protocols and a certificate of origin in addition to the animal health certificate from the Government.

Of course, there are also constraints in both human and financial resources.

### Why a common market for East and Southern African?

On 22 October 2008, heads of States and Governments of the 26 countries in Eastern and Southern Africa that have membership in COMESA, EAC, and SADC, made a landmark decision that the three RECs should immediately start working towards a merger into a single FTA to deepen regional integration. The three have a combined population of 565 million, and a gross domestic product of US$875 billion. These are 57% of Africa's population and 59% of the GDP. The total land mass of the COMESA-EAC-SADC region is 14.8 million km² or 49% of Africa's total land mass.

The decisions of the Tripartite Summit have far-reaching implications on the operations of the three RECs with regard to joint planning, programming, and implementation of the common agenda. In addition, there will be a need for development partners to rationalize and harmonize their support in the tripartite framework.

Since then, the Agreement to establish the Tripartite FTA has been developed and will be signed in mid-2011. The purpose of the Agreement is to enhance collaboration (through joint investments) and avoid the duplication of effort that has characterized the COMESA region as a result of multiple membership of the regional communities.

Annex 14 of the Agreement to establish the Tripartite FTA specifically addresses SPS, requiring Tripartite member countries to harmonize SPS measures and, where necessary, to implement joint programs.

### What role do you envisage for IITA in COMESA?

IITA and other regional specialized scientific institutions have a huge role to play They can ensure that the best science informs agricultural planning and development, using the CAADP framework that has proved to be an effective instrument in harnessing knowledge and bringing it to sector planning processes at the national and regional levels. However, governments are responding slowly to the all-inclusive principle of CAADP; non-State actors such as IITA, farmers, and the private sector have not been engaged to the extent necessary to achieve the effective transfer of scientific knowledge and expertise.

### What support do you need?

At this stage, it is important for all players to recognize the transformation taking place in the agricultural sector on this continent—the bumper harvests and the increased investments. This is largely driven by RECs through support to country CAADP processes and regional integration programs. Policy reforms and technical support are important elements of the transformation process that cannot be achieved by RECs acting alone; specialized institutions such as IITA and other nonstate actors need to fill this gap. It is, thus, important that development partners, donors, and other actors respond positively to the call by the African Union to align with regional priorities embedded in the RECs' regional integration programs and in so doing support the transformation process currently taking place on this continent.

### What is your vision for African agriculture, trade, and economy?

I look forward to deeper regional integration among the African countries. The Tripartite framework provides the best means to achieve this. By strengthening infrastructure on key trade corridors and facilitating the transport of goods while strengthening the countries' SPS systems through the best science available, agricultural value chains will expand beyond the COMESA region. New opportunities will be opened for the private sector. At the same time, it is my hope that the Tripartite framework will encourage collaboration in scientific research and innovations to further strengthen value addition and trade in value-added food products.

# IAPSC: Protecting Africa's plant health

*Jean-Gerard Mezui M'ella is the Director of the Inter-African Phytosanitary Council (IAPSC), the African Plant Protection Organization with headquarters in Nlongkak, Yaounde, Cameroon. IAPSC is an intergovernmental organization with 53 members under the umbrella of the African Union. It coordinates plant protection procedures in Africa.*

*The IAPSC Director coordinates the activities of its four sections (Phytopathology; Entomology; Documentation, Information and Communication; Administration and Finance). He represents the African region in the Commission for Phytosanitary Measures of the International Plant Protection Convention (IPPC/FAO), promotes compliance with International Standards for Phytosanitary Measures (ISPMs), and represents the African Union Commission on diplomatic matters in Central Africa. In this interview, he talks about the important work of IAPSC.*

### Why is IAPSC important?

IAPSC is a technical office of the African Union/Directorate of Rural Economy and Agriculture. It is one of the 10 Regional Plant Protection Organizations of the IPPC. As the regional organization for Africa, it works in collaboration with the national plant protection organizations of the 53 countries of the AU.

IAPSC mostly implements its activities through the eight African Regional Economic Communities (RECs) and sub-RECs. It addresses phytosanitary issues in Africa including the following:

- The vulnerability of African crop production systems to the impact of diseases, insect pests, and noxious weeds;
- Economic losses incurred through spoilage;
- Noncompliance with ISPMs, trade regulations, and equivalents;
- Dearth of phytosanitary data (Pests Risk Analysis, diagnostics, surveillance, etc.)

AU-IAPSC safeguards agriculture and natural resources from the risks associated with the entry and establishment or spread of pests of plants and plant products to ensure food safety and quality supply to intra-African and international markets.

### How would you assess the state of plant protection in Africa?

Africa still has a lot of problems with plant protection. In fact, most African countries inherited an administration put in place before independence, which to a certain extent, has safeguarded the plant health of the different countries. There were departments of Agriculture and Divisions such as plant pathology, entomology, agricultural chemistry, and also plant quarantine. After independence, with the coming into

force of the IPPC, adopted by the FAO Conference of 1951, the global approach and harmonization of phytosanitary measures started to take shape.
For example, a common format for phytosanitary certificates was set up, common action was secured to prevent the spread of pests of plants and plant products, guidelines were provided regarding phytosanitary matters and the relevant actions to be taken by national governments in the implementation of plant quarantine.

IAPSC promotes cooperation among countries to prevent the movement of serious pests. It provides a forum for African countries to promote their views on plant health. In addition, quarantine structures in Africa differ from one region to another. In fact, some countries have operational quarantine stations but others do not. We at IAPSC encourage the creation of regional and subregional quarantine stations, although even those in existence find it difficult to comply with IPPC standards. It is our hope to have quarantine stations in each country.

**Harmonizing phytosanitary regulations and policies in Africa must be quite challenging. How are you doing this?**
Nontariff barriers such as SPS measures are often used as a disguised way to restrict trade. It is becoming essential, following the World Trade Organization's agreement on SPSMs for member countries of the WTO to ensure that the SPS measures they apply are in line with this agreement. To do so, the technical and organizational capacity of the various organizations at national, regional, or international levels have to be given the necessary tools to deal with the new challenges.

The 1995 WTO agreement was set up to remove unnecessary, unjustified, and arbitrary pressure on international

*Quarantine inspector reading about banana bunchy top.* Photo by L. Kumar, IITA.

trade in plants and plant products. This was a new situation for the various stakeholders, e.g., new themes such as transparency, scientific justification, notifications, inquiry points, risk analysis, and standards are now the guiding principles.

It is thus of the utmost importance for African countries, where phytosanitary capacity deficits are most severe, to begin a process of developing a strategy for capacity building to meet their obligations under the WTO rules.

In 2003, the RECs became the implementation arm of IAPSC whose technical programs are assessed by the RECs during the annual meetings of the Steering Committee and General Assembly.

IAPSC, much like AU, encourages regional common markets.

**What are your major challenges?**
Besides funding, the major challenges IAPSC faces on a daily basis include the entry of new pests on the African continent that annihilate the efforts of member countries; the proliferation of invasive pests; climate change that brings about new plant heath challenges; and a lack of scientists specialized in plant protection.

**How do you ensure that regulations or policies are strictly implemented?**
We endeavor to strengthen the capacities of countries so that they can prevent and control the introduction of plant pests in Africa. We encourage the setting up of Centers of Phytosanitary Excellence, the creation of phytosanitary networks, and the regular updating of pest lists in Africa.

**What are you doing to improve the links and working relationships among NPPOs and networks in Africa?**
We organize workshops and seminars on plant matters; we publish a quarterly phytosanitary news bulletin; and we enrich on a regular basis the phytosanitary information in the International Plant Protection Portal of FAO.

IAPSC provides information on quarantine pests on plants as well as for the protection of plant products for the AU member countries through both the paper and electronic media. Paper-based information systems include a scientific analysis, a phytosanitary situation in Africa, reports of service activities, and a collection of phytosanitary regulations and standards. Electronic information on compact discs covers a database of the meetings and phytosanitary regulations of member States. The Phytosanitary News bulletin of IAPSC is issued four times a year. It welcomes contributions and articles from National Plant Protection Organizations.

There is a web site for the worldwide dissemination of information (http://www.au-iapsc.org), and a library that hosts scientific books.

Our workshops and seminars aim at sharing information on the phytosanitary situation and on the findings in crop protection research.

We frequently conduct monitoring and evaluation exercises (country visits, exchange and information sharing among countries). All these activities help in networking among the partners in Africa.

**What support do you need from the member countries? From partners? From clients?**
To improve the prevailing situation concerning quarantine standards, regional cooperation and compliance with international regulations, the following priorities have been identified:

1. Ensuring that all African countries are parties to the IPPC;

2. Ensuring the harmonization of plant protection policies across RECs through capacity building;

3. Regularly updating pest lists and quarantine pests;

4. Harmonizing phytosanitary inspection systems; surveillance, emergency responses, risk analysis: procedures to analyze and reduce the risk of new pests entering a country;

5. Setting up a harmonized pesticide management system.

**Describe your collaboration with IITA.**
IAPSC-IITA cooperation is in the following key areas: Cassava pests' diagnostics and control technique methods, Cassava germplasm and planting material exchange, Banana pests' diagnostics and control technique methods, Banana germplasm and planting material exchange, and Harmonization of African countries' phytosanitary systems.

**What could international bodies such as IITA do to ensure that Africa's agriculture is safeguarded?**
IITA, like other bodies, should work with country structures through IAPSC, and collaborate with recognized subregional and regional structures of the public and private sectors in plant protection.


*IITA researchers conduct plant health tests in lab.* Photo by L. Kumar, IITA.

# Transgenic banana for Africa

Leena Tripathi, l.tripathi@cgiar.org

Banana (*Musa* spp.) are one of the most important food crops after maize, rice, wheat, and cassava. Annual production in the world is estimated at 130 million t, nearly one-third of it grown in sub-Saharan Africa, where the crop provides more than 25% of the food energy requirements for over 100 million people. East Africa is the region that produces and consumes the most banana in Africa. Uganda is the world's second largest producer after India, with a total of about 10 million t.

The banana Xanthomonas wilt (BXW) disease caused by the bacterium *Xanthomonas campestris* pv. *musacearum* (Xcm) was first reported about 40 years ago in Ethiopia on *Ensete* spp., a close relative of banana. Outside Ethiopia, BXW was first identified in Uganda in 2001, subsequently in the DR Congo, Rwanda, Kenya, Tanzania, and Burundi. The disease is highly contagious and is spread plant-to-plant through the use of contaminated agricultural implements. It is also carried by insects that feed on male buds, and is present on plant material, including infected debris. The rapid spread of the disease has endangered the livelihoods of millions of

*Plants established in confined field trial 5 months after planting.* Source: L. Tripathi, IITA.

farmers who rely on banana for staple food and cash.

Infection by Xcm results in the yellowing and wilting of leaves, uneven and premature ripening of fruits, and yellowish and dark brown scars in the pulp. Infected plants eventually wither and die. The pathogen infects all varieties, including East African Highland Banana (EAHB) and exotic types, resulting in annual losses of over US$500 million across East and Central Africa.

Options for BXW control using chemicals, biocontrol agents, or resistant cultivars are not available. Although BXW can be managed by following phytosaniary practices, including cutting and burying infected plants, restricting the movement of banana materials from BXW-affected areas, decapitating male buds, and using "clean" tools, the adoption of such practices has been inconsistent. They are labor-intensive and farmers believe that debudding affects the fruit quality.

The use of disease-resistant cultivars has been an effective and economically viable strategy for managing plant diseases. However, resistance to BXW has not been found in any banana cultivar. Even if resistant germplasm is identified, conventional banana breeding to transfer resistance to farmer-preferred cultivars is a difficult and lengthy process because of the sterility of most cultivars and also the long generation times.

Transgenic technologies that facilitate the transfer of useful genes across species have been shown to offer numerous advantages to avoid the natural delays and problems in breeding banana. They provide a cost-effective method to develop varieties resistant to BXW. Transgenic plants expressing the Hypersensitive Response Assisting Protein (*Hrap*) or Plant Ferredoxin Like Protein (*Pflp)* gene originating from sweet pepper (*Capsicum annuum*) has been shown to offer effective resistance to related *Xanthomonas* strains.

*Banana plantation damaged by Xanthomonas wilt.* Source: L. Tripathi, IITA.

IITA, in partnership with the National Agricultural Research Organization (NARO)-Uganda and the African Agriculture Technology Foundation (AATF), has developed transgenic banana expressing the *Hrap* or *Pflp* gene using embryogenic cell suspensions or meristematic tissues of four banana cultivars, Sukali Ndiizi, Mpologoma, Nakinyika, and Pisang Awak. More than 300 putatively transformed plants were regenerated and validated via PCR assay and Southern blot. Of these, 65 transgenic plants have exhibited strong resistance to BXW in the laboratory and screenhouse tests. The plants did not exhibit any differences from their nontransformed controls, suggesting that the constitutive expression of these genes has no effect on plant physiology or other agronomic traits.

The 65 resistant lines were planted in a confined field trial in October 2010 at the National Agriculture Research Laboratories (NARL), Kawanda, Uganda, after approval was obtained from the National Biosafety Committee. These transgenic lines are under evaluation for disease resistance and agronomic performance in field conditions. The transgenic lines are


*Confined field trial of banana plants.* Source: L. Tripathi, IITA.

slated for environmental and food safety assessment in compliance with Uganda's biosafety regulations, and procedures for risk assessment and management, and seed registration and release. After completing the necessary biosafety validation and receiving approval from the Biosafety Committee, the Xcm-resistant cultivars are expected to be deregulated for cultivation in farmers' fields in Uganda.

We plan to stack the *Pflp* and *Hrap* genes in the same cultivars to enhance the durability of resistance against Xcm. We have developed more than 500 transgenic lines with the double genes construct (pBI-HRAP-PFLP) which are being evaluated for disease resistance under contained screenhouse conditions.

This technology may also provide effective control of other bacterial diseases such as *moko* or blood disease, of banana occurring in other parts of the world. The elicitor-induced resistance could be a very useful strategy for developing broad-spectrum resistance. The elicitor is a protein secreted by pathogens that induce resistance. The transgenic banana carrying these genes may also display resistance to fungal diseases such as black sigatoka and *Fusarium* wilt. Experiments on this are being conducted in our lab in Uganda.

We are also planning to stack genes for resistance to Xcm and nematodes into one line to produce cultivars with dual resistance that would tackle two of the most important production constraints in Eastern Africa.

The development of Xcm-resistant banana using the transgenic approach is a significant technological advance that will increase the available arsenal of weapons to fight the BXW epidemic and save livelihoods in Africa. It can become a high-value product for farmers.

This research is supported by the Gatsby Charitable Foundation, AATF, and USAID.

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The *Pflp* and *Hrap* genes are owned by Taiwan's Academia Sinica, the patent holder. IITA has negotiated a royalty-free license through the AATF for access to these genes for use in the commercial production of BXW-resistant banana varieties in sub-Saharan Africa.

# IITA R4D Review



The IITA R4D Review is published by IITA, Africa's leading research partner in finding solutions for hunger and poverty.



Issue 6, March 2011

The **IITA R4D Review** is a six-monthly magazine intended to help IITA and research and development partners, investors, collaborators, and beneficiaries discuss and develop the best new ideas for people creating, leading, and transforming tropical agriculture.

The R4D Review has six sections:

**Features** provides an in-depth, rigorous presentation of a significant advance in research-for-development thinking and its application to real world needs that help establish an intellectual agenda for discussion—and change—within the organizations and for society at large.

**Best Practice** describes the how and why behind a successful research for development achievement.

**Tool Box** provides a nuts-and-bolts explanation of a useful research-for-development tool that can be translated into action in many different situations.

**Who's Who** recounts a personal story of an IITA staff that contains lessons for colleagues.

**Looking In** features people from outside IITA whose ideas hold salient lessons for those within IITA.

**Frontiers** is a forum for forward-looking articles that explore new science and technology trends affecting development needs (i.e., starting projects or technologies in the pipeline).

## CONTRIBUTIONS needed

The R4D Review is looking for new sources of solid, useful ideas that can improve research-for-development practice. Please send your contributions or participate in the discussions in the R4D Review interactive site at www.r4dreview.org. The general guidelines for contributions are also available at this site. Prospective authors can also send submissions, communications, comments, and suggestions to: The Editor, R4D Review.

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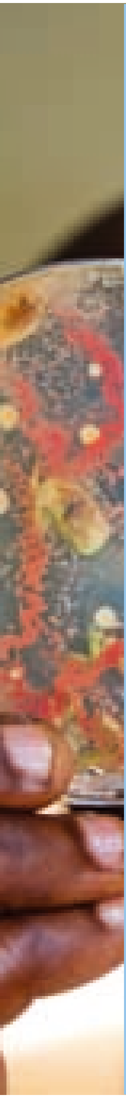

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