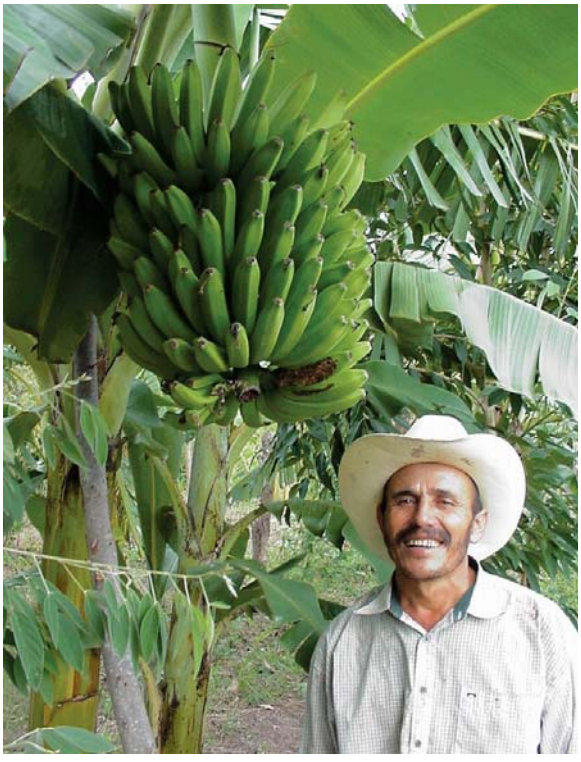
I. Van den Bergh

*Improved crop varieties have been considered an indispensable element in agricultural development, but do farmers have other priorities in seeking to improve their lives?*

# Learning to manage diversity

*Honduran farmer evaluating FHIA hybrids on his land.* C. Staver



This paper is based on a talk given by Franklin Rosales from INIBAP-LAC regional office at a symposium on the *Conservation and Use of* Musa *Biodiversity for Improving Livelihoods* held in Leuven, Belgium, on 18 October 2005.

In the heady days of the green revolution, agricultural scientists believed that breeding highly productive varieties, and feeding them a steady diet of fertilizers and pesticides, could save the world from poverty and starvation. Banana breeders evidently had a harder time of it than their counterparts working on rice, wheat or maize (see *Hungry for improvement* in this report). However, the absence of banana hybrids has not prevented the export industry from delivering consistently high yields. Large-scale producers have sought to make up for any shortcomings of the Cavendish cultivars that dominate the international trade by investing heavily in their culture and protection and keeping an eye out for useful mutants. What lessons can we draw from this experience for smallholder producers of bananas and plantains? Are they best served by the conventional model of varieties and intensified production systems or are there other, more effective ways, to help small-scale farmers meet their objectives?

Over the last twenty years, INIBAP and its partners have looked at many dimensions of the challenge of producing slowly-evolving bananas in a rapidly evolving world—and this experience has been quite different in the parts of the world where INIBAP operates regional offices. In Latin America, where INIBAP first set up a regional office in 1987, researchers have worked with and around the dominant export banana industry, looking at various 'greener' production technologies, including purely organic production. Regional offices established in West Africa in 1988 and in East Africa in 1989, have focused mainly on deploying and evaluating new cultivars in the context of food security-focused African farming systems. Meanwhile in Asia, where INIBAP set up shop in 1990, the focus has been on developing systems to deploy disease-free planting material of superior varieties.

The emphasis in the networks that developed around each regional office has generally been on helping national partner organizations to identify and meet what were seen as the distinct challenges of banana production in each region. More recently, however, a new paradigm of 'managing diversity in production systems', using the principles of agroecology as a foundation, is providing INIBAP with a conceptual framework for drawing together these diverse experiences into a coherent whole.

## Matching hybrids with farmers

In other crops, the conventional wisdom is that pest- and disease-resistant varieties provide a sound foundation for integrated crop management strate-

gies but in bananas this principle has been hard to establish. Perhaps because of the relatively limited diversity of bananas, farmers and consumers have tended to develop strong preferences for their familiar cultivars and, because of the complexity of banana breeding, the disease-resistant cultivars that have been developed rarely substitute directly for existing varieties.

The *Fundación Hondureña de Investigación Agrícola* (FHIA) has perhaps had the greatest success in using conventional breeding to generate highly productive, disease-resistant varieties but all of these differ to some extent in taste and other fruit characteristics from existing varieties. Much of the effort of INIBAP and its partners has been invested in disseminating and evaluating these 'FHIA hybrids' with farmers in Latin America, Africa and Asia. It was initially assumed that varieties, both dessert and cooking banana types, offering high levels of disease resistance and yields as much as five times higher than traditional cultivars would be welcomed by farmers with open arms. Certainly tens of thousands of plantlets of these varieties have been distributed to farmers, through various projects. However, the record on adoption has been at best mixed and the factors that favour adoption are still not fully understood.

The most enthusiastic adoption of FHIA's improved hybrids has been in Cuba. Since 1992, more than 16,000 ha have been planted. Economic analysis suggests that the new varieties offer farmers benefits of more than $400/ha/yr, mainly in reduced fungicide applications. But why isn't everyone following the Cuban example? Is there something unique in the Cuban situation? One factor appears to be that Cuban farmers were already

*Samuel Addo and his wife carrying a bunch of FHIA-21.*
A. Nkakwa Attey

accustomed to intensive banana production, with major use of 'inputs' (including pesticides, fertilisers, irrigation and labour). When foreign exchange restrictions and other economic forces sharply reduced access to pesticides, farmers were perhaps more ready to adapt to the different taste and other characteristics, in return for the high levels of disease resistance and production offered by the new hybrids.

Experiences are still being digested from the TARGET project in Africa, which saw some 64,000 plantlets of FHIA hybrids and other highly productive varieties distributed in four countries (see *Improved hybrids up for adoption* in the 2003 annual report), and from a CFC-funded project that saw more than 31,000 plantlets distributed in

*Ghanaian farmers participating in the TARGET project were invited to vote on which new variety they liked best (right) after evaluating them in their fields (left).*
A. Nkakwa Attey

three African and three Latin American countries. Evidently access to good quality planting material can be an issue limiting adoption of the new cultivars. Both these projects took care to ensure the quality of the initial planting materials, to set up nurseries to harden the plantlets, to provide farmers with training on how to handle tissue-culture materials and, to some extent, set up mechanisms to

*For farmers to have access to improved planting material, 'clean seed systems' must be established. Commercial plantation may use plants derived directly from tissue culture (above) whereas for smallholders, plants propagated from corms (below) may be more useful.*
R. Markham

encourage further propagation of the new materials by conventional methods. However, these experiences fall far short of establishing national systems to ensure the long-term availability of clean planting material.

INIBAP has come closest to institutionalizing such systems in Asia where 17 National Repository, Multiplication and Dissemination Centres have been established in 14 countries. These Centres maintain disease-free mother stocks of potentially useful varieties that can then feed into private- or public-sector systems for larger-scale multiplication. This has been achieved most successfully in the Philippines where a partnership between highly efficient private sector producers of tissue-culture plants (mainly for the export industry) and public sector providers of expertise have teamed up to supply large numbers of high quality plants to small-scale farmers at very competitive prices (see *Bringing back an old favourite, the capitalist way* in the 2004 annual report).

Lacking the foundation provided by the banana export industry, smaller-scale tissue-culture laboratories in East and Central Africa provide plantlets at approximately four times the price of their counterparts in the Philippines and, currently, without similar guarantees of quality (especially freedom from virus infection). Moreover, the upgrading of such systems to ensure quality plantlets at a competitive price represents something of a 'chicken-and-egg' situation—in so far as suppliers' ability to achieve economies of scale and quality control depend on an increased demand but it is hard for demand to grow as long as the supply is inadequate.

## Creating demand

Part of the demand side of the equation, especially where highly productive but unfamiliar banana varieties are concerned, would appear to be the market for processed products. For instance, in East Africa there are indications that FHIA hybrids and others, such as those produced by the International Institute of Tropical Agriculture (IITA), can provide an acceptable and profitable supply of raw material for the traditional banana beer-brewing and wine-making industries, whether on a cottage industry scale or to supply more commercial breweries. In Latin America and elsewhere, the new varieties serve as raw materials for making banana chips, which have a limited but profitable market as a snack food. Meanwhile in India and Southeast Asia, bananas serve as a raw material for a wide range of flours, ketchups and various high-value confectionary products.

So far, these industries are small-scale and only locally important. Probably by their nature,

processed banana products will always remain niche markets but in this case perhaps this is a virtue rather than a vice. For small-scale farmers there may be economic stability in supplying a series of local, regional and international markets, rather than large-scale commodity markets. Moreover, these are markets that can add value to the diversity of genetic resources that they hold (specifically if certain varieties are found to be better suited to particular products).

The role of INIBAP in the area of post-harvest marketing and processing is not one of leading innovative research but rather of promoting the exchange of experiences. By commissioning case studies of how banana-based enterprises have developed in different regions and analysing successes, INIBAP seeks to draw and share conclusions on how a rather limited public sector investment can help to catalyze the development of enterprises that offer

positive opportunities for small-scale farmers and their communities.

## ENSURING SUPPLY

Supplying factories or even urban markets with a dependable supply of bananas presents smallholder farmers with quite a different challenge from their traditional one of assuring household and community food security. Varieties remain an important consideration in this new market-oriented game but production systems that offer high productivity and predictability are also at a premium.

One approach that INIBAP has been experimenting with in both Latin America and Africa involves high-density annual planting of plantains and cooking bananas. By re-planting annually with tissue-culture plants—and, if necessary, rotating with other crops—farmers may be able to reduce problems of chronic, soil-borne pests such as nematodes, while increasing the productivity of limited land holdings. The dense shade that is established by the banana plants effectively excludes weeds while, through mechanisms that are poorly understood, a microclimate seems to be established that reduces the incidence of black Sigatoka. An added bonus in hurricane-prone areas is that the dense stands are much less susceptible to wind damage and, to minimise the risk of losing the whole plantation during hurricane season, farmers can stagger their plantings over the entire year.


*Using bananas in processed products opens up new opportunities for smallholders.*
B. Favre

Again, Cuba leads the way in adopting high density planting with over 4000 ha currently in production. Once more, the attraction here may be mainly in the reduced need for chemical inputs. However, workshops, training courses and pilot projects on high density production have now been conducted in some 13 countries and there are signs that this approach may be useful elsewhere in Latin America, as well as in West Africa (see *When West Africa meets Latin America* in the 2004 annual report). INIBAP and its partners will need to further analyse these various experiences to work out where and under what circumstances such approaches are most appropriate and most likely to succeed.

*Most of the bananas grown by smallholders are sold in local markets.*
Clockwise from left, D. Mowbray, A. Javellena, C. Lusty

## LIVING WITHOUT PESTICIDES

The high cost of synthetic pesticides and growing resistance on the part of the fungi (especially the one causing black Sigatoka) to conventional products remain strong incentives for the development of new products and new approaches. Projects in Latin America have looked at a wide range of plant and compost extracts for their effectiveness in reducing pathogen attack, either by boosting the plant's defence mechanisms or through direct toxicity to the fungi. After extensive trials, two botanical products, derived from the plants *Momordica charantia* and *Senna reticulata*, have completed small-scale assays and moved to 'semi-commercial' production in Costa Rica. However, there is little reason to suppose that in the longer term such products will prove inherently superior to their synthetic counterparts.

A more radical approach, that has been developed largely empirically, is simply to do without pesticides and other synthetic inputs, with or without the official designation of 'organic' production. In principle, the trade-off here is to accept lower yields in return for the higher price that some con-

*A dry climate (top left,* G. Blomme) *makes it easier to grow organic bananas, as long as irrigation is available (right,* I. Van den Bergh).

sumers are prepared to pay for a fruit that is certified as having been grown without chemical inputs. In reality, the trade off is a much more subtle one, determined by the demand and price differential for organic bananas on the one hand and the cost of production on the other. Organic farmers, by definition, do not have to pay the costs of pesticides but they may be applying (and sometimes preparing) other products that are allowed under the organic certification regime or they may have to invest extra labour in assuring soil fertility or pest management in other ways. In some places, farmers simply benefit from the lower production costs of non-pesticide production and accept a lower yield, without seeking the price advantage associated with organic certification.

Part of the strategy for organic banana production involves selecting conditions that are inherently less favourable for the fungal leaf diseases such as black Sigatoka. In particular this involves growing bananas in less humid environments, usually with ground-level irrigation. This was the strategy in Peru, where, in 1998, INIBAP took a leading role in establishing organic banana production as part of a post-El Niño recovery programme in the northern part of the country. The first 400,000 boxes were exported in 2001, with a value of $2.4 million dollars, and as more companies have joined the effort, exports are now at four times that level, placing Peru in third position among organic banana exporters in the world. Another project developed organic banana production in Bolivia, to supply a national urban market (see *The highs and lows of organic bananas in South America* in the 2003 annual report).


*In Ecuador, an organic producer (right) controls diseases through a 'special diet' of natural fertilizer (above).* R. Markham

*In Alto Beni, Bolivia, INIBAP has helped farmers produce organic bananas.* A. Vezina

## Working with nature

In the forests of South-east Asia, it's relatively easy to find the wild relatives of the cultivated banana—but it's very rare to find a sick one. Sometimes this is for reasons that are inherent in the situation of the wild plant, rather than the cultivated version, such as the sexual reproduction that allows it to evolve in parallel with its pathogens and the scattered stands of the plant that slow the spread of pathogens. But other features of the natural environment can perhaps be mimicked in banana plantation. Soils that are rich in organic matter support a great diversity of saprophytic organisms that may compete with potential pathogens, as well as biological control agents that may attack directly and keep in check the nematodes and fungi that would otherwise overwhelm the banana plants. Perhaps most interesting of all are bacteria and fungi that grow within the banana plant ('endophytes') or on the surface of its roots ('mycorhizae'), helping to protect it against pathogen attack. The more we can learn and understand about the processes that keep bananas healthy in their natural environment, the more we can hope to manage these same processes to ensure that bananas remain healthy and productive on farms as well.

## Partners in health

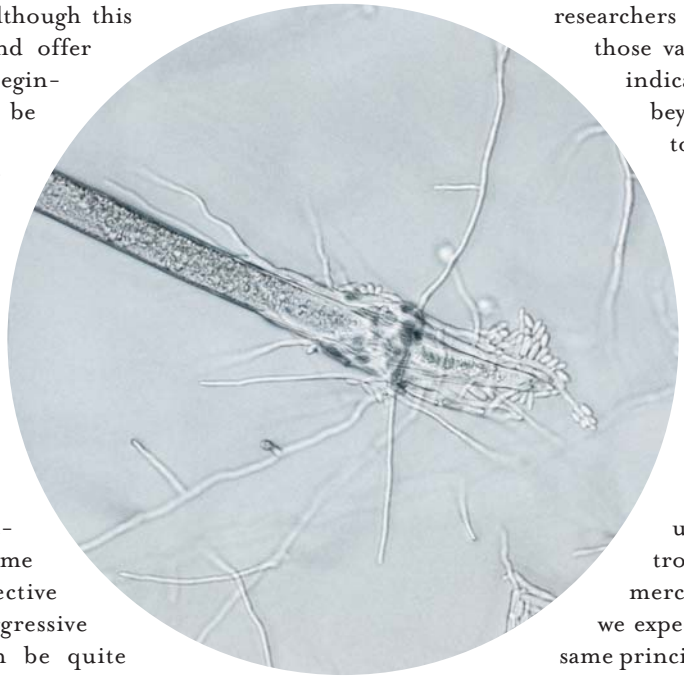
What INIBAP is now attempting is to draw together the knowledge gained in organic production projects and in specific studies of pathogens in order to learn more generally how to work with the living organisms that protect bananas in their natural habitat (see *Working with nature*). Although this approach may be more ambitious and offer greater technical challenges at the beginning, it should prove in the end to be more durable.

Researchers are finding, for instance, that bacteria and fungi living 'endophytically' within the tissues of plants without causing disease are a widespread phenomenon and that such organisms may help to protect the host plant against disease-causing agents. In some cases, the protective endophyte and aggressive pathogen can even be quite closely related, as in the case of endophytic fusarium species that can protect against both nematodes and perhaps against the aggressive fusarium strains that cause Panama disease as well.

The search for the most effective endophytes can be a painstaking process of screening and characterizing numerous samples of plants and microorganisms. However, the networking approach of INIBAP is ideally suited to mobilizing the complementary resources of partners in such a concerted global effort. Thereafter, cost-effective means of culturing, formulating and applying the chosen products to banana plants must be developed in the same way. Various organisms and approaches are currently under evaluation and there remains much work to be done to define the circumstances in which the extra cost of treating tissue-culture plants is justified by better establishment and yields. However, in Costa Rica, treatments with endophytic fungi are now proving their value on 22 ha of intensively produced bananas. If these trials are successful, the potential benefits in terms of reduced nematicide applications alone could be enormous.

*A handful of soil contains millions of beneficial micro-organisms.*
R. Markham

Also in Latin America and the Caribeean, INIBAP and its partners are working with banana producers selling to the export and local markets to understand what constitutes a healthy soil for durable banana production. By comparing 42 farms of known history in four countries, the researchers involved are identifying those variables that will serve as indicators of soil health and, beyond that, will learn how to manage the crop and its inputs—especially organic matter—in order to restore ecologically damaged land and achieve low pest levels and a healthy, productive crop.



*A 'good' fungus attacking a nematode.*
A. Meneses

Once we understand the underlying principles of how soil health can be managed under the relatively controlled conditions of commercial banana plantations, we expect to be able to apply the same principles to managing the pest and soil fertility problems encountered by small-scale farmers everywhere. And, once more, INIBAP's trademark approach of sharing knowledge and sharing the task of testing new options will be ideally suited to identifying a range of solutions, tailored to the individual situations and aspirations of our ultimate clients, the small banana producers and their communities.