Banking on the future

The genebank INIBAP created is now the foundation of an ambitious plan to conserve the diversity of the world's favourite fruit.

Rony Swennen (left) and Ines Van den Houwe (right), shown handing over one of the first consignments of plantlets to scientists from the Taiwan Banana Research Institute, have been managing the INIBAP Transit Centre since its creation in 1985. KULeuven

Training courses on how to use banana descriptors to characterize varieties have stimulated various efforts to harmonize banana nomenclature. E. Arnaud, INIBAP

Although only a small fraction of the 250 000 known species of flowering plants have been domesticated, most of them currently play only a minor role in the human diet. Most of the burden of feeding the world falls on just a few crops, of which rice, wheat and maize are the most important. Bananas and plantains are not far behind.

Because the number of staple crop species is so small, their genetic diversity is disproportionately important to meeting the challenge of feeding future generations. The rationale is that the varieties created by farmers and their wild relatives provide a reservoir of variability from which solutions to existing and unforeseen problems can be drawn, hence the need to conserve them. But conservation is a complex task that requires answers to various questions, including which diversity to conserve and where best to conserve it (genebanks, field collections, farmers' fields and, in the case of wild species, natural reserves).

To address these issues and place diversity conservation on a secure, long-term footing, INIBAP is developing and implementing a Global Conservation Strategy for *Musa*. Building upon existing strengths at the international collection managed by INIBAP, and several regional and national collections, the strategy aims to rationalize the global effort to conserve the *Musa* gene pool and promote the safe use and distribution of a wide range of diversity, all the way to farmers' fields.

In contrast to other major crops, for which up to one hundred thousand varieties may exist, the banana is in the enviable position of possessing a manageable level of diversity. With an estimated one thousand varieties, the ambition of conserving the entire banana gene pool is not an unrealistic one.

A first draft of the strategy has been developed within the framework of the Global Crop Diversity Trust, an endowment fund established by the FAO and the centers of the Consultative Group on

This paper is based on a talk given by Rony Swennen from KULeuven at a symposium on the *Conservation and Use of* Musa *Biodiversity for Improving Livelihoods* held in Leuven, Belgium, on 18 October 2005.

International Agricultural Research to support the long-term conservation of vital food crops (see their website at www.croptrust.org).

Know thy diversity

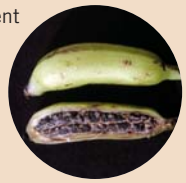
Because domesticated bananas and plantains are seedless, their genetic diversity must be conserved either in field collections as full-size plants, or in genebanks as plantlets derived from the culture of meristem tissue (actively dividing tissue from which all other tissues are derived) and kept in test tubes under slow-growth conditions. The world's largest collection of *Musa*, held at the INIBAP Transit Centre (ITC) and managed by the *Katholieke Universiteit Leuven* (KULeuven) in Belgium, currently contains 1183 accessions[1] (see *High-tech care*).

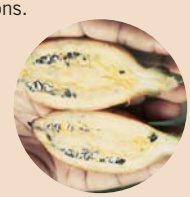
The maintenance of a central genebank is a necessary foundation for the conservation effort but provides only part of the solution. Field collections are also important for taxonomic characterization and evaluation. Currently there are some 60 collections, each dedicated to conserving part of the banana gene pool; however, there is growing concern about their long-term prospects. Numerous national collections, particularly those that are poorly resourced in Africa and in Asia and the Pacific, are threatened by poor management, natural disasters (flooding, drought, etc.) and diseases. Indeed, some accessions have already been lost from the field collections from where they originated and are now represented only by *in vitro* cultures.

Investment in genebanks is easier to justify if the genetic material being conserved is widely used by breeders and other researchers. But so far only a narrow range of genotypes is used and, even at the ITC, only a fraction of the accessions are regularly requested. Conventional breeding has traditionally rested on a rather narrow range of genotypes capable of engaging in fertile crosses, but other techniques, such as genetic transformation, should widen the range of materials from which useful genes can be accessed, underlining the need for more complete characterization. In that perspective, the ploidy levels of the accessions in the ITC collection have been determined by the Institute for Experimental Botany and

The domestication of the banana

Wild bananas are typically full of seeds. They became edible when some plants mutated to produce fruits that had more flesh than seeds, prompting farmers to propagate the offshoots (known as suckers) growing at the base of the plants. But since these edible diploids were still fertile, they could also be fertilized by wild bananas. Domestication went into high gear when, during such a crossing, one of the parents gave 'by mistake' all of its chromosomes, instead of half as sexually reproducing organisms normally do. What these new triploid varieties gained in productivity, they lost in fertility. From that point on, diversity was mainly created by farmers selecting advantageous mutations.





Fruit full of seeds of a wild Musa acuminata. R. Markham, INIBAP

The domestication of the banana plant for its fruits started with the appearance of fleshy parthenocarpic fruits – fruits produced without the need for pollination. S. Sharrock, INIBAP

Edible diploids are still eaten in certain parts of the world. In Papua New Guinea (below) the parthenocarpic fruits of Musa peekeli *are eaten despite the presence of seeds. In Thailand and India, semi-wild* Musa balbisiana *are similarly propagated by farmers and eaten when other foods are scarce.* S. Sharrock, INIBAP

The tallest banana plant on earth, Musa ingens, *grows in Papua New Guinea. Like all wild bananas, it is diploid, but unlike the others it has 7 pairs of chromosomes, instead of the usual 10 or 11 pairs.* S. Sharrock, INIBAP

Wild beginnings

Wild bananas belong to the genus *Musa*, which is native to the tropical and sub-tropical forests of Asia and Oceania that extend from India to the Pacific. Botanists have identified some 50 species of bananas, the exact number being subject to change as new specimens are collected and taxonomic arguments are settled. Like humans, wild bananas are diploid, that is they have two sets of chromosomes, one from each parent.

The majority of today's bananas are related to either Musa balbisiana *(right), or* Musa acuminata *(above) or both.* K. Tomepke, CARBAP

[1]An accession is a species, a variety or a population registered at a genebank.

Cultivating diversity

The most well-known triploid bananas, at least in banana-importing countries, belong to the Cavendish group that dominates the international trade. These bananas trace their origin to *Musa acuminata* only, but many cultivars also have *Musa balbisiana* in their lineage. Other species have also left a trace in certain varieties, but their contribution is more limited, except in the Pacific, where another species gave rise to an unusual group of bananas that are rich in precursors of Vitamin A.

By propagating the suckers of their favorite mutants, farmers created bananas of various colours and shapes to suit all sorts of tastes and uses. Clockwise: K. Tomekpe, CARBAP, S. Sharrock, INIBAP, M. Hakkinen, V. Lebot, CIRAD, J. Daniells, QDPI

characterization using morphological characters and genetic markers is under way.

Molecular characterization also holds the hope of contributing to a definitive taxonomy of bananas. The banana is notorious for the proliferation of names associated with a single variety or highly similar varieties. Although some names are clearly synonyms, others are more difficult to pin down because they correspond to morphological differences that depend on the conditions under which the plant is grown. Environmental influences on morphology need to be teased out and varieties distinguished on a sound genetic basis. Molecular markers capable of distinguishing between very closely related cultivars have yet to be found, but matching morphological characters with molecular profiles should serve as a springboard for harmonizing the taxonomy and rationalizing the *Musa* collections around the world. Indeed, one of the first major steps of the strategy is to coordinate a global effort to characterize *Musa* accessions and establish a working taxonomy by which all researchers on banana can understand one another.

Plantains are a large group of cooking bananas that contain genes from Musa balbisiana *as well as* Musa acuminata. *They are at their most diverse in West and Central Africa.* K. Tomepke, CARBAP

Easily recognized by their erect bunch, Fe'i bananas are found only in the Pacific Islands. Their origin is obscure. J. Daniells, QDPI

Bananas originate from the tropical forests of Asia, where rates of deforestation are particularly high. R. Markham, INIBAP

Stopping the diversity drain

The urgent need for a concerted strategy is underscored not only by the precarious situation of some genebanks and field collections, but also by the disappearance of traditional varieties from farmers' fields and the destruction of natural habitats harbouring wild relatives.

At present, the majority of banana farmers rely on only a fraction of the known diversity. Of the 105 million tonnes currently being grown, some 16 millions are accounted for by the export trade, which is represented by just a few, genetically very similar, cultivars belonging to the Cavendish group. The rest of the production is eaten or sold locally but increasingly tends to be dominated by a relatively small number of cultivars.

Many varieties are either no longer cultivated or found only in a few strongholds, frequently in remote or marginal areas where the tradition inherited from a bygone age, when crop diversity was the key to food security, still prevails. On-farm conservation can play a role in maintaining cultivated diversity (see *Reconciling modernity and tradition to conserve diversity* in the 2004 annual report) but the importance of that role will depend on the sustainability of the mechanisms put in place to foster it.

Field collections, such as the one managed by the Centre Africain de Recherches sur Bananiers et Plantains *(CARBAP) in Cameroon (left) are an important element of a global strategy for conserving the diversity of bananas, but staff may have to destroy infected plants in their fight against diseases (right).* R. Markham, INIBAP

Also at risk are the banana's wild relatives, which disappear when their natural habitat—the tropical and sub-tropical forests of Asia—is destroyed by logging, replaced by cities or transformed into cultivated land. Since conservation in genebanks and field collections puts a stop to their evolution, wild relatives also need to be conserved in their natural habitat where they can continue to change and adapt.

A better understanding of the diversity of bananas and more effective mechanisms for their conservation and exchange should lead to the development of healthier and tastier bananas for consumers everywhere, as well as providing novel solutions to the production problems that are inherent in agricultural systems based on a narrow range of varieties. Consumers in industrialized countries can expect to see more than the standard Cavendish banana in their shops. In developing countries, bananas could play a larger role in providing food security and fighting specific nutritional deficiencies. In the end, however, it is by demanding and using diversity that we, as a world community, will ensure its conservation.

Deborah Karamura of INIBAP is an aknowledged expert on East African highland bananas, a highly diversified group of some 80 varieties, used mainly in cooking and beer-making, which occupy the fertile mountains around the Great Lakes area and are found nowhere else. INIBAP

The world's foremost expert on bananas, and INIBAP's first director, Edmond de Langhe was born in what was then Belgian Congo, a place to which he has returned many times to work on bananas. R. Stevens

Collecting the past to secure the future

Banana taxonomists tend to be real enthusiasts, who will always want to explore new areas, pose new questions and collect more plants. According to experts on wild bananas, more exploration is needed to refine the boundaries between species and sub-species and to ensure a complete coverage of the existing diversity—or what is left of it, given the rate at which natural habitats are being lost. However in the context of conservation, scarce resources have to be allocated strategically to surveying the areas of highest diversity or those whose diversity seems most at risk.

The same holds true for cultivated varieties, which are also disappearing fast. In India, for example, more than 90% of tribal hamlets are estimated to have halted cultivation of lesser-known traditional varieties. In Africa, which is a secondary centre of diversity for plantains and an endemic group of highland bananas, INIBAP is planning to return to the Democratic Republic of Congo and Tanzania, where previous collecting missions have uncovered varieties absent from genebanks.

A former merchant marine ship captain, Markku Hakkinen embarked on a second career as a banana specialist some 30 years ago after becoming fascinated with a banana plant he had bought at a market in his native Finland. He is currently a research fellow at the University of Helsinki and close collaborator of INIBAP. He has conducted many collecting missions in Southeast Asia and has written over 30 articles on bananas. Mrs Hakkinen