When breeders went looking for genes to restore some of the diversity left out of commercial plantations, they headed straight to Asia, where bananas come from. Several decades of hard sweat later, the resulting hybrids are making their way back to Asia to help smallholders fight banana diseases.

Thanks to sexual reproduction, which shuffles the genetic cards and once in a while comes up with a winning hand, the wild relatives of today’s bananas have been able to keep up with pests and diseases. The balance tipped in favour of the diseases when farmers started selecting for parthenocarpic plants, i.e. plants that do not need to be fertilized by pollen to produce fruits and as a result tend to give seedless fruits. As farmer selection took over from natural selection, the vegetatively reproducing banana plants produced better fruit but began to lose ground to the pathogens. Over time, a diversity of cultivars catering to all sorts of tastes and uses was generated by farmers, but at the expense of resistance to diseases.

When the diseases originating in Southeast Asia reached the commercial plantations of Central America, banana breeding programmes were set up to develop resistant varieties. The first thing breeders did was to send off botanists on collecting missions to Asia and the western Pacific to boost their stock of wild Musa and cultivars. It took a lot of patience and hard work to blend the best characteristics of wild and cultivated varieties, but each of the breeding centres that has taken up the challenge has turned out hybrids that are resistant to the important diseases (see ‘Wild genes in your banana’).
The case is made for the importance of conserving, documenting and evaluating genetic diversity

Many of these improved hybrids are now going back to Asia to help smallholder farmers fight the diseases that are bringing down their yields. A range of varieties, both dessert and cooking bananas, are conserved in the International Musa Germplasm Collection in Leuven, Belgium, and evaluated for their yield and resistance to pests and diseases all over the tropical world through the International Musa Testing Programme (IMTP). In Asia, as in Africa, INIBAP with its national partners has embarked on an additional phase of varietal assessment by farmers themselves.

First stop
Leading the way is the Philippines, where INIBAP’s Asia-Pacific regional office is located. “It is normal that we should start in our own backyard”, jokes Agustin “Gus” Molina, the regional coordinator, himself a Filipino. “But the main reason we are the first ones in Asia promoting improved hybrids is that the local banana industry is hit particularly hard by diseases and is looking for alternatives.” Funded through the Bureau of Agricultural Research and the Philippine Council for Agriculture, Forestry and Natural Resources, Research and Development, the project has distributed, with the help of provincial and state colleges and universities, as well as non-government organizations, such as local Rotary Clubs, over 30 000 in vitro plantlets of selected improved hybrids, FHIA-03, FHIA-18, FHIA-21, FHIA-23 and FHIA-25, alongside the local cultivars ‘Bungulan’, ‘Lakatan’ and ‘Cardaba’.

Wild genes in your banana

The long history behind the development of every new variety is often little appreciated and sometimes poorly recorded. In classical breeding, genetic diversity is drawn from multiple sources to bring together characteristics for good agronomic performance and tolerance to different stresses in a single variety. The pedigrees behind some of the high-impact wheat and rice varieties are complex, involving hundreds of crosses and germplasm from many sources going back over decades. The history of banana breeding is simpler and thanks to the publication of some obscure notes by the collector, Paul Allen, relating to expeditions in 1959 and 1961, we are able to trace the lineage of a number of improved banana varieties.

Jonathan Robinson, an IPGRI consultant, traced the genetic resource history that led to the making of FHIA-03 as part of an exercise to examine the impact of genetic resources. FHIA-03 was produced by the Fundación Hondureña de Investigación Agrícola (FHIA) in 1987 as a cooking banana resistant to black leaf streak disease. The variety has been taken up on a large scale in Cuba, Nicaragua and Tanzania and is rapidly appearing in farmers’ plots further afield.

FHIA-03 is a tetraploid (AABB), having four sets of chromosomes each donated from different parents. Breeders started by crossing a triploid (ABB) ‘Gaddatu’, a cooking banana from the Philippines, and the wild diploid Musa balbisiana (BB), probably from either the Philippines or Papua New Guinea.

In total, some 14 crosses involving 11 wild banana types and 2 triploid landraces took place to bring about FHIA-03. Many of the characteristics for pest and disease resistance as well as valuable agronomic traits came from wild bananas. The subspecies, Musa acuminate ssp. burmanica provided some of the resistance to black leaf streak disease and a wild diploid, ‘Pisang jari buaya’, provided resistance to nematodes. Crosses between four wild types from Papua New Guinea, Java, Malaysia and the Philippines gave birth to a vigorous diploid (SH-2095), which produces large bunches weighing up to 30 kg, and long fruit that do not fall to the ground when ripe. SH-2095 is a parent of many FHIA varieties.

Asian farmers, then, should find something familiar in the improved hybrids making their way to their fields. Many of the genetic traits of the new bananas originally came from Asia. Although the road has been long and the transactions numerous, the case is made for the importance of conserving, documenting and evaluating genetic diversity, and for the value of sharing resources across regions.
the farm provides fresh produce to the other 11 orphanages. FHIA-18, FHIA-23 and FHIA-25, as well as local varieties ‘Lakatan’ and ‘Bungulan’, will soon be on the menu when the newly planted banana varieties come to fruit.

As in previous trials, the FHIA varieties are proving to be high yielding and resistant to the main banana diseases. It is too early to say whether they will be accepted by farmers and consumers, but Gus is confident that the improved hybrids will find a niche in Asia. “Asians are used to bananas of all tastes, shapes, sizes and colours. After all, bananas prepared in many ways provide an important source of food for local people. The improved hybrids just add to this diversity, whereas in Latin America, where people are used to just a few varieties – the Cavendish dessert bananas and one or two plantain cultivars – there is much less interest in improved hybrids, even if they were bred in Central America.” According to this theory, the diversity-deprived consumers of Europe and North America should rate low on the uptake scale and there is some evidence to support this argument. Before the 1950s, consumers in the United States were slow to warm up to the Cavendish banana that is so ubiquitous nowadays. They thought it was too different from ‘Gros Michel’, the only banana they had ever eaten but that could no longer be grown on commercial plantations because of Fusarium wilt. Even if diversity breeds diversity, Gus does not think acceptance will happen overnight. For one thing, the improved hybrids do not taste as good as the local cultivars, he says, all chauvinism aside. “Improved hybrids are an acquired taste. But once you introduce them they will become part of the available diversity and people will get used to them and eat them.”

For the moment, the new varieties are most likely to win the hearts of farmers through their high yields and disease resistance. Farmers who have difficulties with banana diseases should be the first to adopt them, but one can never predict how events will turn out. For example, as a result of its short shelf-life, FHIA-03 brought out the best in human nature when it was introduced to subsistence farmers in Calamba near Los Baños. A bunch being too big for a single family to eat, farmers started sharing their bounty with their neighbours and soon everybody on the block knew about the new variety.

**Plant laundering**

The tissue culture plantlets for the project were supplied by the Bureau of Plant Industry of the Department of Agriculture, which has been designated,
Decentralizing germplasm supply

The INIBAP Transit Centre (ITC) in the Katholieke Universiteit Leuven (KULeuven), Belgium, provides a maximum of five samples of any one accession upon request. With a remit for long-term conservation and research, the ITC was never designed to respond to large scale demands for germplasm from farmers. Some smaller genebanks exist to help supply planting material at the regional level, but their reach is limited and quarantine measures can impede the movement of plant materials across borders. National Repository, Multiplication and Dissemination Centres (NRMDCs) represent the best way of getting large amounts of planting material to the farmers who need it.

Seventeen NRMDCs have been set up in 14 countries. Bangladesh, China-mainland, India, Indonesia, Malaysia, Papua New Guinea, Philippines, Fiji, Sri Lanka, Taiwan, Thailand and Vietnam received their in vitro plantlets in or before 2003. Cambodia, Myanmar and China-Hainan are expected to receive theirs in 2004. Each country, having received a small grant from the European Union as seed money, is now responsible for keeping the centres going. “They only received about US$ 2000. In a way it is a good thing that we did not have more money because by investing their own resources, the countries put more value on their centre”, says Gus Molina, INIBAP’s regional coordinator for the Asia-Pacific region.

The inter-regional movement of germplasm dates back to the origins of agriculture and underpins the present day crop varieties that are grown throughout the world. Before 1993, breeders could easily go to the area of origin and diversity of a crop and collect the specimens they needed. The Convention on Biological Diversity (CBD) affirmed the sovereign rights of nations over their genetic resources. The new policy put a damper on collecting and the movement of plant material and indeed slowed the acquisition of new materials by public in-trust genebanks, such as the International Musa Germplasm Collection. Now it is expected that the International Treaty on Plant Genetic Resources for Food and Agriculture, with its provisions on access and benefit sharing, will facilitate the exchange of genetic resources that play a key role in food security and revitalise breeding.

In the meantime, it is hoped that the NRMDCs will promote exchange of germplasm and provide countries with a focus for conserving their landraces and wild relatives of Musa, many of which are threatened with extinction.

In the Philippines, as National Repository, Multiplication and Dissemination Centres (NRMDC). These centres are part of a network of similar NRMDCs that have been set up in 14 countries throughout the Asia-Pacific region (see ‘Decentralizing germplasm supply’). The NRMDCs were established to provide a ready access to improved hybrids and local cultivars at the national level. The collection is maintained as in vitro plantlets and a foundation stock is planted in an insect-proof greenhouse to protect it from insect-transmitted viruses.

What Gus likes best about these centres is that they will be distributing clean planting materials, i.e. free of nematodes, bacteria, fungi and viruses. He wants to enlist these tissue culture plants in the fight against banana diseases, especially viruses, against which the improved hybrids tend to be as powerless as any cultivar. His main target is the banana bunchy top virus (BBTV).

Transmitted by an aphid, BBTV is by far the most serious viral
disease affecting bananas. In the Philippines, where it infects the popular cultivars ‘Lakatan’, ‘Bungulan’ and ‘Latundan’, it constitutes one of the major constraints to production and is also present in many countries in the Asia-Pacific region. Infected plants show stunted growth and rarely produce fruit. Once present, the virus is very aggressive and hard to contain at the farm level, demanding a concerted effort from the entire community.

The disease situation has reached the point where, on the island of Luzon, the demand for ‘Lakatan’ is being met by large commercial plantations producing for the export market, rather than by the small-scale farmers who traditionally supplied the local market. The big companies have succeeded where smallholders failed by using clean tissue culture planting material. In Taiwan, the spread of Fusarium wilt race 4 on Cavendish cultivars has been similarly brought under control by a massive use of tissue culture plants, coupled with wide-scale planting of resistant somaclonal variants.

To reach the smallholders, the plan is for some farmers to establish nurseries as a viable business. The nursery owners will buy in vitro plants that they will grow and harden off in plastic bags in the nurseries until they are ready to plant and sell to other smallholders. Because of the large quantities required, the NRMDCs will first send the small in vitro plantlets to private tissue culture laboratories, such as Lapanday Fruits Co., for multiplying on a large scale.

Because of the economies of scale that can be achieved by producers like Lapanday, the plantlets will be affordable for the smallholders. Each in vitro plant will cost less than 10 US cents and another 10 to 15 cents will go towards the cost of growing and hardening off. Even with the nursery owner’s take, the planting materials will be less expensive than if they had been supplied directly as ready-to-plant materials by private laboratories.

Trials are also under way to try and devise the most appropriate production strategy for farmers. Plots in which the plants are uprooted every year and replaced with clean planting materials are compared with plots in which tissue culture plants are used the first year only and suckers are allowed to take over. Plots have been set up in areas of varying disease intensity to determine which strategy works best under a given disease pressure. In heavily infested areas, it may be necessary to replant every year, but in less disease ridden ones, it may not be essential.

Previous studies on the benefits of biotechnology to small-scale banana farmers conducted in East Africa have shown that farmers were very impressed by the monetary advantages of using tissue culture plants. They welcomed the higher yields and shorter production cycles. Small-scale farmers in Asia who might have been tempted to give up on bananas altogether should similarly welcome this chance to boost productivity and defend their livelihoods against spreading epidemics of disease.