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## **Breeding a Better Banana**

*by Michelle Hibler, with field research by Diane Hardy in Honduras*

From a distance, the banana groves at the experimental farms of the Honduran Foundation for Agricultural Research (FHIA) in La Lima, in northeastern Honduras, look much like all the other groves that blanket the countryside: hot, humid and lush. In the dappled sunshine under a canopy of broad leaves, large, well-filled bunches of green fruit hang from sturdy trees.

But that's where the resemblance ends. These are no ordinary bananas. Careful inspection reveals that the fruit is distinctly shorter and stouter than the Cavendish dessert banana most North Americans and Europeans are familiar with. In its green, unripe stage, this banana is delicious cooked. When ripe, it has a pleasantly tart flavour reminiscent of apples.

More importantly, the new banana -- code named FHIA-01 -- resists the diseases that are devastating plantations throughout the tropics. It also grows well in poor soils and at cooler temperatures, offering some promise of extending the banana's range into semi-tropical or upland areas where today's heat- and humidity-loving varieties won't grow.

After decades of painstaking breeding, FHIA-01 -- or "Goldfinger" as the world will come to know it -- is the first banana variety ever bred that could replace the standard Cavendish banana. It may well save the world's banana export industry from collapse as diseases take an unsurmountable toll. More important yet, it could ensure reliable food supplies for the millions of people in Africa, Asia and Latin America for whom bananas and plantains are staple foods.

### **A GLOBAL THREAT**

The story of Goldfinger began in 1959 when the United Fruit Company -- now United Brands -- witnessed the demise of the standard export banana, the Gros Michel, to race 1 of Panama disease. Fortunately, Gros Michel could be replaced by the Cavendish varieties that were resistant to the fungus that causes the disease. The industry was saved. But because no other natural variety existed to replace Cavendish if -- or when -- it too fell prey to disease, United launched a breeding program in Honduras to develop bananas that would withstand anticipated new diseases.

That foresight paid off, according to Dr Phillip Rowe, who heads FHIA's Banana and Plantain Improvement project. The diseases that United Brands anticipated would evolve to destroy Cavendish now exist. The two most threatening are Black Sigatoka, a fungal leaf spot disease, and race 4 of Panama Disease.

First observed in Fiji as recently as 1964, Black Sigatoka is ripping through plantations" the world over. Spotted in Honduras in 1972, it had spread throughout Central America by 1984 and now reaches as far south as Ecuador. Much of Africa is also infected by what's being called the black plague. There's no way to stop its spread as long as conditions are right for infestation," says Rowe.

Attacking all major varieties of bananas and plantains, Black Sigatoka turns the plant's leaves a mottled yellow, brown and black, thus impeding photosynthesis. Depleted of its energy reserves, the plant cuts back its fruit production, often to half. This could spell hunger in areas where bananas and plantains are staple food crops. For exporters, Black Sigatoka is ruinous: the disease also causes premature ripening of the fruit. Although they appear normal, bananas from affected plants ripen and spoil before arriving at markets.

Black Sigatoka can be controlled, but the cost of chemical fungicides --- a staggering US\$800-1000 per hectare per year --- is prohibitive for all except large multinational exporters. Chemical control is certainly impractical for plantains, which are grown in scattered plantings on small farms, particularly since fungicides must be applied whenever a new leaf appears. In Guatemala, some growers are spraying up to 50 times a year.

The massive application of chemicals on plantations, usually through aerial spraying, is also drawing the ire of environmentalists and concerned consumers. What's more, says Phillip Rowe, the airborne fungus is developing a resistance to available pesticides.

As Black Sigatoka continues its devastating march, many small growers in affected countries are phasing out of production. Just outside La Lima, a discouraged farmer laments that he doesn't know how he can stop the devastation of his small plantation. Like most others, he cannot afford the expensive chemical controls. In the neighbouring country of Panama, more than a third of plantain farmers have abandoned production since Black Sigatoka struck in 1981.

Race 4 of Panama Disease may prove an even more formidable foe. Although it is now found only in Australia, Taiwan, South Africa and the Canary Islands, the soilborne fungus is spreading rapidly. Race 4 is a killer disease that wipes out crops completely. And it cannot be controlled by existing fungicides. The only control measure is genetic resistance," says Rowe.

## **A COMPLEX PARENTAGE**

Breeding for that resistance is a major thrust of the research housed at FHIA since 1984 when United Brands turned over its research program. FHIA is financed by the USAID and the Honduran government. IDRC and other donors have supported the breeding program since 1985.

As researcher Dr Franklin Rosales explains, breeding bananas is more complex than breeding any other crop. (see box A banana breeding primer). The main difficulty is a trait that endears bananas to consumers -- its lack of seeds. Fortunately for farmers, bananas and plantains are easily multiplied by removing and replanting the sprouts produced by mature plants. But the sprouts are clones. Identical to their parents, they offer no hope for improved varieties.

Breeders therefore turn to wild or other varieties that may not have good eating characteristics but do produce viable pollen or seeds. Desirable characteristics such as disease resistance can be combined in new plants and eventually crossed with standard varieties that have all the desirable eating qualities. The FHIA program draws on a gene pool of more than 800 different cultivars collected in Southeast Asia, the bananas' centre of origin.

It's a staggering endeavour. As Rosales explains, in each of the 24 years of breeding that led up to Goldfinger's development, some 10,000 hybrid plants were set out in the fields. We have to walk through all the rows," he says, look at plant size, fruit bunches, see if they are resistant. Then we select just a few." To date, fewer than 20 very elite" hybrids have been retained for their potential as cultivated crops.

Banana breeding is also painfully slow. A full cycle, from seed to seed, takes three years. Compare this to rice, says Rosales, where you can obtain three crops a year.

Even pollinating the flowers is difficult. At first light, workers on ladders quickly hand pollinate the one or two flowers that have opened that day before the sun and heat dry out the sticky pollen. Each flower represents a hand: the process will be repeated every morning for a week or more before the entire bunch is pollinated. Three months later, the bananas are harvested. But there's no way of knowing where the few -- if any -- peppercorn-sized seeds are hidden without crushing and sieving the entire bunch. In FHIA's facilities, specially trained workers strip the fruit off the bunches and peel the bananas by hand. Although a press developed by Dr Rowe has made the mashing a little easier, it's still a laborious, messy process. At FHIA, more than 20,000 bunches of bananas are crushed each year in the search for seeds.

The seed harvest is meagre -- one or two seeds per bunch. And not all of these will grow into plants. The banana-seed germination rate is poor, below five percent in the wild. Using tissue culture techniques that involve "rescuing" the embryo in the seeds that have them and growing them in a nutrient medium, Drs Rowe and Rosales have boosted the germination rate to 50 percent. The young plants are then transplanted into nursery beds until large enough to be set out into the fields.

In Goldfinger's breeding, the first big breakthrough came in 1977 with the development of a hybrid that was resistant to burrowing nematodes -- a widespread pest controlled by potent, expensive pesticides -- and race 4 of Panama disease, and that had a good bunch size. Crossed with a female Brazilian apple-flavoured "Dwarf Prata" clone, it showed good resistance to Black Sigatoka. FHIA-01 was born.

## **A TOUCH OF GOLD**

Drs Rowe and Rosales have unbounded hopes for Goldfinger. They're justifiably proud. Tested in six Latin American and African countries as part of the International Musa Testing Program sponsored by the International Network for the Improvement of Banana and Plantain (INIBAP), it has proven resistant to race 1 of Panama Disease and to Black Sigatoka. "We got lucky," says Dr Rowe: in trials in a number of other countries, including Australia, FHIA-01 has shown strong resistance to race 4 of Panama disease and to the burrowing nematode.

In fact, Goldfinger appears to have it all: a hardy dessert banana, it can be grown without pesticides, and in areas where traditional banana varieties don't grow. Highly productive, its fruit can be eaten green, boiled or fried as chips. FHIA's workers, in fact, now prefer it over their traditional plantain and it is almost three times as productive. The fruit's shipping qualities are about the same as Cavendish's, but the fruit ripens slowly and sequentially, hand by hand, over a couple of weeks.

Goldfinger's unique flavour when ripe should make it highly popular, say the researchers. In countries where consumers can choose between Cavendish and other apple-flavoured bananas, the latter are preferred and sell for about twice the price of the Cavendish. In informal test trials in Honduras, "everybody loved the flavour," says Dr Rowe. What's more, Goldfinger doesn't oxidize, retaining its golden yellow colour when cut. That makes it ideal for fruit salads, juices and purees such as baby foods.

Goldfinger's disease-resistance and hardiness make the hybrid even more important for domestic consumption than for export. As Drs Rowe and Rosales point out, it could be grown by smallholders in areas where Cavendish cannot. Goldfinger is amazing even its breeder: this past fall they harvested a bunch that tipped the scales at about 50 kg.

Goldfinger is only one arrow in FHIA's bow. PHIA-02, a Cavendish hybrid highly resistant to Black Sigatoka, is also being tested in various countries. Equally promising is FHIA-03, a rustic cooking banana being tested in seven African and eight Latin American and Caribbean countries where it's proving more vigorous than conventional plantains and cooking bananas. It's even thriving in areas where dessert bananas and plantain won't grow such as in poor, dry, acid and rocky soils. FHIA-03 also appears to be resistant to Moko, a bacterial disease and to Race 2 of Panama Disease.

The superior hybrids developed for banana breeding are also proving useful in developing high-yielding, disease-resistant, tasty plantains. And this is where Dr Rowe sees the greatest potential, both for increased

food availability in tropical countries and for export markets. "What we really anticipate happening," he says, "is that North Americans and Europeans who have never tasted a plantain will become plantain consumers."

The work is not over. Goldfinger will soon be field-tested in farmers' plots in many more Latin American and Caribbean countries. But many growers are not waiting for the final results to be tabulated. Word of Goldfinger's testing has brought interested parties from Cuba, Ecuador, Israel and South Africa to FHIA. South Africa's Leeways Laboratory Ltd plans to set up a tissue culture lab in Honduras so it can reproduce plants more quickly for clients that include the multinational company, Dole. FHIA, in collaboration with other labs, expects to have seedlings available for commercial use next year.

All this interest is good news to Dr Rowe. "We have been thinking of ways to get these two hybrids (FHIA-01 and 03) out to the African countries that need them most. I am convinced that FHIA-01 would immediately double production for the 70 million Africans for whom plantains are a staple food," he says. Early estimates put the cost of the new hybrid seedlings at US\$0.50 per plant. "That's a very good price," says Dr Rowe, "It looks to us like the best possible use of funds for humanitarian purposes in West Africa."

Neither Rowe nor Rosales expect major banana exporters to jump on the Goldfinger bandwagon. Any change in variety requires changes in packaging, shipping techniques, temperature control, etc, says Dr Rowe. It's unlikely they'll go through that expense as long as they can control Black Sigatoka. But, if present trends continue, that day may not be very far off.

The researchers also anticipate that the multinationals will eventually bow under growing pressure from environmentalists and consumers for a pesticide-free product. "There's a great future for organically grown bananas," says Leeways director Jeff Parsley. Touting Goldfinger as an environmentally friendly or ecological banana may well entice consumers in industrialized countries. But the real winners will be the millions of small producers and their families for whom Goldfinger promises more food, at an affordable price.

## **A BANANA BREEDING PRIMER**

Normally, when breeding for genetic improvements in crops, the breeder can choose both the male and female parents for making cross-pollinations. This is because most species of plants are diploids (they have two sets of chromosomes), which have both seeds and pollen.

Not so for bananas and plantains. While diploid plants are common in Southeast Asia, the cultivars of all bananas and plantains grown for local consumption and for export are triploids (they have three sets of chromosomes). Triploids of any species are ordinarily sterile. This sterility is caused by the genetic laws that dictate that any parent must contribute half of its chromosomes to a sexual union and these chromosomes must be in complete sets. Half of three sets would be one and one-half: this incomplete set means that no seeds are produced when triploids such as the Cavendish bananas are pollinated.

Fortunately, there are some triploid banana clones that do produce seeds when pollinated, making genetic improvement of both bananas and plantain possible. The triploid Gros Michel is one such plant. It contributes all three sets of its chromosomes intact when its eggs are united with the pollen of the male parent. But seed production is very low: Gros Michel produces an average of only two seeds per bunch when pollinated with diploids.

Because banana breeding relies on fixed female parental lines, any genetic improvement must come from the male parent. As Phillip Rowe explains, "it's as if one woman was the mother of a village with different fathers." The bulk of breeding work, therefore consists of developing a "father" with the desired characteristics.

Goldfinger has an international lineage. Its "mother" was a Brazilian, apple-flavoured banana variety

known as Dwarf Prata. Its "father" was the result of multiple crosses of a wild Southeast Asian plant originally selected for its resistance to burrowing nematodes.

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