GATSBY

RAISING BANANA YIELDS IN UGANDA

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Banana is a staple in the highlands of Eastern and Central Africa, with 50 million smallholders depending on it for food and income. However, falling soil fertility and attacks from pests and diseases saw yields decrease for decades – a syndrome researchers called 'banana decline'.

- Over a 15 year period from 1993, Gatsby funded a variety of projects addressing banana decline in Uganda
- Interventions were made at different points of the research value chain, with strategies including research into diseases; the multiplication and distribution of improved varieties; farmer training; and the exploration of potential transgenic solutions
- Results included the development of the first generation of transgenic banana plants with resistance to two of the crop's most destructive diseases. Projects also developed improved disease diagnostics; transferred new technologies to African research institutes; and created cascade systems to get improved varieties into the hands of smallholders

BANANA DECLINE

"The plants were yielding less and less and I was beginning to think we could no longer grow banana here." — Mr Akilleo Mukiibi, smallholder farmer in Bamunanika District, Uganda.

Banana and its close relative plantain provide 25 per cent of food energy requirements for more than 100 million people in sub-Saharan Africa, but are vulnerable to attacks from pests and diseases.

Plants that are well-watered, weeded and supplied with organic matter to maintain soil fertility can, to a considerable extent, resist attacks. But the region's hard-pressed, resource-poor farmers are seldom able to provide this level of management, which means alternative approaches need to be developed.

BANANA STREAK DISEASE

In 1993 Gatsby began funding projects to reverse declining banana yields. Early work focused on understanding why new varieties developed with resistance to Black Sigatoka disease were showing symptoms of a virus. Gatsby funded a joint-project between the International Institute for Tropical Agriculture (IITA) and the John Innes Centre in the UK which found varieties were suffering from Banana Streak Disease (BSD), which is caused by viruses of the Badnavirus genus.

Work on sequencing the virus responsible and investigating its variability uncovered a previously unknown kind of virus behaviour, whereby sections of viral DNA are integrated in the plant's genome, lying dormant until the plant becomes stressed. At this point, the virus can be activated, with a severe impact on the plant.

The project subsequently produced improved diagnostics to monitor BSD infection, and Gatsby funded further projects to transfer these diagnostics to national research programmes in Africa.

DISSEMINATING NEW VARIETIES

Once diagnostic techniques were available that could reliably detect the various forms of BSD in tissue culture and complete plants, dissemination of improved varieties could begin. In Uganda, Gatsby supported IITA and the National Agriculture Research Organisation to rapidly multiply and disseminate such varieties.

Banana and plantain are conventionally propagated by cutting off the shoots or 'suckers' that form around the base of a mature plant and planting them separately to form a new stand of the crop. However, this approach is very slow as only a few suckers are formed each year.

It can be accelerated by using tissue culture as the first stage of multiplication, followed by 'false decapitation' in researcher-managed nurseries, which encourages plants to produce numerous small suckers that can be distributed to farmers for traditional propagation.

IITA and its national partners imported materials screened for BSD and multiplied them in local tissue culture laboratories. The materials were then established in plantation nurseries, which provided ideal conditions for further multiplication and the closer monitoring of plants for disease. Disease-free plants were then used to establish secondary nurseries, where planting materials could be disseminated directly to farmers. Farmers participated in evaluations comparing new cultivars with existing varieties at each nursery stage.

By 2003, 250 mother gardens had been established and 40,000 tissue cultured plantlets distributed in Uganda. Farmers were also trained to improve crop management and post-harvest handling. The project was extended in certain areas to include a phase aiming to integrate cattle into the banana-growing system as a way of increasing incomes and raising soil fertility through manure. Those participating in the extension saw incomes from banana sales more than triple.

A THREAT TO PROGRESS

In 2004, a type of bacterial wilt called Banana Xanthomonas Wilt (BXW) swept through Uganda, threatening to derail progress. BXW is caused by the bacterium Xanthomonas campestris pv. Musacearum (Xcm). It induces premature ripening of fruits; internal brown discolorations of fingers and vascular tissues; wilting of bracts and male buds; and progressive yellowing leading to complete wilting. Eventually, infected plants wither and the plant rots.

BXW can be spread by insects, cutting tools, wind-driven rain and infected seedlings. Once it occurs in a field, there is no remedy other than to cut down all infected plants, completely dig out the rootstock, and place the field under fallow or a prolonged crop rotation regime. A six-month fallow period is needed to avoid reinfection from material in the soil.

In Uganda, Gatsby support was used to raise awareness of BXW, train farmers and extension officers, and research appropriate control strategies. The Gatsby-founded Kilimo Trust subsequently supported a national control programme, based on good farmer practice of male de-budding – timely removal of the male bud interrupts the insect transmission cycle and helps prevent the spread of the disease.

ALTERNATIVE APPROACH

In parallel to these efforts, Gatsby supported IITA scientists attempting to produce transgenic banana plants with resistance to BXW, after attempts to develop resistant varieties through conventional breeding had only limited success as no source of germplasm with resistance to Xcm has been identified.

By 2011, IITA's work had progressed considerably, facilitating the genetic modification of the banana plant with genes which confer resistance to bacterial wilt in sweet pepper. The plant ferredoxin-like amphipathic protein (Pflp) and hypersensitive response-assisting protein (Hrap) genes rapidly kill the cells that come into contact with the bacteria, blocking the disease's spread.

IITA has developed banana suckers infused with: Pflp; Hrap; and both genes "stacked" to enhance the durability of resistance. During tests in controlled greenhouse conditions they have shown no sign of susceptibility to BXW, and, following approval by the Ugandan bio-safety committee, a set of field trials have been established, raising the possibility of a dual-approach control strategy in the future.

USAID and other donors are now funding IITA to take forward related work to combat BXW and other threats to banana production in the region, including Black Sigatoka, Fusarium Wilt and nematodes, as well as longer-term solutions to prevent such outbreaks in the future. This will require the capacity building of national agricultural research systems in terms of biosafety regulations and facilities, and risk assessment and management. Support is also needed to develop emerging private sector tissue culture companies to sustainably deliver technologies to farmers.

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