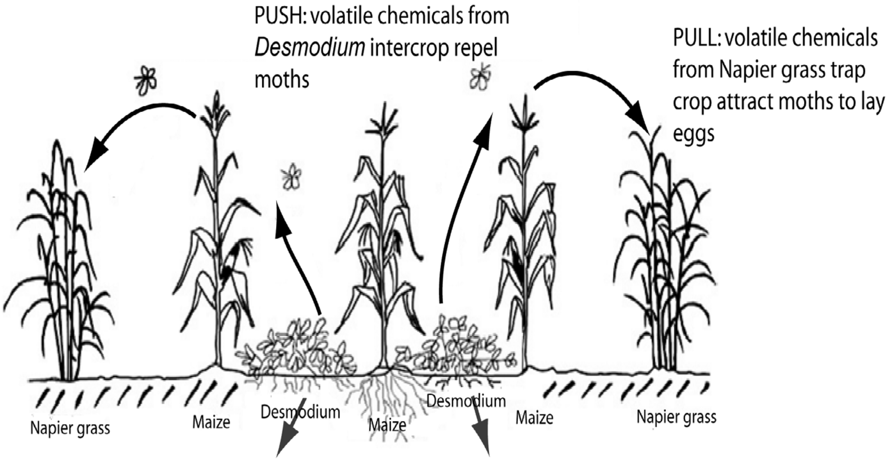
GATSBY

PROTECTING MAIZE FROM PARASITIC PESTS

AUGUST 2014

Maize is the staple crop for millions of East African farmers. However, it is vulnerable to attacks from the parasitic weed *Striga* and stemborer moths. Estimates suggest eliminating *Striga* could save the region almost half a billion dollars a year, while preventing stemborer losses could feed 27 million more people in the region.



- In 1993 Gatsby began funding an international research partnership to develop solutions for the problems afflicting maize in East Africa
- Rothamsted Research in the UK and the Kenya-based International Centre of Insect Physiology & Ecology studied the multiple interactions among cultivated crops, wild host plants, different stemborer species and their natural enemies
- These studies led to the development of an integrated pest management approach known as "push-pull", with the potential to triple maize yields
- Dissemination of push-pull began in 1997, and within 15 years more than 55,000 East African farmers had adopted the technology

THE ISSUE

Maize is the staple crop for millions of East African smallholders. However, it is highly vulnerable to attacks from pests, notably the weed *Striga* and stemborer moths.

Striga seed germination is triggered by exudates from the roots of other crops. The *Striga* plant penetrates these roots, sucking water and nutrients from its host and stunting growth. Each *Striga* plant produces up to 50,000 seeds. These can lie dormant for 10 years or more waiting for a suitable host, so infestation can rapidly reach critical levels, in some cases forcing farmers to abandon fields. *Striga* can reduce maize yields by 30 to 80%, and is estimated to cost East Africa US$437 million a year.

Under natural conditions, stemborers feed on wild grassy plants. These grasses also provide an attractive habitat for the borers' major natural enemies – tiny parasitic wasps whose attacks keep the stemborer population down. As such, borers were of no special consequence in Africa until the introduction of maize from Latin America.

At this point, maize's large stems and comparatively weak chemical defences began to provide an excellent breeding ground for stemborers, while also providing protection from the wasps. As such, the borer population flourished, with larvae feeding on maize leaves before boring into the plant's stem and eating it from the inside.

Yield losses to borers average 20 to 40%, but reach 80% in some areas. Estimates suggest preventing these losses to borers would increase the maize harvest enough to feed 27 million more people in East Africa.

PULL

In 1993 Gatsby began funding a partnership between two agricultural research institutes to develop solutions for the stemborer problem afflicting maize in East Africa. The Kenya-based International Centre of Insect Physiology & Ecology (ICIPE) and Rothamsted Research in the UK began investigating the multiple interactions among cultivated crops, wild host plants, different stemborer species and their natural enemies.

Studies of more than 400 wild grasses indicated 30 that attract female moths to lay their eggs. Of these, two were particularly promising – Napier grass (*Pennisetum purpureum*) and Sudan grass (*Sorghum sudanense*). Planted among maize, these grasses provide too much competition for nutrition, but planted in a border row around a maize field, the grasses release volatile chemicals that entice stemborers to lay their eggs on the grass, rather than the maize.

Moreover, Sudan grass also attracts the parasitic wasp *Cotesia sesamiae*, which injects its eggs into the stemborer larvae. When hatched, the wasp larvae eat the stemborer. Similarly, when stemborer larvae bore into the stems of Napier, the grass secretes a gum, physically trapping the borer and preventing most larvae from completing their life cycles.

PUSH

Napier is used for fodder in East Africa. Researchers also found that another fodder crop, Molasses grass (*Melinis minutiflora*), has an opposite effect, repelling borer moths, even when only one row is planted in every ten of maize.

Molasses grass releases a nonatriene compound – a feeding stress chemical also produced by maize plants when attacked by stemborers. At high concentrations of the chemical, stemborers are repelled, taking it as a sign that the possible host plant is already fully exploited. The chemical also attracts the *Cotesia* wasp as it normally signals the presence of possible stemborer hosts. Thus Molasses repels stemborers while attracting their enemies.

While Molasses grass provides fodder, researchers were keen to find alternatives to add further dimensions to the system. They focused on legumes, which provide forage while also improving soil fertility by "fixing" part of their nitrogen requirements from the atmosphere.

During investigation of silverleaf Desmodium (*Desmodium uncinatum*), researchers found that their maize plots, previously infested with *Striga*, became virtually *Striga*-free after just one growing season. Experiments showed Desmodium roots were releasing chemicals that undermined the growth of the weed. These chemicals stimulate the germination of *Striga* seeds but inhibit the post-germination growth of the parasite's radicle – the part that attaches to the host plant. This "suicidal germination" thus reduces the number of *Striga* seeds in the soil. Experiments showed eliminating *Striga* had an even greater impact on increasing maize yields than controlling borers.

Overall, push-pull technology reduces the impact of stemborers and *Striga*, increases soil fertility, provides additional groundcover which helps with soil and water conservation, and produces fodder for livestock, enabling farmers to start or expand dairy production and use additional organic manure to reduce their dependence on expensive fertilisers.

DISSEMINATION

In early 1997 researchers began disseminating the push-pull technology to farmers. They established trial and demonstration plots on selected farmers' fields in two districts of Kenya – Suba, on the eastern shores of Lake Victoria, and Trans Nzobia, further north. By training a network of farmer-teachers, helping establish farmers' groups, and facilitating farmer field schools and field days, the team ensured rapid adoption.

The ICIPE team also linked up with national scientists to introduce the technology in Tanzania and Uganda, using similiar dissemination strategies. By 2012, more than 55,000 farmers in East Africa had adopted the technology.

As the technology has spread across the region, ICIPE has worked with farmers to adapt the model for various agro-ecological conditions and different crops, including sorghum and cotton.

CHALLENGES

Desmodium seed demand
In Kenya, the success of the system created extra demand for Desmodium seed that outstripped local supply. This was worsened by the fact that government policy stated only the public sector Kenya Seed Company could distribute seed that was the product of national agricultural research. ICIPE addressed this by successfully lobbying for policy change before beginning a seed multiplication project. This was initially implemented by informal farmers' groups and subsequently in partnership with the private sector Western Seed Company.

Credit for livestock
To fully capitalise on push-pull, farmers must integrate livestock to take advantage of fodder production by increasing manure and dairy production. But ICIPE found farmers lacked the credit to buy cattle. They tackled this by partnering with Heifer International and the National Agriculture and Livestock Extension Programme and linking push-pull adopters to them.

Investment costs and timescales
Push-pull is also a system that, for all its long term benefits, takes two years to fully establish, has high installation costs and requires additional labour to maintain.

IMPACT

An independent study in 2010 found push-pull more than tripled maize yields from 1.2 t/ha to 4.2 t/ha and more than doubled milk output from 1.5 l/day to 3.8 l/day. It highlighted push-pull as a springboard for diversifying the farming system, especially by incorporating dairy operations.

The scientific work behind the technology has been recognised through a number of international prizes, including the 2010 Nan Yao Su Award for Innovation and Creativity in Entomology.

Push-pull is one of four key technologies for combating *Striga* being evaluated in a four-year Gates Foundation programme across Western Kenya and Nigeria. ICIPE have secured further funding from a variety of donors, including the European Union, to scale the technology. ICIPE aims to reach one million farmers across Africa with push-pull by 2020.

The Gatsby Charitable Foundation
The Peak, 5 Wilton Road
London SW1V 1AP
T 020 7410 0330 F 020 7410 0332
www.gatsby.org.uk
Registered Charity Number 251988