The push pull system – a less risky, less expensive and sustainable option for pest control Photo: Bert Lof

The Push-Pull system
a viable alternative to Bt maize

Flemming Nielsen

In early 2000, a five-year test programme with genetically engineered Bt maize was initiated in Kenya. The aim of this programme is to reduce the considerable damage of stemborer larvae that attack the leaves and stems of maize plants resulting in yield losses of 15 - 40% in East Africa. The recommended practise today for stemborer control is the use of chemical pesticides. Not only can the farmers hardly afford these expensive chemicals, these chemicals also cause environmental and health problems. It is evident that alternative solutions to suppress these pests are badly needed.

Although Bt maize is being promoted rather aggressively at present, it is certainly not the only option. Promising organic alternatives have been developed. One of them is the push-pull system that relies on natural repellent and trapplants. The system has passed the trial phase successfully and is now being promoted by the national extension system in Kenya. Not only does the push-pull system address the stemborer problem – it also suppresses the noxious witchweed (*Striga hermonthica*) that causes further yield losses of 10-20%.

Background
Stemborers are larvae of moths such as *Noctuid Busseola fusca*. In Africa four indigenous species of stemborer are significant pests in grains. They feed on natural grasses and used to be kept in check by natural enemies like the wasp *Cotesia sesamiae*. However, this balanced eco-system was disturbed when maize was brought into Africa about 100 years ago. Maize had little resistance to the African stemborers. About 70 years ago an exotic stemborer found its way to Africa from India and Pakistan. This is the spotted stemborer *Chilo partellus* that in its area of origin is a harmless pest. However, in Africa it has no natural enemies and consequently it has developed into a major pest in maize.

Approaches to pest control
Four main approaches to fighting stemborers have been developed:

a. Pesticide application
Pesticide application has been the recommended practise for a long time but it is expensive, causes health and environmental problems and kills natural predators.

b. Genetically modified Maize
Bt maize that produces pesticide thus killing the stemborer larvae is currently being tested but not released yet. Bt maize is created by adding a pesticide-producing gene from the bacterium *Bacillus thuringiensis* (Bt) to the maize. It was originally developed to kill the European corn-borer, which is a close relative of the African stemborer, so it is likely to be efficient in controlling the pest, at least initially. Early last year the multinational company Novartis started a 5-year test programme in Kenya with Bt Maize at the cost of US$ 6.2 million. They are collaborating with the governmental Kenya Agriculture Research Institute (KARI), the Kenyan Ministry of Agriculture and the International Maize and Wheat Improvement Centre (CIMMYT).

Apart from the problems of genetic pollution (see pg. 25) and farmers' dependency on a few multinational companies (see editorial pg. 4) for their seeds, there is also evidence that pests quickly develop resistance to Bt maize.

To reduce the risk of genetic pollution, most countries require farmers to have a buffer zone of 100 m to related non-GE crops. Most countries are likely to increase the demanded buffer zone after recent studies have shown that pollen is easily spread 800m or even further (New Scientist 24 November 2001). To delay the development of insect resistance to Bt maize it is recommended that farmers create a "refugia" of non-GE crops for the pests to feed on. Most small-scale farmers will not be able to create the required buffer zone or allocate land for a "refugia".

c. Introduction of natural predator insects
In Asia, the wasp *Cotesia Flavipes Cameron* is a natural enemy of the *Chilo partellus* stemborer. In 1993, the Kenya-based International Centre of Insect Physiology and Ecology (ICIPE) introduced the wasp to Africa as a biological control agent. The wasp tracks down the stemborer larvae buried deep inside the maize stalks and lays its eggs into the pest. The eggs hatch and consume the borer from within.

After successful field trials the wasp is now being released on a larger scale. It shows great potential in fighting the introduced spotted stemborer and three of the indigenous species. Results so far indicate that the stemborer population has been cut by half in Kenya's Kwale and Kilifi districts, four years after the initial release. The wasp has steadily spread and is now found throughout the southern part of Kenya.

ICIPE is currently working with national programmes in Kenya, Uganda, Somalia, Ethiopia, Mozambique, Malawi, Zambia, Zimbabwe and Zanzibar to release the Cotesia wasp.

So far, no side effects have appeared or are anticipated because the wasp is very specialised. However, history tells us that the introduction of a foreign species can have totally unanticipated long-term consequences.

d. The push-pull system
The fourth approach is the push-pull system in which intercropped repellent plants "push" the insects out of the fields to trap crops outside the fields that "pull" the insects in. This system makes optimal use of existing biological interaction and relies on mechanisms that have proven to be stable in nature over extended periods. This system is now beyond the trial phase and is being actively disseminated in Kenya.

This article takes a closer look at the push-pull system because it is the most "mature" alternative to genetically modified crops. It is also the least risky, offers the best long-term stability, can be managed by small-scale farmers, and requires no expensive inputs.

The Push-Pull system
The Kenya-based ICIPE has headed the development of the push-pull system for maize in East Africa. Close collaborators include the governmental Kenya Agricultural Research Institute (KARI) and the Institute of Arable Crop Research (IARC), Rothamstead, UK.

Initially, the principal scientist Dr. Zeyaur Khan and his team identified more than 30 grasses with strong stemborer-attracting odours. Farmers were invited to select the grasses they preferred. They chose Napier grass (*Pennisetum* purpureum) and Sudan grass (*Sorghum vulgare Sudanese*) both of which are important fodder crops. The grasses produce a gummy substance that traps the pests and only 10% of the stemborer larvae survive to adulthood.

Of the repellent plants that were researched, the choice was for Molasses grass (*Melinis minutiflora*) and the leguminous Silverleaf (*Desmodium uncinatum*). Research shows that the molasses grass repel stemborer by releasing a complex mixture of volatile substances (terpinoles, nonatrienes etc). It also increases stemborer parasitism by harbouring a natural enemy, the wasp *Cotesia* sesamiae. In trials, Molasses grass reduced crop loss from 40% to 4.6%.

Silverleaf also turns out to have a number of positive attributes apart from repelling the stemoborer. It is nitrogen fixing, a good forage crop and surprisingly it also happens to be very efficient in suppressing the noxious Striga (witchweed, *Striga hermonthica*) weed that is spreading quickly across Africa. Striga is a parasite that feeds on the maize roots and can cause a total crop loss. Currently the average crop loss due to Striga in East Africa is estimated to be 10-20%. Trials have shown that maize intercropped with Silverleaf can suppress Striga by a factor of 40 compared to mono-cropped maize. The reason for this effect is not understood yet but is currently being researched by ICIPE.

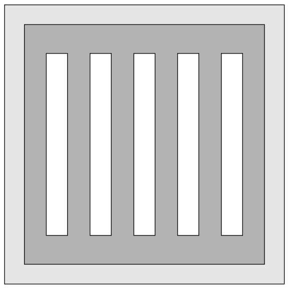

Figure: Push-pull system

In practise, the push-pull system consists of line planted maize with intercropped rows of Molasses grass and/or Silverleaf, surrounded by a belt of Napier and/or Sudan grass.

On-farm testing
The push-pull system was initially tested by more than 600 farmers in 6 districts of Kenya. In the fertile region of Trans Nzoia a yield increase of 15-20% was observed. In the semi-arid Suba district, where both stemborer and Striga damage is high, a substantial increase in maize yield has occurred over the last four years. Economic analysis of the on-farm trials shows that farmers who plant Napier grass and Silverleaf together get a return of US$ 23 for every US$ 10 invested, as compared to a return of US$ 14 from mono-cropped maize.

After the successful on-farm trials, the push-pull system has now been officially released in Kenya and is being disseminated through the extension system. The response by farmers is very positive.

The future
The biological principles of the push-pull system are not new. In fact they are used in many traditional intercropping systems. However, the application of science has made it possible to make very efficient use of these basic biological principles. Similar systems are likely to work elsewhere but may require different repellent and trap crops. Other research centres are already experimenting with push-pull systems. For instance the ARC-Grain Crops Institute in South Africa is conducting research on the use of Vetiver grass as a trap crop around maize fields.

The push-pull system is an ideal option as it builds on existing resources, does not create dependency, is manageable by small farmers and does not pose a threat to the eco-systems. It is estimated that full adoption of the push-pull system by small-scale farmers in East Africa will increase food production sufficiently to feed 6-8 million more people.

However, this system is of little interest to profit-oriented private companies, as it does not require any external inputs. And it is this very fact that may be the biggest obstacle to its dissemination.

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Flemming Nielsen, ILEIA, PO Box 64, 3830 AB Leusden, The Netherlands.
F.nielsen@ileia.nl

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For more information contact:
- International Centre of Insect Physiology and Ecology (ICIPE), P.O. Box 30772(Nyayo Stadium),Nairobi, Kenya Email: icipe@icipe.org; Home page: http://www.icipe.org
- ARC-Grain Crops Institute, Private Bag X1251, Potchefstroom, South Africa e-mail:JOHNNIE@IGG2.AGRIC.ZA