Gatsby Occasional Paper

# The Quiet Revolution:

## Push–Pull Technology and the African Farmer


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Last, but not least, we thank all the farmers who cheerfully related their 'push–pull' experiences.

## Dedication

This paper is dedicated to the late Professor Thomas Odhiambo, founder Director of ICIPE. His vision of science in Africa has been an inspiration to many and he is responsible for the initial idea that led to the development of the habitat management technology.

# Contents

# Foreword

The Trustees of the Gatsby Charitable Foundation have been supporting agricultural research and development in Africa for the past 20 years. Gatsby's mission is to increase the physical yields of small farms and the nutritional and market value of subsistence crops in ways that are both valuable to low-income households and environmentally sustainable. Gatsby aims to achieve this by supporting projects along a spectrum, from applied research at institute level, through the dissemination of improved varieties and cropping systems, to adaptive on-farm activities and multiplication of improved planting material[1]. Gatsby also helps small-scale enterprise through provision of micro-finance and business development support[2].

The habitat management or 'push–pull' project illustrates how action across the spectrum can lead to the development of a technology that markedly improves the lives of subsistence farmers. This project's success owes much to the very high quality of research and the vision, tenacity and determination of the principal scientists. The close working relationship that evolved between the various partners was another contributing factor.

Push–pull is just the kind of technology needed to support a 'uniquely African green revolution', as called for at the meeting of African Heads of State in July 2004. The participants agreed that efforts to increase agricultural productivity in Africa must be based on technologies that are more environmentally friendly and people-centred than those that fuelled the original Asian green revolution. Habitat management fits well with this concept and is worthy of support by all who wish to see Africa's declining yields and rising poverty levels reversed.

We believe the experiences gained during this project will be of interest to others involved in agricultural development in Africa and we hope the lessons learned will encourage further innovations in this challenging field.

Michael Pattison CBE
Director
The Gatsby Charitable Foundation
London, April 2005

[1] A review of all Gatsby-funded projects in Africa can be found in the Gatsby Occasional Paper: *Raising Yields, Creating Partnerships: Gatsby's On-Farm Work in Africa*.

[2] See *Building from the Base: The Work of the African Gatsby Trusts* for more.

Both publications are available on the Gatsby website (www.gatsby.org.uk).

# 1. Push and pull: plants versus pests

The Obinga family are subsistence farmers who eke out a living on the Kenyan shore of Lake Victoria. It is not an easy life; their farm is small and rainfall is often unreliable. Yet the Obingas are better off than many of their neighbours: fields of tall, strong maize plants promise ample food for the next six months; three crossbred dairy cows enjoy a plentiful supply of fodder brought to their stalls; the children drink milk every day; and sales of milk, maize and fodder grass bring in vital cash to spend on daily necessities and to invest in farm and household improvements.

Only two years ago, the scene was dramatically different. Years of cereal cropping without inputs had reduced soil fertility and the maize plants were being attacked by insect pests and parasitic weeds. The family's thin zebu cows produced little milk, and herding them along the roadside to find forage was a full-time job for the children. Meanwhile, Mrs Obinga was constantly engaged in the backbreaking, seemingly fruitless task of weeding the fields. The granary was empty, the family frequently went hungry, and there was no maize left over to sell. That meant no money to invest in fertilizer or other inputs to improve the situation. The family seemed trapped in a downward spiral of declining yields and deepening poverty and hunger.

*Obinga inspects his healthy maize crop. Inset: two years ago all his fields looked like this: the maize was devastated by dual enemies - the stemborer* Chilo partellus *and the parasitic weed* Striga hermonthica.

How were the family's fortunes turned around in such a short time? The answer lies in a novel approach to crop management that exploits the natural relationships between plants and insects. When scientists investigated the ecology of a widespread cereal pest, they discovered that introducing a carefully selected mix of forage plants into maize fields had a dramatic effect on cereal yields and total farm output. The so-called 'push–pull' technology that emerged from their research (see box on next page) makes use of natural plant chemicals that drive insect pests away from the crop and attract them to other host plants, which withstand attack better than maize. Along the way, the scientists discovered intriguing new properties in the forage legume, desmodium. Besides being nutritious for dairy cows, it repels insect pests of maize and substantially reduces damage from striga, a destructive parasitic weed. In short, the push–pull system can improve food security and farm income in an environmentally friendly way, making it an ideal ingredient in the long-term struggle to reduce hunger and poverty in Africa.

*Maize field with border rows of Napier grass and an intercrop of* Desmodium uncinatum.

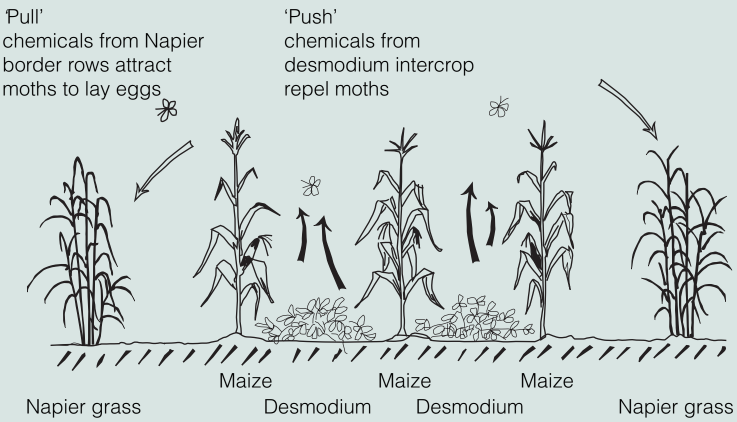
## What is push–pull?

The technique known today as 'push–pull' (or stimulo-deterrent diversion) was first documented as a potential pest control strategy in 1987 in cotton and 1990 in onion. However, neither of these studies exploited natural enemies, using instead an added chemical deterrent or toxin to repel or kill the pest. In contrast, the push–pull system described here uses no manufactured deterrents or toxins. Instead, it exploits natural insect–plant and insect–insect relationships.

"Push–pull is not something scientists have invented," says Ahmed Hassanali, Head of the Behavioural and Chemical Ecology Department at the International Centre of Insect Physiology and Ecology (ICIPE). "We have discovered several cases of integrated use of the forces of attraction and avoidance by different arthropods in their search for suitable hosts, feeding areas or egg-laying sites."

Insect behaviourists and chemical ecologists tend to agree that promising integrated pest management (IPM) tactics based on plant chemicals frequently fail because they are too narrowly based. They often target a single chemical and a single phase in the life cycle of a single pest species. The ICIPE–Rothamsted approach makes use of a wider range of behaviour-affecting chemicals produced by both plants and insects. It introduces nature's built-in checks and balances into a man-made environment – such as a maize field – by manipulating the habitat, relying on a carefully selected combination of companion crops planted around and among the maize plants.

Farmers using push–pull for pest control not only reap three harvests (maize, Napier grass and desmodium); when they plant a desmodium intercrop they also dramatically reduce the devastating effects of the parasitic weed *Striga hermonthica*. (See www.push-pull.net)




This publication describes the development of the push–pull technology and its dissemination to farmers in eastern Africa[1]. We illustrate – through the eyes of some of the participating farmers – the benefits the project has brought, together with the obstacles that impede more widespread impact and the strategies that could help overcome these hurdles. Finally, we examine why the project has been successful.

## Starting with stemborers

The story begins in 1994, when the Gatsby Charitable Foundation funded researchers at the Kenya-based International Centre of Insect Physiology and Ecology (ICIPE) and Rothamsted Research in the UK to investigate the ecology of stemborers. These are the larval stages of various species of moth and the major insect pest of maize and sorghum in eastern and southern Africa.

[1] The full title of the project is 'Habitat management strategies for control of stemborers and striga weed in cereal-based farming systems in eastern Africa'. Project funding to date amounts to US$5.98 million, 65% of which was funded by the Gatsby Charitable Foundation.

Stemborers naturally feed on wild grasses, but when maize and sorghum became cultivated crops across vast areas of Africa, the insects began to feed on them as well. Lack of defence mechanisms in maize and sorghum allowed insect populations to flourish and become a problem of economic importance. In maize – Africa's most important food crop – losses to stemborers average 20–40% but can reach 80%. As a control method, pesticides are expensive and harm the environment. Since they cannot reach insects inside the maize stem, they are often ineffective. Moreover, they kill the stemborer's natural enemies. Preventing crop losses from stemborers could increase maize harvests by enough to feed an additional 27 million people in the region.

"It used to be thought that native grasses caused the stemborer problem and that getting rid of them would remove the stemborers too," says Zeyaur Khan, entomologist at ICIPE and leader of the project. But, in fact, the reverse is the case; the borers simply transfer to the maize. No one had studied the relationship between the grasses and the borers in depth, so, prompted by Professor Thomas Odhiambo, then Director of ICIPE, Khan launched a survey.

## Multiple interactions

The initial objective was to study the multiple interactions among cultivated crops, wild host plants, different stemborer species and their natural enemies. This information would then be used to develop an integrated pest management (IPM) approach to controlling the insects. The scientists studied 400 wild grasses and grouped them according to their efficacy in attracting female moths to lay eggs and their ability to support larval development. "We already knew that some wild grasses act as 'trap plants', enticing egg-laying females but depriving the larvae of a suitable environment," says Khan. This is often because the grasses also attract the borers' natural enemies. Other grasses simply act as reservoirs for the pests and increase their populations. The survey results indicated that around 30 grass species were suitable hosts for stemborers, but only a few of them attracted both moths and their enemies. "These grasses were the ones with potential to be exploited as trap crops to draw the borers away from the maize and reduce their populations," adds Khan.

*The large stems of maize plants provide an ideal habitat for stemborers. Species of greatest economic importance include* Busseola fusca *(native to Africa and inhabiting higher altitudes) and* Chilo partellus *(introduced from Asia in the 1930s and found at low and mid-altitudes).*

The findings were encouraging, but the team knew that farmers with small amounts of land would be unlikely to plant a wild grass simply to attract pests. So farmers were consulted to find out which grasses were most useful as cattle fodder. Researchers at the Kenya Agricultural Research Institute (KARI) helped identify suitable farmers to consult.

## The pull...

Two trap crop grasses appeared particularly promising: Napier grass (*Pennisetum purpureum*) and Sudan grass (*Sorghum sudanense*). Grasses planted among the maize plants provide too much competition, but researchers found that when they were planted in border rows around a maize field, the stemborers were enticed to lay their eggs on the grass rather than the maize. The grasses were providing a 'pull'. These grasses also have effective defence mechanisms to protect themselves against stemborer attack. Sudan grass is an attractive habitat for the parasitic wasp *Cotesia sesamiae*; these tiny insects inject their eggs into the stemborer larvae and, when the eggs hatch, the wasp larvae eat the stemborers. Napier grass has a particularly ingenious way of defending itself: when the larvae bore into the stem, the grass secretes a sticky gum, physically trapping the borer and preventing most larvae from completing their life cycle. Both grasses attract additional stemborer predators such as ants, earwigs, spiders and cockroaches, which are found in significantly larger numbers in push–pull plots than in control plots.

In 1997, the scientists began on-farm trials to evaluate the benefits of Napier grass, which has the added value of being a perennial and is already grown widely for livestock fodder. Researchers and farmers worked together to identify which varieties provide both a good habitat for the stemborer and good forage. 'Bana' was an obvious choice, since it has smooth, broad leaves (an improvement on some local varieties that have rough leaves and sometimes make cows cough) and is highly attractive to stemborers. Besides increasing their maize yields, the farmers planting Napier border rows benefited from a ready supply of grass to feed their livestock or sell to other farmers.

### ...and the push

Khan describes how he came across the repellent effects of another fodder crop, molasses grass (*Melinis minutiflora*), while visiting KARI's Kitale research station. This discovery was to become the 'push' component of the system. "Molasses grass has a very strong, sweet smell, which caught my attention. Quite by chance the KARI researchers had planted a plot of molasses grass next to one of maize. There was little stemborer damage on the maize closest to the molasses grass, but the other side of the plot was heavily infested."

Khan decided to investigate further. Trials confirmed that, indeed, molasses grass has a strong repellent effect on stemborer moths, even when only one row is planted in every ten of maize. Even more intriguing was the discovery that, like Sudan grass, molasses grass attracts the parasitic wasp, *Cotesia sesamiae*. This puzzled the scientists, who could not initially understand why the parasite would be drawn to a location where it was unlikely to find its host.

*Obinga is multiplying his stocks of Napier grass by taking cuttings from the rhizomes. He keeps a 'bulking plot' especially for this purpose.*

*Molasses grass planted around a zero grazing unit. Farmers like Lillian Wang'ombe have discovered that the grass not only repels stemborers, but also reduces the number of ticks attacking their cattle.*

Meanwhile, at Rothamsted Research, John Pickett (Head of the Biological Chemistry Division) and his team were helping to piece the puzzle together by investigating the nature of the plant chemicals (known as semiochemicals) that attract or repel stemborer moths. The most relevant compounds have been identified by a combination of insect electrophysiology and mass spectrometry and tested on the insects using bioassays. "We have discovered six host plant volatiles that attract female stemborer moths to lay their eggs," says Pickett.

The next step was to investigate the volatiles produced by the intercrop plants – the 'push' chemicals – and to find out why molasses grass repels stemborers but attracts their natural enemies.

A nonatriene compound emerged as a key stimulus. "The nonatriene is what we call a 'feeding stress' chemical," explains Pickett. "It is normally produced by molasses grass, but maize plants produce it when they come under attack from the stemborer."

It appears that, at low concentrations of the chemical, additional pests arrive, attracted to a plant that is already weakened by pest attack; but at high concentrations the pests are repelled, taking it as a sign that the plant is already fully exploited. At high or low concentrations, parasitoids are attracted to find their prey. "Molasses grass has evolved an ingenious defence strategy, since its release of volatile chemicals mimics that of damaged plants," adds Pickett. The use of chemicals by plants to protect themselves from attack in this way was an important discovery and was reported in the leading international journal *Nature* (14 August 1997). This work, which has led the scientists to develop a general hypothesis regarding the role of plant semiochemicals in determining insect recognition of host plants, could lead to a major new line of defence in IPM strategies in many different cropping systems.

## Discovering desmodium

Molasses grass is accepted by farmers as a 'push' intercrop since it provides fodder for cattle. But Khan and his colleagues were keen to find alternatives that might add a further dimension to the habitat management system. The team focused their attention on legumes, since these not only provide nutritious food and forage but also improve soil fertility because they 'fix' part of their nitrogen requirements from the atmosphere. Cowpea (*Vigna unguiculata*) and silverleaf desmodium (*Desmodium uncinatum*) looked promising candidates. Cowpea had long been grown for grain and fodder in parts of West Africa, while desmodium originated in South America and had been introduced into Kenya in the early 1950s.

During this phase of the work, the Suba District Agricultural Officer visited the ICIPE team at their Mbita Point research station on the shores of Lake Victoria. Deeply concerned about the devastating effects of the parasitic 'witchweed' *Striga hermonthica* on local maize harvests (see box), he asked whether there was anything ICIPE researchers could do. Since the team were primarily entomologists and fully occupied by their stemborer research, they declined his request, without knowing they were on the verge of an important discovery that would address his concerns.

Khan and his colleagues tested desmodium as a 'push' intercrop with maize on-station at Mbita Point. "All our experimental plots are infested with striga," he says. "So imagine our amazement when we found that maize plots with a desmodium intercrop not only had little stemborer damage but

### A sleeping enemy

Western Kenya is the 'maize basket' of the country. In some locations, two maize crops can be grown in a year. But in many areas, as the Obinga family discovered, the parasitic weed *Striga hermonthica* is taking over. The seeds are so tiny that Obinga could have unwittingly brought them into his field and sowed them along with the maize. Stimulated by chemicals released by the roots of the crop plants, the seeds germinate, but instead of growing roots and drawing nourishment from the soil, they parasitise the maize, weakening or even killing it.

Each mature plant produces around 50 000 seeds, which remain viable in the soil for up to 20 years, awaiting a suitable host. Recommended control methods for this 'sleeping enemy' include heavy application of nitrogen fertilizer, crop rotation, chemical germination stimulants, herbicide application, hoeing and hand-pulling, and the use of resistant or tolerant crop varieties. These have met with scant enthusiasm from farmers who have little cash or time to spare. Increased cropping frequency and deteriorating soil fertility favour the growth of striga and the survival of its seeds. Yield losses range from 30 to 100% and, in some cases, infestation has reached such a high level that farmers have no choice but to abandon the land.

*The parasitic witchweed* Striga hermonthica

*After just two seasons, Joseph Litunya's maize field is free of striga and he has plenty of desmodium forage to feed to his crossbred dairy cow.*

also became virtually free of striga after only two seasons." In fact, eliminating the striga had an even greater effect on increasing maize yields than controlling the stemborers. This indeed brought a new dimension to the push–pull technology and posed the question 'how?' (see box).

The effects of desmodium on striga, combined with the potential of push–pull to increase yields of food and fodder, were hugely exciting, but the team was justifiably cautious. Although farmers were already familiar with intercrops, the idea of using them to affect insect behaviour was new and the farmers would need to grasp the idea and understand how it worked. This understanding would allow them to adapt the approach to their own needs and to changing conditions in the future. In short, the dissemination strategy should be based on knowledge and education.

### How does desmodium suppress striga?

Most legumes act as false hosts of striga in that they stimulate germination but do not support growth of the weed. However, field trials showed that when legumes were intercropped with maize, far less striga was seen with desmodium than with other legumes such as cowpea, soybean and sun hemp. In addition, desmodium progressively reduced the number of striga seeds in the soil. Experiments revealed that the desmodium roots were releasing chemicals that undermined the growth of the weed, a so-called allelopathic effect.

Work to identify the chemicals responsible has been funded by Gatsby, the Rockefeller Foundation and the Biotechnology and Biological Sciences Research Council (BBSRC) of the UK. The research team have discovered three new isoflavanone compounds (uncinanone A, B and C) and a previously known isoflavanone (genistein). They now know that desmodium not only stimulates germination of striga seeds but also inhibits post-germination growth of the parasite's radicle – the part that attaches to the host plant. This is known as 'suicidal germination' and explains why desmodium can actually reduce the number of striga seeds in the soil.

The research work is time consuming. Hassanali at ICIPE reckons it will take another five or six years to isolate and characterise all the compounds produced by desmodium roots and to understand their roles in post-germination inhibition of striga. Nevertheless, the range of potential applications is broad and encouraging. Witchweeds threaten the staple food of more than 100 million Africans. Of the 23 species prevalent in Africa, *Striga hermonthica* is the most significant, parasitising a range of crops including maize, sorghum, millet, rice and sugarcane.

*Investigating the effect of desmodium on striga. Plants on the right have little striga infestation since they have been exposed to root exudate from desmodium, but those on the left (controls supplied with water only) are heavily parasitised.*

# 2. Uptake and impact: knowledge is the key

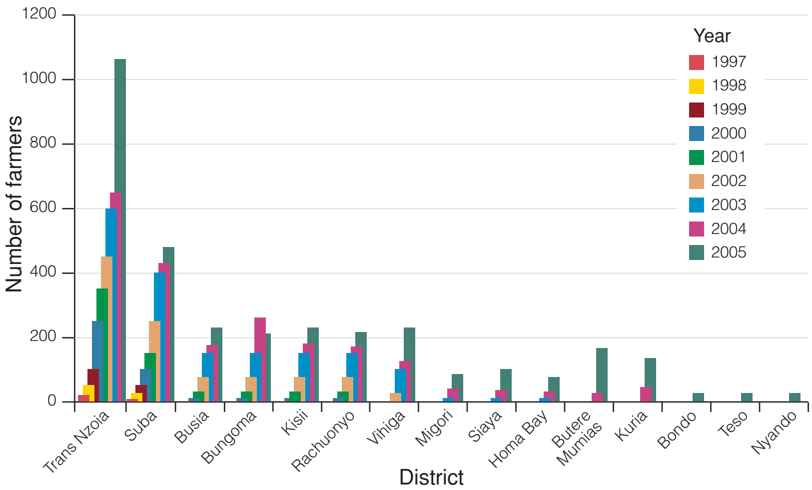
In early 1997, Khan and his colleagues began disseminating the push–pull or habitat management technology to farmers, aiming to transfer both the technology and the knowledge of how it worked. Training in scientific methods encouraged farmers to experiment further, gain ownership of the technology and pass on their new knowledge to others. By training a network of farmer–teachers, the team have established a mechanism for rapid adoption, which is the key to widespread impact. Over 3000 farmers have now adopted the technology (see graph) and most of them can relate stories of major upturns in their fortunes and living standards.

*The push–pull garden at ICIPE's Thomas Odhiambo Campus at Mbita Point, Kenya.*

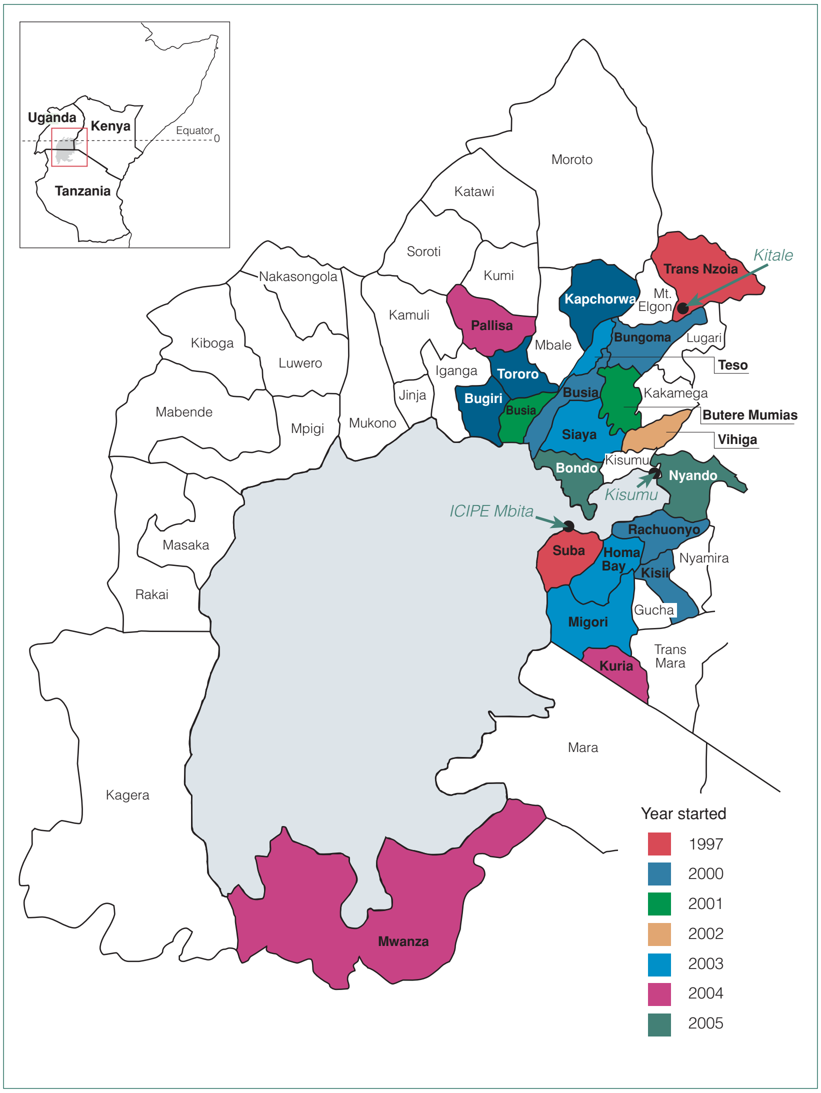
## Seeing is believing

Although the researchers could explain the technology with confidence, they soon discovered that farmers remained highly sceptical unless they could see a push–pull plot for themselves. The first step, then, was to establish a push–pull garden at Mbita Point, which farmers and others could visit. Next, the researchers began to establish trial and demonstration plots on selected farmers' fields.

Researchers from KARI and government extension staff helped identify suitable areas for on-farm trials. The team chose two districts for the initial trials: Suba, on the eastern shores of Lake Victoria, and Trans Nzoia, further north. In both areas, there is a high reliance on maize and a lack of food security. Livestock ownership is also widespread but good quality fodder is in short supply.




*Rates of adoption of the push–pull technology in Kenya, 1997–2005.*




*A map of East Africa showing districts where farmers have adopted push–pull. On-farm work commenced in Trans Nzoia and Suba Districts.*

Trans Nzoia: wet and cool agro-ecology, altitude > 2000 m. Over 70% of the arable land is under maize. One crop per year. District suffers from low soil fertility (deficient in nitrogen) and high levels of stemborer attack (*B. fusca*). Initial trials here focused on a single aspect, i.e., planting border rows of Napier grass around a maize plot.

Suba: warm, semi-arid agro-ecology, altitude approx. 1200 m. Two maize harvests are possible, but the October short rains can be very unpredictable. Striga and stemborer (*C. partellus*) constrain yields. Initial trials focused on the use of border rows of Napier grass around the maize with an intercrop of desmodium.

The success of the dissemination tactics employed in the first two districts led the team to replicate the system elsewhere. In each new location the researchers begin by inviting local farmers to a *baraza* (public meeting), publicised through local chiefs, district agricultural officers and church leaders. The researchers listen to farmers' problems and explain the benefits of the push–pull technology. Based on criteria such as willingness to experiment, having enough land and cattle, availability of Napier grass and extent of the stemborer and/or striga problem, farmers are asked to nominate their own representatives, normally 10 per district. These 'guinea pig farmers' test the technology in their own fields. In exchange, they receive free desmodium or molasses grass seed. In some areas they are also given stocks of the Napier grass variety 'Bana', although many farmers already grow Napier and can multiply their own stocks.

After the first season, most trial farmers are keen to expand their push–pull plots, while field days and informal contacts attract additional local interest. If farmers can show a degree of commitment to the project by planting border rows of Napier, the project will supply desmodium seed for the intercrop. In all areas, ICIPE and KARI technicians and Ministry of Agriculture staff are available to advise and help with keeping records.

The demonstration plots proved to be a powerful advertisement for the technology and word spread quickly. Despite recruiting additional technicians, the researchers realised they needed to provide more extensive help and support if new project farmers were to acquire sufficient knowledge to apply the technology correctly. The solution was to recruit some of the more experienced farmers as teachers to help their colleagues (see box). An internal review of the farmer–teacher system suggests it is working well, but needs close supervision from ICIPE or KARI technicians to ensure the teachers visit their students regularly and give good advice. Some farmer–teachers already have long waiting lists of prospective students. Indeed, Musa Aluchio in Butere Mumias District has 87 farmers queuing up for his services.

## Information and awareness

Every Thursday and Sunday evening, more than five million Kenyan farmers listen to '*Tembea na majira*' ('Follow the path'), a rural 'soap' broadcast on national radio. Like the original concept for the UK radio programme 'The Archers', the storyline introduces new ideas and technologies for improving agriculture. Habitat management or push–pull features regularly and many farmers who have adopted the system heard about it here. The use of drama to convey educational messages is popular in western Kenya and can be highly effective. Some of the younger community members in Vihiga and Butere Mumias Districts have written a push–pull play, which they perform for their peers, entertaining and educating at the same time. Researchers hope to spread the idea to other districts.

Analysis by KARI of the flow of information about push–pull indicates that multiple communication channels are involved in spreading awareness of the technology. In addition to ICIPE and KARI field technicians (and in the absence of a fully functioning government extension service), these channels include unofficial ones such as non-government organisations (NGOs), community-based

### Farmer–teachers spread the word

Peter Koinange is a respected elder in his village of Wamuini, 10 km southeast of Kitale in Trans Nzoia. Although there is no striga here, stemborers cause considerable damage and the soils are poor and lack nitrogen. Koinange was one of the first farmers to host on-farm trials in 1997, when he planted Napier grass around his maize plot. "It was incredible," he remembers. "Before, I had to spend a lot of money on insecticide and fertilizer. Adding the grass meant I could use fewer inputs and still get a better yield." He later added a desmodium intercrop and established a seed multiplication plot.

Koinange is one of a rapidly growing group of farmer–teachers who are spreading the word about push–pull. When he had successfully managed his push–pull plot for three years, he was given a bicycle, a notebook and a small allowance of KSh750 (about US$5) per month. He visits five farmers every two weeks to give advice and guidance. Visits and progress are recorded by both teacher and students and regularly reported to ICIPE technicians.

Training in scientific methods has encouraged farmer–teachers to experiment further, equipping them with new skills so they can expand the range of options they offer to other farmers. For example, Koinange has experimented with molasses grass, discovering that it not only repels stemborers from maize but also keeps ticks off his cattle. He has since planted a border of molasses grass around his zero grazing unit and some of his neighbours have copied the idea.

*Peter Koinange shows off his desmodium crop.*

*Cecilia Ogony (22) is the youngest farmer–teacher (pictured with two of her trainees). She has almost quadrupled her maize yields using push–pull and is saving the money she earns from sales of maize and fodder grass to buy a dairy cow.*

*Some of the educational leaflets produced by ICIPE and KARI.*

organisations, traders and fertilizer or seed sellers, particularly in the more remote areas. To ensure consistent and correct messages, KARI and ICIPE have jointly produced a range of information leaflets in English and local languages. These are being widely distributed as part of the educational dissemination strategy.

## A basket of options

A striking aspect of the habitat management technology is the wide range of benefits it provides farmers and its adaptability to individual needs. In addition to raising crop yields, it addresses issues of soil fertility, erosion and moisture conservation, and provides a reliable source of good-quality fodder. With push–pull, farmers struggling to make ends meet on as little as 0.25 ha of land can grow enough to eat, build a livelihood and start to accumulate assets.

Although dissemination efforts focus mainly on small-scale farmers, where the need for food security and income generation is greatest, the technology has been enthusiastically adopted – and adapted – by medium-scale farmers too (see box). Some farmers plant only border rows of Napier grass around their maize plot, utilising the 'pull' part of the technology. Those adopting both 'pull' and 'push' can choose to plant either desmodium or molasses grass between the rows of maize. The planting scheme can be varied too – desmodium

### Meeting different needs

At first glance, the Gumo family farm in Kiminini (Trans Nzoia) has little in common with that of the Chapya family, who live in Ebukanga (Vihiga). The Gumos have 40 ha, keep ten crossbred dairy cows and earn money by selling milk. The Chapyas, with ten people to feed, have to survive on only 0.25 ha of land.

Both families, however, have adopted push–pull and have seen a dramatic increase in their farm output. Due to shortage of desmodium seed, Livingstone Chapya planted only a small plot (measuring 35 x 15 m) with the technology but was amazed at the result. "Before, the farm was purple with striga," he says. "But after planting push–pull, I harvested two sacks (180 kg) of maize. I was only getting a quarter of that from the same area before." He has since expanded the size of his push–pull plot and feeds the Napier grass and desmodium to his zebu heifer. He also sells forage when he has enough. He no longer has to buy maize or seek off-farm work; instead, he can invest time and resources in improving his farm and household assets.

*Livingstone Chapya currently has a zebu heifer but will soon have sufficient forage to support a crossbred animal.*

*Josephine (a farmer–teacher) and Charles Gumo grow desmodium as a sole crop, harvesting fodder and seeds.*

Josephine Gumo is relieved she no longer needs to apply expensive fertilizer and pesticide to get an adequate maize yield. "With push–pull, I get a bigger harvest – even without using inputs – and the stemborers have all gone." She plants border rows of Napier and one row of desmodium to every five of maize, to allow for mechanised ploughing. Despite having a relatively large farm, she used to struggle to feed the cows in the dry season. Now that she has solved her fodder problem, she keeps new heifer calves and has noticed an increased milk yield – from 8 litres per cow per day to 12. Within five years she hopes to have 20 cows and will need to employ six full-time staff to manage the workload.

The contrasting stories of these two families show that the push–pull technology is widely applicable across a range of farm sizes and socio-economic circumstances.

can be planted either in alternate rows (the most effective way to deal with striga) or, if there is no striga, in one row for every three or five of maize, to allow for easier ploughing by ox or tractor. Molasses grass can be planted at a range of densities and provides an effective 'push' even at only one row in ten of maize.

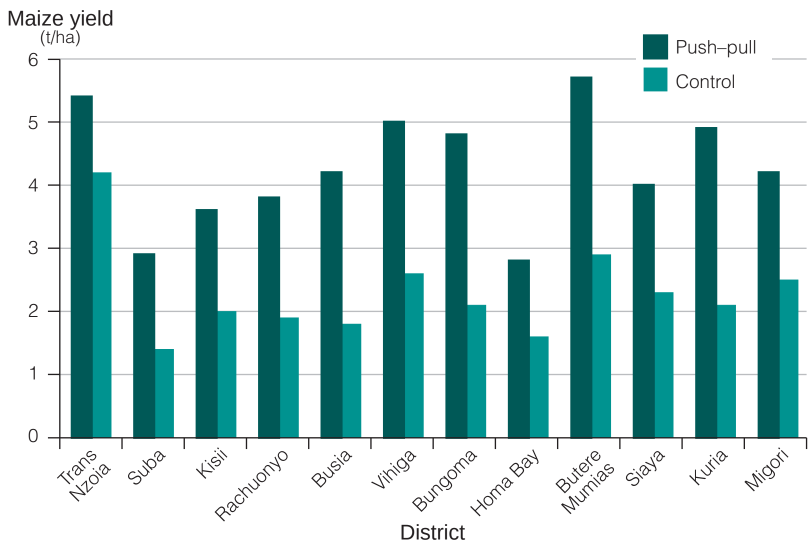
The robustness and flexibility of the system is demonstrated by successful adoption in different agro-ecologies. The system is used, for example, in the lakeshore region, where two rainy seasons allow two crops of maize and where striga is the main threat to food security. It is also highly effective in the highlands of Trans Nzoia, where there is no striga but farmers experience serious stemborer and soil fertility problems. Plans for the system's adaptation to more arid conditions, where sorghum is the main cereal and striga is rampant, are discussed in Chapter 4.

## Food to eat, money to spend

Farmers adopting the habitat management technology have increased their maize yields by an average of 30% in areas affected by stemborers, and by over 100% where both stemborers and striga occur (see graph). The Obinga family now harvest two bags of maize (180 kg) from a push–pull plot of only 20 x 30 m, while the same area before would have given them only half a bag (45 kg). Cecilia Ogony, a farmer–teacher in Siaya, reports a similar yield improvement. Many families, even on quite small farms, are now self-sufficient in maize and some may even be able to sell part of their harvest. Yield gains are due not only to the control of pests; the desmodium intercrop also improves soil fertility (see 'Safeguarding the environment'). Furthermore, the Napier border rows help protect the maize from lodging (falling over) in strong winds.

Market forces play a large part in the adoption of any new agricultural technology. Although farmers recognise the value of the push–pull approach in controlling stemborers and striga to boost maize production, many cite the additional income-generating opportunities offered by growing forage as their main incentive to switch to the new system. Sales of Napier grass and desmodium to neighbours with stall-fed cattle provide a new source of income and, since the forage can be harvested regularly, this brings in money when there are no other crops to sell. Home-grown forage also obviates the need to spend many hours each day either gathering forage for stall-fed cattle or herding the animals as they graze.

Some farmers have made enough profit from the sale of forage to buy a dairy cow; others now have sufficient fodder to upgrade their cows by crossing their native zebus with exotic breeds (such as Ayrshires and Friesians), thereby increasing milk yields. A regular supply of milk not only raises farm income, it also improves the nutritional status of the farming family, especially the children (see box on next page).




*Average maize yields in push–pull fields in 12 districts of western Kenya in 2004.*

*All areas are affected by stemborers and striga except for Trans Nzoia, where there are stemborers but no striga.*

### Milk to spare

Lillian Wang'ombe farms 1 ha in Wamuini, near Kitale in Trans Nzoia with her husband John. As her maize crop used to be infested with stemborer, there was barely enough to feed the family and none left over to sell. She heard about push–pull from her mother and was impressed by the way the technology got rid of the stemborers without using insecticide. After planting Napier grass and desmodium, Wang'ombe found she had enough maize to feed her five children for the whole year and still had a surplus for market. Within one season she had enough Napier grass to give some to her mother, in return for milk. Before long, it was obvious that there was enough fodder to keep a cow and, after selling the surplus maize, she was able to buy her first crossbred cow and pay a deposit on a second. Wang'ombe now has three cows, two of which are due to calve. When they do, there will be enough milk for the household and to sell. The children eat well and the family has been able to buy schoolbooks, medicines and furniture. "Some people laughed at us when we first planted Napier grass without cows on such a small farm, but now they come to us for advice!" she says.

*Lillian WangÕombe feeds her crossbred dairy cows with home-grown Napier grass.*

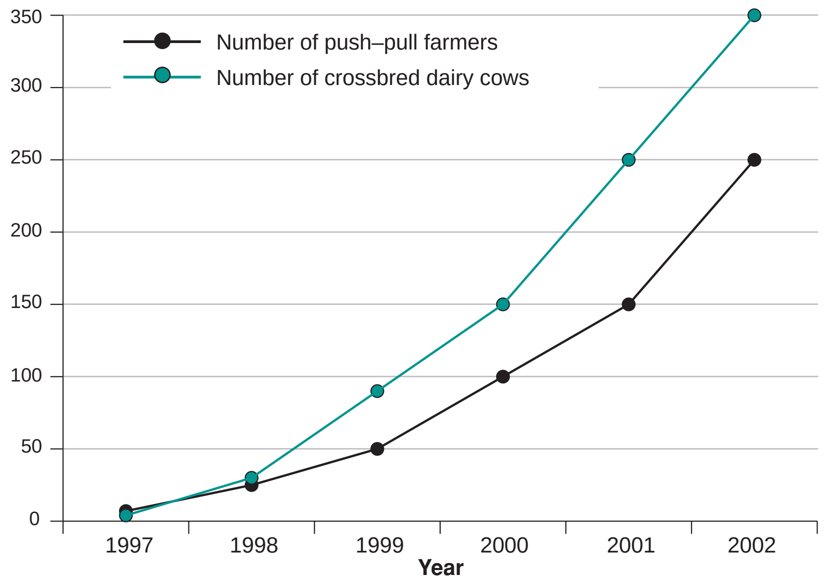
In Suba District, farmers currently produce 7 million litres of milk per year, far short of the estimated annual demand of 13 million litres. Most cattle are the indigenous zebu type and a major constraint to keeping crossbred dairy cattle is the seasonal shortage and generally poor quality of available feed. The push–pull technology, adopted by over 400 farmers in this district, is having a big impact. The number of crossbred dairy cattle in Suba rose from only four in 1997 to 350 in 2002 (see graph), putting the district well on the way to self-sufficiency in milk production. Obinga is one of the Suba farmers who upgraded his cattle. He used to keep zebus and obtained a meagre 300 ml of milk per cow per day. With crossbred cows he now gets five times as much.

*Napier grass being sold by traders (KSh50 per bundle) on the roadside in Luanda, western Kenya.*

Sale of desmodium seed is another income-generating opportunity. This came to light when the speed of adoption of the push–pull technology led to a serious seed shortage. In 2003, with Gatsby funding, ICIPE launched a seed multiplication project, and this has now developed into a commercial enterprise (see Chapter 3).

## Asset acquisition

Making the difficult transition from subsistence farming to earning a cash income allows farmers to start acquiring assets and so to increase the income-generating potential of their farms still further. Accumulating assets also gives farmers some insurance against hard times or for when family needs arise. For example, Samuel Ndele, who lives on a 1.2 ha farm in Ebukanga, Vihiga, was experiencing diminishing maize yields due to the combined effects of stemborers, striga and declining soil fertility. When he heard about push–pull on Tambea na majira he thought it might help him. He tried it and was delighted when he harvested twice as much maize from his first plot than he had previously. With the money he earned from selling Napier grass and maize, he bought a sow and fed her on maize and desmodium forage. When she farrowed, he sold all six piglets and bought a zebu heifer and a new roof. Now that he




*Increase in numbers of crossbred dairy cows in Suba District (1997–2002).*

*Since 2002, diseases carried by biting flies have killed many crossbred dairy cattle in Suba and the total number in 2004 had declined to 150. This and other constraints are discussed in Chapter 3.*

has plenty of forage, he can return more of his crop residues (and the manure from the pig's stall) to the soil, improving the fertility of his farm. This year he hopes to build a bigger house and next year he will buy a crossbred cow. "Now every year gets better instead of worse," he says.

## Safeguarding the environment

Many farmers comment on the beneficial effects of the habitat management technology on soil fertility, soil erosion and soil moisture. In addition, the improved availability of forage allows them to return crop residues to the soil instead of feeding them to livestock. Zero grazing units are an excellent source of farmyard manure that farmers can use to enrich the soil either by applying it directly or using it to make compost. Many apply farmyard manure to their Napier grass, which grows faster allowing more frequent harvesting. Improving soil fertility is especially important in Trans Nzoia, where non-push–pull farmers have to use inorganic fertilizer and pesticides if they are to obtain a reasonable maize yield. Farmers like the Wang'ombes and the Gumos have discovered that with push–pull they can get sizeable yields without adding chemicals.

*Sale of piglets and, eventually, milk will allow Samuel Ndele to continue to invest in his farm and improve his income over the longer term.*

Monocropping and the use of chemical inputs are strongly correlated with the loss of biodiversity. By introducing a mixture of crop species into the farm environment and reducing the need to use pesticides, this project reverses that trend. In addition to increased numbers of natural enemies of stemborers, researchers found significantly more beneficial soil organisms in maize–desmodium fields than in maize crops alone. Reducing the use of pesticides and inorganic fertilizers has important benefits for human and environmental health and, of course, releases farmers' cash for other purposes. Another benefit with far-reaching implications is the ability of the system to improve livelihoods on even very small farms. This has the potential to reduce human pressure on the land, thereby slowing human migration to the cities and to marginal or protected areas.

*Bilia Wekesa shows researchers how she makes compost in her zero grazing unit. Farmyard manure, household waste and crop residues are piled up and covered with maize stover and will make good compost after about three months.*

## Extending the benefits

With Gatsby's help, the ICIPE team is linking with national scientists to introduce the technology in Tanzania[1] and Uganda. Dissemination efforts in Uganda began in 2001 and, after some initial difficulties with trial design, made good progress. Ugandan researchers selected study sites, visited farmers, identified their problems and exchanged visits with ICIPE staff. They also conducted laboratory-based studies to determine which fodder grasses the local stemborer moths find most attractive. Nevertheless, adoption was disappointingly slow until the ICIPE team had the idea of taking the Ugandan farmers to Kenya to visit demonstration plots. Since then, the pace has quickened and 159 farmers in five districts are now testing the technology. Field days held on-farm in Uganda, managed by National Agricultural Research Organisation (NARO) staff and government extension officers, have increased the farmers' knowledge of striga and stemborer biology and have given them more confidence to adopt the technology and explain it to other farmers.

A similar initiative involving farmer exchange visits helped establish trial and demonstration plots in Tanzania in 2003. The technology is being tested by 20 farmers in the lakeshore region and 30 more in the coastal region of eastern Tanzania. Both areas are characterised by low-input maize-based crop–livestock farming and maize yields are adversely affected by striga, stemborers and declining soil fertility.

## New zones, different crops

Although developed initially for maize, the habitat management technology can also benefit sorghum- and millet-based farming systems. These cereals are more tolerant of drought than maize and are grown in areas where rainfall is scant and unreliable. Striga and stemborers can also be severe constraints in such areas. Researchers have found that, when these cereals are intercropped with the drought-tolerant greenleaf desmodium (*Desmodium intortum*) and bordered by rows of Napier grass, the effects of striga and stemborer can be greatly reduced. "This adaptation of the technology will be particularly applicable for arid and semi-arid regions throughout Africa," says Khan.

## A good return?

Although the long-term benefits are clear, the early stages of establishing a push–pull plot place heavy demands for labour on participating farmers. (This and other constraints are discussed in Chapter 3.) So, does the technology offer farmers a good return on their investment?

A formal cost–benefit analysis, performed by the project's socio-economist, Esther Njuguna, has helped to answer this question. Njuguna collected data from 25 farmers in Suba and 45 in Trans Nzoia, measuring their income, expenditure, use of inputs and labour. Overall, the technology has a benefit-to-cost ratio in excess of 2.5 when evaluated over several years. "This indicates that it is efficient and consistently gives farmers a good return on their investments," she says. "Economic gains are greatest in areas where both striga and stemborers pose a constraint to growing maize. Returns are good even for farmers who have small plots and little money to invest – and these, after all, are the ones who need help the most."

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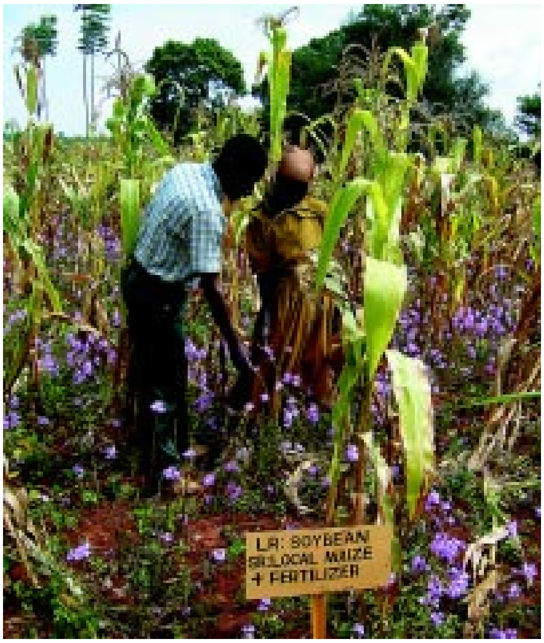
[1] The work in Tanzania is funded by the Maendeleo Agricultural Technology Fund.

*Project Leader, Zeyaur Khan, illustrates the beneficial effects of push–pull on sorghum crops in a trial at Mbita Point. Good results have also been achieved on-farm in Suba District.*

It is important to emphasise that the high labour inputs for establishing the Napier border rows and desmodium intercrop are a one-off, while the benefits continue for many years. Hence, the benefit-to-cost ratio is likely to increase as time goes on.

A collaborative project between ICIPE, the International Maize and Wheat Improvement Center (CIMMYT) and the Tropical Soil Biology and Fertility (TSBF) Programme[2] has revealed that the gross margins of push–pull can be greater than those of other striga control strategies. The scientists studied combinations of desmodium, soybean or sun hemp and local maize or imazapyr herbicide resistant (IR) maize, developed by CIMMYT. IR maize has a low dose (30 g/ha) of imazapyr herbicide added as a seed coat to herbicide-resistant maize. The herbicide attacks the striga seedling before or at the time of attachment to the maize root and any imazapyr not absorbed by the maize seedling diffuses into the soil, killing non-germinated striga seeds. The various options were tested with or without fertilizer.




*Christian Were (pictured with Dickens Nyagol from ICIPE), is testing various crop rotations together with IR maize and the push–pull technology on her farm in Siaya District.*

The results showed that push–pull with local maize and no fertilizer gave the best return. Adding fertilizer is inappropriate in dry areas since drought frequently affects crop growth and the investment cannot be recovered. The high gross margins of push–pull are related to the low input costs, since Napier and desmodium are perennial crops and, once planted, provide income for several years.

Christian Were is one of the farmers comparing these options. Although she found that a combination of push–pull with IR maize and fertilizer provides the best control of striga, her preferred option is to grow local maize in a push–pull plot. “With this system I don’t have to buy fertilizer or seed,” she explains. “And I get more maize when I plant a desmodium intercrop than I do with the other legumes.”

[2] TSBF is a programme coordinated by the International Center for Tropical Agriculture (CIAT). This work was not funded by Gatsby.

# 3. Challenges and constraints: from seeds to policy

As they start to be adopted, new technologies often encounter obstacles, some of which may have been unforeseen at the outset of the project. Hurried dissemination, without first addressing these obstacles, may lead to failure. For example, desmodium is labour-intensive to establish since the plot requires frequent and thorough weeding if the emerging seedlings are not to be overcome by weeds. Until farmers have seen desmodium seedlings growing, they cannot tell the weeds from the crop. This is where visits to Mbita Point and help from farmer–teachers prove invaluable. The high incidence of HIV/AIDS in some areas is another factor contributing to shortage of labour. Here too, farmer–teachers or farmer groups may be able to help by mobilising support within the local community.

## The need for seed

As word spread about desmodium's ability to suppress striga, farmers throughout the trial districts began clamouring for seed, creating a serious shortage. Although the Kenya Seed Company was importing seed from Australia, the price was high and availability limited. Gatsby responded by providing additional funds for a seed multiplication project. Initially, this was implemented by informal groups of farmers, who planted desmodium bulking plots primarily for the seed harvest. The activity proved lucrative, with seeds fetching a high price in the market – between US$15 and 20 per kg.

The quantities produced, however, were rather small and in 2003 Khan sought help from the private sector. He approached the Kitale-based Western Seed Company to undertake commercial seed production through contracts with local farmers and community groups. The initiative began with 300 farmers in Bungoma and Trans Nzoia, who were trained in seed production and preparation and given 250 g of seed each to multiply (see box overleaf).

*Harvested desmodium seed before (left) and after on-farm processing.*

### Turning a tidy profit

*Bilia Wekesa harvesting desmodium seed. Her homemade overall prevents the hairy seed pods sticking to her clothing.*

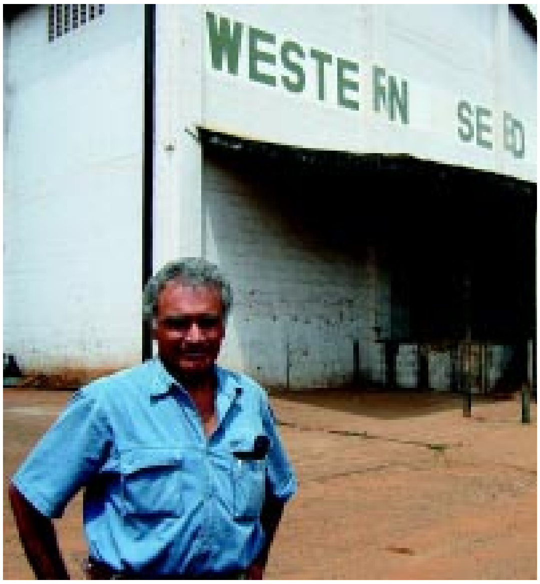
A worsening stemborer problem and the high cost of fertilizer and insecticide meant that Bilia Wekesa could no longer rely on maize as the main source of income from the 1.6 ha she farms near Kitale in Trans Nzoia. She heard about push–pull on the radio and thought it sounded 'too good to be true'. But after attending a *baraza* she decided to try the system.

Wekesa collected enough seed from her initial desmodium intercrop to plant her own bulking plot and is now a contract producer for Western Seed. She harvests weekly and prepares the seeds by placing them on a large stone and threshing them with a piece of rubber. "Establishing the plot and collecting and cleaning the seed are hard work and take a lot of time, but the profit is good, so it's worth it," she says. "I make more money from selling desmodium seed than from maize or Napier grass, from a much smaller area of land. And the money is available all year round."

Western Seed undertakes to buy the harvest from all its contract farmers. It then cleans the seed, checks germination and viability, and packs and stores the seed. In 2004 the number of contract farmers increased to 450 and, by the end of 2005, there should be over 700 farmers involved. While the company currently sells most of its packaged seed to ICIPE (for distribution to new project farmers), after 2005 it hopes to sell seed on the open market. In conjunction with ICIPE, the company has started a promotional scheme, whereby a 100 g pack of desmodium seed is given away with every purchase of a bag of hybrid maize seed. This scheme could reach up to 3000 new farmers each year, considerably expanding the market for desmodium seed. Sufficient information to enable farmers to adopt the technology and make contact with Western Seed and/or ICIPE will be included in the package, together with suggestions for contacting local farmer–teachers.

Although busy with his own maize development programme, Saleem Esmail, Chief Executive of Western Seed, was keen to assist because he was convinced of the benefits of the habitat management approach. But did it make good business sense to become involved? "Yes, probably there will be long-term benefits," he replies cautiously. "There is an element of risk." In fact, profitability is not the immediate reason for his involvement. "There is a need to address the whole sustainability of farming in Africa," he continues. "We cannot sell to farmers who have no cash – first we have to help put money in their pockets." Esmail believes that, by raising farmers out of poverty, his company can lead them into the cash economy so that they become tomorrow's seed buyers.

Linking a commercial seed company with numerous small-scale farmers can cause logistical problems, which is why the scheme is restricted to only two districts at the moment. ICIPE is currently covering the cost of seed inspection and certification, which are required by law and conducted by the Kenya Plant Health Inspectorate Service (KEPHIS). Once seed production is on a purely commercial basis, it will benefit farmers to




*Saleem Esmail, Chief Executive of Western Seed Company.*

form groups so that they can reduce inspection costs, ease the work of seed preparation (possibly by using simple hand-driven threshing machinery) and get a better price from the seed company. If additional private seed companies become involved (one in Maseno has expressed interest), competition will help keep seeds affordable.

## Credit and cows

The second major constraint preventing farmers from capitalising fully on the push–pull technology is the lack of cash or credit to buy crossbred dairy cattle. Although some (like the Wang'ombes) have saved money from sales of forage, this is not possible for all farmers, particularly those with large families and small farms. Development schemes and programmes are available, but have no formal links to ICIPE or its partners. For example, the Kenya Ministry of Agriculture and Livestock Development previously gave farmers an in-calf heifer if they had a zero grazing unit and year-round supply of quality forage. The farmer then undertook to pass on an in-calf heifer to the next farmer in the scheme. Although this programme has ceased, there is hope that the success of push–pull may encourage ministers to reinstate it. Meanwhile, farmers can apply to similar NGO-run schemes such as the Rural Outreach Programme (ROP) and Heifer International (see box). The role of the project in this respect is restricted to the provision of information, but once farmers are aware, they can take advantage of such opportunities. Furthermore, the technology helps them meet the most essential entry criterion, namely a reliable source of high-quality forage.

When adapting push–pull to sorghum- and millet-based farming systems in the drier areas, an obstacle that has yet to be overcome is the need to protect the intercrop and border rows from herds of cattle, which traditionally graze freely on crop residues after the grain has been harvested. Here, farmers will incur additional input costs (for fencing and/or labour) to protect their forage crops. Cost–benefit studies may be needed to determine whether this issue is likely to deter adoption. In current project areas involving maize cropping systems, most cattle are stall-fed, tethered or herded and free-grazing cattle are uncommon.

### The gift of hope

A cow named Zawadi (meaning 'gift') represents Joseph Litunya's aspirations for the future of the farm he shares with his parents and five brothers. Since adopting the push–pull technology, his family have not only doubled their maize yield but also satisfied the criteria for the local Rural Outreach Programme (ROP), which helps farmers without cash or access to credit to acquire a crossbred dairy cow. Zawadi is 75% Ayrshire, and when she calves, Litunya hopes she will give over 6 litres of milk per day, which will provide the family with much-needed income. As a farmer who would otherwise have had no opportunity to obtain an improved (crossbred) cow, Litunya is only too glad to help someone else in his situation by offering them his first in-calf heifer and sharing his knowledge of dairying with them.

Litunya has also helped found the Busia Farmers' Group, which is helping all its members to acquire improved dairy cows. Registered with the Ministry of Social Services, this formal group has better access to credit and development funds than individuals, and the members may have better status with schemes such as ROP. In time, the members also hope to win a contract for commercial production of desmodium seed.

*Thanks to a plentiful supply of forage grass and a home-built zero grazing unit, Joseph Litunya has met the criteria for a livestock scheme that provides crossbred dairy cows to farmers who lack the required cash or credit.*

*Adopting push–pull has doubled the Wekesas' maize harvest, but pests and diseases mean that much of the harvest is lost while stored in the granary.*

## Storing the surplus

Overcoming the major constraints to growing maize is certainly a good starting point, but it is frustrating for farmers when they cannot store the surplus grain. Post-harvest losses caused by pests and diseases are extremely high in maize. Together with acute cash shortages, the risk of such losses often forces farmers to sell their crop immediately after harvest. Improved storage conditions would not only increase the amount of maize available to eat but also enable farmers to sell their surplus later, when prices are higher. While research institutes such as CIMMYT are investigating this problem generally, the ICIPE–Rothamsted project is hoping to secure additional funding for research into potential solutions that would be particularly appropriate for push–pull farmers.

## Pest defence strategies

Because it increases crop diversity on the farm, the habitat management approach might be expected to minimise the risk of pest and disease attack. However, the success of both desmodium and Napier grass as cash crops means that many farmers are planting them as sole crops, where there is a risk of pest and disease outbreaks. Indeed, project staff in Bungoma and Busia Districts have already noted an insect-borne disease of Napier grass that causes the plants to become yellow and stunted. Interestingly, a local variety appears to be resistant. KARI plant breeders are therefore working to incorporate this source of resistance into the popular 'Bana' variety. Potential insect pests on desmodium include the pollen beetle (*Mylabris* spp.) and the pod borer (*Maruca vitrata*). Scientists at ICIPE and Rothamsted are working on a defence strategy targeted on these insects, which involves traps baited with floral volatiles. The idea is that farmers could make their own traps with the appropriate flowers.

Another pest that threatens the success of the project is the tsetse fly, which transmits *nagana* disease (trypanosomosis) to cattle. Improved (crossbred) animals are particularly susceptible and several project farmers in Suba have lost their newly acquired improved animals to the disease. Control programmes are in operation (funded by the Kenyan Government and the European Union), but have met with difficulties. A large-scale eradication programme has yet to gather significant momentum and is unlikely to provide a long-term solution, while local control approaches have not led to sustained area-wide suppression. Meanwhile, the lack of effective control may deter farmers from investing in improved dairy cattle.

*Pod borer (*Maruca vitrata*) found on a desmodium seed production plot at KARI, Kitale. The insect is not currently an economically significant problem. However, the project team needs to be proactive in investigating control measures to combat the threat of attack from this and other pests of desmodium and Napier grass.*

Entomologists at ICIPE believe that area-wide efforts managed by local communities offer the best hope for successful control. Establishing such initiatives is not easy; a community-based suppression programme using baited traps in the Lambwe Valley collapsed after a few years because farmers lost interest following low catches of flies and reduced incidence of disease. But there is potential for educating and empowering communities to implement their own control measures. ICIPE scientists have helped establish several successful community-based programmes, in Kenya in the 1980s and more recently in Ethiopia.

ICIPE technician, George Genga, advises farmer–teacher Musa Aluchio when to harvest his desmodium seed. At present, the harvest from an intercrop can only be sold through unofficial channels.

## Promoting policy change

In Butere Mumias, project activities are in their second season. The team expects to see a rapid increase in adoption here, since the local member of parliament, the Honourable Julius Arunga, is a devotee of the technology. The advantages of having a politician involved include greater chances of raising funds, such as money from the Constituency Development Fund, which is allocated by local MPs and could be used to establish additional demonstration plots. Interested politicians like Arunga may also be able to tackle long-standing policy constraints, such as regulations concerning seed supply and certification.

Seed supply regulations have placed several obstacles in the project's path, but the team made a major breakthrough when they influenced a change of policy regarding the distribution of seed that was the product of KARI research. Until 2000, such seed could only be distributed through the Kenya Seed Company. The problem was that this public sector organisation did not perceive a demand for desmodium and was unwilling to distribute the seed. Since the change of policy, the private sector (Western Seed) has been allowed to distribute seed originating from KARI and the project team have begun to address the desmodium seed supply problem.

Harvesting desmodium seed is time-consuming, but the profit is good.

The team has had less success with seed certification regulations. Seed must receive KEPHIS certification if it is to be sold commercially. Current rules state that all certified seed must be grown as a sole crop. This precludes seed from desmodium intercrops from being sold through approved channels. Although seed yields from sole crops are often better than from intercrops, there is greater risk of pests and diseases. Farmers do harvest intercropped desmodium for seed – for their own use and to distribute informally. But if they could sell certified seed, their profit would be greater and this would represent another significant benefit for the push–pull system. The project team and the Director of Western Seed are working to change the regulations but it is proving to be a slow process.

# 4. Across the spectrum: learning from experience

The story so far is one of success. Thousands of Kenyan farmers have adopted push–pull and most have experienced impressive gains in their food security and incomes. The research team and the farmers they have worked with have learned much about plant and insect chemistry and the principles that underlie environmentally friendly pest control. Constraints to adoption have been identified and strategies for addressing them have been devised. The key question now is how widely can the technology be applied elsewhere in Africa? Experience shows that out-scaling of projects in African agriculture is difficult and requires considerable investment of time, money and other resources. Local adaptation is also essential if new technologies are to reach their full potential in different areas.

The push–pull technology is flexible and can be successfully adapted and introduced to new cropping systems and agro-ecologies. Habitat management options can be developed and fine-tuned for a range of cereal crops, while introducing the genes that code for stemborer-repellent and striga-inhibiting chemicals into food legumes could extend the reach of the technology still further, to areas where striga affects food security but where few people keep livestock. Perhaps most importantly, the technology points the way to a much broader approach to IPM than previously attempted – an approach that sets pest and disease management in the context of the health of the whole agro-ecosystem.

## From science to impact

When Gatsby began supporting agricultural research in Africa 20 years ago, the prime objective was to alleviate hunger by raising the yields of key crops through the transfer of existing technology to farmers' fields. However, action across the whole research and development spectrum is still needed if real improvements in rural livelihoods are to be achieved. This action ranges from strategic research (building knowledge), through applied research (developing new technologies), to adaptive on-farm research (fine-tuning technologies to local conditions) and to scaling up and out (involving intensive programmes to educate farmers).

The push–pull project provides a good illustration of the need to base new agricultural technologies on sound science. Detailed knowledge of the chemical mechanisms responsible for the push–pull effect helps to ensure the continuing efficacy of the system and allows it to be adapted to new situations. As Pickett says: "Science-based solutions are more robust. Understanding the underlying mechanisms means that if the technology ceases to work, we will be able to find out why and take appropriate action." Knowledge also gives researchers and farmers confidence to experiment further with the technology.

Linking the science with the results is a deliberate feature of many Gatsby-funded projects, and one that other donors find attractive. Indeed, the habitat management project has secured significant funding from sources other than Gatsby, including the UK's Department for International Development, the Rockefeller Foundation and the Global Environment Facility of the United Nations Environment Programme, among others.

## A flexible agenda

In 1994, when Gatsby began supporting research on maize stemborers, push–pull was little more than a promising idea in the minds of an informal global network of chemical ecologists. That it has now become mainstream thinking in several national research systems is due in large part to the freedom enjoyed by the scientists involved to pursue new research directions as these arose – and in particular the links between the environmental

*William Abonyo Seko, a farmer–teacher, passes on his knowledge of striga control to other farmers.*

aspects of the technology and its implications for poverty eradication. When Professor Odhiambo and his colleagues at ICIPE decided to focus on developing a strategy to attract stemborers away from maize, they never anticipated that one of the 'push' plants would also suppress the parasitic weed striga and that a major benefit of the technology would be improved livestock production. The flexibility of the project's funding mechanisms was a key factor in maintaining the open-ended nature of the work.

## Investing in farmers

Although a knowledge-intensive technology is expensive to disseminate, the project's focus on farmer participation and training has sown the seeds of widespread and self-sustaining impact. Participating farmers have a sense of ownership and feel pride in what they have achieved, which encourages them to learn more and pass on their knowledge to others. They also have increased confidence and this is demonstrated when they form farmer groups, which have a louder 'voice' and can attract more resources than individuals. Teaching farmers to experiment and innovate makes them inherently more adaptable and resilient in the face of changing conditions – whether these are economic forces, such as from globalisation, or ecological, as a result of climate change.

The team has high hopes that farmer–teachers will eventually accept much of the responsibility for passing on knowledge. Currently there is still a need for technical backstopping from trained ICIPE or KARI scientists. Indeed, Pickett believes the project will need careful stewardship for some time to come. "Push–pull is a highly self-reliant technology and it is really up to the farmers to make it work for their own situations," he says. "But because it is so flexible, it needs some kind of anchor point. For example, if farmers start planting field beans in the space between the maize and the Napier, someone has to remind them that this may interfere with the 'pull' of the Napier grass and upset the balance of the system. It is also important at this stage to spot new challenges quickly – for example the dangers of disease in Napier grass or insect pests on desmodium." The need for backstopping also extends to quality control, for

*Training in scientific methods has helped Mary Rabilo (pictured with ICIPE technician George Genga) to develop her own forage ration for dairy cows, which contains ground maize and* dagaa *(small fish from Lake Victoria) mixed with chopped desmodium leaf. She has evaluated different combinations of ingredients and developed a mix that costs less than bought concentrate feed, yet gives a higher milk yield.*

example the monitoring of desmodium seed produced by farmers to prevent a shift in its genetic make-up and/or loss of the active chemical stimuli.

## Building partnerships and institutions

Adopting a partnership approach to R&D increases motivation and speeds up progress. It can also allow for a gradual exit of the initial funding and managing institutions, which can pass on responsibility to national organisations. The ICIPE–Rothamsted collaboration has worked well, due mainly to good communication. The lead scientists talk to each other weekly and will soon have a dedicated low-cost telephone line installed between their desks in Kenya and the UK. They do not compete for funds and neither organisation considers itself the leader, but each has a clearly defined role. The partnership is based on mutual benefit: while ICIPE researchers benefit from Rothamsted's advanced equipment, Rothamsted scientists rely on the ICIPE team's local knowledge and field experience. Both sides appreciate the exchange of experience and the challenging of existing ideas that the partnership entails. "Science today is highly interdisciplinary," says Hassanali. "We can no longer work in isolation. When people are asked to contribute intellectually they develop more enthusiasm and motivation." The two institutions have also fostered close links through exchange visits of research students.

The team have succeeded in involving a wide range of stakeholders. They have conducted workshops at Mbita Point for government extension officers, farmers, teachers and community opinion leaders such as chiefs and church ministers. The project experience highlights the need to recognise the interdependent but separate roles of scientists, extension workers and farmers. Although farmers can and should be active partners in research, they will often need continued support from trained researchers.

Eventually, it is expected that KARI and the government extension service will take on responsibility for supporting technology dissemination in Kenya. For this transition to be successful, ICIPE must continue working closely with KARI, helping to build capacity through training and collaborative research. The process was given a boost at the 2004 KARI conference (see box).

### Push–pull proves to be a winner

In November 2004, the KARI team involved with the project were awarded the KARI Best Scientific Programme award. This is presented at KARI's biennial scientific conference and generates intense competition among the 26 regional centres.

Each centre may submit up to three projects, which are judged on scientific merit, benefits to rural communities, impact on the ground, sharing of information, participation of stakeholders, sustainability and other criteria. "The idea is to encourage competitiveness and focus on research that works towards the mission, vision and objectives of KARI, while creating local impact and improving research management," says Charles Nkonge, Director of the Kitale research centre, where the project team is based. "The push–pull project was a clear winner and met all the judges' criteria."

Winning the award has raised national awareness of the technology and attracted the attention of government ministers who attended the conference. There is now more hope that policy constraints will be addressed, for example by making the rules governing small-scale seed production more flexible. The award has also attracted additional donors: for instance, Oxfam have pledged funds to support technology dissemination in Kenya's Central region.

*Charles Nkonge, Director of KARI's Kitale research centre, and his team congratulate each other on winning the Best Scientific Programme trophy.*

*Environmentally friendly and people-centred technologies like push–pull are the key to Africa's 'unique green revolution'.*

## The big picture

The experience of the push–pull project confirms that science can successfully support the interests of small-scale farmers and promote food security and sustainable livelihoods. With the essential ingredients of commitment, drive and enthusiasm, much can be achieved on a local scale. Thanks to push–pull, more and more families like the Obingas are finding a means to escape from the trap of diminishing yields and deepening poverty and hunger.

That is not to say that the technology will continue to spread unchecked. Issues such as a continuing under-investment in national agricultural research and development, the lack of agricultural credit for small-scale farmers and the frailty of public sector seed supply systems could well frustrate widespread impact if they are not dealt with soon. In addition, poor market access and inadequate post-harvest processing are likely to cause problems in the future when districts become self-sufficient in commodities such as maize. All too often in the past, these factors have led swiftly to the collapse of prices once surpluses have been achieved in a given area.

If these problems can be tackled, the habitat management technology will make a substantial contribution to the 'uniquely African green revolution' called for by Kofi Annan, United Nations Secretary-General, at a meeting of African Heads of State in July, 2004[1]. The technology also fulfils several of the agriculture-related recommendations of the United Nations Millennium Project's Task Force on Hunger[2]. Global opinion is now united in the belief that efforts to improve Africa's agricultural productivity must be based on technologies that are highly environmentally friendly and people-centred, in comparison to those that fuelled the Asian green revolution. Push–pull is one of these technologies: it is a new and much healthier approach to pest management; it teaches farmers how to become food-secure and build a livelihood on just a small piece of land, without demanding inputs of cash or labour that are beyond their resources; in providing forage for livestock it contributes directly to poverty eradication, since it enables farmers to meet Africa's rapidly rising demand for milk and meat; and in protecting and enhancing soil fertility it tackles what is perhaps the most fundamental constraint of all to the development of African agriculture.

If push–pull continues to spread and achieve a positive, long-term impact, it will play a vital part in helping African countries reverse their backward slide and set themselves on the path towards achieving the Millennium Development Goal of halving poverty and hunger by 2015.

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[1] www.un.org/apps/sg/sgstats.asp?nid=1010
[2] www.unmillenniumproject.org