# BIOLOGICAL PEST CONTROL: PUSH-PULL IN EAST AFRICA

## Location: Kenya

*A highly successful, ecologically based pest and weed management system was introduced in 1999 to resource-poor smallholder maize farmers in Kenya. Used by thousands of farmers in East Africa, the "push-pull" strategy significantly increases maize yields, helps control pests and reduces reliance on pesticides.*[1]

## CHALLENGE

Maize and sorghum are the primary staple crops for millions of people in eastern and southern Africa. Stem borers, the parasitic *Striga* weed, and low soil fertility are the main constraints to grain production in these regions.[2] Seventeen species of stem borers have been found to infest maize throughout Africa, significantly limiting yield potential. Though the impact varies by region, crop cultivar, and farming practices, losses due to stem borer in eastern Africa average 20-40 percent, reaching as high as 80 percent in some areas. *Striga's* impact on yield can be even greater, with 30 to 100 percent losses recorded in many areas. *Striga* losses are exacerbated by low soil fertility, a problem prevalent in East Africa. When the two pests occur together, farmers frequently lose their entire grain crop.[3]

Chemical pesticides have proven largely ineffective in controlling stem borers, and are also prohibitively expensive and potentially harmful to human health, soil, water quality and biodiversity. In addition, inorganic compounds kill the stem borer's natural enemies. Traditional practices—burning unharvested biomass or wild host species—are however also not recommended as they impact beneficial insects.

Economic losses from stem borers and *Striga* weeds amount to about $7 billion annually, primarily affecting resource-poor and subsistence farmers. Research suggests that preventing stem borer and *Striga* weed crop losses and improving soil fertility in eastern Africa could increase cereal harvests to feed an estimated 27 million people.[4]

## RESPONSE

Researchers from the Rothamsted Research Station (UK) and the International Center of Insect Physiology and Ecology (ICIPE) have worked in East Africa for the last 15 years on an effective ecologically based pest management solution for stem borers and *Striga*. Their research produced the successful "push-pull" intercropping technology, which manages pests, increases animal forage and enhances soil quality and fertility.[5] From initial experimental trials, to on-farm experimentation and finally, widespread implementation, the push-pull selective intercropping strategy has yielded consistently positive results.[6]

The push-pull system manages pests through an attract-repel plant chemical strategy that encourages biological control by natural enemies and reduces stem borer reproductive success. Through selective intercropping with important fodder species and wild grass relatives, stem borers are simultaneously repelled—or pushed—from the system by one or more plants and are attracted to—or pulled—toward "decoy" plants, protecting the crop from infestation.[7] Intercropping maize

with additional plants known to both repel stem borers and attract natural enemies (parasitoids which feed on the tissues of other living animals) can further decrease stem borer densities by appreciably enhancing parasitism rates.

An extensive selection process has identified multiple plant species for Kenyan push-pull systems. Attractant plants such as Napier grass (*Pennisetum purpureum*) and Sudan grass (*Sorghum vulgare*) are highly effective trap crops serving to "pull" stem borers away from the maize crop. Molasses grass (*Melinis minutiflora*) successfully repels (i.e. "pushes") stem borers away from the corn crop while significantly enhancing prevalence of parasitoid wasps, thus increasing stem borer mortality and reducing crop losses.[8]

Two leguminous plants, *Desmodium uncinatum* and *Desmodium intortum*, also contribute to repel stem borers. In addition, these leguminous produce root chemicals that work with each other to limit *Striga's* reproductive success, and have been used to control *Striga* weed invasion.[9]

*Desmodium* is a perennial legume that exerts a chemical inhibition, or allelopathic[10] effect, on *Striga* even when maize is out of season. When intercropped with Napier grass, the two plants control two of Africa's most detrimental maize pests and also prevent soil erosion, fix nitrogen, enhance soil organic matter, conserve soil moisture, and increase quantity and diversity of beneficial arthropods. The push-pull intercropping systems serve as models for creating more productive and ecologically sustainable subsistence maize systems for eastern and southern Africa.[11]

## RESULTS[12]

- In 1997, push-pull polycultures showed significantly higher rates of biological control (via enhanced parasitism) in several multi-year comparative trials. High rates of parasitism by natural enemies are beneficial as they leads to high rates of mortality of pests, which in turn leads to decreased crop losses. In the study, maize monocultures showed parasitism rates of 4.8 percent and 0.5 percent for *C. partellus*, and *B. fusca*, respectively. The push-pull systems had parasitism rates of 6.2 percent and 18.9 percent for *C. partellus*, and *B. fusca*, respectively.
- A 2000-2003 study in seven Kenyan districts and three Ugandan districts found that the push-pull system helped more than 1,500 participating farmers increase maize yields by an average of 20 percent in areas with only stem borers; yields were increased by more than 50 percent in areas with both stem borers and *Striga* weed infestations.
- A seven-year (1998-2004) agronomic and cost-benefit study in six western Kenyan districts showed that push-pull technology consistently delivered significantly higher maize yields when compared to maize–bean intercrops and maize monoculture systems. The push-pull system yields range from a low of 1.9 tons per hectare in Suba district to a high of


Newly-developed climate smart push-pull field with Brachiaria grass on border and greenleaf *Desmodium* intercropped with sorghum. © Centre of Insect Physiology and Ecology

Lepidopteran stem-borers, (larval insects) are ubiquitous pests that attack cereal crops throughout all growth stages. The larvae cause damage ranging from 20 to 80 percent loss of yield; *Striga* or 'witchweed' are parasitic weeds that affect cereal crops (maize, sorghum, rice and sugarcane) in many parts of Africa.

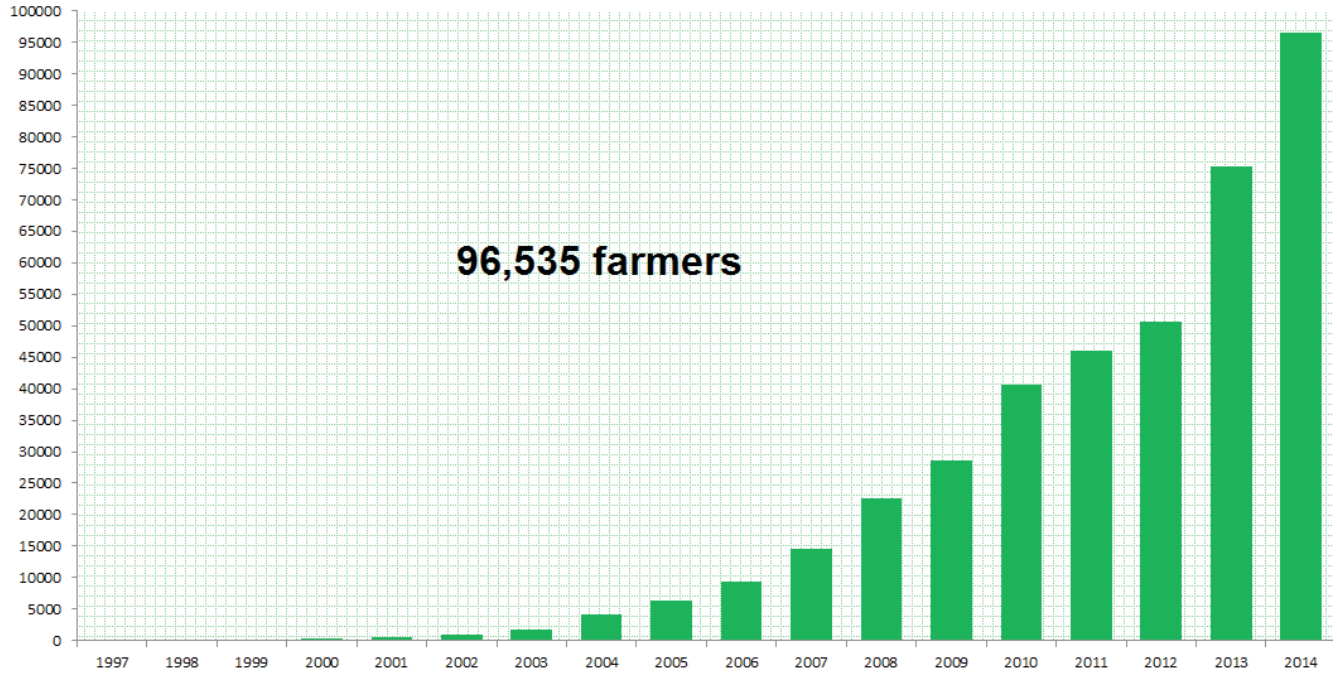
Over 96,000 East African farmers have adopted the push-pull system. Their maize yields have increased from an average of 1 ton to 3.5 tons per hectare without the use of chemical insecticides and with minimal external inputs.

A conventional push-pull field with Napier grass on border and silver leaf *Desmodium* intercropped with maize. © Centre of Insect Physiology and Ecology

6.3 tons per hectare in the Kisii district. In comparison, yields in the maize–bean intercrop ranged from a low of 0.9 ton per hectare in Suba district to a high of 3.9 tons per hectare in Trans-Nzoia districts. Maize monocultures were low yielding—between 1 ton per hectare in Suba and Busia districts to 3.9 tons per hectare in Trans Nzoia districts. Higher yields are recorded in push-pull systems despite a reduction in the area of land allocated to maize due to the intercropping of selected grasses and legumes.[13]

- In the same study, a cost benefit analysis showed that with the exception of one district, the push-pull systems outperformed bean and maize monoculture systems economically in the first year despite higher initial variable and labor costs. In calculating labor and non-labor costs, variable costs, and revenues for each farm and cropping system, the gross benefits were significantly higher for farms using push-pull systems than for farms using maize–bean intercrop and maize mono-crop systems in *all* years and in *all* districts studied.[14]
- The push-pull and *Striga*-suppression tactics have contributed to increased livestock production of both milk and meat by providing quality fodder for livestock and different crop residues. In the Suba district, dairy cattle production suffered from the unstable availability and seasonality for fodder production, but with more than 250 farmers have adopted push-pull systems, the number of improved dairy cattle increased from 4 in 1997 to 350 by 2002. This increase in fodder supports small farms where land competition is high, and a growing industry as well as a way to generate an alternative income.
- A study by the University of Haifa in Israel assessing the impact of push-pull technology on soil quality showed the abundance and diversity of beneficial soil arthropods were significantly higher in push-pull plots as compared to maize monocultures.
- The habitat management strategies are a promising method for gender empowerment, as the program has focused trainings equally for both men and women. For the farmers who have adopted push-pull since 1998 to 2014, more than 50 percent are women. This has provided women with income through the sale of farm grain surpluses, fodder, and seed.[15]

**Figure 1: Number of farmers who had adopted push-pull in East Africa by 2014[16]**



- By 2014, over 96,000 East African farmers have adopted the push-pull system. Their maize yields have increased from an average of 1 ton to 3.5 tons per hectare without the use of chemical insecticides and with minimal external inputs.

Push-pull is one of the most successful examples of conservation biological control, which holds great promise for maize growing regions throughout eastern and southern Africa. In addition to enhancing maize yields, the strategy increased small livestock production, conserved soil resources, controlled important weeds, enhanced functional biodiversity, and increased incomes and women's empowerment. Push-pull is an appropriate technology for poor farmers in East Africa because it is based on locally available renewable inputs and can thus be easily integrated into traditional poly-culture cropping systems. On a larger scale, principles of push-pull can be applied to low-input and organic agriculture systems worldwide.

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## ENDNOTES

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12 Unless otherwise indicated all sources for this section are from: Khan, Zeyaur R. and John A. Pickett. "The 'Push-Pull' Strategy for Stemborer Management: A Case Study in Exploiting Biodiversity and Chemical Ecology." *Op. Cit.*

13 Khan, Zeyaur. et al. "Economic performance of the 'push-pull' technology for stemborer and *Striga* control in smallholder farming systems in western Kenya.". *Crop Protection* 27.7 (2008): 1084-1097.

14 *Ibid*.

15 *Push–Pull and Gender: Improving Livelihoods and Social Equity.* ICIPE, 2013. http://www.push-pull.net/Push-Pull-and-Gender.pdf (accessed October 7, 2014).

16 Push-Pull.net (ICIPE). *Adoption.* http://www.push-pull.net/adoption.shtml (accessed December 8, 2014).

**FRONT PAGE PHOTO:**

A young farmer in conventional push-pull field, Kuria. © Centre of Insect Physiology and Ecology

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