"PUSH-PULL" ANNUAL REPORT FOR THE YEAR 2000-2001

COMPLETED STUDIES (Abstracts of papers in refereed journals. For full list see Publications List)

Khan Z.R., Pickett J.A., Wadhams L. and Muyekho F. (2001) **Habitat management strategies for the control of cereal stemborers and striga in maize in Kenya. *Insect Science and Its Application* 21(4), 375–380.**

ABSTRACT: Maize is the principal food and cash crop for millions of people in the predominantly mixed crop–livestock farming systems in Kenya. Stemborers and striga (*Striga hermonthica*) are major constraints to increased maize production in eastern Africa. An intercropping and trap crop system has been developed, using a 'push-pull' strategy, for the control of stemborers in smallscale maize farming systems. The 'push-pull' strategy involves trapping stemborers on highly susceptible trap plants (pull) and driving them away from the crop using repellent intercrops (push). Napier grass (*Pennisetum purpureum* Schumach) and Sudan grass (*Sorghum vulgare sudanense* Stapf.) are used as trap plants, whereas molasses grass (*Melinis minutiflora* Beauv.) and two species of desmodium (*Desmodium uncinatum* Jacq. and *Desmodium intortum* Urb.) repel ovipositing stemborers. The integrated 'push-pull' strategies were shown to increase parasitism of stemborers through attraction of parasitoids to one of the intercrops, molasses grass. The leguminous intercrop, silver leaf desmodium, drastically reduced damage to maize by the parasitic weed, striga. This aspect was further investigated and developed for integration with stemborer control. On-farm trials with farmers in Kenya have shown significant yield increases in maize farming.

Khan Z.R., Pickett J.A., van den Berg J., Wadhams L.J. and Woodcock C.M. (2000) **Exploiting chemical ecology and species diversity: Stem borer and striga control for maize and sorghum in Africa. *Pest Management Science* 56, 957–962.**

ABSTRACT: Stem borers, comprising the larvae of a group of lepidopterous insects, and parasitic witchweeds, particularly *Striga hermonthica* and *S. asiatica*, cause major yield losses in subsistence cereal production throughout sub-Saharan Africa. Studies are described that have led to the development of a 'push-pull' strategy for minimising stem borer damage to maize and sorghum. This involved the selection of plant species that could be employed as trap crops to attract colonisation away from the cereal plants, or as intercrops to repel the pests. The two most successful trap crop plants were Napier grass, *Pennisetum purpureum*, and Sudan grass, *Sorghum sudanensis*. The intercrop giving maximum repellent effect was molasses grass, *Melinis minutiflora*, but two legume species, silverleaf, *Desmodium uncinatum*, and greenleaf, *D. intortum*, gave good results and had the added advantage of suppressing development of *S. hermonthica*. In terms of stem borer control, the plant chemistry responsible involves release of attractant semiochemicals from the trap plants and repellent semiochemicals from the intercrops. With *M. minutiflora*, parasitism of stem borers was also increased by certain chemicals repellent to ovipositing adults. The mechanism of striga control has not been fully elucidated, but allelopathic effects from the *Desmodium* species have been shown to involve stimulation of germination and interference with haustorial development. Significant beneficial effects have been obtained with the individual components of these push-pull strategies. However, the most robust crop-protection package is obtained when these components are combined. The trap crop and intercrop plants also provide valuable forage for cattle, often reared in association with subsistence cereal production. There has been considerable take-up of the system within the communities where farmer-managed trials have been carried out, particularly in the

Trans Nzoia and Suba districts of Kenya, and the programme is set to expand throughout and beyond Kenya.

INTRODUCTION

Stemborers are the major insect pests of cereals in many areas of eastern and southern Africa. At least four species infest maize in the region, with yield losses reported to vary from 20–40% depending on agroecological conditions, crop cultivar, agronomic practices and intensity of infestation.

Parasitic weeds in the genus *Striga* infest 40% of the arable land in the savanna region, causing an annual crop loss of 7 to 13 billion dollars. Around the Lake Victoria basin, infestation by *Striga hermonthica* causes 30 to 100% loss in maize yield. Striga infestation is associated with increased cropping intensity and declining soil fertility. Infestations by *Striga* spp. have resulted in the abandonment of much arable land by farmers in Africa, and the problem is more serious in areas with low soil fertility and rainfall.

Spraying for stemborer control with pesticides is not only expensive and harmful to the environment, but also is usually ineffective, as the chemicals cannot reach the larval stages that reside inside the stem. On the other hand, weeding—the conventional method for striga control—is both time-consuming and labour-intensive.

It is estimated that preventing crop losses from stemborers and striga weeds could boost maize harvests enough to feed an additional 30 million people in the region.

The 'push-pull' habitat management approach— developed by ICIPE in partnership with several institutions including the Kenya Agricultural Research Institute (KARI), the Kenya Ministry of Agriculture, and the Institute of Arable Crops Research, Rothamsted, UK—exploits chemical ecology and biodiversity in a novel manner to limit crop losses to stemborers and striga weeds. At the same time, it conserves soil and water while preserving biodiversity.

The approach involves trapping stemborers on highly susceptible trap plants (the pull) and driving them away from the maize crop using repellent intercrops (the push). Plants which repel stemborers as well as inhibit striga have also been identified. On-farm trials with farmers in Kenya have confirmed that these approaches, conducted separately and together, result in significant yield increases.

A major accomplishment of **Biological Control of Cereal Stemborers in Subsistence Agriculture in Africa** project during the 2000–2001 period was the evaluation of the impact of a parasitic wasp, *Cotesia flavipes*, introduced by ICIPE in 1993 on stemborer populations in southeastern Kenya. Our analysis indicates that the parasitoid has decreased the stemborer population by 30–50%, which, coupled with work conducted on crop losses caused by stemborers, suggests a maize yield increase of about 8–10%. Additionally, we now have evidence that *Co. flavipes* is established in several countries beyond Kenya, including Tanzania, Uganda, Malawi, Mozambique, Zanzibar and Ethiopia. An important activity over the coming years will be to conduct impact assessment in these countries as well.

A second parasitoid of *Chilo partellus*, one of the most important borers in the eastern and southern African region, has been imported into Kenya, and we believe that it will result in additional mortality to stemborers. Host-range testing of this new parasitoid, *Xanthopimpla stemmator*, has shown that it can successfully parasitise four of the major stemborer species found in eastern and southern Africa. The project was evaluated by an external team in early 2001, and the team recommended that the Netherlands Government continue providing support. As such, a new 4-year project was approved for 2002 to the end of 2005.

Other projects in this sub-division are looking at the impacts of genetically modified maize, and control of pests of banana (*Musa* spp.).

RESEARCH HIGHLIGHTS

A. 'Push-Pull' Strategies for the Management of Stemborers and Striga Weed in Maize-Based Farming Systems in Eastern and Southern Africa

The plants that are used as trap or repellent plants in a push-pull strategy are Napier grass (*Pennisetum purpureum*), Sudan grass (*Sorghum vulgare sudanense*), molasses grass (*Melinis minutiflora*) and silver leaf desmodium (*Desmodium uncinatum*). Napier grass and Sudan grass have shown potential for use as trap plants, whereas molasses grass and silverleaf desmodium repel ovipositing stemborers. Molasses grass, when intercropped with maize, not only reduces infestation of the maize by stemborers, but also increases stemborer parasitism by a natural enemy, *Cotesia sesamiae*. In addition, *Desmodium*, when intercropped with maize, inhibits striga. All four plants are of economic importance to farmers in eastern Africa as livestock fodder and have shown great potential in stemborer and striga management in farmer participatory on-farm trials.

In addition, the habitat management approach reduces soil erosion (via the cover crop of *Desmodium*) and increases soil fertility (via its nitrogen-fixing properties). The full integration of several crop protection approaches in the push-pull management system (i.e. trap crops and increased parasitism of pests), prevents high selection pressure on any single approach, thereby creating a sustainable system by preventing the rapid development of resistance or adaptation by pests; this is a common problem with single control measure, such as the use of pesticides or genetically-based resistance.

The farmers 'feedback is highly positive, particularly among those who maintain improved dairy cattle, as they readily see the advantages of combining maize and forage production systems. Transfer of the push-pull technology is being expanded into Uganda, Ethiopia and Malawi.

1. Level of participation

The 'push pull 'approach is being tested by more than 600 farmers in Trans-Nzoia, Suba, Busia, Bungoma, Kisii and Rachuonyo districts of western Kenya. The numbers of farmers participating in field trials has increased steadily in the past two years.

2. Food security

Intercropping or mixed cropping of maize, grasses and fodder legumes has enabled farmers in the study areas to increase crop yields and has thus contributed to improved food security (Fig. 1).This feature is in keeping with the mixed farming systems prevalent in eastern and southern Africa.

3. Dairy and livestock production

Push-pull 'strategies have contributed significantly —especially on small farms— to increased livestock production (milk and meat) by availing more fodder and crop residues. For example, in Suba District of western Kenya, which produces 6 million litres of milk against an estimated annual demand of 13 million litres, the majority of cattle are indigenous (Zebu). In this district, a major constraint to keeping improved dairy cattle for milk production is the inadequate supply and seasonality of feed, often of low quality. Push-pull 'strategies, adopted by 150 farmers in this district, have increased livestock feed supply and milk production measurably.

4. Exploiting biodiversity

The 'push-pull 'approach embodies maintenance of species diversity through intercropping with different plants as a means of avoiding the pest problems usually associated with monocultures. It is well established that wild host plants on uncultivated land adjacent to crop fields are important refugia for natural enemies as well as sources of nectar, pollen, and host/alternate prey.

Although the effectiveness of the þush-pull ’strategy in controlling stemborers had been demonstrated, there was lack of information on its impact on stemborer predators. Our studies show that [mainly generalist] predators are significantly more abundant in push-pull intercrops than in maize monocrops. The predator complex included ants, spiders, earwigs and cockroaches. Other taxa were also recovered, although in relatively lower numbers. They included coccinellids, staphylinids, reduviids, nabiids and gryliids. These predators are crucial pest population regulators. Stemborer populations were conspicuously lower in þush-pull ’fields than in maize monocrops. The pest management potentials of þush-pull ’through enhancement of stemborer predator numbers was demonstrated in this study (Fig. 2).

5. Income generation and gender empowerment

The þush-pull ’strategy has contributed towards raising smallholder farmers ’incomes through sale of farm grain surpluses, fodder and *Desmodium* seed, and to the empowerment of the Women, Farmers ’ and Youth groups.

6. Ethiopia, Malawi and Uganda

The þush-pull ’technology is being introduced in Ethiopia, Malawi and Uganda. Planning workshops, exchange of scientists and technical staff, and establishment of field experiments were initiated with selected farmers in close collaboration with national scientists and extension staff.

Ethiopia

A planning workshop in Makelle, Ethiopia was organised on 28 and 29 August 2001 to review the stemborer and striga problems in cereal-based farming systems in Ethiopia. More than 45 scientists and extensionists from different parts of Ethiopia held a 2-day discussion with representatives of ICIPE, Kenya Agricultural Research Institute and the Ministry of Agriculture and Rural Development (Kenya). The Ethiopian delegation agreed that the technology could find an important place in the management of striga and stemborers in their country, with appropriate adaptations. It was agreed that a substantive research project will be developed and field trials will start in early 2002. A proposal is now ready for discussion and finalisation.

Two Ethiopian scientists also visited ICIPE in July 2001 to familiarise themselves with the strategy.

Malawi

A planning workshop of 15 scientists from Malawi, ICIPE, and IACR-Rothamsted was held on 4–5 October 2001 at Bvumbwe Research Station, Limbe, Malawi to discuss plans to undertake þush-pull ’research and validation of trials under Malawian conditions. It was agreed that field trials should start in late 2001 in Limbe area. With the help of ICIPE technical staff, 10 farmers in Limbe were selected and field trials were initiated in November 2001. On-station trials for training and demonstration are also planned at both Bvumbwe Research Station, Limbe and Chitedze Research Station, Lilongwe.

Uganda

On-station trials were conducted in 2001 in collaboration with scientists from the National Agricultural Research Organisation (NARO). The Ugandan Project is selecting appropriate trap and repellent plants for stemborer control and conducting on-farm trials with 30 farmers in three locations.

7. Mechanism of *Striga* suppression by *Desmodium*

An allelochemical mechanism (seed germination with haustorium inhibition) was shown to play a significant role in *Striga* suppression by *Desmodium*. Five to six compounds of a complex blend from *Desmodium* root exudate were identified, some with germination-stimulation and some with haustorium-inhibition activities. Other haustorium-inhibiting components present in the polar fraction of the exudates are being isolated for characterisation and bioassays. This will constitute a basis for introducing *Desmodium* traits responsible for *Striga* suppression into food legumes and maize.