

# HABITAT MANAGEMENT STRATEGIES FOR CONTROL OF STEMBORERS AND STRIGA WEED IN CEREAL-BASED FARMING SYSTEMS

## *Background, approach and objectives*

Maize and sorghum are the principal food and cash crops for millions of the poorest people in the predominantly mixed crop–livestock farming systems of eastern and southern Africa. Stemborers [*Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) and *Busseola fusca* Fuller (Lepidoptera: Noctuidae)] and striga weeds [(*Striga hermonthica* and *Striga asiatica* (Scrophulariaceae))] are the two major biotic constraints to increased maize and sorghum production in eastern Africa.

At least four species of stemborers infest maize and sorghum crops in the region, causing reported yield losses of 20–40% of the potential output. Stemborers are difficult to control, largely because of the cryptic and nocturnal habits of the adult moths and the protection provided by the stem of the host crop for immature stages. The main method of stemborer control, which is recommended to farmers by the governments' ministries of agriculture in the region, is the use of chemical pesticides. However, this is uneconomical and impractical for many resource-poor small-scale farmers.

Parasitic weeds in the genus *Striga* threaten the lives of over 100 million people in Africa and infest 40% of arable land in the savanna region, causing an estimated annual loss of \$7 to \$13 billion. Infestations by *Striga* spp. have resulted in the abandonment of some arable land by farmers in Africa. The problem is more widespread and serious in areas where both soil fertility and rainfall are low. Unfortunately, subsistence farmers in the region must engage themselves in weeding out striga, which is a time-consuming and labour-intensive activity, mainly delegated to women and children. Recommended control methods to reduce striga infestation include heavy applications of nitrogen fertiliser, crop rotation, use of trap crops and chemicals to stimulate suicidal seed germination, hoeing and hand pulling, herbicide application and the use of resistant or tolerant crop varieties. Effectiveness of all these methods, including the most widely practised—hoe weeding—is seriously limited by the reluctance of farmers to accept them, for both biological and socioeconomic reasons.

The third constraint, poor soil fertility, has also been identified by farmers as a major limiting factor to cereal production. It results from a poor inherent fertility status together with high population pressure and poor management practices. Due to the low inherent fertility status of the soils in the target region, their low buffering capacity and the inability of small-scale farmers to invest in soil fertility management, soils are degrading rapidly and are hardly able to sustain acceptable maize yields. N and P are the major limiting nutrients. Lack of adequate soil management also negatively affects the soil organic matter pool that is responsible for a series of production and environmental service functions essential for sustainable crop production in a healthy environment. The use of inorganic fertiliser to supply plant nutrients by resource-poor farmers is limited. Although many soil fertility restoration technologies such as cereal–legume rotations, biomass transfers, farmyard manure, tree-fallowing and green manure cover crops exist that can redress this situation, their potential for use is greatly influenced by the land size, capital and labour constraints. Striga has been known to cause large losses in maize yields on N limited soils of eastern Africa. In western Kenya and eastern Uganda, widespread P deficiency limits maize yields on high P-fixing soils. Under these conditions, the maize crop responds to moderate applications of P fertiliser when striga weed population is low. However, this response was found to be negligible under high striga infestation and it was concluded that small additions of P fertilisers are not effective under high striga occurrence. It is therefore, recommended that P fertilisation must be combined with effective and sustainable striga control, or else resource-poor farmers would require very high P fertilisation to sustain maize yield increases.

Therefore, reducing the yield losses caused by stemborers and striga and by improving soil fertility through improved management strategies could significantly increase maize and sorghum production, resulting in better nutrition and purchasing power for many producers of these crops.

A sustainable solution to these problems can only be provided by a single platform technology that simultaneously addresses these major constraints.

With funding from the Gatsby Charitable Foundation, ICIPE and collaborative partners have developed alternative strategies for stemborer and striga management using technologies appropriate to resource-poor farmers which have shown a high adoption rate by farmers and potential for spontaneous technology transfer within farming communities. This has resulted in significant impact on food security by increased farm productivity in the region. (See 2002–2003 ICIPE Annual Scientific Report.)

The R&D work, undertaken as a joint collaborative effort with KARI, the Ministry of Agriculture (Kenya) and Rothamsted Research in UK, is based on novel strategies that combine a 'push-pull' tactic for controlling stemborers on one hand, and an *in situ* suppression and elimination of striga on the other, in maize-based farming systems. The 'push-pull' tactic involves trapping stemborers on highly attractant trap plants (pull) while driving them away from the maize crop using repellent intercrops (push). The striga control tactic on the other hand is based on the use of intercrops that act through a combination of mechanisms, including seeds that fail to develop and attach onto the host. These strategies undertake a holistic approach to understanding and utilising chemical ecology and agrobiodiversity for stemborer and striga management. These plants also improve soil fertility by fixing nitrogen.

Plants that have been identified as effective in 'push-pull' tactics include Napier grass (*Pennisetum purpureum*), Sudan grass (*Sorghum vulgare sudanense*), molasses grass (*Melinis minutiflora*), silverleaf desmodium (*Desmodium uncinatum*) and greenleaf desmodium (*Desmodium intortum*). Napier grass and Sudan grass have shown potential for use as trap plants, whereas molasses grass and silverleaf desmodium repel ovipositing stemborer moths. Molasses grass, when intercropped with maize, not only reduced infestation on the maize crop by stemborer moths, but also increased stemborer parasitism by a natural enemy, *Cotesia sesamiae*. In addition, desmodium, when intercropped with maize, suppresses and eliminates striga. These 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. These innovations have found ready acceptance among the small-scale and medium-scale farmers in East Africa. The adoption of the 'push-pull' technology in high population density areas around the Lake Victoria region is very high and consisted of more than 3500 farmers in 15 districts in the region by the end of 2005 (see Figures 1 and 2). Similarly, more than 600 farmers in 3 districts in central Kenya have also adopted the technology where KARI scientists are implementing a Farm Africa-funded project on this technology.

The major objective of this programme is to reduce poverty by improving the livelihood of resource-poor farmers through increased production of cereal crops, fodder plants and milk.

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## Work in progress

### 1. On-farm management of stemborer and striga infestation for increasing maize yield

The habitat management strategies based on the 'push-pull' and striga suppression-elimination tactics, conducted in 15 districts in Kenya have helped more than 3500 participating farmers

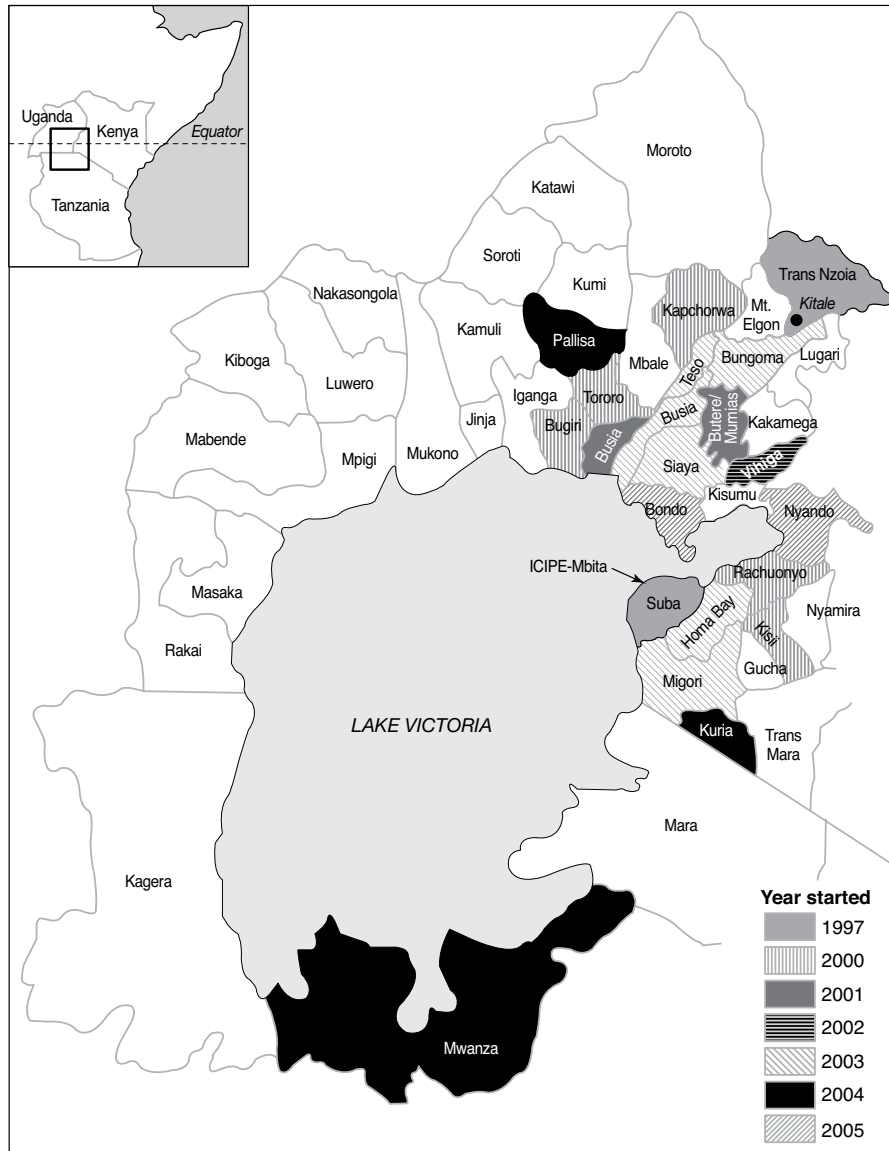


Figure 1. Districts in which the 'push-pull' technology has been adopted

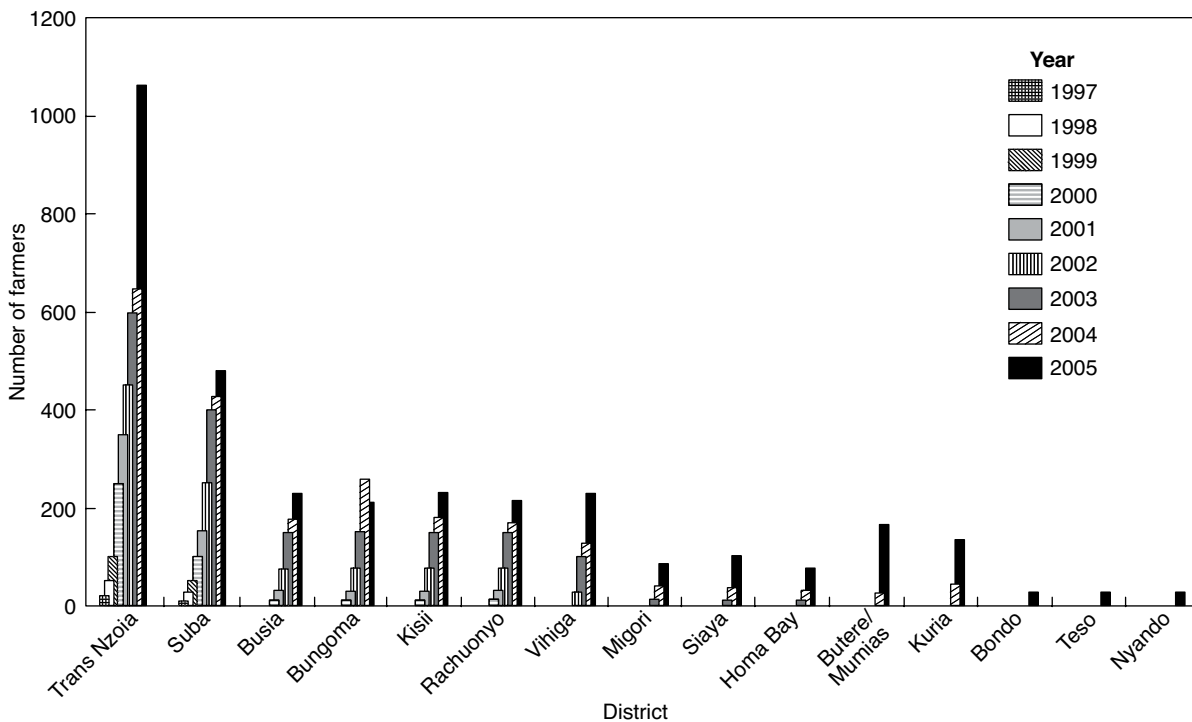


Figure 2. Adoption of the push-pull technology in Kenya, 1997–2005



**Table 1. Comparison of stemborer and striga infestation, and yield of maize crop in 'push-pull' and control maize fields in various districts of Kenya in 2004 and 2005**

District	No. Push-pull farmers	Stemborer infestation (%)		Striga infestation (Striga/100 maize plants)		Yield (t/ha)	
		Push-pull	Control	Push-pull	Control	Push-pull	Control
<b>2004</b>							
Trans Nzoia	650	6.8	19.0**	-	-	5.4	4.1*
Suba	430	7.8	22.7**	37.6	266.4**	2.9	1.6**
Kisii	180	5.6	16.3**	2.4	41.5**	2.6	2.0*
Rachuonyo	170	4.7	18.0**	121.5	408.9**	3.7	1.9**
Bungoma	160	5.8	19.6**	4.0	150.6**	4.8	2.1**
Busia	175	4.2	10.3**	26.3	462.7**	4.1	1.9**
Vihiga	125	1.0	2.1*	52.5	393.3**	5.3	3.1**
Migori	40	15.7	31.0**	230.9	1526.4**	4.4	2.7**
Homa Bay	30	12.6	15.5 ns	56.1	125.2*	3.0	1.6*
Butere/Mumias	25	4.3	13.5**	79.2	486.8**	4.7	2.7**
Siaya	35	1.6	4.2**	76.7	875.9**	4.0	2.3**
Kuria	45	5.6	16.3**	1.5	22.6*	2.6	2.0*
<b>2005</b>							
Trans Nzoia	1065	6.2	18.9**	-	-	5.7	4.1**
Suba	480	3.6	20.5**	8.9	190.5**	3.8	1.6**
Kisii	230	3.3	10.2**	3.4	27.9*	4.4	3.7**
Rachuonyo	215	0.0	2.7*	14.0	283.9**	3.8	1.4**
Bungoma	211	5.6	14.3**	11.2	176.6**	4.5	2.8**
Busia	230	5.1	15.2**	90.0	477.5**	5.6	2.7**
Vihiga	230	7.1	17.2**	87.9	602.4**	4.5	2.6**
Migori	85	5.3	28.0**	59.8	516.4**	3.6	1.7**
Homa Bay	75	4.4	11.7**	74.2	257.3**	4.3	2.2**
Siaya	100	3.0	9.5**	90.8	494.4**	3.1	1.7**
Teso	25	5.1	12.6**	420.1	1384.3**	3.8	1.1**
Butere/Mumias	165	6.2	31.3**	150.1	620.3**	5.6	2.5**
Bondo	25	8.3	14.0**	261.0	610.1**	1.7	0.9*
Kuria	135	4.1	30.9**	6.4	214.5**	4.2	1.7**
Nyando	25	1.2	8.1**	105.9	432.0**	-. <sup>++</sup>	-. <sup>++</sup>

- No striga in Trans Nzoia district.

\*\*No harvest, crop failure due to drought.

\*Difference significant (P < 0.05); \*\* difference significant (P < 0.01); ns, not significant.

(Figure 2) to increase their maize yields by an average of 20% in areas where only stemborers are present and by more than 50% in areas where both stemborers and striga are problems (Table 1).

## 2. Development of habitat management strategies for sorghum

The Project is developing strategies for control of stemborers and striga weed for sorghum farmers. (See 2002–2003 ICIPE Annual Scientific Report.) This technology will be particularly applicable for the arid and semi-arid regions where striga intensity has resulted in the abandonment of arable land by farmers. Higher crop yields and improved livestock production for sorghum and millet producing farmers would support many rural households under existing socioeconomic and agroecological conditions and thus, there would be less pressure for human migration to environments designated for protection.

On-station and on-farm trials were continued during 2004 and 2005 to evaluate effectiveness of greenleaf desmodium, *Desmodium intortum*, in controlling stemborers and striga weed when intercropped with sorghum. *Desmodium intortum* is a drought tolerant species and can fit very well with sorghum and millet. There were highly significant reductions in both *S. hermonthica* emergence and the proportion of stemborer-damaged plants in the intercrop compared to the monocrop in both trials during most of the period. Moreover, grain yields were significantly higher in the former in both trials. These results demonstrate that intercropping sorghum with *D. intortum* offers an effective control of both pests, leading to higher grain yields (Tables 2 and 3).

## 3. Use of food legumes for the management of striga in maize and sorghum crops

We continued to evaluate different food legumes for use in management of striga in maize and sorghum crops. Several food legumes were intercropped with maize or sorghum in on-station trials, and data on striga emergence and grain yields were collected (Table 4). Intercropping maize

**Table 2. Use of greenleaf desmodium, *Desmodium intortum*, for management of striga weed and stemborers in sorghum, on-station trials at ICIPE-Mbita, 2004–2005**

Cropping season	Treatment	Stemborer damage (%)	No. of striga/84 sorghum plants	Yield (t/ha)
2004 Long Rains	Sorghum monocrop	19.6	269.5	1.9
	Sorghum with <i>D. intortum</i>	11.9*	0.0**	2.7**
2004 Short Rains	Sorghum monocrop	9.2	130.1	3.2
	Sorghum with <i>D. intortum</i>	5.5ns	0.2**	5.7**
2005 Long Rains	Sorghum monocrop	2.9	532.2	2.9
	Sorghum with <i>D. intortum</i>	1.9*	1**	4.6**
2005 Short Rains	Sorghum monocrop	9.5	411.7	1.9
	Sorghum with <i>D. intortum</i>	2.4**	0.4**	2.9**

\*Difference significant ( $P < 0.05$ ); \*\*difference significant ( $P < 0.01$ ); ns not significant.

**Table 3. Use of greenleaf desmodium, *Desmodium intortum*, for management of striga weed in sorghum, on-farm trials in Rachuonyo District, Kenya, 2005**

Treatment	Stemborer damage (%)	No. of striga/84 sorghum plants	Yield (t/ha)
Sorghum monocrop	11.8	349.0	2.2
Sorghum with <i>D. intortum</i>	2.7**	78.8**	3.2*

\*Difference significant ( $P < 0.05$ ); \*\*difference significant ( $P < 0.01$ ).

or sorghum with desmodium resulted in significantly lower striga infestation and enhanced grain yields than any of the five legumes tested.

#### 4. Evaluation of 'push-pull' technology by participating and non-participating farmers

We undertook an extensive study on perception of 900 'push-pull' participating farmers and 900 visiting farmers in 15 districts in Kenya on the technology. Participating farmers rated their own 'push-pull' fields as compared to their own practice in controlling stemborers and striga, and increasing soil fertility and maize grain yields. The visiting farmers compared the 'push-pull' strategy with control plots during field days organised in each district. The performance of the technologies was rated on a scale of 1–4, where 1 was the least and 4 the best performing.

The key criteria which farmers considered in evaluating the push-pull technology were reduced stemborer damage, reduced striga weed, increased maize grain yields and ability of the technology to improve soil fertility (Table 5). Across the districts and all the criteria, there were significant differences in the performance rating between the push-pull technology and the farmers' practices, except for reduced stemborer rating in Migori, Nyando and Rachuonyo districts as evaluated by participating farmers. Another exception was on striga rating in Bondo and Nyando districts, and also on soil fertility rating and increased maize grain yields in Bondo district by participating farmers. In both participating and non-participating groups the highest score was on reduced striga count followed by stemborer control. In addition, mean scores for increased maize yields and ability of the technology to improve soil fertility were all above 3.0 (Table 5).

**Table 4. Use of food legumes for the management of stemborers and striga in maize and sorghum crops, long rains, 2005**

Treatment	Mean striga counts/54 plants	Yield (t/ha)
<b>Maize</b>		
Maize + <i>Desmodium uncinatum</i>	1.2 c	5.9 a
Maize + <i>Crotalaria ochroleuca</i>	57.7 b	3.4 b
Maize + Green gram ( <i>Vigna radiata</i> )	63.2 ab	2.8 bc
Maize + Groundnut ( <i>Arachis hypogaea</i> )	80.2 ab	2.5 bc
Maize + Cowpea ( <i>Vigna unguiculata</i> )	132.0 ab	2.3 c
Maize + beans ( <i>Phaseolus vulgaris</i> )	149.0 ab	2.3 c
Maize monocrop	307.0 a	2.3 c
<b>Sorghum</b>		
Sorghum + <i>Desmodium uncinatum</i>	1.5 c	4.6 a
Sorghum + <i>Crotalaria ochroleuca</i>	69.3 b	3.7 b
Sorghum + Green gram	272.5 ab	2.7 c
Sorghum + Groundnut	341.5 ab	2.7 c
Sorghum + Cowpea	306.3 ab	3.0 bc
Sorghum + beans	410.8 ab	3.0 bc
Sorghum monocrop	1124.3 a	3.3 bc

For each crop (maize or sorghum) means within a column followed by different letters are significantly different ( $P < 0.05$ ).

**Table 5. Rating of 'push-pull' technology as compared to farmers' own practices by participating and visiting farmers in different districts of western Kenya, June 2005**

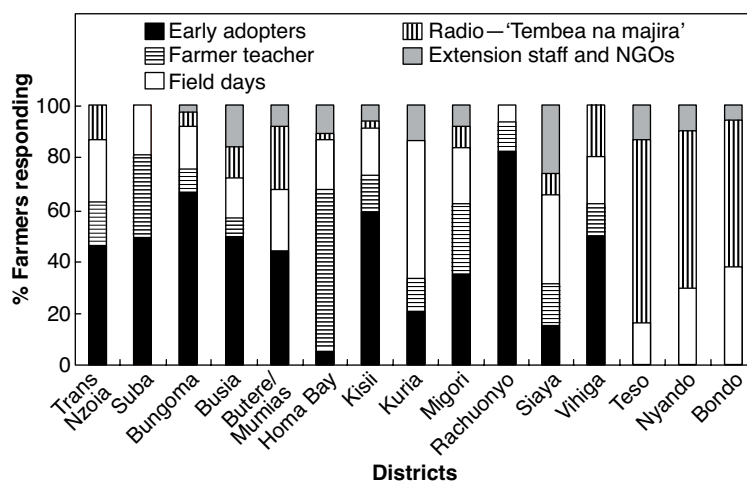
District	Technology	Rating by practising farmers				Rating by visiting farmers			
		Reduced stemborer	Reduced striga	Increased soil fertility	Increased yield	Reduced stemborer	Reduced striga	Increased soil fertility	Increased yield
Bungoma	PP	3.3	3.5	3.4	3.9	3.7	3.6	3.4	4.0
	FP	2.7**	2.8**	2.8**	3.1**	2.2**	1.5**	2.0**	1.8**
Busia	PP	3.5	3.3	3.2	3.8	3.3	3.5	3.2	3.9
	FP	2.7**	2.6**	3.1ns	2.7**	2.2**	2.0**	2.5**	2.5**
Butere/Mumias	PP	3.3	3.1	3.1	3.5	4.0	3.9	3.3	3.9
	FP	2.7**	2.1**	2.0**	2.4**	1.4**	1.6**	1.4**	1.1**
Homa Bay	PP	3.1	3.2	3.4	3.5	3.7	3.9	3.6	3.9
	FP	1.7**	1.5**	1.9**	2.1**	1.9**	1.7**	2.0**	2.0**
Kisii	PP	3.3	2.8	3.0	3.4	3.8	3.9	3.3	4.0
	FP	2.9*	2.4ns	2.6**	2.9*	3.1*	2.6**	2.8**	3.3**
Kuria	PP	3.4	3.3	3.5	4.0	3.7	3.5	3.5	4.0
	FP	2.3**	2.0**	2.1**	2.2**	1.9**	2.2**	2.1**	2.0**
Migori	PP	3.4	3.3	3.3	4.0	3.9	3.8	3.4	4.0
	FP	3.0ns	2.0**	2.1**	2.4**	2.2**	1.3**	1.9**	1.8**
Rachuonyo	PP	3.0	3.0	2.9	3.1	3.8	3.7	3.2	4.0
	FP	2.7*	2.2**	2.3**	2.6*	2.1**	1.6**	2.5*	1.7**
Siaya	PP	3.6	3.5	3.3	3.7	3.5	3.5	3.5	4.0
	FP	2.4**	2.2**	1.8**	2.7**	2.5**	2.2**	1.9**	1.6**
Suba	PP	3.5	3.8	3.2	3.6	++	++	++	++
	FP	2.7**	2.4**	2.3**	2.7**	++	++	++	++
Vihiga	PP	3.7	3.8	3.6	4.0	3.7	3.8	3.6	4.0
	FP	1.8**	2.3**	2.1**	1.9**	1.8**	2.3**	2.1**	1.9**
Trans Nzoia	PP	3.7	-	3.3	4.0	3.7	-	3.3	4.0
	FP	1.6**	-	1.7**	1.6**	1.6**	-	1.7**	1.6**
Bondo*	PP	3.0	1.8	2.6	2.2	3.3	3.4	3.1	4.0
	FP	2.8ns	1.5ns	2.0*	2.1ns	2.3**	1.9**	2.2**	1.5**
Nyando*	PP	2.4	1.9	2.8	2.4	3.5	3.9	3.4	3.8
	FP	2.3ns	1.8ns	2.1**	1.8ns	1.4**	1.8**	1.8**	1.6**
Teso*	PP	3.7	2.9	3.2	3.6	3.8	3.7	3.5	4.0
	FP	2.4**	1.5**	2.1**	1.7**	2.1**	1.7**	1.7**	1.3**

Rating scale of 1–4, where 1 is the least performing and 4 is the best performing technology.

PP, Push-pull technology; FP, Farmer's own practice; \*New districts where farmers adopted the push-pull technology in the long rains season of 2005; -, no striga in Trans Nzoia; ++, rating not done; \*, difference significant ( $P < 0.05$ ); \*\*, difference significant ( $P < 0.01$ ); ns, difference not significant ( $P > 0.05$ ).

### 5. Sources of information regarding 'push-pull' and reasons for its adoption by farmers

Nine-hundred farmers in 15 districts were interviewed on how they obtained information about the 'push-pull' technology and the reasons for adopting it. Farmers in most of the districts, who adopted the technology more than three years ago learnt about it from field days, farmer teachers and earlier adopters, whereas the majority of farmers in the three new districts (Bondo, Nyando and Teso) learnt about it mainly from a national radio programme 'Tembea na Majira' (Figure 3). More than 80% of the farmers in Butere/Mumias, Homa



**Figure 3.** Sources of information on the 'push-pull' technology and proportions of farmers who accessed them before adopting 'push-pull' in different districts

Bay, Migori, Suba and Vihiga districts indicated striga control as the main reason for adopting the technology, whereas majority of the farmers in Trans Nzoia district adopted it for stemborer control (Figure 4). Increased farm productivity was also reported as another reason for adopting the technology by about 25% of the farmers in Bondo, Bungoma, Kisii, Kuria, Siaya and Teso districts (Figure 4). Soil improvement as the primary reason for adopting the technology appeared low.

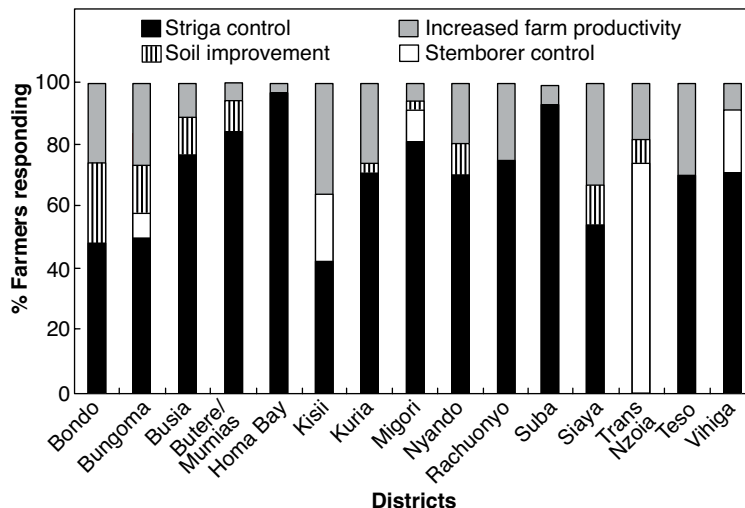
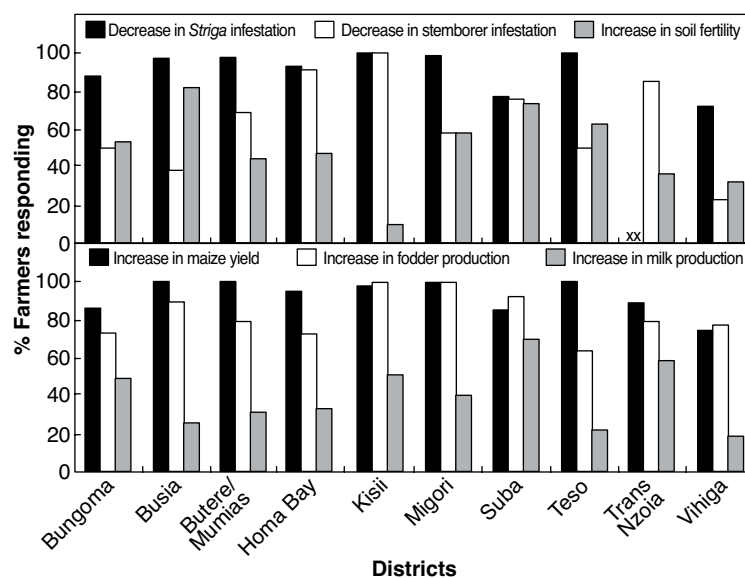


Figure 4. Reasons given by farmers for adopting the 'push-pull' technology in different districts

### 6. Farmers' perception of benefits realised following adoption of the 'push-pull' technology

Majority of farmers in 9 out of 10 districts (except Trans Nzoia) reported a reduction/decrease in striga infestation on their farm after adopting the 'push-pull' technology (Figure 5). About 80% of the farmers in Trans Nzoia, Homa Bay, Kisii and Suba districts, and more than 50% of those in Bungoma, Butere/Mumias, Migori and Teso districts reported reduced stemborer infestation after adopting the technology. Over 80% of the farmers in Busia district, and over 50% in Bungoma, Migori, Suba and Teso reported an improvement in soil fertility in the 'push-pull' plots as a result of reduced soil erosion and increased nitrogen fixation. Increase in maize and fodder production was reported by majority of farmers in all the 10 districts following adoption of the technology, whereas more than 50% of the farmers in Kisii, Suba and Trans Nzoia districts reported an increase in milk production due to increased fodder production (Figure 5).



xxNo striga in Trans Nzoia district

Figure 5. The benefits realised by farmers following adoption of the 'push-pull' technology in various districts in Kenya

### 7. Farmers' perception about labour issues on adoption of the 'push-pull' technology

Labour has been an important constraint in the adoption of new technologies. A study was undertaken in 14 districts of Kenya on farmers' perception on labour changes following adoption of the 'push-pull' technology. In all the districts in Kenya, 94–100% of new adopters reported an increase in labour requirement during the first year of establishment of the technology as compared to their own practice. However, 88–100% of 'push-pull' practising farmers reported a decrease in labour requirement in subsequent years in the 'push-pull' plots as compared to their own practice (Figure 6). Farmers in Butere/Mumias, Migori, Siaya, Nyando and Bondo districts reported that labour increase in the first year was mainly due to planting of the 3 crops (maize, Napier grass and desmodium) at the same time (Figure 6). Increase in labour in the first year in Suba, Bungoma,