Integrated pest and soil management to combat *Striga*, stemborers and declining soil fertility in the Lake Victoria basin

R8212 **(**ZA 0524**)**

FINAL TECHNICAL REPORT

01 October 2002 – 31 March 2005

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International Centre of Insect Physiology and Ecology (ICIPE)

20 April 2005

"This publication is an output from a research project funded by the United Kingdom Department for International Development for the benefit of developing countries. The views expressed are not necessarily those of DFID."

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Executive Summary

Demonstrations with best-bet technologies for the control of *Striga* weed and stemborers and enhancement of soil fertility were initiated in the long rainy season (March to July) of 2003 in Kenya and Uganda and during the more reliable second rainy season (October 2003 to January 2004) of 2003/04 in Tanzania. Components of these best-bets were cropping systems (maize intercropped with stemborer moth-repellent *Desmodium* ['push'] with stemborer moth-attractant ['pull'] Napier grass planted around the field [push pull system], continuous maize and rotations with grain [soybean] and herbaceous [*Crotolaria*] legumes). Their effect on suppression of *Striga* and stemborers and soil fertility improvement were compared using two maize varieties (Imidazolinone resistant [IR] and a local landrace or improved commercial variety) under two fertilizer levels (no fertilizer and medium fertilizer). Stemborer damage to maize varied substantially between locations and seasons in all countries and the push pull technology was observed to suppress stemborer damage from the second (Kenya/Tanzania) or third (Uganda) season onwards. IR maize fully controlled *Striga* emergence in Tanzania and substantially suppressed *Striga* emergence in Kenya. In Uganda, IR maize did not show any effect on *Striga* emergence. The push pull technology equally suppressed *Striga* emergence but again only after 2 or 3 seasons. Other systems or fertilizer application did not show significant reductions in either stemborer or *Striga* infestations. These notwithstanding, differences in grain yield of maize between cropping systems were minimal and only fertilizer application was observed to substantially increase maize yield in all countries.

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Baseline information related to the target villages was obtained during participatory rural appraisal (PRA) sessions. PRAs indicated that maize is the major food crop in the area, and that *Striga*, stemborers and soil fertility are major constraints to efficient maize production and food security.

Farmers from the target villages were exposed to the various options demonstrated during the first 2 seasons during field days in the villages. This formed the basis for the selection of options to be tested by them during the adaptation trials which started during the long rainy season of 2004 in Kenya (148 farmers; 38% female farmers in Vihiga district and 60% female farmers in Siaya district) and Uganda (24 farmers in Busia district; 56% female), and during the second season of 2004 in Tanzania. Many of these farmers combine crop rotation with IR maize, or intercropping IR maize with push pull technology. Preliminary farmer evaluation showed that in Vihiga district (Kenya), legume-IR maize rotations were preferred over the push pull technology; while in Siaya district (Kenya), the push pull treatments scored highly for all criteria. In Busia district (Uganda), soybean and crotalaria rotations scored the highest.

Farmer evaluations were done in 6 villages (Kenya and Uganda) in short rainy seasons of 2003 and 2004, where 202 (in 2003) and 362 (in 2004) farmers participated. Results showed that in Siaya, farmers highly scored push pull technology while in Vihiga and Busia, crotalaria and soybean rotations scored better. Ordinal regression analyses indicated that treatments were significantly different, with women generally ranking them higher than the men in Kenya and Uganda. The low wealth class farmers highly ranked push pull technology in Kenya, while the high class ranked soybean and crotalaria rotations better. In Uganda, low wealth farmers ranked all treatments higher than their middle and high class counterparts.

Background

Maize is one of the most important cereal crops in eastern Africa and serves both as a staple food and cash crop for millions of people in the Lake Victoria Basin. Grain yields under farmers' conditions average about 1.0–1.5 t/ha or less than 25% of the potential yield of 4-5 t/ha. The low maize yield is associated with several constraints. Farmers consistently list *Striga*, stemborers and declining soil fertility as the three major constraints to efficient maize production in the region.

Striga is a parasitic weed that infests approximately 158,000 ha of arable land in the Lake Victoria Basin in Kenya alone. *Striga* could cause yield losses of between 30% and 50%, although losses of up to 100% are not uncommon, with a value in the order of US$ 37-88 million per year.

Stemborers seriously limit maize yields by infesting the crop throughout its growth stages. The yield losses caused to maize vary widely in space and time but range from 20-40% of potential output in eastern Africa, depending on agro-ecological conditions, crop cultivar, agronomic practices and intensity of infestation.

Soil infertility results from the poor inherent fertility status together with high human population pressure and poor soil and crop 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 strategies, soils are rapidly degrading and are hardly able to sustain acceptable maize yields, with nitrogen and phosphorus being the major production-limiting nutrients. Lack of appropriate 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.

A range of technologies addressing various aspects of *Striga*, stemborers and soil fertility management have been developed and disseminated. These include the push pull technology for the control of maize stemborers and *Striga*, herbicide resistant (Imidazolinone resistance-IR)-maize for the control of *Striga* and various crop rotation options for restoring depleted soils. Research conducted at the International Centre of Insect Physiology and Ecology (ICIPE), Kenya, showed that the root system of the maize intercrop (*Desmodium*) in the push pull technology, originally developed to control stemborers in maize, produces both *Striga* seed germination stimulants and lateral growth inhibiting chemicals thereby hindering the attachment of the striga's haustorial root system to that of the host plant (maize). The germinated *Striga* plant soon dies (suicidal germination). Similarly, research at the International Maize and Wheat Improvement Centre (CIMMYT) shows that when applied as a seed dressing, the herbicide in the IR maize (imazapyr) is imbibed by the germinating seed and absorbed into the growing maize seedling before any damage is inflicted on the host plant by *Striga*. Additionally, imazapyr from the seed-coat that is not absorbed by the maize seedling diffuses into the surrounding soil and kills ungerminated *Striga* seeds.

The technologies developed and disseminated by this project are helping to reduc**e** the vulnerability of small-scale poor farmers to the vagaries of different pests and declining soil fertility that threaten their food security. The project is increasing the local knowledge and capacity to deal with pest and soil fertility problems thereby leading to a sustainable increase in food production. Involving both private and public institutions such as seed companies, non- governmental organizations (NGOs), agricultural extension and research bodies will also increase access to new technologies. To ensure long term sustainability, the project is working exclusively through existing institutions.

Project Purpose

The purpose of the Project is to develop and disseminate an integrated pest and soil fertility management approach/strategy (IPSFM), in particular, against *Striga*, stemborers and declining soil fertility, to enhance food security, income generation and environmental sustainability, thereby reducing poverty in Lake Victoria basin of Kenya, Uganda and Tanzania, resulting in an overall improvement in the communities' livelihood status.

The project seeks to address the following 5 outputs which have been identified as constraints to the realisation of food security in the region:

1. Provide a better understanding of the relative contribution of the target pests and low soil fertility to the observed maize yield gap, and of farmers' indigenous coping strategies to overcome these constraints in the target areas, as affected by the biophysical and socio-economic environment.

2. Identify, develop and adapt best-bet IPSFM strategies for the suppression of *Striga* and stemborers and improved soil fertility management, including the push pull technology, herbicide-resistant and stress-resistant maize varieties and test them in farmer-participatory trials, taking into account the overall biophysical and socio-economic factors driving farmers' decision making processes.

3. Identify institutional channels and a suitable policy environment and empower them to initiate the dissemination phase of the best-bet IPSFM strategies.

4. Help build capacity of farmers, national research and extension systems and other stakeholders to conduct biological, ecological and socio-economic research on integrated management of *Striga*, stemborers and soil fertility.

5. Put in place a monitoring and evaluation system to evaluate the new technologies and options at every stage and analyse and estimate their adoption and impact.

Research Activities

1. Understanding of the problems and indigenous coping strategies

The project's first intended output was a better understanding of the problems and indigenous coping strategies. More specifically, a better understanding was pursued of the relative contribution of the target pests and soil fertility depletion to the observed maize yield gap, and of farmers' indigenous coping strategies to overcome these constraints generated in the target areas as affected by the biophysical and socio-economic environment.

Therefore, PRAs were conducted at the beginning of the project, with specific objectives to: i) understand the farming systems, ii) take inventories of the popular maize varieties grown in the villages, and understand the selection criteria, iii) understand the production constraints, especially pest and soil fertility problems, iv) understand the indigenous coping strategies to the pest and soil fertility problems, and v) select the target villages for the action research.

Within the overall target area (the Lake Victoria Basin), western Kenya was chosen to represent the Kenyan part, the Mwanza region was selected for Tanzania and the Eastern region for Uganda. In each country, 2 target areas (usually districts) were chosen to represent zones with high and low market access. Representative communities were then selected in function of high *Striga* and stemborer infestation, poor soil fertility level, high importance of maize and adequate rainfall. In Uganda, only 1 target area was selected for the first year of the project (2003).

In Kenya, Vihiga and Siaya districts were selected as target areas to represent the respective low and high market access, based on the average travel time to the nearest market. Both districts have adequate rainfall and face severe *Striga*, soil fertility and stemborer problems. Both districts are relatively easy to access from the major urban centre, Kisumu town, and considered as being representative of the farming systems in the lake basin. PRAs were conducted in 4 communities in each of the districts between 17th December 2002 and 31st January 2003. More than 150 subsistence farmers participated, of whom two thirds were women. In Tanzania, the Mwanza region was selected as being representative of the Lake

Victoria basin, and two districts were selected: Misungwi and Sengerema. In Misungwi, four villages were selected while three were selected in Sengerema where PRAs were conducted in January and February 2003. In total, 243 farmers attended, including 55 women. In Uganda, Busia was selected as the representative district, from which four villages were selected. The PRAs took place in March 2003 and a total of 81 farmers participated of whom 29 were women.

In each country, the research team comprised of scientists and extension officers. After an extensive literature review and discussions with key informants, a detailed checklist was developed and a method of data collection agreed upon. Extension workers, in consultation with farmer representatives, mobilized farmers to attend the meetings. After proper relevant introductions and explanation of the purpose, several PRA tools were used, including group discussions (separate for men and women where possible), village mapping and transect walks. The major topics discussed in each group were the crop production systems and their production constraints, in particular *Striga*, stemborers and soil fertility. Farmers would also describe the methods they know and the coping strategies they practice. The results were compiled and posted to the wall for review and correction. Each group made presentations on the major points to the general assembly. Drawing of resource maps and transect walks were used to provide more detailed information and to triangulate some of the information from both the resource maps and data collected.

2. Identification and testing of best-bet options

2.1 Identification of options and design of demonstration sites

During the PRA exercise in all countries, farmers listed and ranked *Striga*, stemborer and low soil fertility as the major constraints to efficient maize production. They then listed several indigenous coping strategies used to combat these constraints. After in-depth discussion among the project scientists, a synthesis of options was compiled. Components of these best-bets were cropping systems (push pull, continuous maize and rotations with grain [soybean] and herbaceous [*Crotolaria*] legumes). Their effects on suppression of *Striga* and stemborer and soil fertility improvement were compared by use of two maize varieties (IR and a local landrace or improved commercial variety) under two fertilizer levels (no fertilizer and medium fertilizer). Any modification to these was to take into account the dominant cropping system in the target areas. In Kenya, no modification was done. However, in Uganda, two improved open pollinated varieties (OPVs) were used in 2003 while IR-maize replaced one of the improved varieties in 2004. In Tanzania, cowpeas were used in place of soybean. The proposed treatment structure was explained to the target farmer communities to get feedback on their acceptability and appropriateness. They subsequently endorsed the treatment structures after relevant consultations. These treatments were demonstrated in 2 farms in each of the 4 villages in Kenya and Tanzania and 2 villages in Uganda. Soil samples were collected from each demonstration site in all the villages and analyzed for *Striga* seed bank and physical and chemical characteristics.

In the push pull and continuous cropping systems, maize was planted in all seasons. In the rotations, the legumes were planted in the 1st and 3rd seasons while maize was planted in the 2nd and 4th seasons in the whole farm. In the push pull technology, *Desmodium* was planted in the 1st season then frequently clipped in the subsequent seasons to minimize competition with maize. Data on *Striga* emergence, stemborer damage and grain yield of maize were determined in all cropping seasons.

2.2 Farmer evaluation

During the 1st season (March-August 2003), demonstration trials were set up in four districts: Siaya and Vihiga (Kenya), Busia (Uganda) and Misungwi (Tanzania) (October 2003-January 2004). Because some treatments had in place the rotation crops (crotalaria and soybeans) in the 1st and 3rd seasons, no farmer evaluation was organized. In the 2nd and 4th seasons, farmer evaluations were conducted since all treatments had maize.

Farmer evaluations of the trials followed a semi-structured guideline. During the introductory meeting, both farmers and project scientists introduced themselves and the purpose of the visit was discussed. A review of the various treatments was presented to the farmers and other participants. Farmers listed and ranked the criteria they would use to evaluate the plots. In the 2nd season in Kenya and Uganda, farmers in all villages used *Striga* and stemborer suppression, soil fertility enhancement, grain yield, labour saving and overall criteria to evaluate treatments, but in the 4th season, they added crop vigour, fodder supply and soil erosion control to the list.
Next, each farmer was supplied with an evaluation form consisting of a short component of farmers' characteristics, an evaluation table and some final questions. The farmers' characteristics included age, gender, experience, farm size, area under maize, type of house, number of animals and an evaluation table. The latter had row for each treatment and a column for each of the criteria on which they were being evaluated. Farmers then scored each treatment for each criterion using a scale of 1 (very poor) to 5 (very good) and an overall score for each treatment. Finally, the farmers chose the top three or four treatments they would like to try in their own fields and were asked to make any proposals for change, alternative treatments or other recommendations or remarks. After the individual evaluations, the farmers and scientists regrouped and discussed the choices. This forum also gave farmers an opportunity to question scientists and extension staff in an interactive discussion.

In total, 362 farmers, of whom about 50% were women, participated in the evaluation in the 6 villages in Kenya and Uganda (Table 1). In Uganda alone, about 30% of the participants were women while in Kenya they constituted about 50%. Several stakeholders attended the farmer evaluation with the Ministry of Agriculture extension officers participating in all villages as the lead facilitators.

Table 1: Number of participating farmers by gender per site and stakeholders during the short rains of 2003 and 2004.

			Short rains 2003				Short rains 2004			
			Date	Farmers (N)		Stakeholders	Date	Farmers (N)		
Country	District	Village		F	M			F	M	Stakeholders
Kenya	Siaya	Ngoya	8/12	17	9	MoA	7/1	36	40	SCODP, MoA, politicians, Cereal Bank
		Nyalgunga	19/12	20	16	MoA	6/1	57	37	SCODP, MoA, CAFARD
	Vihiga	Ebulonga	9/12	15	24	MoA	8/12	17	15	MoA, RP, Dairy Society,
		Ematsuli	11/12	14	27	MoA	10/12	49	51	MoA, RP, Africa Now, Dairy Society, CPDA, ECPK
Uganda	Busia	Angorom	14/1	5	18	MoA, DDAO	18/1	12	26	MoA , DAO, DIO
		Kubo West	13/1	21	16	MoA	19/1	6	16	MoA
Total				92	110			177	185	

3. Dissemination of best-bet IPSFM options

Field days were conducted in all villages in Kenya and Uganda during the 2nd and 4th cropping seasons to coincide with farmer evaluations. However, in Tanzania, only one field day was conducted during the 1st season. Farmers and other stakeholders were invited to these field days (Tables 2). Flyers and other extension materials were distributed to all stakeholders during the field days and other stakeholder meetings. Over 100 brochures were distributed to stakeholders and extension staff.

Table 2: Stakeholders who attended farmer evaluation/field days.

Stakeholder	Country		
	Tanzania	Kenya	Uganda
Policy makers	3	3	2
NGOs	5	15	-
Research	10	5	8
Farmers	42	444	120
Extension	4	1	5
Total	64	468	135

4. Capacity building

The project scientists worked with the government extension staff during PRA sessions, identification of best bets, site selection, trial establishment and management, farmer evaluation and technology selection for adaptation. During all these stages, they were exposed to project activities thus gained experience in their implementation. Informal training was conducted during farmer evaluations, field days and selection of farmers for adaptation. Topics included general trial management, agronomic recommendations, data collection and scoring treatments during field evaluations. In all countries, several stakeholders benefited from these informal training sessions (Table 2).

Outputs

1. Understanding of the problems and indigenous coping strategies

1.1 Farming systems and wealth ranking

The Lake Victoria basin is characterized by small-scale subsistence farmers with small land holdings. Although all sites have two cropping seasons, in Kenya and Uganda the major season falls between March and July, and the often unreliable short one falls between December and February. In Tanzania, however, there is only a limited demarcation between the two seasons: the rains fall from November to January, with a very short dry period, and resume from March to May.

The PRAs revealed that maize is the most important crop in almost all sites in the three countries. In Western Kenya, maize is the most important crop followed by beans and sweet potatoes. The latter are also grown in the rest of the sites. In Vihiga (the district with good market access), 4 out of the 5 communities grow kales (compared to only 1 in Siaya). Similarly, in Vihiga 3 out of 5 communities grow cowpea (compared to 0 in Siaya) and bananas (compared to 1 in Siaya). In Tanzania, the first crop is maize in all but one site, but the importance of the other crops highly varies. Depending on the site, cotton, sorghum, rice, or cassava is the second crop, with cotton clearly being the most important cash crop. The situation is somewhat different in Uganda where cassava is the first crop, followed by maize in 2 out of the 4 villages. In the other two villages, maize is the first crop in one followed by cassava while millet is the first crop in the other followed by cassave. Sorghum and the other crops such as groundnuts, banana and cotton are also important.

Livestock is important in Tanzania and Kenya. In the Tanzanian sites, almost 40% of farmers own cattle, 30% own goats and 15% own sheep, all of local breeds. Free grazing is practiced by all, with no intensive methods. In Kenya, many farmers own cattle and to a lesser extent the small ruminants. In Siaya, there is free grazing but in Vihiga the most common husbandry system is tethering. In both Kenyan districts, farmers grow forage crops with Napier grass being particularly popular. In both Ugandan villages, livestock ownership is rare, most likely because of the high tsetse fly infestation in the areas.

In the Lake Victoria region, a wide range of maize varieties is grown. The favourite type is white and flint, although several others are also found. All sites have many local varieties, usually late maturing. Improved OPVs are common and popular, and usually are of shorter duration, providing some drought tolerance. The Kenyan hybrids are popular in Kenya and Uganda, but have not reached Tanzania. Generally, the results showed a high potential for improvement of adoption of the improved maize varieties in the region. Clearly, breeding in the region has not resulted in widely adapted maize varieties. Therefore more attention should be given to the preferences and priorities of farmers in the region with regards to maize seeds. Moreover, the acceptance of Kenyan varieties in Tanzania (Katumani) and Uganda (H511) shows that economies of scale can be reached by specific breeding for the region. Harmonization of seed regulations should also help the development of regional seed companies.

For most farmers, wealth can clearly be measured by three criteria: size of the land holdings, number and type of cattle or other livestock and type of residential house. In each village, farmers offered fairly precise limits to three categories: poor, medium and well-off farm households. In Kenya, the major criteria for wealth ranking were land size, type of residential house and number and type of cattle, all mentioned in both districts. In Vihiga, there were other criteria often mentioned, such as child education, business ownership and use of farm inputs.

In Tanzania, the criteria used in categorizing households into wealth groups were mainly number of cattle, farm size, type of residential house, farm implements and food security. Most farmers (about 56%) were considered to fall in the poor category. Similarly, in Uganda, the major criteria used for wealth ranking were also ownership of land, cattle and a reasonable residential house. However, having some other businesses and investments were also often mentioned.

1.2. Constraints and coping strategies

For the region as a whole, *Striga* clearly stood out as the major constraint to efficient maize production. There was less uniformity on the other constraints, but soil fertility and stemborers were frequently mentioned. Stemborer, however, was clearly not a problem in all sites. In Western Kenya, *Striga* was mentioned by all villages as the topmost maize production constraint. In Siaya, *Striga* was followed by low soil fertility, other pests and diseases and stemborers in that order. In Vihiga however, low soil fertility, lack of capital/farm inputs and other crop pests and diseases were the major constraints after *Striga*. In Tanzania, *Striga* was also generally considered the most important pest, followed by drought and stemborers. Other problems frequently mentioned were storage pests, diseases and problems with seed supply and quality. In Uganda, Striga was mentioned as the topmost constraint in three of the four villages. Soil fertility was mentioned in the top two constraints by about 50% of the respondents, while stemborers were mentioned in the top five in the four villages. Other major constraints mentioned were mole rats and moisture stress, followed by monkeys and termites.

Overall, farmers are fairly knowledgeable about *Striga* biology. They recognize it as a parasite, and that it reproduces through flowers. Most communities also see the linkage of *Striga* with continuous maize growing and poor soil fertility. Against *Striga*, farmers know the benefit of farmyard manure, crop rotation and fallowing, but few farmers use these methods. In Kenya, these methods were clearly more adopted by the wealthier farmers. Farmers generally know the symptoms of stemborer infestation such as exit holes and dead heart, but understand little of the biology. They have some indigenous coping strategies, especially uprooting the severely damaged plants and crop rotation, but pesticide use is limited to the wealthier farmers. In all sites, declining soil fertility is a major problem leading to decreased maize yields. Farmers generally recognize the major factors: increased human population, continuous maize cropping and limited use of soil improvement techniques. Many farmers use intercropping and crop rotation but the use of fertilizers, especially inorganic, is limited.

In conclusion, the PRAs revealed that *Striga*, stemborers and soil fertility are major problems in this area, and that farmers are eager to work on them in order to achieve food security. Based on indigenous knowledge and international research, there is an opportunity to improve the livelihoods of small scale farmers in the region through technological improvements. However, investment opportunities of these farmers are small and technologies should therefore be carefully considered and tested through participatory methods. A particular concern is the lack of livestock in Uganda, which makes technologies involving fodder crops such as push pull technology less interesting. Fortunately, many organizations are active in the region, in extension and rural development. They are however, not usually organized on a large scale, so the project needs to particularly put an effort to involve them in its activities in the area.

2. Identification and testing of best-bet options

2.1 Technical evaluation of the demonstration trials

Presentation of the data in this section depended on the occurrence of significant interactions between different factors as presented in Tables 3, 4, 5, 6 and 7.

Table 3: Significance levels for the various factors and their interactions for the target sites in Kenya in 2003. Values in bold are significant at 5%.

Factor	Long rainy season 2003			Short rainy season 2003		
	Stemborer damage at 10 wks	Striga emergence at 10 wks	Maize grain Yield	Stemborer damage at 10 wks	Striga emergence at 10 wks	Maize grain Yield
District (D)	0.9058	0.0859	0.1944	**<0.001**	0.5502	0.1498
System (S)	0.1762	0.5134	0.7069	**0.0013**	**0.0025**	0.1749
D x S	0.9222	0.1301	0.2295	**0.0118**	0.8351	**0.0051**
Variety (V)	0.4285	0.6331	0.8099	**0.0339**	**<0.0001**	0.6711
D x V	0.8928	0.3676	0.7025	0.1906	**0.0001**	0.4941
S x V	0.1446	0.1483	0.4315	0.0682	0.0554	0.3959
D x S x V	0.6114	0.1006	0.3995	0.2349	**0.0268**	0.5937
Fertilizer (F)	0.5056	0.4515	**<0.0001**	0.9329	0.6408	**0.0005**
D x F	0.7281	0.2219	0.4121	0.2391	0.9655	0.5761
S x F	**0.0228**	0.5229	0.1895	0.1825	0.8464	0.3107
D x S x F	0.4899	0.8252	**0.0178**	0.7494	**0.0037**	0.5540
V x F	0.6469	0.9541	0.1569	0.1712	0.1023	0.9883
D x V x F	0.7281	0.9455	0.4858	0.8870	0.4815	0.7007
S x V x F	0.1036	0.5937	0.2723	0.2151	**0.0187**	0.5240
D x S x V x F	0.1225	0.9751	0.9752	0.2331	0.8675	0.6330

Table 4: Significance levels for the various factors and their interactions for the target sites in Kenya in 2004. Values in bold are significant at 5%.

Factor	Long rainy season 2004			Short rainy season 2004		
	Stemborer damage at 10 wks	Striga emergence at 10 wks	Maize grain Yield	Stemborer damage at 10 wks	Striga emergence at 10 wks	Maize grain Yield
District (D)	0.1749	**0.0172**	0.8582	0.4128	**0.0003**	0.3302
System (S)	**0.0363**	**0.0036**	0.8022	0.0880	**0.0003**	0.1411
D x S	0.8218	**0.0101**	0.2910	0.3301	**0.0125**	**0.0460**
Variety (V)	0.6994	**0.0002**	**0.0035**	0.2120	**<0.0001**	0.3024
D x V	0.8001	0.7248	**0.0456**	0.5670	0.5649	0.4638
S x V	0.6057	**0.0005**	0.5883	0.3827	0.0686	0.3250
D x S x V	0.8908	0.5484	0.4209	0.5759	0.9824	0.2872
Fertilizer (F)	0.3642	0.3814	**0.0003**	0.1895	0.1149	**<0.0001**
D x F	0.7058	0.6493	**0.0033**	**0.0118**	0.1294	0.0947
S x F	0.5998	0.6311	0.2131	0.0870	0.5254	0.1971
D x S x F	0.2303	0.9573	0.9104	**0.0432**	0.8544	0.1667
V x F	0.8561	0.5070	0.3242	0.5612	**0.0463**	0.8704
D x V x F	0.5632	0.6851	0.3546	0.0669	0.7312	0.5558
S x V x F	0.9645	0.6186	0.5883	0.9390	0.3435	0.8375
D x S x V x F	0.6280	0.5676	0.7824	0.6632	0.9533	0.4256

Table 5: Significance levels for the various factors and their interactions for the target sites in Tanzania. Values in bold are significant at 5%.

Factor	Short rains 2003			Long rains 2004		Short rains 2004	
	Stem-borer damage at 10 wks	Striga emer-gence at 10 wks	Maize grain Yield	Stem-borer damage at 10 wks	Striga emer-gence at 10 wks	Stem-borer damage at 10 wks	Striga emer-gence at 10 wks
Division (D)	0.1011	0.0872	0.5219	**0.0022**	0.2431	0.3709	0.0818
System (S)	0.1415	0.3334	0.6562	0.0946	0.6353	0.4507	0.1262
D x S	0.7574	0.3267	0.1168	0.0873	0.6206	0.0780	0.1407
Variety (V)	0.5066	**0.0001**	**0.0086**	0.8296	**0.0111**	0.5299	**0.0044**
D x V	0.7847	**0.0002**	**0.0470**	0.9605	**0.0144**	0.4374	**0.0075**
S x V	0.6871	0.2974	0.5689	0.0682	0.5390	0.8468	**0.0348**
D x S x V	0.3920	0.2909	0.9263	0.1653	0.5312	**0.0243**	**0.0377**
Fertilizer (F)	0.7920	0.4627	**0.0204**	0.0928	0.4754	0.2359	0.6202
D x F	0.4939	0.4450	0.9110	0.0928	0.5812	0.3243	0.5346
S x F	0.7562	0.8588	0.1743	0.4097	0.9024	0.2562	0.8372
D x S x F	0.2540	0.7643	0.8054	0.2437	0.9134	0.8482	0.8968
V x F	0.2172	0.5009	0.9416	0.5074	0.5018	0.9628	0.5886
D x V x F	0.0967	0.4814	0.0981	0.6998	0.4999	0.6518	0.5232
S x V x F	0.7396	0.6726	0.5167	0.1618	0.9020	0.9713	0.9030
D x S x V x F	0.5937	0.7738	0.2563	0.2048	0.9156	0.2449	0.9409

Table 6: Significance levels for the various factors and their interactions for the target sites in Uganda in 2003. Values in bold are significant at 5%.

Factor	Long rains 2003			Short rains 2003	
	Stemborer damage at 10 wks	Striga emergence at 10 wks	Maize grain Yield	Striga emergence at 10 wks	Maize grain Yield
System (S)	0.0595	0.6374	0.8107	0.1620	0.6565
Variety (V)	0.1997	0.3971	0.9133	0.4603	0.9081
S x V	0.5236	0.1741	0.3743	0.3185	0.3584
Fertilizer (F)	0.9644	0.7707	0.0870	0.3290	**0.0001**
S x F	0.0761	0.3595	0.5985	0.5519	0.1312
V x F	0.5695	0.3451	0.5985	0.7396	0.4699
S x V x F	0.6931	0.4958	0.2258	0.6481	0.4623

Table 7: Significance levels for the various factors and their interactions for the target sites in Uganda in 2004. Values in bold are significant at 5%.

Factor	Long rains 2004			Short rains 2004		
	Stemborer damage at 10 wks	Striga emer-ence at 10 wks	Maize grain Yield	Stemborer damage at 10 wks	Striga emergence at 10 wks	Maize grain Yield
System (S)	0.6980	0.3127	0.3400	**0.0049**	0.6330	0.8927
Variety (V)	0.9499	0.4592	0.2684	0.1600	0.7735	0.5186
S x V	0.5814	0.6065	0.8001	0.7150	0.8776	0.9505
Fertilizer (F)	0.8979	0.3376	**0.0005**	**0.0003**	0.4744	**0.0001**
S x F	0.0963	0.4320	0.1410	0.1068	0.9901	**0.0034**
V x F	0.5717	0.3524	0.7534	0.7470	0.1322	0.4511
S x V x F	0.9486	0.4704	0.3501	**0.0101**	0.4501	0.4420

2.1.1 Maize yield

In terms of grain yields of maize, push pull technology performed better than the other cropping systems in Siaya but was only significant in the 4th season, during the long rains of 2004 (Fig 1). In the 1st season grain yield in push pull plots was higher than continuous cropping in Siaya while in Vihiga continuous cropping did better than push pull technology. Across all sites fertilizer effect was significant (Tables 3 and 4). Grain yields of maize during the long rains of 2004 were low due to drought that swept the region.

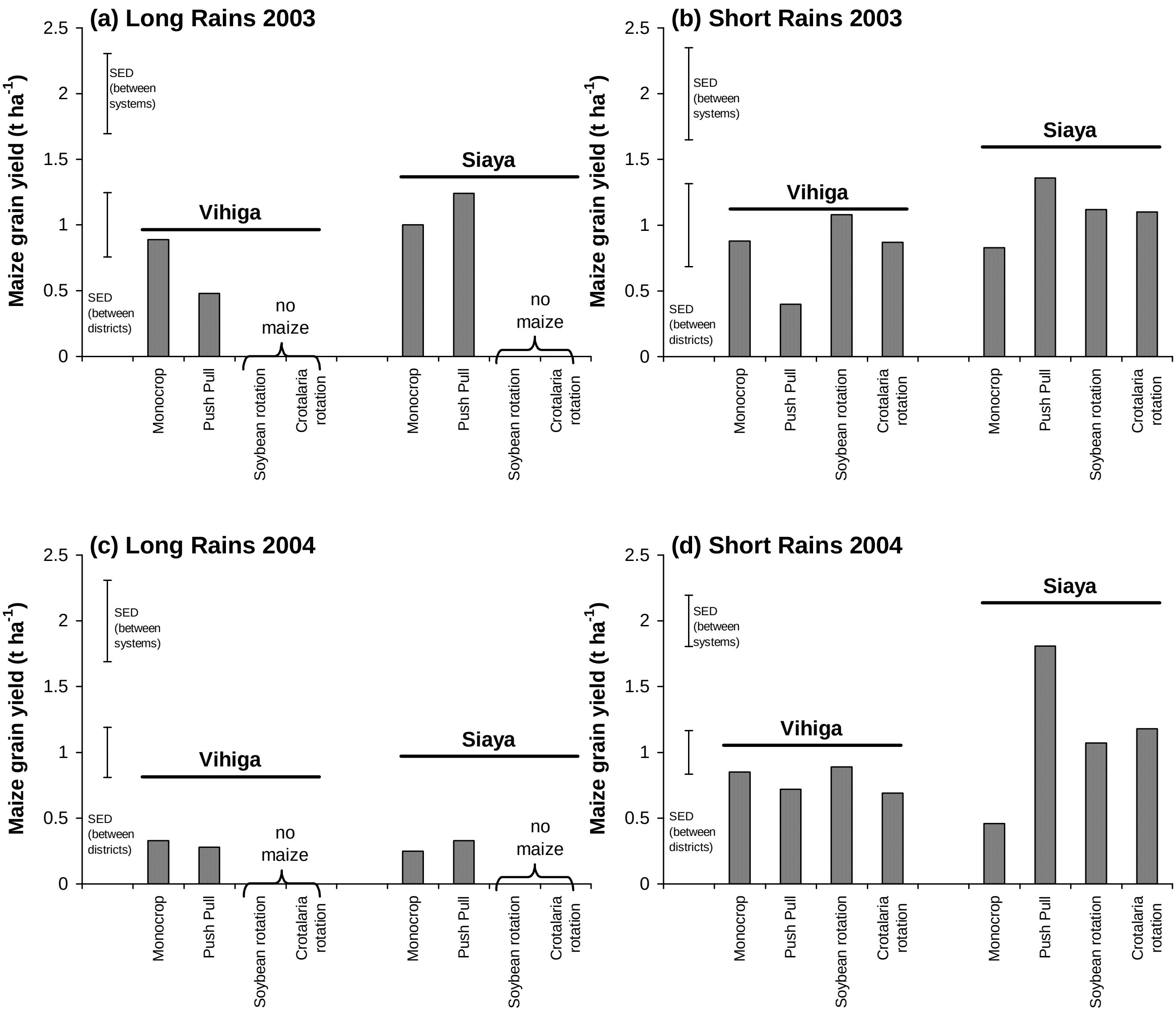

Fig 1: Effect of cropping system on maize grain yield in Vihiga and Siaya target sites in Kenya.

In Misungwi division of Tanzania, Kilima (an improved commercial maize variety) performed as good as IR maize while in Usagara, IR performed better than Kilima (Fig 2a). Overall, fertilizer application significantly enhanced maize grain yields (Table 5 and Fig 2b).

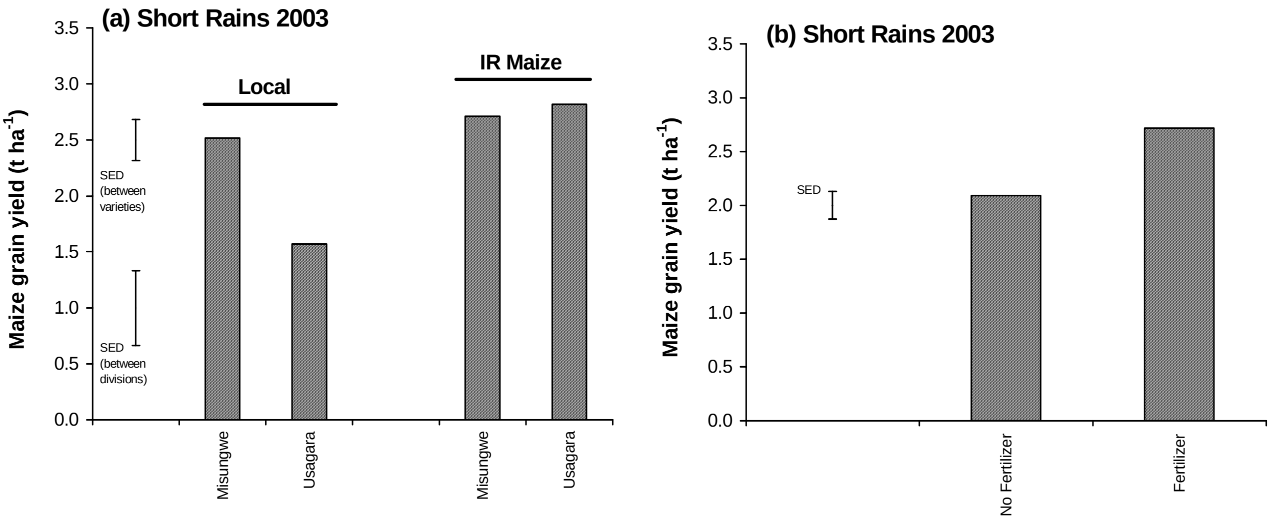

Fig 2: Mean maize grain yield as affected by site and variety in the Lake zone of Tanzania

Fertilizer application significantly increased grain yields of maize from the second season (short rains of 2003) all through to the fourth season (short rains of 2004) in Uganda (Tables 6 and 7 and Fig 3). However, cropping systems had insignificant effect on grain yields of maize in all seasons (Tables 6 and 7 and Fig 3). There was significant fertilizer by cropping system effect/interaction associated with relatively higher response in *Crotolaria* and Soybean rotations in the short rains of 2004 (Table 7 and Fig 3).

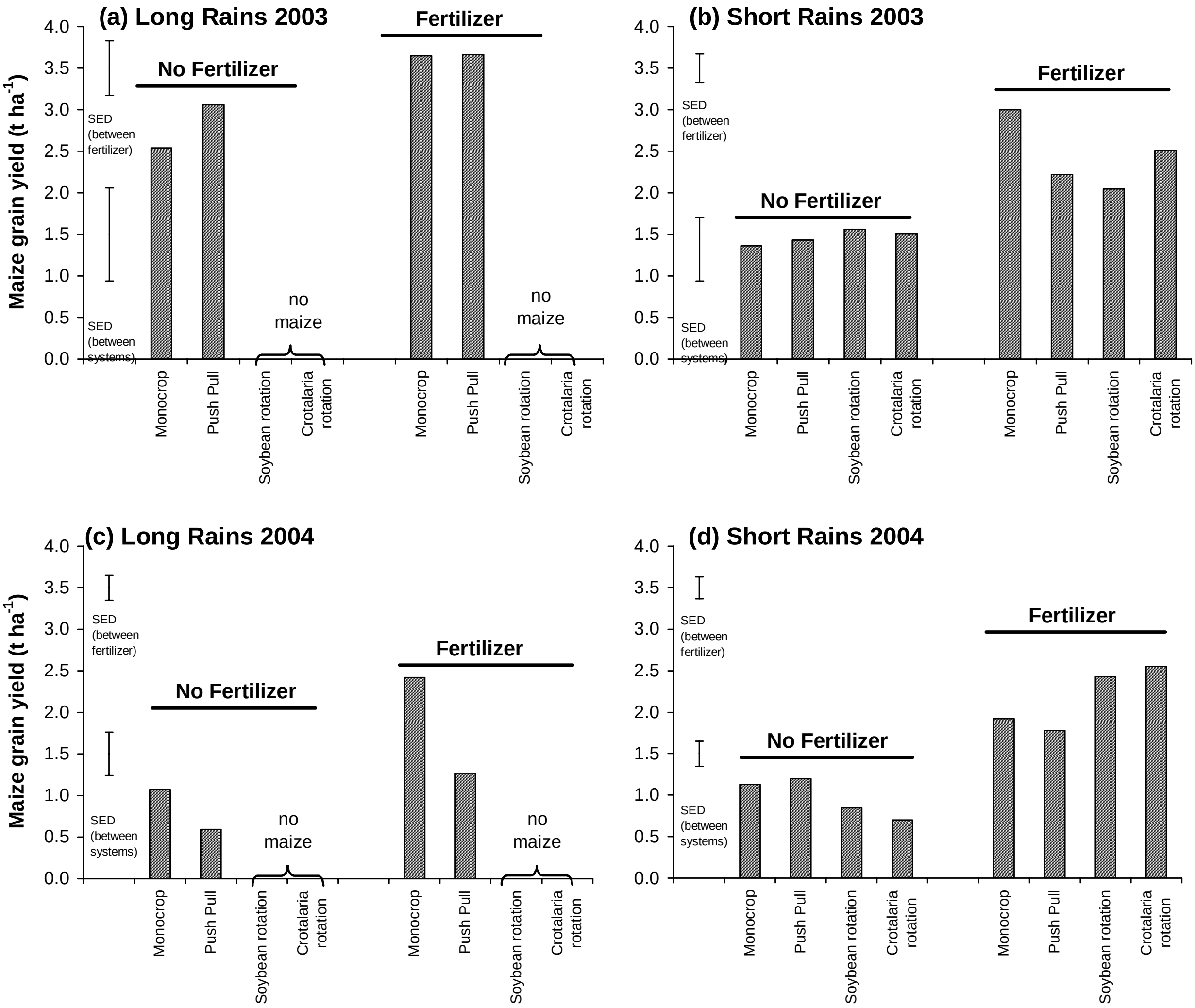

Fig 3: Effect of cropping system and fertilizer on maize grain yields across villages in Uganda.

2.1.2 *Striga* emergence

In Kenya *Striga* emergence was significantly lower in push pull technology compared to other cropping systems in the 2nd, 3rd and 4th seasons (Tables 3 and 4 and Fig 4). During the 3rd and 4th seasons, this reduction was significant where IR maize was planted (Fig 4).

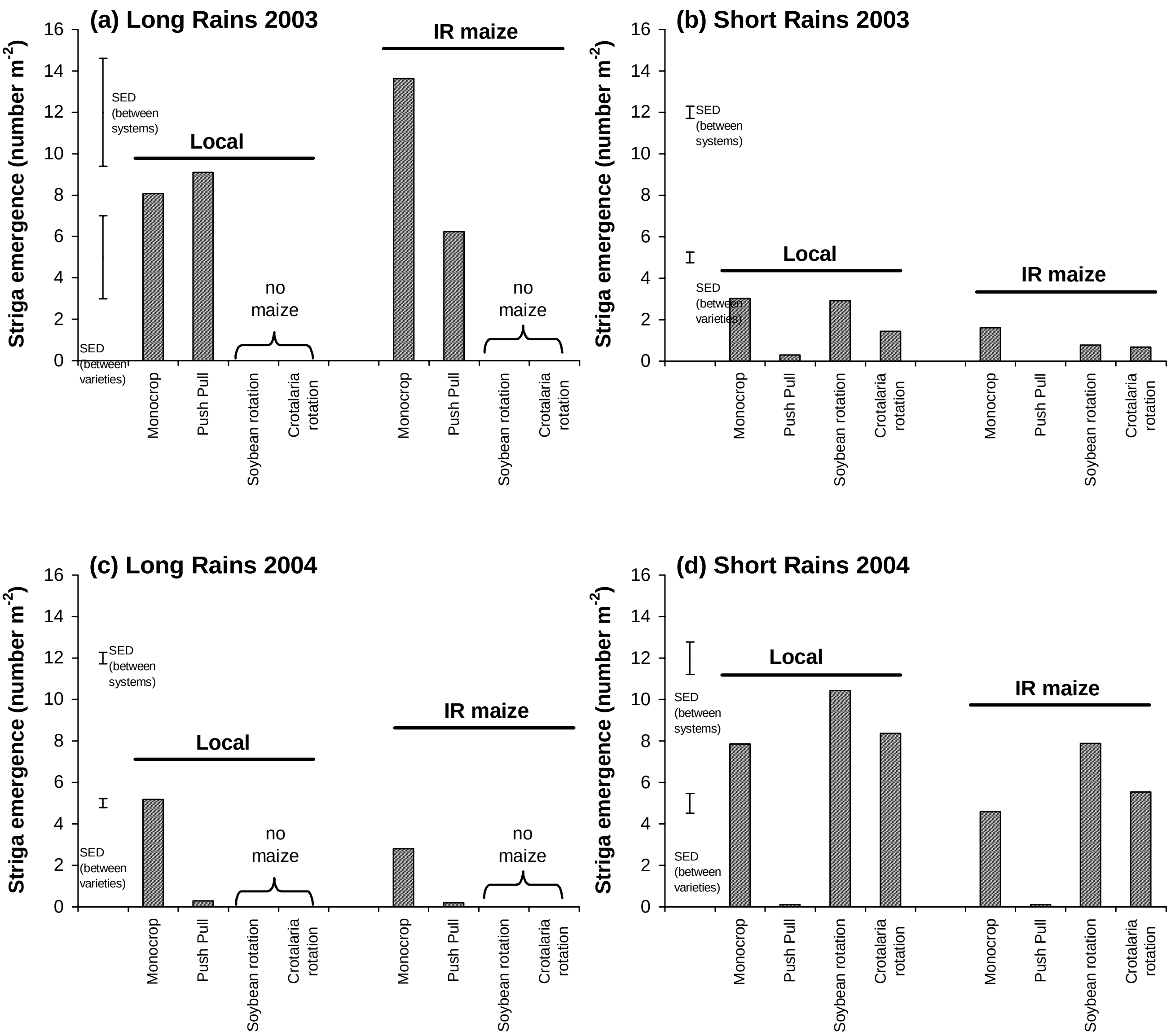

Fig 4: Effect of cropping systems and maize variety on *Striga* emergence in western Kenya.

In Tanzania, there was significant difference between maize varieties in *Striga* emergence (Table 5), with IR maize having lower or no emergence compared to Kilima in all seasons (Fig 5). Overall, *Striga* emergence was consistently higher in Usagara than Misungwi (Fig 6).

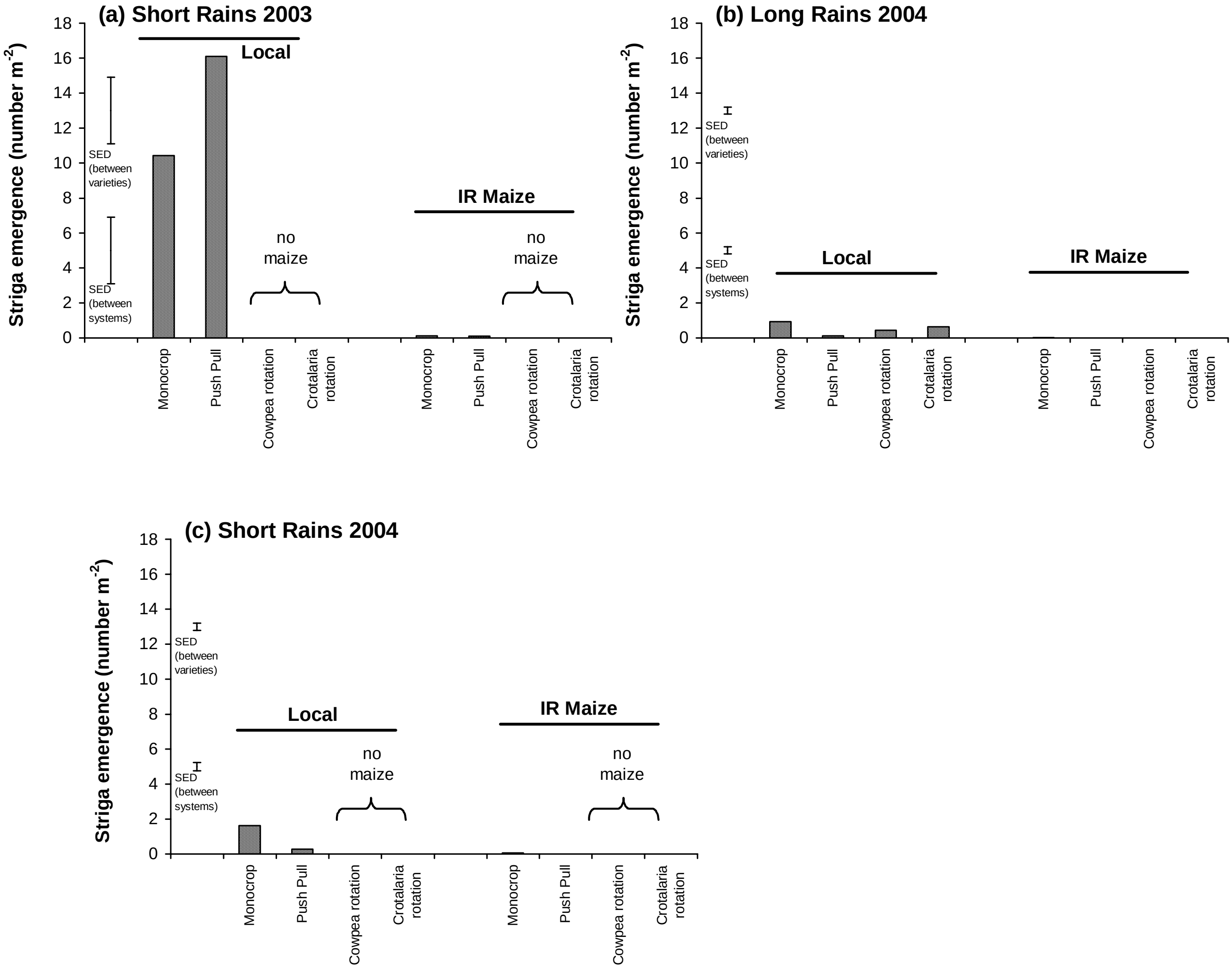

Fig 5: Effect of cropping system and variety on *Striga* emergence in Tanzania.

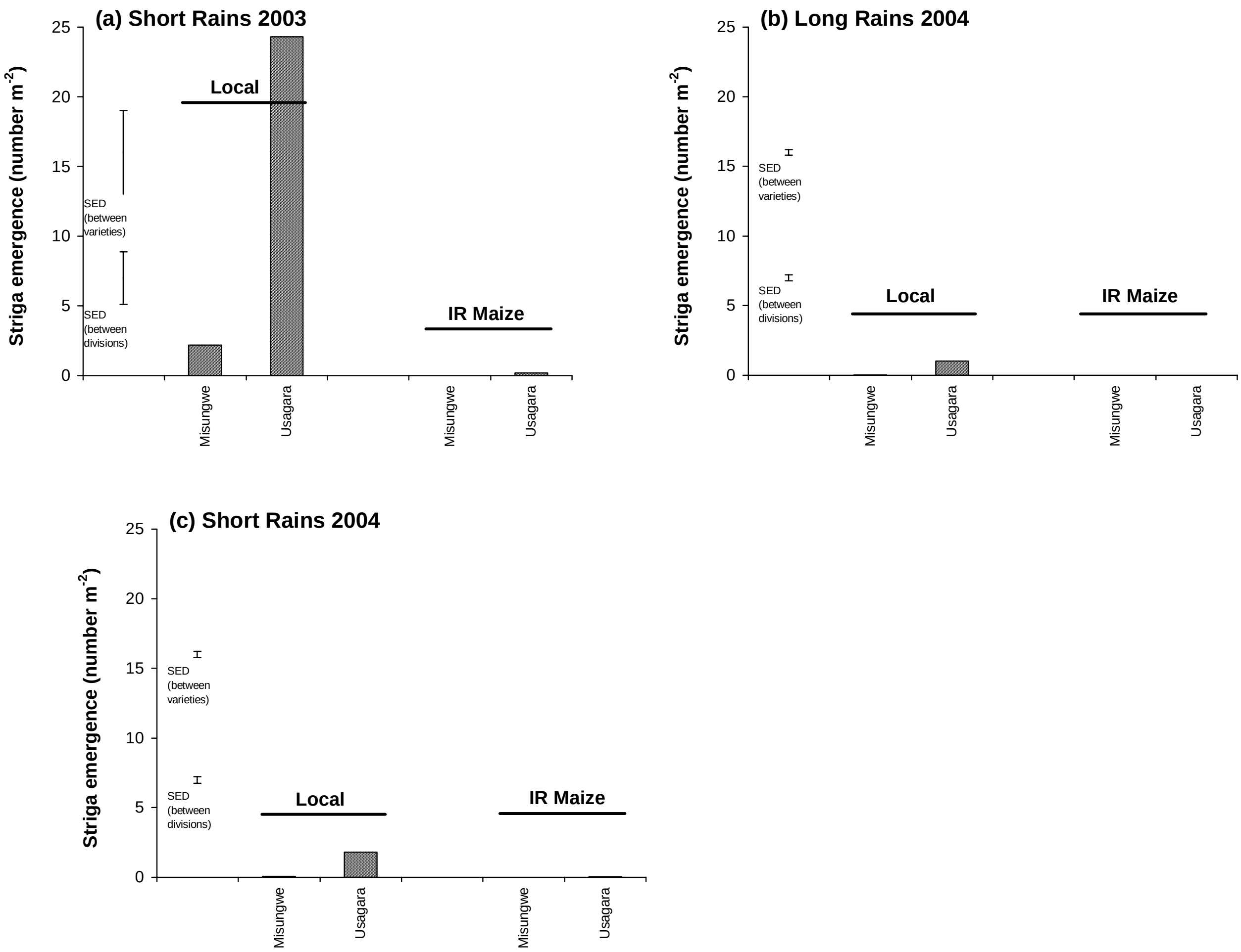

Fig 6: Effect of maize variety on *Striga* emergence in each division in Tanzania.

Generally, push pull technology greatly reduced *Striga* emergence compared to the other cropping systems in Uganda (Fig 7) from the 2nd season all through to the 4th season. *Crotolaria* increased *Striga* emergence in both 2nd and 4th seasons. However, there was no significant effect of maize varieties on *Striga* emergence (Tables 6 and 7 and Fig 7).

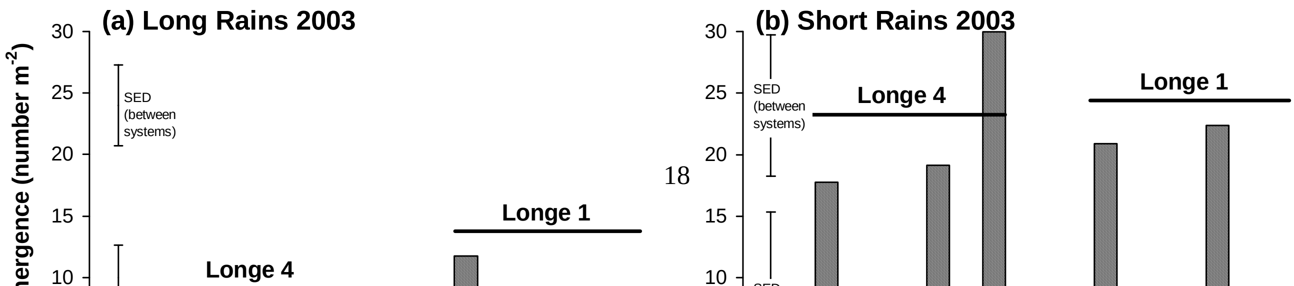

Fig 7: Effect of cropping system and maize variety on *Striga* emergence across villages in Uganda.

2.1.3. Stemborer incidence

There was no significant difference in stemborer infestation between districts during the 1st , 2nd and 4th seasons in Kenya, while in the 2nd season, there was a significant difference, with higher infestation in Siaya than in Vihiga (Tables 3 and 4 and Fig 9). During the 2nd and 3rd seasons, push pull cropping system markedly reduced stemborer damage to maize than any other cropping system in Siaya. Similarly, stemborer damage was significantly lower in push pull than in continuous maize in LR 2004 in both districts (Table 4 and Fig 9).

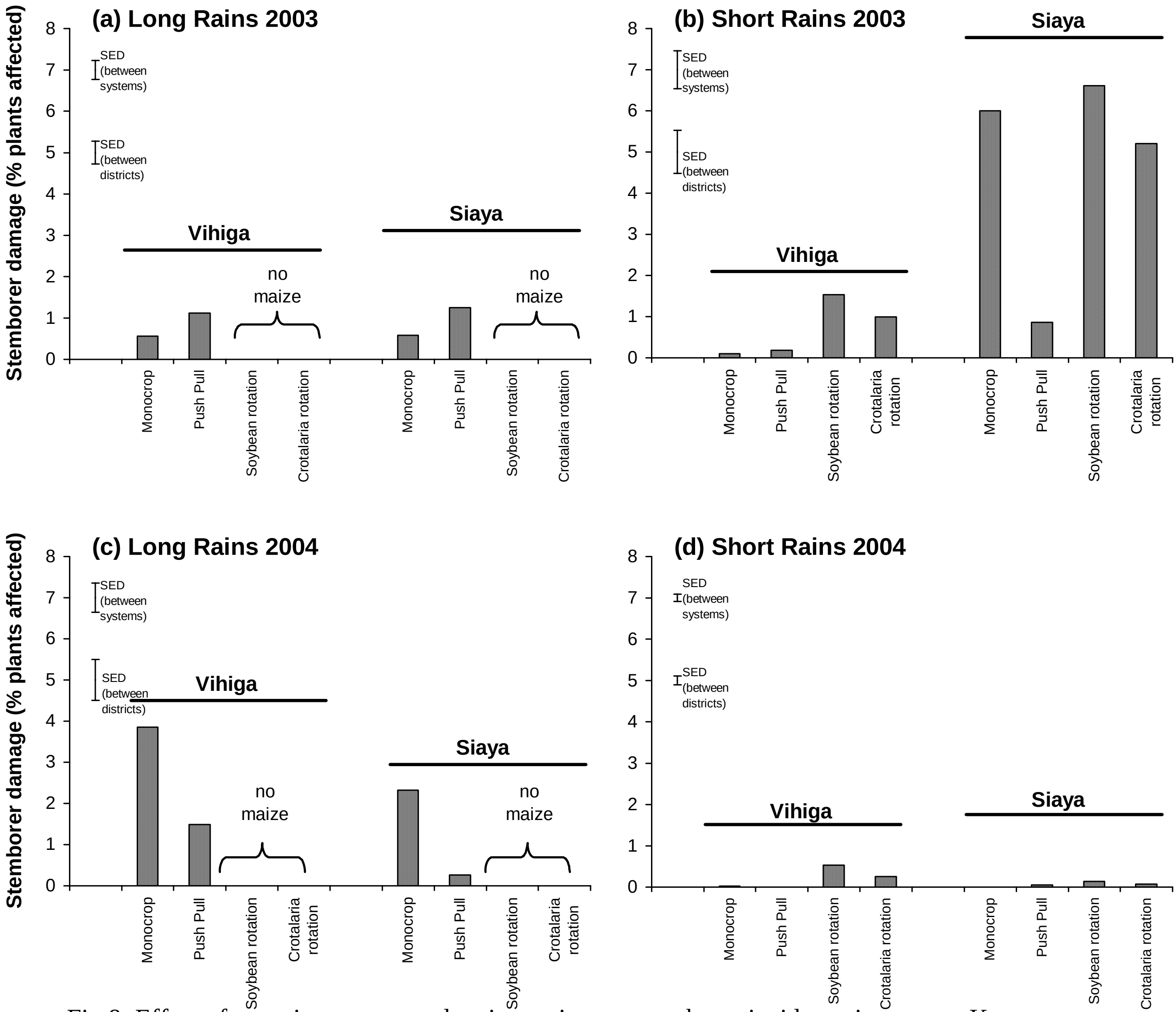

Fig 8: Effect of cropping system and maize variety on stemborer incidence in western Kenya.

In Tanzania, maize varieties and cropping systems did not have any effect on stemborer damage (Table 5 and Fig 9) although Misungwi had relatively higher stemborer infestation than Usagara during the short rains of 2003 and long rains of 2004 (Fig 10).

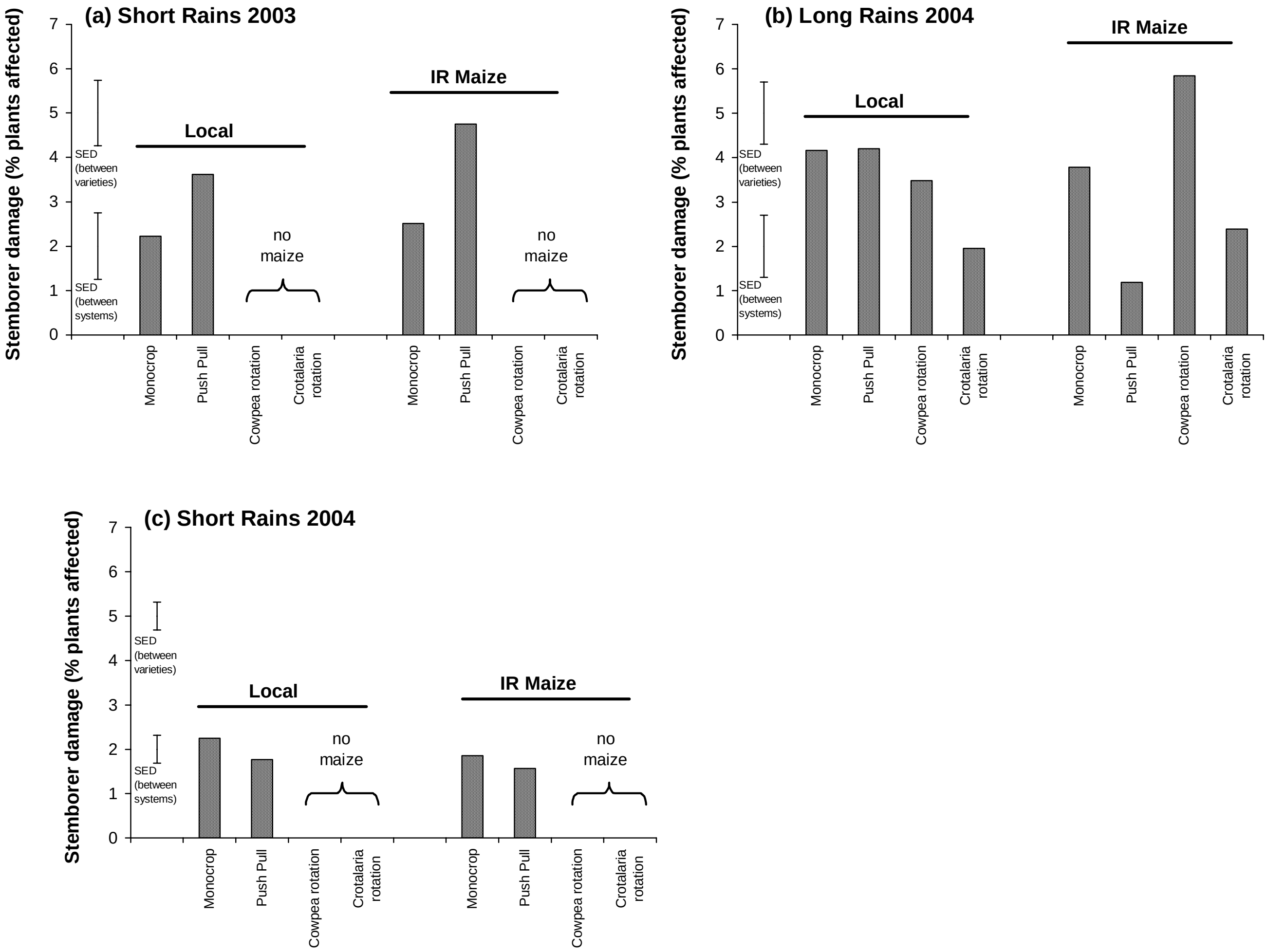

Fig 9: Effect of cropping system and maize variety on stemborer incidence across all sites in Tanzania.

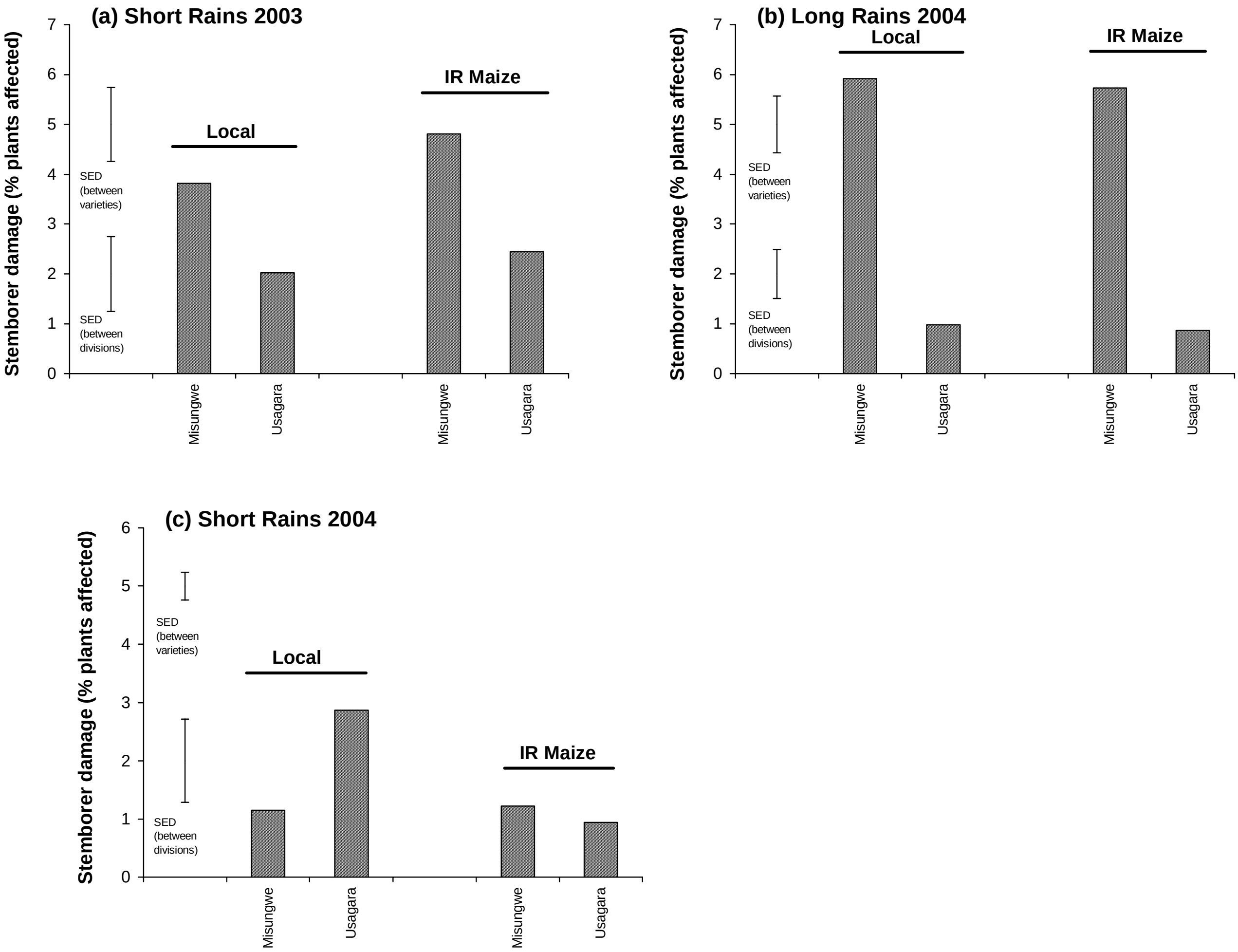

Fig 10: Effect of maize variety on stemborer incidence in 2 divisions of Lake zone of Tanzania.

In the case of Uganda, push pull technology had the least stemborer infestation compared to the other cropping systems (Fig 11). Application of fertilizer significantly increased stemborer infestation during the 4th season (Table 7 and Fig 11). There were however no significant differences in stemborer damage among maize varieties (Tables 6 and 7).

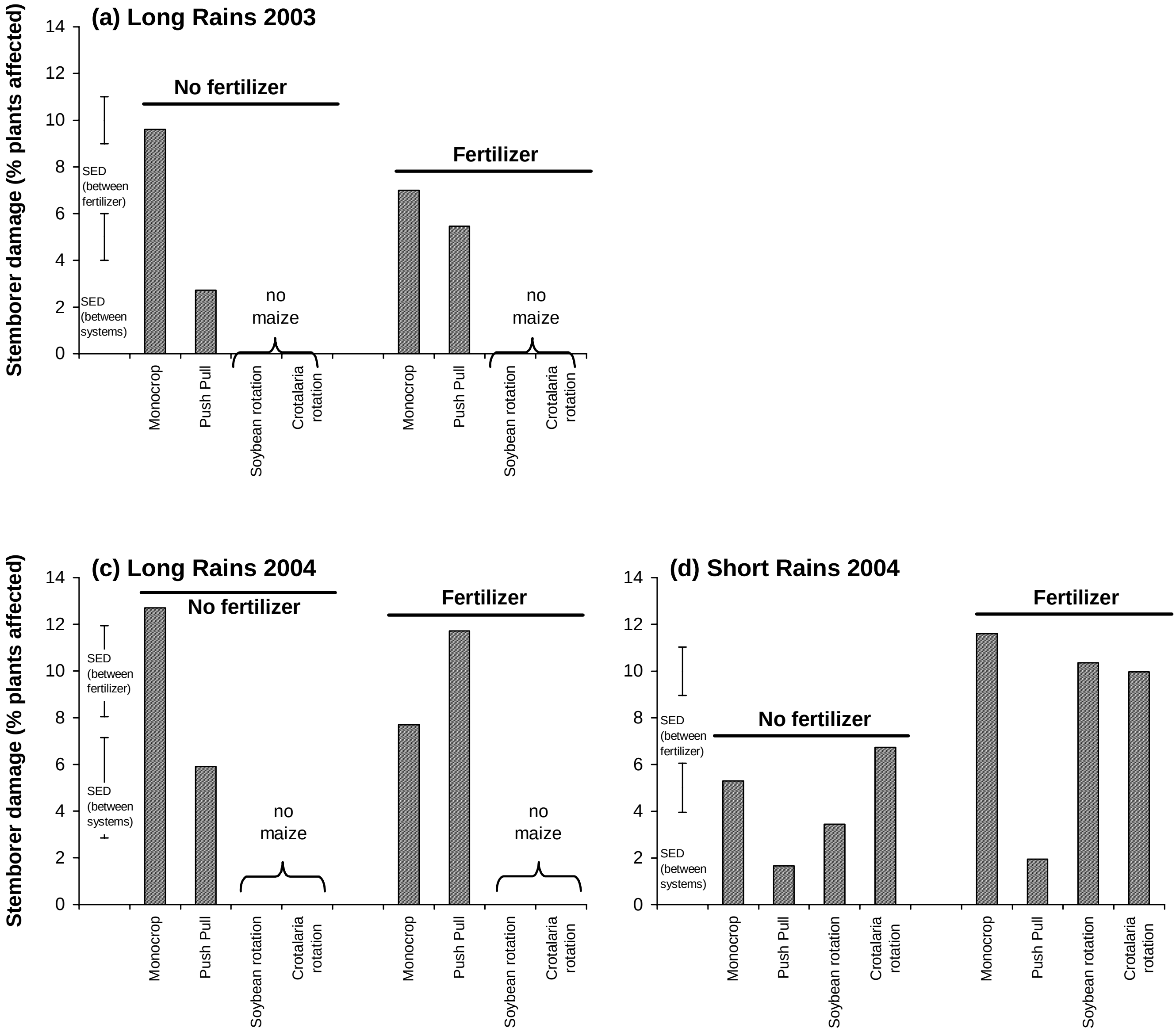

Fig 11: Effect of cropping system and fertilizer on stemborer incidence across villages of eastern Uganda. Data from the short rainy season of 2003 are not included.

2.2 Farmers evaluation of demonstrations

2.2.1 Farmers' scoring of different technology options

Farmers consistently scored push pull treatments highly, giving it a score of 4 (good) on average in Siaya district, Kenya (Table 8). During the short rains of 2003, push pull technology scored highly in Siaya, soybean and crotalaria rotations ranked high in Vihiga while soybean rotations were the most preferred in Busia. Local variety performed better than IR maize in some parts, possibly due to heavy rains that leached the herbicide. During short rains of 2004, farmers in Vihiga evaluated adaptation farmers' fields and scored push pull treatments highly (above 4). In Vihiga and Siaya, crotalaria-maize rotation came second and soybean-maize treatments third. In Busia (Uganda), soybean-maize rotation equally scored highly, with IR+F receiving the highest score (4.3), followed by push pull technology.

Table 8: Mean overall scores for the different technologies in Kenya and Uganda, short rains 2003 and 2004.

Short rains 2003					Short rains 2004		
Treatment description**	Busia N=59	Treatment description	Siaya N=62	Vihiga N=80	Busia*** (N=60)	Siaya *** N=154	Vihiga N=109
PP L1+F	4	PP IR+F	4.5	2.9	3	3.9	4.6*
PP L1-F	3.3	PP IR-F	4.2	2.8	3.7	4.5	4.4*
PP L4+F	3.4	PP L+F	4	2.9	3.6	4.5	
PP L4-F	2.7	PP L-F	4.3	2.9	3.2	4.1	
CRT L1+F	2.9	CRT IR+F	2.5	3.7	2.6	3.6	4
CRT L1-F	2.4	CRT IR-F	3.4	3.1	3.9	2.8	3.1
CRT L4+F	4	CRT L+F	2.4	3.7	2.7	3.9	4
CRT L4-F	2.6	CRT L-F	3.4	3	4	3.7	3.3
SOY L1+F	3.9	SOY IR+F	4	3.1	4.3	3.2	3.1
SOY L1-F	4.2	SOY IR-F	3.2	2.6	3.7	2.7	2.6
SOY L4+F	3.2	SOY L+F	3	3.3	3.1	2.8	3
SOY L4-F	3.2	SOY L-F	1.9	3.5	3.8	3	2.7
MON L1+F	2.8	MON IR+F	2.5	2.5	3.2	2.7	2.8
MON L1-F	3.4	MON IR-F	2.6	2.4	4.2	2.6	2.5
MON L4+F	3.5	MON L+F	2.3	3.2	2.9	2.6	3
MON L4-F	2.4	MON L-F	2.4	2.6	2.9	2	2.8

*The poor rains of this season resulted in a very poor maize stand count in push pull treatments. Because of presence of visitors, farmers were asked to evaluate an adaptation trial. So these numbers are not representative of the push pull technology results of the season.
**Treatments in Busia in 2003 were slightly different, since IR was not approved yet for the trials. Therefore, in stead of IR, Longe 1 (L1) was used.
***IR maize had some technical problems in the short rains of 2004, especially in Siaya and Busia: despite seed treatment, *Striga* infestation levels were unusually high. Probable causes were herbicide leaching due to heavy rains in the beginning of the season, or poor quality of the seed treatment.
PP (push pull), L (local maize variety), L1 (longe 1), L4 (longe 4), IR (IR-maize) CRT (crotolaria), SOY (soybean), F (fertilizer), MON (maize monocrop)

2.2.2. Statistical analysis of farmers' scoring of different technology options

Scores are ordered categorical data. Averaging these scores has some theoretical statistical problems since it assumes they are continuous numerical data. Taking averages therefore implies making certain assumptions on the distribution. The theoretically correct way of analysing such data is through log likelihood ratios, mainly ordinal regressions.

Analyses using ordinal regression revealed that push pull treatments were generally more preferred (Table 4). The estimated coefficients are log-odd ratios, compared to the last entry (here monocrop of local variety without fertilizer). The analyses generally confirmed the comparison of the mean scores.

In Uganda, farmers generally appreciated soybean-maize rotation with half treatments being significantly different (short rains of 2004) (Table 9). Treatments with IR maize under all cropping systems were for most part significantly appreciated (Table 9). Local maize variety without fertilizer application under rotational cropping systems was also significantly appreciated. Kenyan farmers generally appreciated push pull technology than their Ugandan counterparts during the two seasons. Crotalaria-maize came second while soybean-maize rotation came third during both seasons. In Uganda, soybean-maize rotation is appreciated the most followed by the push pull technology.

Table 9: Overall appreciation of technologies during short rains 2003 and 2004 in Kenya and Uganda. Values are log odd ratios relative to the baseline in the last row of the table.

Treatment	Kenya 2004		Uganda 2004		Kenya 2003		Treatment	Uganda 2003	
	general	sig	general	sig	general	sig		General	Sig
PP IR+F	3.73	***	1.36	***	1.99	***	PP L1+F	3.18	***
PP IR-F	3.94	***	1.19	***	1.54	***	PP L1-F	2.05	***
PP L+F	2.97	***	0.64		1.48	***	PP L4+F	2.15	***
PP L-F	3.05	***	0.11		1.63	***	PP L4-F	1.01	***
SOY IR+F	1.31	***	2.54	***	1.69	***	SOY L1+F	3.04	***
SOY IR-F	0.50	***	1.32	***	0.66	***	SOY L1-F	3.63	***
SOY L+F	0.92	***	0.41		1.11	***	SOY L4+F	1.75	***
SOY L-F	0.89	***	1.71	***	0.56	**	SOY L4-F	1.78	***
CRT IR+F	2.32	***	-0.60		1.16	***	CRT L1+F	1.29	***
CRT IR-F	0.91	***	2.07	***	1.19	***	CRT L1-F	0.54	
CRT L+F	2.55	***	-0.44		1.10	***	CRT L4+F	3.31	***
CRT L-F	1.83	***	1.97	***	1.17	***	CRT L4-F	0.90	**
MON IR+F	0.69	***	0.54		0.08		MON L1+F	1.13	***
MON IR-F	0.32	*	2.43	***	0.05		MON L1-F	2.24	***
MON L+F	0.67	***	0.02		0.53	**	MON L4+F	2.42	***
MON L-F	0.00	.	0.00	.	0.00	.	MON L4-F	0.00	.

*** significant at 0.1%; ** significant at 1%; * significant at 5%; abbreviations as in Table 8

The methodology also allowed comparing farmer evaluation by gender and by wealth class. For example, in Kenya (Table 10), interaction coefficients (male effect) for gender were negative and significant for the push pull technology. This indicates that women preferred the push pull methods than did men.

Similarly, ordinal regression allowed for the analysis by wealth class. For example, the interaction terms between wealth class and soybeans were negative and significant. This indicates that soybean, clearly a cash crop, was more appreciated by middle and high income groups (Table 11).

Table 10: Appreciation of technologies by gender in Kenya short rains 2004 (F= 157, M= 143). Values are log odd ratios relative to the baseline in the last row of the table.

	General model		Model with gender interaction term				
Treatment	General	Sig	Female	sig	Male (interaction)	sig	Male
PP IR+F	3.73	***	4.42	***	-1.34	***	3.09
PP IR-F	3.94	***	4.35	***	-0.82	*	3.53
PP L+F	2.97	***	3.35	***	-0.81	*	2.55
PP L-F	3.05	***	3.44	***	-0.81	*	2.63
SOY IR+F	1.31	***	1.45	***	-0.28		1.17
SOY IR-F	0.50	***	0.41		0.22		0.62
SOY L+F	0.92	***	1.12	***	-0.43		0.69
SOY L-F	0.89	***	0.97	***	-0.17		0.80
CRT IR+F	2.32	***	2.57	***	-0.51		2.06
CRT IR-F	0.91	***	0.98	***	-0.15		0.83
CRT L+F	2.55	***	2.77	***	-0.47		2.31
CRT L-F	1.83	***	1.97	***	-0.29		1.68
MON IR+F	0.69	***	0.71	***	-0.05		0.66
MON IR-F	0.32	*	0.37		-0.11		0.26
MON L+F	0.67	***	0.63	***	0.08		0.72
MON L-F	0.00	.	0.00	.	0.00	.	0.00
Male					0.03		0.89

*** significant at 0.1%; ** significant at 1%; * significant at 5%; abbreviations as in Table 8.

Table 11: Appreciation of technologies according to wealth classes by land category, short rains 2004. Values are log odd ratios relative to the baseline in the last row of the table.

	Low	sig	Middle (interaction)	Sig	High (interaction)	sig
PP IR+F	3.61	***	0.13		0.19	
PP IR-F	3.96	***	-0.11		0.41	
PP L+F	3.42	***	-0.47		-0.54	
PP L-F	2.97	***	0.06		0.28	
SOY IR+F	0.27		1.04	*	1.77	***
SOY IR-F	0.27		0.19		0.42	
SOY L+F	0.01		0.98	*	1.21	**
SOY L-F	-0.06		0.97	*	1.46	***
CRT IR+F	1.85	***	0.49		0.72	
CRT IR-F	0.90	**	-0.02		0.17	
CRT L+F	2.01	***	0.44		1.19	*
CRT L-F	2.02	***	-0.31		0.11	
MON IR+F	0.14		0.57		0.76	
MON IR-F	-0.98	**	1.51	***	1.62	***
MON L+F	-0.12		0.77		1.35	**
MON L-F	0.00	.	0.00	.	0.00	.
High class	-0.74	*				
Middle class	-0.35					
Low class	0	.				

*** significant at 0.1%; ** significant at 1%; * significant at 5%; abbreviations as in Table 8.

2.2.3 Farmers' selection of technologies

Most of the farmers in Siaya district (77%) selected push pull technology as their first choice while in Busia, Uganda, the proportion was about 29% (Figure 12). In Vihiga, farmers (61%) selected push pull only during visiting and evaluation of core farmers' fields. Crotalaria-maize rotation (25%) was selected by slightly a higher number of farmers compared to soybean-maize rotation (20%). Local maize variety also attracted more farmers in the monocrop technology (23.7%) due to its performance in grain yield and relative pest resistance.

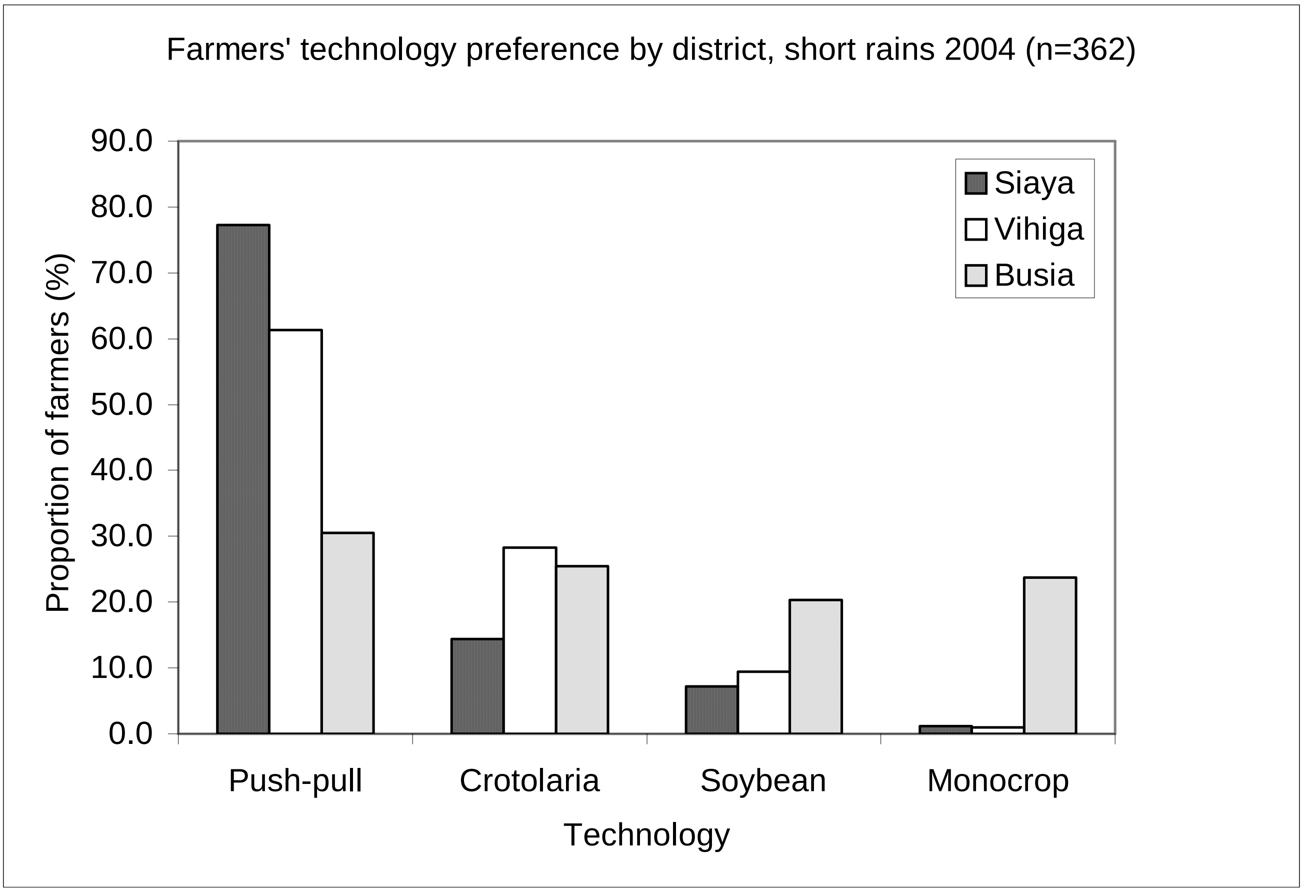

Fig 12: Technology preference by district during maize phase short rains of 2004

2.2.4 Farmers' experimentation in the long rains of 2005

Before the beginning of the long rainy (LR) season of 2005, farmers in Kenya were invited for a meeting. During this meeting they were given farmer evaluation results and asked to select the technologies they would adapt on their farms without the crops in the field. A total of 474 farmers in Kenya are experimenting technologies during LR 2005. Out of these, 42% selected IR maize, 29.5% selected push pull, 26.6% selected soybean while a paltry 1.1% selected Crotalaria (Figure 13).

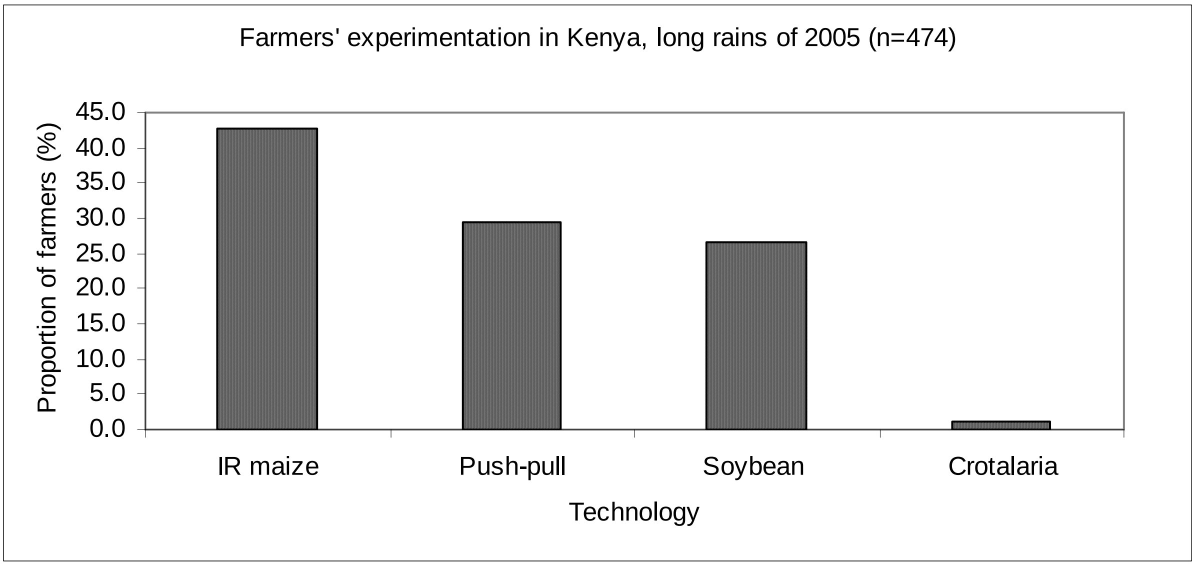

Fig 13. Proportion of farmers experimenting with different technologies in Kenya, long rains 2005

3. Dissemination of best-bet IPSFM options

Many organizations were found working in the target areas (Table 12). However, coverage was usually limited, with most organizations only covering a few of the sites. Notably lacking was access to credit facilities as only a few of the farmers had access to rural credit.

Table 12: Projects active in the target sites

	Kenya	Tanzania	Uganda
Research	ICRAF	ARI-Ukiriguru: research	
Extension	- Ministry of Agriculture(NALEP) - MoALD	- Agricultural extension - Tanzania Cotton Authority (TCA)	- Extension Staff
International NGOs	- CARE	- Catholic Relief services (CRS): - CARE-International: - CARITAS: tree nurseries - Heifer Project International (HIP): - FINCA: credit	- FINCA - SG 2000
Local NGOs and CBOs	- Christian Relief development agency - CRDA, (NGO) for dairy goats - CPDA, - KICRP, - Women groups, - Youth groups. - Integrated christian based project-Kima, - SCODP	- HESAWA: well construction -KIMKUMAKA: extension and input supply - Environmental Management project - DSPDE: Rehabilitation Schools - Roman catholic church	- Babiri Bandu (CBO) - BUDIFA - COWE - FFS - FITCA - Focus - FOSEM - IPPM/FFS - NAADS - WCA

In Kenya, the International Centre for Research in Agroforestry (ICRAF), working on soil conservation methods, and the international NGO, CARE, are active in Siaya. The extension service of the ministry of agriculture and a local NGO, SCODP, working on making fertilizer and other agricultural inputs available to farmers, are active in both sites. Many other local projects and community based organizations (CBOs) are also active in the region.

In Tanzania, the active institutions in the project include two government institutions: the Lake Zone Agricultural Research and Development Institute (LZARDI) in Ukiriguru, the extension service and two NGOs, Kimkumaka and CARE international. LZARDI is a government research institute with a mandate to develop new technologies for farmers in the Lake zone of Tanzania and also educate them on general improvement of agriculture. It is located in Misungwi district in Mwanza. Agricultural extension is one of the core functions of the Ministry of Agriculture and Food Security. The main objective of the extension is to transfer recommended agricultural technologies from researchers to farmers. CARE-International is an international NGO with a local office in the Misungwi district of the Mwanza region. It is responsible for educating farmers on the improvement of agricultural production through the use of improved agronomic practices. Kimkumaka, a local NGO located in the Nyamagana district of Mwanza, is linked to the Catholic Church. It provides advice to farmers on the improvement of agricultural activities besides provision of inputs such as seeds and low cost farm implements.

In Uganda, all the villages had some development projects except one that relied entirely on the public extension services. There was a disparity in the number of projects between men and women of the same village, which could relate to the gender orientation of the projects.

4. Capacity building

4.1 Students

Rutto, Esther, 2005. Economic Evaluation of Innovative Technologies to Combat *Striga*, Stemborer and Declining Soil Fertility in Western Kenya. MSc dissertation, Agricultural Economics, Moi University, Kenya. Degree expected at the end 2005.

Wangare, Lucy, 2004. Ex-Ante Evaluation of the Economic Potential of Herbicide Coated Maize Seed in the Control of *Striga* in Western Kenya. MSc dissertation, Agricultural Economics, University of Nairobi, Kenya.

4.2 Farmer and stakeholders

For farmer and stakeholder capacity building refer to Table 2.

5. Impact assessment

5.1 Factors influencing adoption

The farmer evaluation results revealed that the livestock breeds kept, size of landholdings, primary crop grown, market availability for the products, cost of inputs and price stability of the outputs/products and effectiveness of the technology in pest control and grain yield enhancement were the factors influencing technology adoption in the target areas. In areas where farmers keep mainly local breeds of livestock, like Siaya and Busia, there is generally low demand for high quality fodder, which is a major by-product of the push pull technology. In such cases, save for the technology's effectiveness in *Striga* and stemborer control, the adoption of the technology would not be as expected. In places where land is not a limiting factor, like eastern Uganda, farmers may not value continuous cropping, rotational crops or push pull cropping systems. Fallowing is still an option for farmers in Busia but in Vihiga where land holdings are small, farmers may not forego a whole maize cropping season. Maize in Uganda is not a primary crop; therefore farmers may not be keen to adopt maize-based farming systems. Lack of market for these technologies' outputs inhibits adoption. For example, farmers in Busia have no value for *desmodium* and market for Napier, while in Vihiga there is high demand for the fodder, which is a major driving factor for adoption of the push pull technology. The output prices for soybean and maize are fluctuating while input prices are steadily rising, thereby influencing adoption of these technologies. Effective control of *Strig*a weed and high maize grain yields realised also foster technology's adoption.

5.2 Farmers' interest

During farmer evaluations, those in Kenya preferentially chose push pull technology (77%). This trend however, changed during adaptation trials/technology selection where 40% preferred IR maize, 29% preferred push pull and 31% adapted soybean and crotalaria rotation. In Tanzania, most farmers selected IR maize, cowpea rotation and push pull technology in that order.

Contribution of outputs to development (impact)

This project is creating benefits related to various aspects of rural livelihoods in the target areas which are in line with DFID's development goals:

(i) **Food Security**: By increasing food production and decreasing variability on a sustainable basis, the project is contributing directly to food availability and food security.
(ii) **Human Health**: Enhancing the production of soybean in local communities has shown clear beneficial impacts on health indices, especially for children.
(iii) **Gender Empowerment**: Women's contribution to agricultural production in Africa is very high. Despite variations across cultural and socio-political backgrounds, women contribute enormously towards agricultural resource allocation decisions.
(iv) **Dairy and Livestock Production**: The proposed strategies will contribute significantly to increased livestock production by producing more fodder, especially on small farms where competition for land is high.
(v) **Soil Conservation and Fertility**: *Desmodium* and other legumes such as dual purpose grain legumes have been introduced into eastern Africa for livestock fodder and to increase soil fertility. Appropriate legume-cereal rotations/combinations can substantially reduce the need for external mineral nitrogen inputs and improve the use efficiency of other inputs.

This project has been extended until the end of 2005 (i) to continue in the demonstration sites to evaluate the medium to long term benefits of the best-bet options and their combinations, with special attention given to socio-economic analysis; (ii) to complete the evaluation of the first generation of on-farm trials, which were hampered due to serious drought in the Lake basin during the long rainy season of 2004; (iii) to extend the products of the project to more farmers beyond the target villages; (iv) to foster the availability of seed and fertilizer; and (v) to assess the short and medium term impacts of the technologies in the target regions.

The proposed activities will, firstly, yield conclusive information on the medium to long-term effects of the best-bet options on the *Striga* seed bank, stemborer reduction, the overall soil fertility status and economic performance for the target areas. This information is essential for ensuring food security, income generation and environmental sustainability. Secondly, farmers' assessment on the best-bet options requires several feedback cycles over several seasons, keeping in mind the nature of the technologies evaluated (e.g. rotations require at least 2 seasons to assess residual effects) and the relatively high potential for drought occurrence around Lake Victoria. Thirdly, the project will deliver its products to a large number of farmers within and beyond the target villages around the Lake Victoria basin through enhanced linkages with farmer groups, NGOs and other projects operating in the Lake Victoria basin. Fourthly, some components of the best-bet technologies require access to improved seeds and/or fertilizer. Public-private sector linkages with seed companies and input suppliers operating around Lake Victoria will foster access to seed and fertilizer, with special attention given to resource-poor communities through application of the credit supply principles developed and evaluated by the Sustainable Community-based Input Credit Scheme (SCOBICS), a research product developed by a NRSP-funded DFID project. Lastly, the potential for alleviating poverty and spreading the products through areas beyond the target areas will be evaluated through impact assessment activities.

In Kenya, the promotion of soybean as both human and animal feed through other stakeholders will enhance the uptake of the technology for soil fertility improvement and its ability to stimulate suicidal germination of *Striga* seed in the soil. The project will also link with other stakeholders in the promotion of *Desmodium* forage legume for livestock feed as a way of accelerating the uptake of the push pull technology. In Uganda, the addition of forage value into the project is a strong inducement for the uptake of the push pull technology. The use of soybeans as animal feed will also promote the use of soybeans in rotation with maize to improve soil fertility and *Striga* control. In Tanzania, both *Desmodium* and Napier grass can be used as livestock feed and can reduce costs of buying supplementary feeds for milk production. Since *Desmodium* and IR maize seeds are not enough to satisfy the growing demand, and since no private sector seed companies are active in the target areas, NGOs and community-based groups will be encouraged to multiply the seeds.

In Kenya, the organizations to benefit from the research activities are the four farmer groups we are currently working with directly, as well as a large number of farmer groups that will be reached through NGOs like Care for Relief Everywhere (CARE), the Christian Relief Development Agency (CRDA), the Kima Integrated Christian based Rural Project (KICRP), the Sustainable Community Oriented Development Program (SCODP) and Farming in Tsetse Control Areas (FITCA). The Ministry of Agriculture (MoA) and the Ministry of Livestock Development (MLD) will also greatly benefit. In Uganda, the organizations to benefit are the two farmer groups we are currently working with and the farmer groups that will be reached through linkages with NGOs such as COWE (Care for the Orphan, Widows and the Elderly), BUDIFA (Busia District Farmers Association), FITCA (Farming in Tsetse Control areas), and LWDA (Lumino Women Development Association). LGDPs (Local Government Development Program) and NAADS (National Agricultural Advisory Services) will also benefit. In Tanzania, the expected organizations and groups that will benefit are the four farmer groups currently involved in the project and others reached through contacts with NGOs like CARE-International, the Evangelical Lutheran Church of Tanzania and the World vision of Tanzania.

Biometricians Signature

I confirm that the biometric issues have been adequately addressed in the Final Technical Report:

Signature:

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Date: 9 May 2005

Abbreviations

MoA	Ministry of Agriculture
CPDA	Christian Partner Development Agency
DAO	District Agricultural Officer
DIO	District Information Officer
DDAO	Deputy District Agricultural Officer
CAFARD	Conservation Agriculture for Sustainable Development
ICRAF	International Centre for Research in Agroforestry
CARE	Care for Relief Everywhere
CRDA	Christian Relief Development Agency
KICRP	Kima Integrated Christian Based Rural Project
SCODP	Sustainable Community Oriented Development Programme
FITCA	Farming in Tsetse Control Areas
IPPM/FFS	Integrated Pest and Production Management/Farmer Field School
NAADS	National Agricultural Advisory Services
COWE	Care for the Orphan, Widows and the Elderly
BUDIFA	Busia District Farmers Association
SG 2000	Sasakawa Group 2000