RIU

# Push–pull deals with pests and improves soils

**Validated RNRRS Output.**

'Push–pull' pest management means growing plants that repel pests together with those that attract and kill them. One of these partnerships, Napier grass and the legume Desmodium, prevent stemborer and witchweed in maize. These push–pull partners are also good fodder crops and improve soil fertility. Other integrated pest and soil management strategies proven in Kenya, Uganda, Tanzania, Malawi, Ethiopia and Nigeria are now available for small farmers to improve mixed maize–livestock systems—crop rotation, intercropping, manure and fertilizer, dual-purpose grain legumes and resistant varieties. Over 6000 smallholders in Kenya and Tanzania already use environmentally friendly push–pull methods to control witchweed and stemborer, improve soils, and grow more fodder for livestock. These technologies have great potential for other cereals, particularly sorghum and millet.

Project Ref: **CPP52:**
Topic: **1. Improving Farmers Livelihoods: Better Crops, Systems & Pest Management**
Lead Organisation: **ICIPE, Kenya**
Source: **Crop Protection Programme**

---

**Document Contents:**



---

## Description

**Research into Use**
NR International
Park House
Bradbourne Lane
Aylesford
Kent
ME20 6SN
UK

**Geographical regions included:**

Ethiopia, Kenya, Malawi, Nigeria, Tanzania, Uganda,

**Target Audiences for this content:**

Crop farmers,

***CPP52***

## *A. Description of the research output(s)*

### *1. Working title of output or cluster of outputs*

**Improving livelihoods of small-holders through integrated pest and soil fertility management in maize-livestock production systems**

### *2. Name of relevant RNRRS Programme(s) commissioning supporting research*

- Crop Protection Program (DFID)

**Other funding sources**:
- Kilimo Trust, Uganda
- African Agricultural Technology Foundation (AATF), Kenya
- Biovision International, Switzerland
- Rockefeller Foundation, Kenya

### *3. Relevant R numbers (and/or programme development/dissemination).*

R8449, R8212

**Institutional partners**: - ICIPE (Z.R. Khan, D. Amudavi & C. Midega), CIMMYT (H. De Groote & F. Kanampiu), TSBF-CIAT (B. Vanlauwe), Rothamsted Research (L. Wadhams), Maseno University (G. Odhiambo), NARO (J. Kikafunda), LZARDI (I. Rwizah)

### *4. Description of output or cluster of outputs (396 words)*

The outputs involve integrated soil fertility and pest management strategies, including: Crop rotation, ‘push-pull’, intercropping, organic inputs and fertilizer, dual purpose grain legumes, and imazapyr-resistant maize (IR-maize).

**‘Push-pull**’ technology controls ***Striga*** and **stemborers** and improves soil fertility. A cereal is intercropped with a legume, silverleaf **desmodium** and **Napier grass** is planted around the **intercrop**. The desmodium produces volatile chemicals which repel the stemborer moths from the maize (push) while those released by Napier grass attract and trap the moths (pull). The desmodium roots produce semiochemicals which stimulate *Striga* seed germination and inhibits their attachment with maize, thereby reducing *Striga* seed bank. The legume also improves **soil fertility** through **nitrogen fixation**. Both plants provide **quality fodder** for **livestock**.

**Dual purpose soybean** varieties have a relatively low **nitrogen (N)** harvest index (N grain/N total biomass) and high potential for fixing nitrogen from the atmosphere through symbiosis with indigenous Rhizobia, thus avoiding inoculation. The resulting positive **nitrogen balance** in systems where such varieties are introduced, e.g., in **crop rotations**, benefits subsequent cereal crops. Moreover, some varieties have been shown to trigger suicidal germination of *Striga hermonthica*, thereby reducing the *Striga* seedbank and offering additional benefits to cereal production. Application of **fertiliser** after the dual purpose soybean crop increases its **use efficiency**.

**IR-maize** – **Imazapyr** resistant maize is tolerant to imazapyr herbicide, allowing for coating of the seed which then controls *Striga* during and before attachment hence having a direct action on *Striga.* This results in a reduced *Striga* seedbank. Integration with technologies like 'push-pull' adds value through improving soil fertility. Both **open pollinated** and **hybrid** IR-maize varieties that are resistant to **maize streak virus** (MSV) are available.

**'Push-pull'** was developed during phase I (1994-1997) of the Gatsby Charitable Foundation-funded project. During phase II and III (1998-2000, 2001-2003) it was validated and dissemination started in Kenya and Uganda. **Dual purpose soybean varieties** developed in West Africa, were introduced in East Africa in 2001. **IR-maize** was developed over the last 10 years during Phase I and II of the Rockefeller funded project. During Phase II (2003-2005) hybrids were given to local seed companies for registration and commercialization. Wide scale demonstrations were done for pure stands or integrated with other cultural methods for *Striga* control and soil fertility improvement.

Problems addressed include food and nutrition security, low and declining soil fertility, *Striga* and stemborers infestation, and shortage and poor quality livestock feed frequently mentioned by farmers.

***5. Type of output(s) being described***

| ***Product*** | ***Technology*** | ***Service*** | ***Process or Methodology*** | ***Policy*** | ***Other Please specify*** |
|---|---|---|---|---|---|
| ***x*** | ***X*** | | | | ***Training*** |

***6. The main commodity (ies) upon which the output(s) focussed***

| **Component** | **Main commodity (ies)** | **Possible application** |
|---|---|---|
| Push pull technology | Maize<br>Soybean<br>Fodder | Sorghum<br>Millet |
| Combined application of organic inputs and fertilizer | | |
| Dual purpose soybean rotation | | |
| IR-maize | | |

***7. Production system(s) the output(s) focus upon***

| ***Semi-Arid*** | ***High potential*** | ***Hillsides*** | ***Forest-Agriculture*** | ***Peri-urban*** | ***Land water*** | ***Tropical moist forest*** | ***Cross-cutting*** |
|---|---|---|---|---|---|---|---|
| **x** | **x** | **x** | | **X** | | | **X** |

***8. Farming system(s) the output(s) focus upon***

| *Smallholder rainfed humid* | *Irrigated* | *Wetland rice based* | *Smallholder rainfed highland* | *Smallholder rainfed dry/cold* | *Dualistic* | *Coastal artisanal fishing* |
|---|---|---|---|---|---|---|
| X | | | x | X | | |

***9. How value addition to the output or additional constraints could be addressed by clustering this output with research outputs: (max. 300 words)***

The proposed outputs aim to contribute to increasing food security and improving livelihoods of rural families in eastern Africa through increased productivity and sustainable use of available natural resources. The outputs of increasing food security and improving livelihoods through promotion of integrated pest and soil management in maize systems will provide synergy and complementarity to the proposed outputs.

Livestock production among the smallholder farmers is central to addressing low food and nutrition security. Hence, outputs which contribute to better utilization of fodder and crop residues will be relevant. Promotion of smallholder based goat production, better use of crop residues for fodder and strategies for feeding smallholder dairy cattle will be complementary to enhancing improved livestock production.

Given that the outputs are knowledge-intensive, facilitating better understanding by farmers and improving decision-making in technology choice is necessary. Use of adult learning institutions, e.g., Farmer Field Schools (FFS) with curricula, improved training manuals, and effective facilitators will be helpful.

Successful promotion of the outputs will depend on availability and affordability of farm inputs by the small-scale farmers. Therefore improving farmers' access to markets for inputs and outputs will be valuable to these outputs.

**The current research output can be clustered with**:

- Increasing food security and improving livelihoods through the promotion of integrated pest and soil management in lowland maize systems (R8452/R8215)
- Integrated land management of *Striga* and low soil P (R7962)
- Strategies for feeding smallholder dairy cattle in intensive maize forage production systems and implications for integrated pest management (R7955)
- Promotion of crop residues for fodder (R9339, 7346, 8296)
- Community based goat production in Kenya (R7634)
- Sweet potato management and promotion through FFS (R8417, R8341)
- Improved access to appropriate farm inputs for integrated maize crop management by small-scale farmers in Embu and Kirinyaga Districts, Kenya (R8219/R7405)

# Validation

***B. Validation of the research output(s)***

***10. How the output(s) validated and who validated them (496 words).***

**METHODS USED:**

***(i) Participatory evaluation scoring criteria:***

Evaluations of technology trials were conducted during field days in all villages of selected districts in Kenya and Uganda. Over 1000 farmers and other stakeholders scored and ranked the technologies at the end of each short rainy season with maize planted under all the technologies. The same procedure was followed in each village. The criteria used to evaluate the technologies were *Striga* and stemborer control, soil fertility enhancement, crop yield, and labour saved. Each technology was scored against each criterion on a scale of 1 (very poor) to 5 (very good), and then given an overall score. The farmers then selected the top three or four technologies they preferred to adapt in their own fields.

The farmers adopted the technologies of their choice in the proceeding season. Most of them either chose IR-maize alone, ‘push-pull’ alone or as a combination of IR-maize and ‘push-pull’ system.

***(ii) Biophysical measurements in adaptation trials:***

The adaptation trials were established after farmers had evaluated the technologies for two seasons. Farmers carrying on the adaptation trials were selected based on wealth and gender. The technology trials included ‘push-pull’ with fertilizer, IR-maize with fertilizer and soybean rotation followed by IR-maize. These were compared with farmers’ plots under usual maize cultivar. They were all planted in a 10 by 10 metre plot area. Data were collected on stemborer damage, *Striga* emergence and grain yield of maize and soybean. Results show that IR-maize performed better than farmer’s varieties while the ‘push-pull’ technology resulted in higher maize yields.

***(iii) Economic analysis:***

Economic data were collected to determine the economic viability of the technologies under all seasons and sites. Partial budget and marginal returns analysis for IR-maize and benefit cost analysis of ‘push-pull’ and other cropping systems analysis of their returns to land and labour and net present values at different discount rates were done. Preliminary results show that ‘push-pull’ is profitable in the long term compared to other cropping systems. This is so because during the first year there are high costs incurred in the establishment of Napier and desmodium. IR-maize under the rotations regime is also profitable to the farmers.

***By whom:***

The participatory evaluations data were analysed by farmers by wealth and gender categories with total livestock units (TLUs) and farm size as wealth indicators. The results show that female participants generally rate all technologies higher than do men though not significant, therefore are gender-neutral. Age had a positive and significant relationship with ‘push-pull’ and IR-maize showing that old farmers prefer ‘push-pull’ combined with IR-maize. Farm size had a negative effect on the preference for ‘push-pull' technologies, indicating that the proposed technologies are indeed appreciated by small-scale farmers.

Stakeholders (extension, seed companies) also did validation on their sites which encouraged promotion of the outputs through seed multiplication (companies) and technology transfer (extension). The biophysical measurements in adaptation trials were cross-evaluated by the International Agricultural Research Scientists (IARS). The economic analysis was done by social scientists from the centres.

***11. Where and when the output(s) been validated. (264 words)***

**Push-pull technology**

**Countries:** Kenya, Uganda
**Districts:** Push-pull has been validated in 15 districts in western Kenya (Trans Nzoia, Bungoma, Busia, Butere-Mumias, Vihiga, Bondo, Siaya, Teso, Nyando, Kisii, Migori, Kuria, Homa Bay, Suba, and Rachuonyo); 2 districts in central Kenya (Murang’a and Kiambu), and 5 districts in Uganda (Busia, Pallisa, Bugiri, Tororo, Kapchorwa). Work on validation in Tanzania started in September 2006.
**Years:** Validation has been done since 1998 to date.
**Social Groups**: All types of farmers, with emphasis on small-holder, did the validation.
**Production systems**: Semi-Arid, high potential, peri-urban, cross-cutting
**Farming systems:** Smallholder rainfed humid, Smallholder rainfed highland, Smallholder rainfed dry/cold

**Soybean and legumes**

**Countries:** Kenya, Uganda, Nigeria
**Districts:** Trans Nzoia, Bungoma, Busia, Butere-Mumias, Vihiga, Bondo, Siaya, Teso, Nyando, Kisii, Migori, Kuria, and Rachuonyo, Uasin Gishu, Maragwa, Meru, Tharaka, Embu Murang’a, Kiambu and Nakuru. Uganda (Rakai, Hoima, Busia, Lira, Tororo, Pallisa, Sironko)
**Years:** Kenya and Uganda validation done in 2002-2006. In Nigeria early 1990s.
**Social Groups**: All types of farmers, with emphasis on small-holder, did the validation.
**Production systems**: High potential, peri-urban, cross-cutting
**Farming systems:** Smallholder rainfed humid, smallholder rainfed highland, smallholder rainfed dry/col

**IR-maize seed coating technology**

**Countries:** Kenya, Uganda, Tanzania, Malawi, Ethiopia
**Districts:** IR-maize has been validated in 10 districts in western Kenya (Kisumu, Siaya, Rachuonyo, Nyando, Bondo, Busia, Bungoma, Teso, Vihiga and Kakamega), 3 districts in Uganda (Busia, Pallisa and Bugiri), 2 districts in Tanzania (Tarime and Mwanza)
**Years:** 2000-2006
**Social Groups**: All types of farmers, with emphasis on small-holder, did the validation.

**Production systems**: Semi-arid, high potential, peri-urban, cross-cutting
**Farming systems:** Smallholder rainfed humid, smallholder rainfed highland, smallholder rainfed dry/cold

---

# Current Situation

***C. Current situation***

***12. How and by whom the outputs are currently being used (250 words).***

**Push-pull technology**

'Push-pull' is being used by over 6,000 smallholder farmers for control of *Striga* and stemborer, improvement of soil fertility, and provision of fodder for livestock. Since the technology relies on the use of desmodium seed, availability of the seed is critical. Collaboration with Western Seed Company has led to a community-based desmodium seed multiplication programme with over 600 farmers being contracted by the company. NGOs and stockists are also involved in seed distribution. Researchers are also carrying out trials to assess the potential of the technology on other cereals, particularly, sorghum and millet.

**Soybean and legumes**

Dual purpose soybean varieties are currently being used by smallholder farmers in rotations or intercrops with maize. Various farmer associations and at least one private seed company in Kenya are currently multiplying seeds.

**IR-maize seed coating technology**

In the last two years alone a consortium of NGOs and other partners have widely tested and demonstrated IR-maize seed coating technology for *Striga* control in the region in over 10,000 small-scale farms. Demonstrations of IR-maize are being combined with use of other farm inputs as fertilizers. In July 2005, this technology was launched and three local seed companies were provided with these varieties for commercialization. All the seed companies have been trained on seed treatment and quality control. In December 2006, IR-maize hybrid will be commercially launched. Western Seed Company has already produced 120 metric tons of commercial seed for the long rainy season in March 2007, planting of which is expected in March.

***13. Where the outputs are currently being used (211 words)***

**Push-pull technology**

Push-pull has been introduced in over 15 districts in western Kenya (Trans Nzoia, Bungoma, Busia, Butere-Mumias, Vihiga, Bondo, Siaya, Teso, Nyando, Kisii, Migori, Kuria, Homa Bay, Suba, Rachuonyo) 2 districts in central Kenya (Murang'a, Kiambu), 5 districts in Uganda (Busia, Pallisa, Bugiri, Tororo, Kapchorwa) and has just started in 2006 in 1 district in Tanzania (Tarime).

**Soybean and legumes**

Dual purpose soybeans are grown by smallholders on large areas in Nigeria, where activities were initiated over 15 yrs ago to promote these varieties. In west and central Kenya, where promotion activities started in 2002, various farmer associations are currently producing and multiplying these varieties. In Nigeria, soybean production has been increasing due to local processing of and national demand for soybean products. In Kenya, promotion of soybean production is through a three-tier approach: (i) training of households to use soybean for local consumption, (ii) facilitation access to processing equipment to be managed by farming communities, and (iii) linking farmers to large-scale processors in Nairobi.

**IR-maize seed coating technology**

Promotion of IR-Maize has started in Kenya and commercialization is under way in Uganda, Tanzania, Malawi and Ethiopia.  Demonstrations are being conducted on selection of best varieties for registration and commercialization by seed companies is being done in Malawi and Ethiopia.

***14. The scale of current use (245 words)***

**Push-pull technology**

‘Push-Pull’ technology was first disseminated in 1997 in two districts in Kenya and has quickly spread to over 17 districts. The technology is under dissemination in 5 districts in Uganda and 1 district in Tanzania. More than 6,000 farmers have adopted the technology since then, indicating the potential of spread to wider farmer targets. The number of users is increasing at a faster rate as more stakeholders (national government extension, researchers, NGOs, CBOs, etc) are getting involved in promoting the uptake of the technology.

**Soybean and legumes**

In Nigeria, several tens of thousands of hectares are currently under dual purpose soybean production (IITA is currently implementing an impact study). Total soybean production in Nigeria has quadrupled over the past 15 years up to 500,000 metric tons. As of today, a substantial fraction of this land area is taken up by dual purpose soybean. In Kenya, about 5000 ha is currently under soybean production, of which the dual purpose soybean varieties occupy a marginal, but exponentially growing fraction.

**IR-maize seed coating technology**

The potential market for IR-maize in Kenya alone has been estimated at over 212,000 hectares or 4,000 tones of seed. The technology has been heavily promoted and 120 tones of commercial seed will be on the market in December 2006, enough to plant 6500 ha. Once other varieties are registered in other countries, the production of IR-maize is expected to spread widely and fast in the *Striga* prone areas of sub-Saharan Africa.

***15. Programmes, platforms, policy, institutional structures assisting with the promotion and/or adoption of the output(s) and the key facts of success for capacity strengthening (317 words)***

- **Supportive national policies**. The National Agricultural Sector Extension Programme (NASEP) facilitates the formation of stakeholders' fora and strengthens where they already exist to discuss: what technologies are available for dissemination, extension providers and where they operate and how to avoid duplication and unhealthy competition.

- **Ministry of Agriculture's programmes** - National Agriculture and Livestock Extension Programme (NALEP), Kenya Agricultural Productivity Project (KAPP), and Kenya Agricultural Research Institute (KARI) get technologies to be tested, demonstrated on-farms and promoted to farmers. Ministry of Industry has supported importation of soybean seed.

In Uganda, the National Agricultural Research Organization (NARO) and National Agricultural Advisory Development Services (NAADS) and in Tanzania Lake Zone Agricultural Research and Development Institute (LZARDI) and the Ministry of Agriculture promote technologies.

- **Non-governmental Organizations**: Several NGOs are involved in the scaling up of research outputs through supporting on-farm demonstrations, providing credit to purchase seed and inputs, and offer training. For example, NGOs in the region promoting uptake of these technologies are: COSOFAP (consortium of NGOs in western Kenya), Heifer International, SCODP, Millenium Village, CARE, Hagonglo Cereal Bank, Resource Projects Kenya (RPK), FORMAT, AATF, We RATE in Kenya. In Uganda INSPIRE, a consortium of NGOs and in Tanzania TARDF, TAHEA, Gamasara, ICDP, Mogabiri Extension Center have been facilitating uptake of technologies that show potential for providing multiple benefits to farmers.

- **Farmer groups**: Farmers have been learning about the outputs through groups. For example, efforts are being undertaken by stakeholders to have the 'push-pull' technology promoted through Farmer Field Schools.

- **Private sector**: Commercial seed companies are increasingly becoming important players in technology transfer through production and distribution of high quality seed. For example, Western Seed Company.

For 'Pull-pull', there is a National Steering Technical Committee that draws members from the public sector (policy, research and extension), private sector including NGOs that holds meetings to explore ways of supporting the promotional efforts into technology uptake and dissemination.

---

## Current Promotion

### *D. Current promotion/uptake pathways*

### *16. Where promotion is currently taking place (200 words)*

All the outputs are promoted to farmers, and particularly smallholder farmers in western and central Kenya.

**Push-pull technology**

Promotion in Kenya is through: (i) **field days** and **brochures**, (ii) **radio** programme – "Tembea na majira" - Move with times, (iii) **NALEP** and **KAPP** programmes, (iv) District stakeholder fora, (v) **Farmer teachers**, (v) National Steering Committee and (vi) **seed company** and **stockists**. In Uganda promotion is through INSPIRE and NARO while in Tanzania it is through the National Stakeholders' Forum.

**Soybean and legumes**

Promotion in Kenya is through; (i) farm families receiving **training** on how to integrate soybean products in local meals, using a training-of-trainers approach targeting extension and **NGOs** staff, (ii) **farmer associations** getting exposed to processing equipment to produce soymilk through linkages with a Canadian NGO (Malnutrition Matters), and (iii) **farmer associations** being facilitated to explore options for supplying soybean to large-scale processors in Nairobi and Nakuru.

**IR-maize seed coating technology**

Promotion in Kenya is by **research organizations**, **NGOs**, **extension agents** and **seed companies**. **Demonstration packages** for IR-maize and fertilizer companies were distributed to 10,000 farmers. Farmer evaluations take place regularly on field-days. Seed companies also promote it in Tanzania and Malawi in collaboration with extension agents and research institutions.

***17. The current barriers preventing or slowing the adoption of the output(s) (193 words)***

Several barriers have been observed to limit the adoption of the research outputs by majority farmers. Common barriers include:

- Weak farmer organizations
- Many technologies competing for the same clientele
- Changing climatic patterns hence increasing farmer risks
- Poor infrastructure inhibiting market access for inputs and outputs
- Limited resource investment by local institutions

Specific barriers include:

**Push-pull technology**

- Shortage of desmodium
- High cost of production
- Knowledge-intensive
- Labour-intensive in the first cropping season
- Cultural practices, especially free grazing cattle destroy the perennial Napier and desmodium grass

**Soybean and legumes**

- Lack of sufficient knowledge on how to use the technology and add value to the produce.
- Lack of an organised seed market
- Low world market prices for soybean

**IR-maize seed coating technology**

- *Striga* control is knowledge-intensive
- Results are often not obvious in the current season
- Seed bank depletion is gradual and enhanced benefits require combination with soil fertility improvement
- *Striga* is a community problem for which community mobilization is needed
- Bureaucracy and delays in variety registration delays the technology adaptation
- Poor seed distribution networks in *Striga* prone areas

***18. Changes needed to remove/reduce these barriers to adoption (173 words)***

***General suggestions:***

- Involve all the stakeholders (NGOs, extension and research institutions) in scaling-up/out. Strengthen stakeholder fora at operational level
- Strengthen capacity of farmer groups through training
- Harmonization of technology introduction to target population
- Formulate policy to guide technology development
- Improve access to credit, access to inputs
- Stimulate demand for markets/demand for fodder
- Formulate policy to guide technology development
- Encourage technologies that offer opportunities for diversification of farm enterprises
- Determine cost effective dissemination pathways
- Target technologies to specific needs

***Specific suggestions:***

**Push-pull technology**

- Promote community based desmodium seed multiplication and use of vines in expansion of technology
- Educate farmers on group dynamics and development
- Support for establishment of farmer field schools

**Soybean and legumes**

The three-tier approach to promote soybean, as described above, aims at alleviating the marketing and processing constraints hindering the adoption of dual purpose soybean.

**IR-maize seed coating technology**

- Work with regulatory agencies responsible for variety registration
- Encourage seed companies to expand their stockist distribution network

***19. Lessons learnt about the best ways to get the outputs used by the largest number of poor people (298 words).***

- Methods used in promoting uptake of outputs should show the economic gain, either directly or indirectly and the integrative elements of the technologies. Farmers are interested in getting a high grain and fodder yields that solve their food problem and increase income.

- To get the best value out of the outputs, farmers need to understand the mechanisms through which the technologies work. The technologies are knowledge-intensive and take time to be understood. Therefore, there is need for organizing learning through a clear programme.

- Efficient and wide dissemination of the outputs cannot be achieved unless there is an active system of providing extension services. Extension efforts should focus on working with farmer groups rather than with individual farmers to produce economies of scale in resource use and technology uptake.

- Promotion of the outputs requires different kinds of support, for example, information on technology efficacy, inputs and other requirements hence different players could be involved. Different motivations drive actors to be involved in carrying out various activities. Thus, fostering public-private partnerships is likely to enhance the uptake of the technologies by majority of the resource-poor rural families. By clearly spelling out the roles of each actor, this helps to coordinate different activities required in disseminating the technologies.

- Since the technologies are knowledge-intensive and require upfront investment, they need to be well understood in order to stimulate demand for them. No single diffusion pathway is likely to generate the required level of understanding and preparation for technology uptake. Drawing on the strengths of various pathways in different contexts is therefore necessary.

- Not all smallholder farmers are homogenous. Different social categories, especially women and the very vulnerable need special attention. Targeting extension and promotional efforts based on needs analysis can help reach majority of these groups.

---

# Impacts On Poverty

## E. Impacts on poverty to date

### 20. Impact studies on poverty in relation to this output or cluster of outputs taken place

Khan Z.R., Midega, C.A.O., Njuguna, E. M., Amudavi, D.M., Wanyama, J.W., Pickett, J.A., and Wadhams, L.J. 2006. Economic performance of 'push-pull' technology for stemborers and *Striga* management in western Kenya. Paper in progress.

This study assessed the economic performance of "push-pull" technology compared to the conventional maize mono- and maize-bean inter-crop in terms of net returns to land and labour used and discounted net present values (NPVs) in six districts in western Kenya, where stemborers alone or in combination with *Striga* are major production constraints.

Maize grain yields were significantly higher in the push-pull than in the other two systems throughout the cropping years and with higher gross margins. Although the initial costs of establishing the other two systems were lower than in the push-pull, the net returns to land and labour with push-pull were significantly higher. Push-pull consistently produced positive NPVs of the net benefits compared to the two conventional systems when discounted at 10 to 30%.

Rutto Esther, H. De Groote, Bernard Vanlauwe, Fred Kanampiu, George Odhiambo and Zeyaur Khan. 2005. Farmers' Perceptions and Evaluation of Integrated Approaches to Combat *Striga*, Stemborer and Soil Fertility Problems in Western Kenya: Preliminary Results 2003. Paper presented at the 7th African Crop Science Conference, Entebbe, Uganda, 5-9 December 2005.

This study assessed farmers' opinions regarding the fit of several technologies including the "Push-pull" system, soybean and Crotalaria rotations, and IR-maize in order to prove feedback to the implementing researchers.

Rutto E., H. De Groote, B. Vanlauwe, F. Kanampiu, G. Odhiambo and Z. Khan. 2006. Participatory Evaluation of Integrated Pest and Soil Fertility Management Options Using Ordered Categorical Data Analysis. Contributed paper presented at the 26th Conference of the International Association of Agricultural Economics, Gold Coast, Australia, August 2006.

This study evaluated farmers' perceptions about the efficacy of four technologies namely; push-pull (maize intercropped with *Desmodium* and surrounded by Napier grass), maize-soybean and maize-crotalaria rotations, and IR-maize seed coated with the herbicide to address constraints to food security due to *Striga* , stemborer and declining soil fertility.

Sanginga, N., Dashiell, K.E., Diels, J., Vanlauwe, B., Lyasse, O., Carsky, R.J., Tarawali, S., Asafo-Adjei, B., Menkir, A., Schulz, S., Singh, B.B., Chikoye, D., Keatinge, D., Ortiz, R., 2003. Sustainable resource management coupled to resilient germplasm to provide new intensive cereal–grain–legume–livestock systems in the dry savanna. *Agriculture, Ecosystems and Environment* 100; 305–314.

This study examined two sustainable farming systems that greatly enhance the productivity and sustainability of integrated livestock systems developed and implemented in the dry savanna of Nigeria: These are: (i) maize–soybean rotations that combine high nitrogen fixation and the ability to suppress *Striga hermonthica*; and (ii) miflet and dual-purpose cowpea. The results show that the rate of adoption of soybean varieties and dual-purpose cowpea is very high with an increase of about 228% farmers adopting during the last 3 years, even in the absence of an efficient seed distribution system. The increased production of soybean has been stimulated by increased demand from industries and home utilization. Economic analysis of the two systems shows an increase of 50–70% in the gross incomes of adopters compared to non-adopters still using the current practices, mainly continuous maize cultivation. Furthermore, increases in legume areas of 10% in Nigeria (about 30,000 ha in the northern Guinea savanna) and increases of 20% in yield have translated into additional fixed nitrogen valued annually at US$ 44 million. This reflects, at the same time, an equivalent increase in land-use productivity.

Chianu J N, Ohiokpehai O, Vanlauwe B, Adesina A, and Sanginga N., 2006. An approach for promoting a versatile crop that has remained minor: Case of soybean in the farming systems of Kenya. *Food Policy,* accepted.

This study sought to understand reasons for successes of Soybean promotion in Nigeria and Zimbabwe and the missing links that led to failure in Kenya in order to create a model for sustainable soybean promotion in Kenya. Results show how the model increased the confidence of farmers to produce soybean for home consumption and the market since industrial food/feed processors have guaranteed import substitution at a mutual beneficial price. Other partners in the strategic alliance for sustainable soybean promotion in Kenya provide credit, mineral fertilizers, and know-how on other aspects of value addition all of which enhance soybean yield.

***21. How the poor have benefited from the application and/or adoption of the output(s). (261words)***

**How the poor have benefited from the research generated technologies**

All the proposed technologies have passed the development phase, but they are in the initial stages of dissemination. There is limited real impact documented yet, but substantial ex ante evidence exists.

**Kenya:**

- Over 800 farmers (about 60% women) have participated in evaluating the effectiveness of technologies for *Striga* and stemborer control, soil fertility enhancement, crop yield, and labour saving.
- Adoption and dissemination of the research outputs is gradually increasing among those who have observed and tried the technologies on their farms.
- Adopting farmers are experiencing higher crop yields due to control of *Striga*, stemborer and improvement of soil fertility.
- The technologies are likely to lead to higher incomes.
- The production of fodder, a major by-product of the research outputs, on small farms allows the small-holder to start livestock production, increasing cash flow and manure availability.
- Participatory evaluation and farmer experimentation empowers farmers and women’s groups
- The training of farmers and extension leads to better understanding of the research outputs - Human development.

There is potential for households that participate in groups that receive support in the form of dairy goats or other improved livestock.

**Uganda:**

- About 40% participants (women) have evaluated effectiveness of technologies for *Striga* and stemborer resistance, soil fertility enhancement, crop yield, and labour saving. They observe that the technologies, particularly 'push-pull' if applied on the farm leads to the multiple benefits

**Tanzania:**

For some of these outputs, the Tanzanian farmers are just getting ready to do on-farm experimentation and testing.

---

# Environmental Impact

***H. Environmental impact***

***24. Direct and indirect environmental benefits related to the output(s) and their outcome(s)***

**Reduced pesticide usage**: Because the push-pull strategy helps reduce stemborers incidence on maize, a significant reduction in the usage of chemical insecticides in Lake Basin is expected.

Low-dose herbicide seed coating technology, as opposed to spraying, concentrates the herbicide on the maize seed, reducing levels applied to the environment (typically 30 g/ha as compared to 600 g/ ha). It does not persist in the soil and breaks down after 12 weeks with no effect on subsequent crop. Unlike conventional herbicide application, the coating only has an effect up to 10cm from the maize hill, so intercropping is still possible.

**Protecting fragile environments.** The Lake Victoria basin is subject to rapid degradation due to rapid population increase and the continued use of unsustainable crop management techniques. By developing integrated and sustainable methods of agriculture, the value of output per unit of land will increase and, therefore, the incentive for soil conservation measures. High crop yields and improved livestock production resulting from proposed pest and soil management strategies will support many rural households under existing socio-economic and agro-ecological conditions. Improved use efficiencies of applied nutrients will reduce pressure on the environment and, especially, decreased pollution of ground and surface water from agrochemicals.

**Increased input use efficiency:** Using minimal amounts of fertilizer in rotations with dual purpose grain legumes has been shown to increase the use efficiency of the former and thus to reduce to risk for losses of fertilizer to the environment. An increase in the soil organic matter pool has also been shown to result in various benefits to crop production, resulting in an overall increase in use efficiency of the various production factors.

**Conservation of biodiversity.** The project will contribute to the conservation of biodiversity through intercropping and crop rotation strategies with different plants as a means of avoiding the pest problems inevitably encountered with the production of crops in continuous monoculture.

**Rehabilitation of degraded lands:** Use of desmodium and nitrogen use efficiency (NUE) maize germplasm will allow using previously abandoned land due to *Striga* and low fertility.

***25. Adverse environmental impacts related to the output(s) and their outcome(s)***

No immediate adverse environmental impacts are expected.

***26. Do the outputs increase the capacity of poor people to cope with the effects of climate change, reduce the risks of natural disasters and increase their resilience?***

An enhanced use efficiency of production factors certainly enhances the resilience of the agricultural production systems.

Increased food production and land productivity helps the poor farmers in years of severe drought, to cope with poor/little food production