Reducing Poverty through Improved *Striga* Control

Proceedings of the second *Striga* management stakeholders' conference

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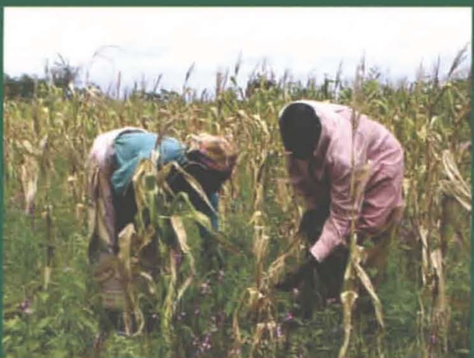
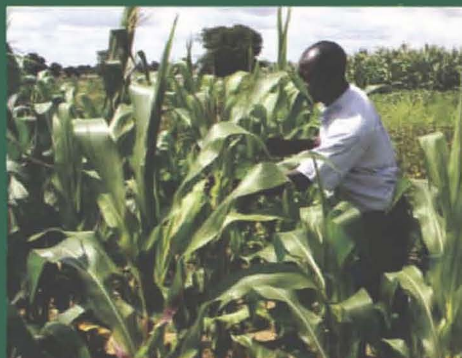
D. Chikoye, J. Ellis-Jones, G. Tarawali, and A.F. Lum





IITA
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Edited by

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Contents

Preface

The second *Striga* Management Stakeholders' Conference was held in Zaria, Kaduna State, Nigeria, from 8 to 9 September 2004. The Conference was attended by 107 participants, representing researchers, extension agents, nongovernmental organizations (NGOs), community-based organizations (CBOs), farmers, and the private sector from 11 States (Bauchi, Gombe, Jigawa, Kaduna, Kano, Katsina, Plateau, Sokoto, Taraba, Zamfara, and the Federal Capital Territory). These States have a combined population of 39 million people, many of whom suffer from the problems related to *Striga*.

The objectives of the Conference were to review the activities of a project supported by the Department for International Development, UK, to control *Striga,* and share experiences with key stakeholders. The objectives of the project were to (1) identify, evaluate, and develop methods for controlling *Striga* spp., (2) disseminate improved *Striga* management options using participatory research and extension approaches, and (3) increase the capability of national research and extension organizations, NGOs, CBOs, Universities, and the private sector to facilitate the uptake of improved weed management practices in small-scale, disadvantaged farming communities.

Twelve technical papers and reports were presented and discussed on the first day of the Conference. On the second day, participants visited selected rural communities in Zaria which were involved in testing improved technologies promoted by the Project. At the end of the Conference, resolutions were compiled as a communiqué which is presented at the end of this book.

D. Chikoye
Coordinator, *Imperata–Striga* Project

Acknowledgements

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Opening remarks

Reducing poverty through improved *Striga* control

S. Blade
Director, Research for Development, IITA, Ibadan

Colleagues, it is with great pleasure that I have the opportunity to deliver these opening remarks to the second *Striga* management stakeholders' conference. This meeting will address innovative technologies that have the potential impact to reduce poverty through improved weed control. This 2-day gathering has attracted researchers, development specialists, donors, policymakers, traditional rulers, and farmers in the Federal Republic of Nigeria. The objective is to share experiences on the integrated weed management strategies developed during a 3-year Project funded by DFID, and to determine the way forward.

Poverty remains the greatest hurdle to improving the quality of life for resource-poor people. One strategy to reduce poverty is through agriculture: the production of more and better quality food will create food security and provide opportunities for enhanced income. The importance of agriculture must be understood within the context of its impact on health, nutrition, income, productivity, and rural development.

Since the inception of IITA in 1967, the dedicated staff have sought to develop innovative technologies that encourage local production in ways which create wealth while reducing risk for both farmers and the rural and urban poor. IITA and its national partners have been recognized at both national and international levels for their success in crop improvement, integrated pest management, and farming systems research.

IITA has now embarked on a research-for-development agenda; that is, we are an organization doing "research for a purpose". We seek partners and collaborators to provide a platform for developing creative solutions to difficult problems.

This Conference provides a useful example of our approach. Weeds, especially *Striga* and *Imperata,* have been a menace to sustainable food production in sub-Saharan Africa, leading to misery and poverty for resource-poor farmers. Many basic and applied research solutions are available in national and international research centers to combat these weeds. However, this knowledge needed new extension approaches, such as the use of the Participatory Research and Extension Approach (PREA), and the involvement of a wide range of stakeholders to get the smallholder farmers to embrace their technology. Such approaches have not always had a high priority with our investors, so we were extremely grateful when DFID (UK) provided funds for 3 years (2001–2004) through their "Competitive Research Facility Program" to execute this valuable, development-oriented project.

Today, we are proud to announce that this Project has had the following tremendous achievements.

- The incomes and life-styles of over 2000 farmers in Project areas have been improved. Local extension agents, NGOs, and the private sector are now facilitating the scaling-out of the interventions.
- Nearly 200 researchers, extension personnel, and farmers have been trained (some up to MSc/PhD levels) in the use of participatory methodologies in weed control.
- A wide range of communication materials has been developed. These include the innovative flannel board used for delivering extension messages, extension guides in both English and local languages, posters, audio/video tapes, a Quarterly Newsletter, and scientific publications. These are widely distributed to farmers, national and international extension agencies, research workers, academic institutions, donors, and policymakers in the West African region.
- The unique PREA that was used considers the farmers as central in developing and disseminating solutions to their problems. It has contributed to the rapid progress made in this Project and is currently being adopted by many institutions within and outside Nigeria.

During this Conference, researchers, extension workers, farmers, traditional rulers, and policymakers will give further reports on their findings and experiences in the past 3 years. It is our hope that this information will be useful to people of diverse interests, and that donors/policymakers will provide more funds and the enabling environment for more farmers to benefit from these technologies. We have specially invited to this meeting the ADPs from Bauchi, Kano, Jigawa, Borno, Sokoto, Katsina, etc., and other institutions from places outside the current pilot sites but where *Striga* is also a problem. This is one of several steps towards the scaling-out of these activities.

Ladies and gentlemen, I would like to take this opportunity once more to thank DFID for graciously financing this project. I also thank our dedicated partners, notably, Ahmadu Bello University (Institute of Agricultural Research/National Agricultural Extension and Research Liaison Services); the University of Agriculture, Makurdi; the Agricultural Development Projects in Kaduna, Benue, Cross River, and Kogi States, Sasakawa Global 2000 and other NGOs, the Local Government Councils, and all the other institutions that participated in this Project. Last but not least, I want to also thank the organizers of the Conference and our distinguished policy-makers and donors who have travelled from afar to come and share their knowledge with us.

I wish all of you successful deliberations during this important meeting.

Reducing poverty through improved *Striga* control

A.A. Kassim
Program Manager, Kaduna State ADP

I feel highly honored to deliver an opening address at this Second *Striga* Management Stakeholders' Conference on "Reducing poverty through improved *Striga* control", organized by IITA in collaboration with the Silsoe Research Institute, UK, Institute of Agricultural Research, Kaduna State ADP, and Sasakawa Global 2000.

I regard this as a special occasion as the theme of this Conference is most relevant and timely. There is no doubt that the subject matter of the Conference strikes at the root of the nation's survival, considering the economic importance of *Striga* in crop production in Kaduna State in particular.

Striga has been a serious problem of cereal and legume crops among farmers in sub-Saharan Africa (including Nigeria). Its effects on crops range from stunted growth, through wilting, yellowing, and scorching of leaves, to lowered yields and death of many affected plants.

The problems of *Striga*-infested fields have been aggravated over the years as a result of the indiscriminate purchase of *Striga*-infested seeds by our farmers, continuous cultivation of *Striga* susceptible varieties, uncontrolled grazing, and nonadoption of integrated *Striga* management strategies, etc. The control strategies introduced to the farmers through this collaboration have been very effective in reducing the *Striga* infestation in fields that were used for the demonstration.

It will be recalled that, due to the immense benefits that our farmers and extension staff have derived from this program, we had earlier put up a proposal to DFID, the sponsors of the Project, for its extension and expansion to cover the entire State so that more farmers would be covered. I do not think it will be too much to repeat this call at this very important Conference.

Finally, it is my hope that the experiences you will share at this Conference, as well as your resolutions, will be of great benefit to our farmers for the control of this noxious weed.

Thank you. May God bless you all.

Reducing poverty through improved *Striga* control

A. Kidd
Rural Livelihood Adviser, DFID

In June 2000, IITA and its partners submitted to DFID, UK, their proposal entitled "Sustainable weed management strategies to reduce poverty and drudgery among small-scale farmers in the West African savanna". This was a bid for the limited competitive funds for the 17 CG centers. This concept note came out as the winner mainly because it followed DFID's philosophy of promoting sustainable development and reducing poverty, especially in the poorest countries in Africa and Asia. DFID agreed that the productivity of smallholder farms in the moist savanna was being reduced by the severe infestation of *Striga*. The resources to adopt participatory evaluation within the farmers' institutional and social contexts gave DFID hope that the Project would achieve ownership right from the onset.

With this belief, DFID provided funds of up to £742 894 (nearly US$1 000 000) on 1 March 2001, for a period of 3 years, to implement this valuable project. In addition, DFID recommended their then capacity building project (CBDD) as a dissemination avenue for ensuring that technologies reached the intended users. This was linked with nongovernmental and community-based organizations that were directly dealing with farmers. Also suggested for the new project was the participatory network (NIPRANET) with five zonal offices in Nigeria. The Cooperative Extension Centre of the University of Agriculture, Makurdi, was a natural partner, in terms of providing both trained personnel and facilities. It housed the DFID-sponsored extension project on Improved Farmer Participation in Research and Extension in Benue (IFPREB).

With this good start, coupled with uninterrupted funding and contributions from experts, it is not surprising that the interventions developed by the Project are now increasing the incomes and livelihoods of over 2000 farmers in Nigeria after only 3 years. More farmers are currently enjoying these benefits through revolving loan schemes generated by the Project.

I wish to attribute this success to IITA and their able partners. These are, notably, the Institute for Agricultural Research/National Agricultural Extension Research and Liaison Services, Ahmadu Bello University, Zaria; the University of Agriculture, Makurdi; the Nigerian Agricultural Development Projects in Kaduna, Benue, Cross River, and Kogi States; the various Local Government Councils; Sasakawa Global 2000; and so many other institutions that participated in the Project.

It is my hope that the Federal Government of Nigeria, the policymakers, and other donors will provide more funds and an enabling environment to ensure that these interventions are scaled-out to other areas. They will then have an impact on the lives of more Nigerians and West Africans.

Thank you.

Project reports/papers

Project description and purpose of the Conference

D. Chikoye
Weed Agronomist and Leader, Savanna Program
IITA, Ibadan

Overview

Striga hermonthica (witchweed or *wuta-wuta*) is a major biotic constraint in the Sahelian and savanna zones of West and Central Africa where it devastates cereals (maize, sorghum, pearl millet, finger millet, hungry rice, and upland rice). These crops are the major staple foods for over 300 million people in sub-Saharan Africa. It causes an annual loss of about US$7 billion, resulting in severe adverse effects on the lives of 100 million people in West Africa alone. The land area infested by *S. hermonthica* is continuously increasing. Reasons include deterioration in soil fertility, shortening of the length of fallow, expansion of production into marginal lands with little use of external soil amendments, and the increasing trend towards continuous cultivation of cereal monocrops in place of traditional rotation and intercropping systems. Many potentially successful approaches have been developed to control this weed. These include using resistant/tolerant varieties, sowing clean seeds that are not contaminated with *Striga* seeds, rotating cereal hosts with trap crops that induce abortive germination of *Striga* seeds, applying organic and inorganic soil amendments such as fertilizer or manure, fumigating soil with ethylene, hoeing and hand-pulling of emerged *Striga*, applying postemergence herbicides, and using biological control agents. However, the adoption of such methods by farmers has been much less than researchers and donors had expected. The current Project seeks to address this problem though creating direct links to farmers.

IITA had financial support from the Department for International Development (DFID) to implement the Project. The objectives were as follows: (1) to identify, evaluate, and develop methods for controlling *Striga* spp., (2) to disseminate improved weed management options using participatory research and extension approaches (PREA), and (3) to increase the capability of NARS, NGOs, CBOs, Universities, and the private sector to facilitate the uptake of improved weed management practices in small-scale, disadvantaged farming communities.

Project activities were implemented in selected communities in Kaduna, Plateau, and Benue States. Project partners were drawn from research institutes, policymakers, development organizations, the private sector, and farmers from the three States. Research institutes provided technical backstopping and training. Development organizations mobilized farmers and provided extension support. The private sector supplied inputs while farmers provided land, local knowledge, day-to-day field management, and helped to mobilize other farmers (Table 1). To inaugurate the project, a workshop was held in July 2001 to allow all key stakeholders to participate in the design and implementation of the Project.

Table 1. Major stakeholders, their roles, and the advantages brought to the partnership.

Partner	Role within the partnership	Benefits to the partnership
Research institutions		
IITA	Overall coordination and management.	Scientific knowledge of *Striga*. Supply of *Striga* trap crops and *Striga* resistant varieties, and expertise in economics and policy analysis.
SRI	Support to other institutions in participatory approaches and other areas of expertise.	Expertise in participatory approaches, chemical applications, and systems modelling.
IAR	Coordinator of activities in the *Striga* zone.	Detailed knowledge of Kaduna State. Ongoing involvement in *Striga* research.
Public sector extension services		
State ADP and Local Government (LG) extension	Support to farmers in areas for which they have prime responsibility.	Large number of extension workers active in areas where *Striga* is a priority problem.
NGOs		
Sasakawa Global 2000 Women Farmers in Agricultural Development	Support to farmers in areas for which they have prime responsibility.	Large number of field workers working in areas where *Striga* is the priority problem, often in support of ADP staff or alternatively where ADP and LG do not have staff. Well-established links with farmers and farmer groups.
Private sector		
Seed companies Chemical companies Fertilizer companies	To participate and contribute to improved ways of supplying inputs that will promote *Striga* control.	Existing suppliers of *Striga* resistant seed varieties, chemicals for weed control, and fertilizer inputs.
Farmers and farmer groups		
150 farmers in 33 villages in the *Striga* zone	Participation as equals in seeking sustainable ways of controlling *Striga.*	Detailed knowledge of their own environments. Existing indigenous knowledge of *Striga*.
Funders		
DFID	Major donor.	Funding for a 3.5 year period.
All project partners	Collaborators.	Contribute time, land, and funds.

The Project employed PREA to encourage farmers to test improved agricultural technologies. The process of engaging farmers consisted of community analysis, problem diagnosis, action planning, experimentation, monitoring, and evaluation. Community analysis allowed the assessment of livelihood strategies, natural resources problems, major crops, household resources, and local institutions. These exercises allowed the identification of priority constraints and targeting of solutions to different resource groups in each community.

Dissemination of results was through the "mother–daughter" approach, which consisted of complementary sets of demonstrations managed jointly by researchers and farmers. The "mother" trial evaluated a basket of improved options where farmers and extension staff observed and compared different management options. "Daughter" trials were subsets (fewer) of technologies under evaluation in the "mother" trial. Farmers tested these with support from extension staff. The approach enabled superior technologies to be exposed more widely to the diverse farming conditions, and accelerated the rate of technology adoption.

During field days, farmers assessed the performance of improved technologies, shared results and experiences with others, learned from achievements and mistakes, and developed the capacity to perform better in future trials.

Project outputs

Methods for controlling *Striga* developed and evaluated jointly with farmers

- Increased testing of leguminous trap crops by over 1000 farmers in three States.

Improved weed management options disseminated using PREA

- More efficient delivery of alternative methods for *Striga* control in central and southern Nigeria.
- Increased use of PREA by development organizations for a wide range of agricultural interventions in West Africa and beyond.
- Increased adoption and adaptation by farmers of researcher-developed technological innovations for *Striga* control.

Capability of NARS, NGOs, CBOs, Universities, and the private sector strengthened

- Improved links made with private sector seed companies to support seed producers.
- Enhanced capacity of NARS and other stakeholders to improve farmer adoption of innovations through participatory approaches.
- Over 80 extension workers trained in the first 2 years.
- Four graduate students trained.

Improved livelihoods, food security, and increased household income

- Less *Striga*, increased yields, greater food security, and more income.
- Individual seed producers established within the community.
- Improved household welfare reported from increased incomes, e.g., the purchase of school uniforms and books, improved housing, and cash to buy seed and fertilizer.

Dissemination of results

- Extension materials (booklets, posters, and flyers).
- Newsletters (three issues).
- Refereed journal publications (over 10 papers published).
- Manual on PREA.

Purpose of this Conference

- Share experiences with all key stakeholders.
- Facilitate policy recommendations.
- Solicit more funds to continue with these activities.

Participatory research and extension approaches used in *Striga* and *Imperata* control in Kaduna, Benue, Cross River, and Kogi States, 2001–2004: an overview

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Summary

This paper summarizes the participatory extension approaches (PREA) that have been used for over 3 years in Kaduna, Benue, Cross River, and Kogi States. Most participants have referred to the Project as the "DFID-Weeds Project", but this has been far more than a project to help farmers to control weeds. It has considered the way in which rural people derive their livelihoods, their priority natural resource problems, their existing coping strategies involving scientists, extension agents, the private sector, and community-based organizations working as equal partners in finding solutions to a priority problem. The Project has involved six research institutions and over 20 extension agencies (State, Local Government, NGOs, and private sector organizations), that provided 88 "extension agents". This involved training and the implementation of a 4-stage PREA in assisting over 100 local communities to overcome their priority problems. More than 1600 "lead" and "secondary" farmers have participated directly in Project activities, as well as a substantial but unknown number of other farmers.

The PREA used involved the following:

- Encouraging and mobilizing communities to undertake their own situational analysis and start thinking about how they could deal with their own problems.
- Action planning by the community, that helps in motivating people and giving the opportunity to disadvantaged groups to express their views.
- Implementation and farmer experimentation.
- Monitoring and evaluation through sharing experiences, self-evaluation, and planning for the next season.

The methodology used is described more fully in a guide for involving farmers in research and development (Ellis-Jones et al. 2005).

The evolution of participatory methods

Until recently, development in many parts of Africa consisted of farmers and communities being told what to do. During the 1950s and 1960s, the underlying concept was that scientific knowledge was superior to farmers' knowledge. Farmers were encouraged to adopt new

Table 1. Research and development trends (1950 to present).

Period	Explanation for nonadoption	Prescription	Activity	Research methods
1950–1960s	Ignorance.	Research.	Transfer technology.	Commodity research.
1970–1980s	Farm-level constraints.	Remove constraints.	Training and Visit. Supply inputs.	Constraints analysis. Farming systems research.
1990–2000s	Technology does not fit.	Change process. Provide options.	Facilitate farmer participation.	Enhance farmer competence. Change professional behavior.

Source: Adapted from Chambers (1993).

technologies because scientists had developed them. Those who adopted were seen as innovators and those who did not were seen as laggards. The extension agent's job was to convince farmers of the development potential of the new technology. However, this research and development process changed from the 1950s to the present (Table 1).

By the 1970s, the lack of adoption by farmers was of considerable concern. Research and extension was seen as top-down, without context, and solely scientifically based. In reaction, scientists reexamined the technologies to determine where these were going wrong. As a result, farming systems research became increasingly important. This focused on understanding and improving existing systems rather than replacing them completely. It was considered essential to base technical change on an understanding of how farmers perceived and managed their farming systems, with development activities being centered on ensuring farmers had access to inputs. This resulted in increased emphasis on on-farm trials and technology development under more realistic conditions, with farmers being part of the technology. Though this approach gave more credence to the farmers, their input was still limited to helping to identify the problem. Whilst much of the philosophy of this approach remains relevant, in practice it has been achieved at a high cost; it is often unable to scale-up recommendations, and has sometimes met with resistance from researchers and extension staff who did not want to be drawn out of conventional modes of operation.

During the same period, Training and Visit (T&V) extension systems were being promoted in many countries. These endeavored to ensure that field staff concentrated on extension without having the burden of other activities, such as administering subsidy schemes or distributing inputs. Nevertheless, T&V still retained a strongly hierarchical structure with village-level extension workers backed by subject matter specialists relying on strong technical messages reminiscent of technology transfer. As a result, T&V systems became both costly and often nonfunctional.

With the demise of T&V in the 1990s, priority has shifted to encouraging increased community and farmer participation in identifying problems and solutions in an equal partnership with researchers and extension workers. In the process of accepting farmers as participants, it became clear that farmers were also experimenting with technologies and adapting them to their own situations. Science was no longer seen as a *privileged* knowledge set but simply as one of the options from which people could choose. As a result, emphasis moved towards finding solutions that start with the community, through negotiation between farmers and scientists.

It has been increasingly realized that new technology alone is insufficient to achieve impact. As a result, many research organizations have moved from a primary focus on productivity to include concerns about the environment, poverty, food, and financial security, reflecting a growing understanding that securing food, eradicating poverty, and protecting natural resources are inseparable goals (PRGA 1997). Many organizations are now developing ways to involve farmers in the processes for generating economically and environmentally sound technologies that are more sustainable and provide more equitable use of natural resources.

Farmer groups are ideal for encouraging farmer involvement and for sharing knowledge at the local level as they allow farmers to use the networks that they have and to use the group to build up new networks to negotiate the technology to fit within their own lives. Farmer-to-farmer extension is premised on the belief that, for farmers, "*seeing is believing*" and other farmers are the best educators. Through discussions with other farmers and groups, they will be stimulated to try out new technologies.

The process of participatory research and extension

Farmers' involvement as decision-makers, rather than research subjects or passive components of the farming system under investigation, is central to farmer participatory research. It has led to the boundaries between research and development becoming increasingly blurred and many different names are used to describe participatory methods.

However, underlying all of these is the acceptance of the central role that farmers could and should play, if given the opportunity, in both research and development. Particular emphasis is placed on their participation throughout a process of analyzing situations, assessing needs and opportunities, setting research and development objectives, setting indicators, planning and implementation, and monitoring and evaluating results. In this way, farmers can also play a key role in the diffusion of research findings.

Participatory research and development can be seen as a continuous process, starting with different stakeholders (researchers, extension agents, farmers, and commercial organizations) sharing experiences, pooling their knowledge and resources, and planning together. Close association and coordination are likely to promote adoption and further adaptation, leading to wider scaling-up and improved livelihoods.

The research and development process requires guiding and facilitating through four key stages (Hagmann et al. 1998; 1999).

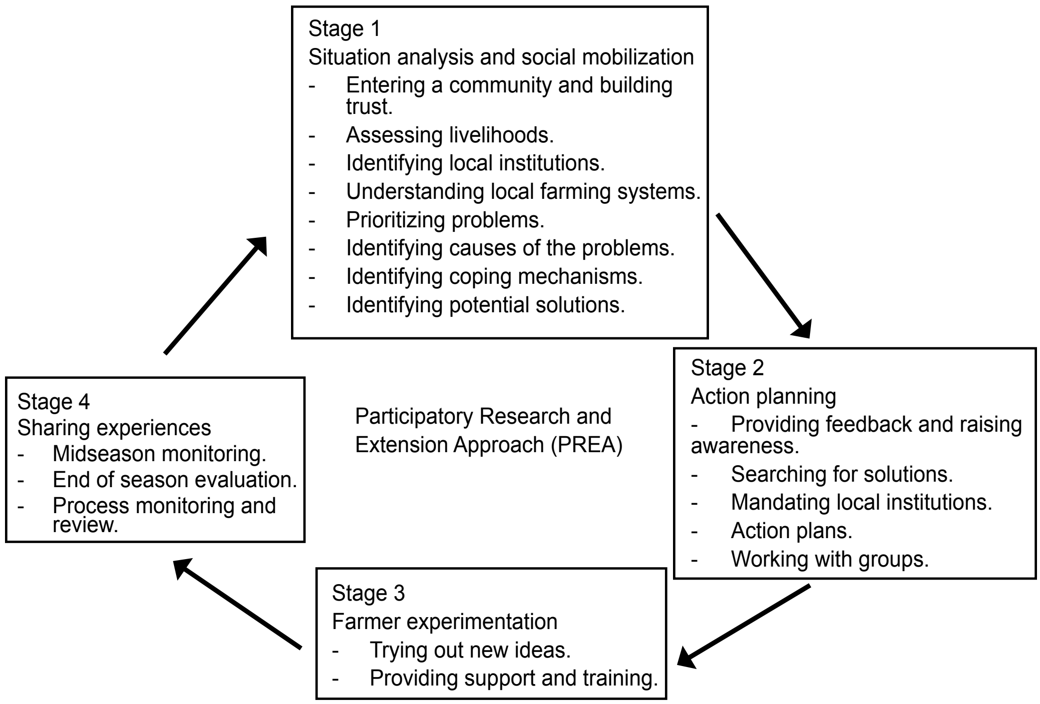

Figure 1. Participatory research and extension approach.

1. Encouraging and mobilizing communities to undertake their own situation analysis and start thinking about how they can deal with their own problems.
2. Action planning by the community that helps in motivating people and giving the opportunity to disadvantaged groups to express their views.
3. Implementation and farmer experimentation.
4. Monitoring and evaluation through sharing experiences, self-evaluation, and planning for the next season.

In each of these stages, several activities are required (Fig. 1). A clear timetable for these activities is also essential (such as that shown in the Annex to this paper). Each stage and the activities required are discussed in detail below.

A large number of participatory tools are available for assisting in collecting and analyzing local information and situations (Box 1). These should not be confused with the 4-stage process of PREA. The tools allow facilitators and community group members to communicate effectively during the process. Their appropriate use allows the community to understand itself better and identify problems and potential solutions.

Different tools can be used in different circumstances, depending on the type and amount of information required. However, overuse can be time-consuming and it is highly unlikely that there would be time to use all of them. They should, therefore, be carefully selected and not used just because they are available or familiar. Participatory tools are like those in a carpenter's

Box 1: Some key participatory tools.

- Livelihoods analysis
- Resource (or wealth) ranking
- Institutional analysis
- Seasonal calendars
- Gender analysis
- Flow diagrams
- Ranking techniques (Preference, Pairwise, and Matrix)
- Causal diagrams
- Mapping
- Participatory budgeting

Table 2. Collaborators in Kaduna, Benue, Cross River, and Kogi States.

	Main focus areas		
	Kaduna (*Striga*)	Benue, Cross River, and Kogi (*Imperata*)	Total
Collaborating institutions Research	IITA, SRI, ABU-IAR and NAERLS	IITA, SRI, UAM-CEC	6
Extension (State, Local Government and NGOs)	ADP, LG, Sasakawa Global 2000, WIFAD, CRC	ADPs, LG, DDS	> 20
No. of extension agents (EAs)	33	55	88
No. of villages/communities	53	59	112
No. of lead farmers and farmer groups	155	235	390
Approximate no. of secondary farmers	± 600	> 1000	> 1600
Other farmers testing technologies	Unknown	Unknown	Unknown

IITA=International Institute of Tropical Agriculture, SRI=Silsoe Research Institute, ABU=Ahmadu Bello University, IAR=Institute for Agricultural Research, NAERLS=National Agricultural Extension and Research Liaison Services, UAM=University of Agriculture, Makurdi, CEC=Cooperative Extension Center,
ADP=Agricultural Development Project, LG=Local Government, WIFAD=Women Farmers in Agricultural Development, CRC=Catholic Resource Center, DDS=Diocese Development Services.

toolbox. Certain tools can be used only for certain jobs and others have more than one use. It is important to plan information collection carefully and decide which tools to use.

Project collaborators

The project has involved collaboration between six research institutions and more than 20 extension agencies, comprising the State, Local Government, and NGOs. Eighty-eight extension agents working in 112 communities have been involved, with 390 local institutions, each with lead and secondary farmers (Table 2).

Situation analysis and social mobilization workshops with communities in both focus areas provided the opportunity to assess livelihoods, confirm that *Striga* and *Imperata* were priority problems, identify local control methods, and agree on a series of farmer-led trials of control options that could be implemented by farmers of all resource categories. To date in the *Striga* zone, over 150 lead farmers (LFs), 600 secondary farmers, and an unknown but substantial number of other farmers have initiated trials. In the *Imperata* zone, over 200 LFs, over 1000 secondary farmers, and unknown numbers of other farmers have also initiated trials. In the first season, LFs were selected by each local community-based organization (CBO) and in the second year, further secondary farmers were nominated again by each CBO. During the farmer testing process, each farmer group undertook midseason and end of season evaluations. These help to identify criteria important to farmers and have provided a suitable forum for a participatory budgeting approach to determine the viability of the technologies.

Participatory research and extension in practice

Stage 1: Situation analysis and social mobilization: entering a community and building trust

If a research and development activity is to be owned by a community, two key conditions need to be in place:

- Real motivation and enthusiasm within the community to resolve their problems.
- Effective community institutions to support the process and take it forward.

Without these, there is little chance that development will be sustained without continuous external support. To motivate people, it is necessary to identify and address their key concerns. Only the people themselves can effectively identify, clarify, and prioritize these concerns and find solutions. It is important to understand that a community is not homogenous but consists of different types of households and institutions with different roles and responsibilities. Local institutions may well have their own deficiencies but a key step in the process is identifying those that can take a lead in promoting the development process and building their capacity to develop and implement action plans responding to local communities' priorities.

The first step is for the research or extension agents to meet, discuss, and agree with as many of the local community leaders as possible the participatory approach to be taken, and to gain their support for the process. This is likely to involve group and individual discussions.

Such meetings are intended to provide information about the following:

- The community, how local people derive their livelihoods (meet their household needs and earn a living), the different types of households in the community based on wealth or access to resources, local institutions, and the crops that people grow and the livestock they keep.
- Natural resource problems with which they are faced (and their prioritization), existing coping mechanisms, and institutions within the community that might have an interest in the priority problems.

Livelihoods analysis

This provides an understanding of the different ways in which households derive a living, the numbers or percentage involved in the community, who in the community is involved, the relative importance of each in providing either food or cash, the trends over the years, and the reasons for these trends. This helps to identify the most important livelihood activities and highlights any concerns that people may have in any of these activities.

Crop production was the main livelihood in all areas where the Project operated. In any community there are differences in wealth, status, and access to resources. It is important to understand these differences and ensure that poor or marginalized people are involved in the development process. It is important to identify the criteria that local people use to determine differences (for instance, access to land, cattle, implements, housing, and number of wives).

Resource or wealth ranking

This exercise can provide the basis for a detailed assessment of the priority needs for different types of household in the community. If the needs of only the articulate and better-off people are considered, others are likely to withdraw from the process. This can easily happen if the community is regarded as a homogenous group of people. The initial resource ranking can serve as a reference for the monitoring and evaluation of the project at later stages.

Most areas identified three categories: well-resourced, average, and poorly-resourced.

Local institutions

Instead of individuals acting on their own, local institutions should take forward any actions developed by the community. Such institutions can be those already existing or new ones formed especially for the task. However, the latter should be considered only if there are no suitable existing institutions. Most communities have local institutions, such as a development council, farmers' association, or women's or youth group. Experience has shown that new institutions are often not sustainable and can be hampered by other community institutions that may feel that this should be their responsibility. Strengthening an existing institution is a good means of developing local capacity. Undertaking an institutional analysis can identify local institutions.

In all areas there were existing institutions with which the Project worked. Each of these identified/elected their own "lead" and "secondary" farmers to work directly with the Project.

Other tools

A detailed analysis of farm activities will help scientists or researchers to understand how the majority of rural communities survive. However, within a community meeting, it will be difficult and time-consuming to undertake a detailed farming systems analysis, although this can be initiated by asking a group of farmers to prepare a cropping or livestock production calendar. At first, however, it may be better to identify the range of crops that people grow (and/or livestock they keep) and prioritize these in order of importance for providing food security, and cash from sales. Gender and age perspectives should also be identified by asking men, women, and younger people to undertake the activities separately. At the same time and within the same groups, people can be asked to identify and prioritize the main problems that they have with their crops (or livestock).

Generally, the priority natural resource problems were declining production because of weeds (*Striga* or *Imperata*), declining soil fertility, and lack of funds to purchase inputs.

Transect walks, mapping exercises, and historical time lines are other tools that can be used both to provide detailed information on the problem(s) and help in raising awareness.

Using diagrams is a useful way to identify and analyze problems and their causes. This is especially important, as solutions can be based on addressing the causes. The priority problem is placed at the top of the diagram. The question "*Why did this happen?"* can establish the root causes. This helps the interrelationships among contributory causes to be seen.

Causal diagramming works most effectively after farmers have discussed, listed, and prioritized their problems. Arrows can be used to represent the cause and effect relationships. Scoring helps to determine which causes are more important than others, adding to greater understanding and a more accurate picture of the scale of the problem. The scores do not give absolute values but help to prioritize the problem areas with respect to the impact that removing them is likely to have. They are, therefore, helpful in decision-making processes.

Causal diagrams were developed with local communities and they helped to provide an improved understanding of local perspectives.

Mapping problems can provide a way to understand local realities and how local people perceive them. Maps are an excellent communication aid, since all people, even those who have never been to school, can make and use maps. They promote participation and encourage discussion about local resources, problems, and opportunities. Once copied on a sheet of paper a map can be used many times with farmers. It is important, however, that considerable thought is given to what needs to be mapped, as drawing can be time-consuming. Typically, this may include homesteads, roads, rivers, and other key landmarks. Mapping *Striga* or *Imperata* infestation within the arable areas gives an indication of the level of infestation.

Maps of *Striga* and *Imperata* infestation help in providing real motivation for control activities. Older people map the weed problem as it existed 10–15 years ago, while more recent comers can map present-day weed infestation. This comparison helps in identifying a trend, allowing a vision of weed problems in another 10–15 years if the weed is not controlled.

Identifying existing coping mechanisms

In seeking how to resolve problems, people need to build on their own knowledge and existing control practices. This can help to build awareness and make a start to explore practical solutions to the identified problems. This can be done by identifying the following:

- What methods do people know?
- Where did this knowledge come from?
- Who in the community are using these methods? Gender differentiation would also be appropriate to show who is responsible for deciding which methods are used and who does the work.
- What are the advantages and disadvantages of each method?
- What is the trend in the use of such practices and the reasons for this?

A wealth of different coping strategies was identified, although farmers were still not controlling the weeds.

Stage 2: Action planning by the community

Whilst the findings from the situation analysis are important for outsiders to get to know the community, the results are even more important for the community themselves. Providing feedback provides an opportunity to raise awareness of the problems and their causes and to reflect on possible solutions and those local institutions that can play a role. Feedback to the community will achieve the following:

- Motivate people to become more involved in an active research and development process that can improve their livelihoods.
- Give an opportunity for poorer and disadvantaged groups to express their views.

Many communities have become disempowered and/or demoralized by research and development programs which have been brought to them in a top-down way, albeit with good intentions. For this reason, if the community is to participate effectively, the people have to conceptualize their own problems and develop their own ways of dealing with them.

Once household and community issues have been explored, it is necessary to do, as follows.

- Provide feedback to the rest of the community about the issues and needs identified in the situation analysis.
- Analyze with the community the underlying causes of the problems identified and identify possible solutions.
- Identify possible local institutions to help to take forward some of these solutions.

Nominated members of each group can best achieve this in the community workshops by providing the reports from their groups. After this it is important to:

- Agree on a schedule of work to be undertaken in addressing those needs.

- Agree on criteria and indicators that enable the community to see whether their work is really leading to an improved situation.

Collective decision-making and local ownership are essential for success.

Once the root causes of the priority problems are better known, it is easier to identify possible solutions. Fresh solutions to old problems need to be generated by blending suggestions from community members with those from people from outside the area. It is here that the roles of researcher and extension agents become increasingly important. The use of appropriate extension materials will assist in creating a better understanding.

The search for solutions should focus initially on people's own knowledge. There may be traditional knowledge that has been forgotten. This can be identified, perhaps from older members in the community and tried out again. Also, people may have heard of solutions and ideas that other farmers practise or that researchers might know or bring to the area.

Options are for visits to innovative farmers, neighboring communities, or research stations, which are all likely to generate more ideas. This allows farmers to see firsthand how others have successfully dealt with problems. Such visits need to be planned and communities need to choose their own representatives, based on their ability to report back, so that everyone can benefit and not just those who have travelled. Another approach is the use of a "mother", "daughter", and "granddaughter" approach (sometimes called "mother–baby" trials) in the research process to raise awareness and encourage farmers to test those research options applicable to their own environments and management conditions (Table 3).

This approach was used successfully. "Mother" trials were established in (1) Zaria, at the Institute for Agricultural Research, providing useful scientific information on *Striga* control, (2) Benue State, at Tarhembe, Tarka LGA, and (3) Kogi State, at Emere, Ankpa LGA on *Imperata* control. Farmers and extension workers from adjoining areas visited these "mother" trials. They selected options they considered best for their circumstances and subsequently established "daughter" trials in their own areas. Midseason and end of season evaluations,

Table 3. "Mother", "daughter", and "granddaughter" trial characterization.

Trials	Type of research
"Mother" trials All options selected by researchers with input from farmers.	On-station or on-farm, researcher-managed with little input from farmers.
"Daughter" trials Best-bet options and local innovations selected by farmers.	On-farm, researcher-managed with significant input from farmers.
"Granddaughter" trials Options selected by farmers.	On-farm, farmer-managed with no input from researchers.

involving many other farmers and facilitated by the extension agents, resulted in other farmers testing some of the technologies on their own; this was the "granddaughter" stage.

Once possible solutions have been selected, the community needs to take actions forward through their local institutions. It must not be left for the extension worker or researcher to make decisions and become the driver and owner of the process instead of the community. There needs to be a consensus about which institutions are used. If a local institution is weak, options need to be agreed on how to strengthen it. If a new institution is created, it should also be supported, for example, by improving leadership and communication. If the leaders of the selected institution in the meeting agree to take responsibility in the presence of others, this helps to create commitment and accountability. At some later stage, leadership and communication training should be provided for key community members.

Lead farmers and groups

Our approach was to work with lead farmers, selected by the community-based organizations they represent. These farmers undertook the piloting and testing of the new technologies. Regular feedback from the lead farmers to the group ensures the group's involvement in planning and implementation, and encourages a process of further farmer-to-farmer testing, adaptation, and diffusion (Fig. 2). The responsibilities of lead farmers and the group were agreed in training on leadership and communication (Box 2).

As such, the lead farmer has the following roles:

A group advisor—helping to strengthen the group leadership, organization, and planning capacities.

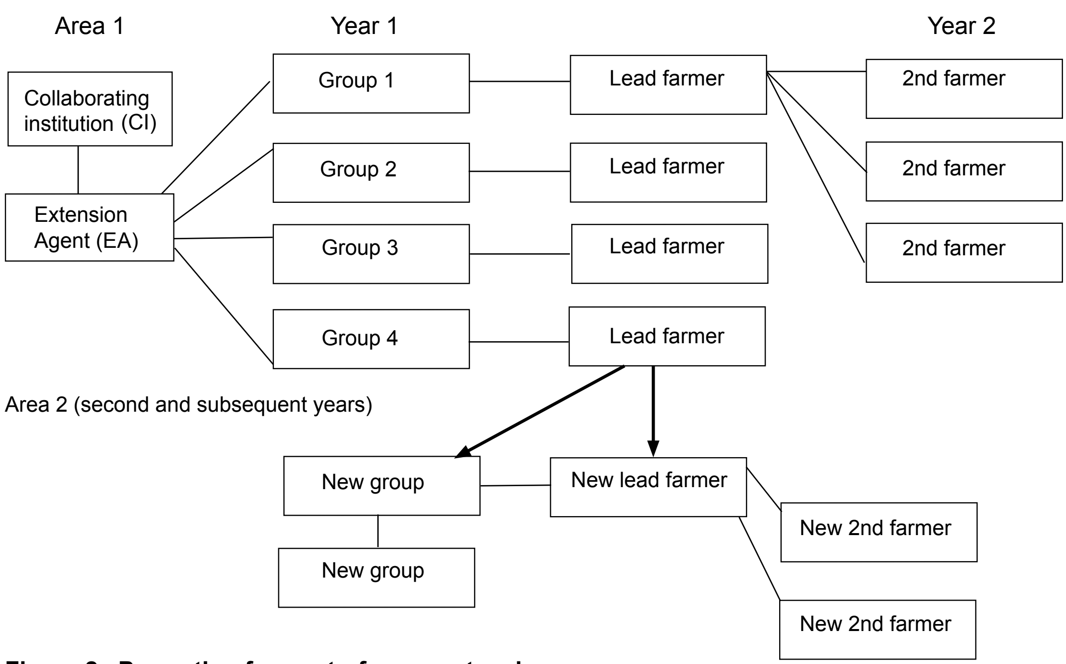

Figure 2. Promoting farmer-to-farmer extension.

Box 2. Roles and responsibilities of local institutions (groups) and lead farmers.

Role of local community institutions

- Formally adopt the program into their activities.
- Appoint persons responsible for reporting on progress and identifying issues/problems that affect the program. This is likely to be the lead farmer.
- Encourage participation by other farmers in trying the new techniques.
- Invite the extension agent to attend meetings on a regular basis.
- Arrange field days that cover all farmers.
- Evaluate the control methods at the end of the season and plan for the new season.

Responsibilities of lead farmers

- Motivate other farmers to try out new technologies.
- Assist with the project planning process using participatory methods.
- Assist the extension agent in training the group and other farmers.
- Host midseason and end of season evaluations of the test plots and demonstrations.
- Ensure that information is disseminated to the community at large.
- Hold regular meetings with other farmers and present concerns to the group and extension agent.
- Facilitate coordination between the group and the extension agent.

A participatory trainer—teaching group members basic technical skills through a Farmer Field School Approach, and

A link person—facilitating communication between the group and the extension agent.

After clarifying the possible solutions and institutional responsibilities, concrete actions need to be agreed and planned. Often this takes place after a visit to another area or research station (the "mother–daughter–granddaughter" approach). The most promising options are selected and agreed, and a decision is taken on who should try them and how. A time plan of action needs to be agreed. At this stage, the community should be able to define the nature of support they expect from researchers or extension agents.

Sometimes potential solutions identified by the community can be standardized technology, where implementation is mainly linked to the organization of material and labor. However, generally, potential solutions are not so clear and new ideas have to be tested and adapted to suit local conditions. It is important that promises of support from researchers, extension agents, or private companies are fulfilled and trust is maintained. This might include providing new seed or credit or making future visits.

Stage 3: Implementation and farmer experimentation

To see whether a new technique is better than the usual practice, a comparison is needed. An easy way of doing this is putting the two, side by side, in the same field, so that both areas are of approximately equal size. Management practices must be similar, as follows.

- Using soils of a similar type (unless different soil types are being tested).
- Using the same seed and same plant spacing (unless you are comparing varieties and/or spacing).

- Planting both areas of land on the same day (unless you are comparing planting dates).
- Applying the same amount of fertilizer (unless you are comparing different fertilizer or manure application rates).
- Weeding on the same day in the same way (unless you are comparing different types or times of weeding).
- Harvesting at the same time.

The researcher/extension agent should act as a facilitator and encourage the selected institutions and farmers to experiment with the new ideas. Farmers should be guided to conduct simple comparisons between local practices and new techniques.

In the case of *Striga* or *Imperata*, a simple paired plot design where the new technique is placed side by side with normal farmer practice in the same field has been an easy way for farmers themselves to compare the performance of the two (Box 3).

Researchers can use the same plots to measure yields and growth parameters and at the same time use a series of paired plots from different farms for a more detailed statistical analysis.

Farmers will often share their experiences informally with one another. This process of learning can be encouraged by good facilitation. Learning in this way is critical to the success of participatory research and extension and lends itself to the use of the test and demonstration plots for training (Box 4).

Observing the trials helps to identify the reasons why one technique performs better or worse than another. When crops are grown with two different techniques, side by side, the differences are usually easily visible. The crops may be larger and bigger and the weeds may be few or take less time to pull out. Such observations should be recorded so that they are not forgotten and can be analyzed in more detail in the future. A record sheet allows experiences to be shared with others. This is part of the monitoring and evaluation process.

Stage 4: Sharing experiences

Monitoring and evaluation

- Monitoring refers to the collection and analysis of information to compare the progress of an activity with an original plan.
- Evaluation is the periodic assessment and review of the extent to which medium and long-term objectives have been reached.

Monitoring and evaluation (M&E) should be an integral part of any testing process and the earlier it is incorporated into program activities, the better. M&E allows farmers, researchers, and extension agents to ensure that stages 1–3 in the PREA are addressing community problems and concerns and their livelihoods are actually improving. This requires the use of indicators as signs of change. These need to be relevant, easily observable, verifiable, and accurate.

M&E helps to assess performance, to share results and experiences with others, to learn from achievements and mistakes, and to develop the capacity to perform better in the future

Box 3. A typical paired plot layout (showing typical dimensions).

Treatment A	Treatment B
Farmer's normal practice. (Local variety in the case of *Striga* control.) (Hand-weeding in the case of *Imperata* control.)	New treatment selected by farmer. (*Striga* tolerant variety.) (Glyphosate or *Mucuna* for *Imperata* control.)

20 m

20 m

Box 4. Using test plots for training and demonstration (Farmer Field School).

The training area for the other farmers in the group can center on the lead farmer's test plot with other farmers encouraged to test the technique on a plot of their own. In this situation, the field becomes a teacher, providing most of the training materials, such as plants, pests, and real problems. Farmers are usually much more comfortable in a field situation than in a classroom. The lead farmer should ensure that other farmers know the date and time and attend training sessions at key stages during the crop cycle. These include:

- Identifying and marking out the plot.
- Preparing the land for sowing.
- Sowing the crop.
- Applying fertilizer.
- Weeding.
- Comparing the effect of the new treatment with the farmer's normal practice.
- Harvesting.
- Evaluating the impact of the new treatment in increasing yields or reducing inputs.

  Immediately after each training session, other farmers can undertake the same work on their own plots.

and fulfil reporting obligations. M&E should help in constantly reviewing the trials, reflecting, learning, and replanning. Information requirements should be kept to a minimum. Choosing a few practical indicators that quickly and effectively provide accurate information can achieve this. M&E indicators should be easily and quickly recorded with maximum community involvement in both collection and analysis. M&E for research or extension and M&E for community needs are often different, although parts will be common.

M&E from a community perspective needs to enable the community to become involved in joint learning by sharing ideas and experiences and reflecting on the successes and failures of the research undertaken. Informal sharing of experiences among neighbors and friends is unlikely to be sufficient to make the information available to everyone in the community. Within most natural resource projects, this requires two, more formal, steps.

- A midseason monitoring and evaluation of the new practices being tested.
- An end of season evaluation where the whole process can be evaluated and plans made for the coming season.

Midseason monitoring and evaluation

In the middle of the season, farmers with the help of researchers and extension staff should organize themselves to monitor the field performance of the technologies that have been tried. All farmers in the community should be invited to visit the experiments, with all host farmers presenting their trials and their views to date. This helps to share knowledge and build confidence through presentation, as well as to encourage farmer-to-farmer extension.

After everyone has had a chance to look at the different technologies, it is important to analyze the findings. Often it can help for men, women, and young people to do this separately so that any differences in perspective become apparent. This assessment can be done using participatory tools.

- Listing the advantages and disadvantages of each treatment.
- Establishing the most important criteria (for example, cost, labor requirement, effect on overall risk, effectiveness, material availability, and yield).
- Scoring each of the technologies using a matrix of technologies and criteria by putting up to three stones (or crosses) in each criterion box. The higher the score, the better the technology.

End of season evaluation

Once the experimentation crop is harvested and the trial completed, conclusions can be made regarding the technology under investigation and decisions made with regard to additional trials to be undertaken the next season. This requires:

- Confirming the advantages (benefits) and disadvantages (costs and risks) of each practice.
- Agreeing which of these can be valued.
- Agreeing these values.
- Comparing each new treatment with the farmer practice by assessing any increases in the value of the crop or crop residue, minus any increase (or decrease) in costs. Costs should include both purchased and household supplied items. This has been referred to as a participatory budgeting process (Galpin et al. 2000).

Process review

Ideally 1–2 months before the start of the new season, a review and planning workshop needs to be organized with the community. This should review the whole process, assessing it against the planned activities and the indicators for success that farmers suggested during the planning phase. This includes criteria such as leadership, strengthening of self-organizational capacities, as well as ensuring the participation of everyone, including the poor, in the process. This analysis normally leads to the next cycle, which starts again with issues of social mobilization and situation analysis; the community review their goals and objectives and develop an action plan for the next season.

Annex. An example of an extension agent's program for the PREA process

It is essential that a program is drawn up and agreed, identifying key activities, when they should be undertaken, and who will be responsible for their facilitation, and ensuring activities are completed on due date.

Activity	J	F	M	A	M	J	J	A	S	O	N	D	J	Responsibility
Stage 1: Social mobilization.														
Identify local institutions.		x	x											EA
Identify crop priorities.		x	x											EA
Identify problem priorities.		x	x											EA
Identify existing methods of *Striga/Imperata* control.		x	x											EA
Raise awareness of *Striga/ Imperata.*		x	x											EA
Stage 2: Action planning	J	F	M	A	M	J	J	A	S	O	N	D	J	Responsibility
Discuss methods for controlling *Striga/Imperata.*			x	x										Group/LF/EA
Mandate local institutions/ select LFs.			x	x										Group/LF/EA
Agree on *Striga/Imperata* control methods/crops to be used.			x	x										Group/LF/EA
Farmers to confirm plots to be used.				x	x									Group/LF/EA
Identify input requirements.			x	x	x									Group/LF/EA
Arrange competitions between farmers' groups.				x	x									Group/LF/EA
Stage 3: Implementation	J	F	M	A	M	J	J	A	S	O	N	D	J	Responsibility
Obtain inputs.				x	x	x								EA/LF
Mark plots.				x	x	x								EA/LF
Plant trials.				x	x	x								EA/LF
Harvest trials (maize, soybean).									x	x				EA/LF
Use existing LF plots for training (FFS).					x	x	x	x	x					EA/LF
Encourage LFs to visit/assist others.					x	x	x	x	x					LF

Annex contd.

Stage 4: Sharing experiences	J	F	M	A	M	J	J	A	S	O	N	D	J	Responsibility
Midseason evaluations by each community (field days).										x	x			Group/EA/LF
Joint evaluations														
End of season participatory evaluations.														
Visit plot, ensure LF explains details to farmer group.											x	x	x	Group/LF/EA
Facilitate discussions on advantages/disadvantages.	.										x	x	x	EA
Facilitate partial budgets.											x	x	x	EA
Deadlines for reports	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**Responsibility**
Monthly reports.	x	x	x	x	x	x	x	x	x	x	x	x	x	EA
Completion of social mobilization forms.			x											EA
Trial plans and input requirements.			x											EA
Field data sheets.										x	x	x		EA
Midseason monitoring and evaluation.									x					EA
End of season evaluation.												x	x	EA

LF = Lead farmer, EA = Extension Agent, Group = Farmers' Group, ES = Extension Supervisor, FFS = Farmers' Field School.

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Dissemination of integrated *Striga hermonthica* control technologies through on-farm trials in the savanna zone of northern Nigeria

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Introduction

The parasitic weed *Striga hermonthica* (Del.) Benth has become one of the most severe constraints to cereal production in many parts of sub-Saharan Africa (Lagoke et al. 1991). Intensification of traditional cereal-based systems has reduced the fallow period that used to keep *Striga* pressure at tolerable levels and has increased the area under continuous cereal cropping. This has allowed *Striga* to become a ubiquitous weed, causing over 50% yield losses in cereals and affecting the livelihood of millions of mostly resource-poor farmers in sub-Saharan Africa (Pieterse and Verkleij 1991).

Several decades of research on *Striga* control technologies have resulted in the identification of a range of technologies. The use of *Striga* tolerant varieties of maize (*Zea mays*), sorghum (*Sorghum bicolor*), and millet (*Pennisetum glaucum*) can be an effective way of reducing *Striga* damage (Parker and Riches 1993; Kling et al. 2000). However, given the variation observed in the tolerance of maize varieties to different *Striga* strains, the weed may show a rapid evolutionary adaptation to *Striga* tolerant cereal varieties in the future. The use of leguminous trap crops that stimulate the suicidal germination of *Striga* is another technology to control *Striga*. Trap crops include varieties of groundnut (*Arachis hypogaea*), soybean (*Glycine max*), cowpea (*Vigna unguiculata*), and sesame (*Sesamum indicum*) (Hess and Dodo 2003). The application of nitrogen fertilizer to cereals on soils with low fertility reduces crop damage caused by *Striga* but no clear relationship between nitrogen application and *Striga* suppression has been established (Parker and Riches 1993). Farmers themselves have developed a range of coping strategies to combat *Striga.* These include hand-roguing, hoe-weeding, the use of manure or compost, and fallowing (Emechebe et al. 2004). As none of the available technologies on its own can provide satisfactory *Striga* control in a broad range of biophysical and socioeconomic environments, many farmers in West Africa fail to control *Striga* in cereals, despite the availability of a whole range of control techniques that have proved to be successful on-station. Therefore, there is a need to design an integrated *Striga* control (ISC) technology that is flexible and robust enough to suit the wide range of farmers' environments.

In the present project, an ISC technology was designed and tested on a large number of farms in the northern Guinea savanna (NGS) of Nigeria. Traditionally, farmers have cereal-based systems using local maize, millet, or sorghum varieties that are occasionally intercropped with legumes such as groundnut, soybean, and cowpea. The ISC included a range of technologies, such as host plant resistance, the use of leguminous trap crops, increased fertilizer application rates, increased planting density, hand-roguing, and hoe-weeding. Before the establishment of the trials, community analyses were conducted in a large number of farming communities and interventions were carried out in those villages where *Striga* was identified as the major biophysical constraint for crop production.

To disseminate the ISC technology, the project adopted the "mother–daughter–granddaughter" trial approach in which farmers gradually gain ownership of the ideas and technologies introduced by the scientists. The "mother" trial was carried out on-station at the Institute for Agriculture Research in Zaria (Kureh et al. 2003), while the on-farm "daughter" and "granddaughter" trials were conducted in 32 villages in Kaduna State. The "daughter" trials were managed by lead farmers who were selected by farming communities and represented institutes or groups within the community. Other members of the community, secondary farmers, laid out their own experiments using the experience and some inputs from lead farmers. These trials were called "granddaughter" trials. The results of the on-farm testing and dissemination of ISC technologies were assessed after data had been collected on the agronomic and economic performance of the on-farm "daughter" and "granddaughter" trials.

This study was conducted with the following objectives:

1. To test the agronomic and economic performance of the ISC technology on lead farmers' fields in the NGS of Nigeria.
2. To monitor the ISC technology transfer from lead farmers to secondary farmers and validate a model for adoption and the widespread dissemination of complex technologies, such as ISC, among farmers.

Methodology

In this study a Participatory Research and Extension Approach (PREA) was chosen to encourage farmers to test alternative *Striga* control options under their conditions, facilitating the wider adoption of such practices (Hagmann et al. 1999). The process consisted of community analysis, problem diagnosis, action planning, experimentation, monitoring and evaluation using a "mother–daughter–granddaughter" approach to the research. Researchers managed "mother" trials; farmers selected and managed "daughter and granddaughter" trials. This allowed farmers and extension staff from Government, NGOs, and farmers' organizations an opportunity to observe, test, and compare different *Striga* management options.

The "daughter" trials were conducted in 2002 and 2003 in Kaduna State in the NGS of Nigeria. Lead farmers and secondary farmers were aggregated in two areas. Out of 148 participating lead farmers, 92 farmers in 32 communities were based within a radius of 50 km from Zaria town (11 °11′ N, 07 °38′ E) in northern Kaduna State.

The remaining 56 farmers were based in 10 communities near Kachia and Kasuwan Magani (10 °24′N; 7 °42′E), towns in southern Kaduna State. All communities typically chose two or three lead farmers representing various institutions or groups within the village, except for one community (Ambron village) near Kachia town where 13 farmers were selected as lead farmers. The lead farmers received technical support from the Project, mostly through local extension agents belonging to Government, NGOs, or farmer organizations that participated in the Project and were trained in ISC and PREA. A total of 33 extension staff were involved in the dissemination of ISC with every extension agent covering between one and three villages.

In northern Kaduna, long-term average annual rainfall was 1050 mm and the growing season typically lasted 150 days. In southern Kaduna, the average annual rainfall was 1350 mm with a growing period of 170–190 days (Fig. 1). The dominant soil type in both areas was shallow Alfisol with a sandy loam to sandy clay loam texture. Farms in northern Kaduna State (north of Kaduna city) generally had characteristics different from farms in southern Kaduna State (south of Kaduna city). Large variations also existed among farms within villages and among villages within an area. Generally, farming in northern Kaduna State can be characterized as slightly more intense, with less fallow land available than in southern Kaduna State. Farmers in northern Kaduna State tended to use more fertilizer, had a higher level of integration between crops and livestock, made more frequent use of ox-drawn implements than the participating farmers in southern Kaduna State. *Striga* infestation, however, represented a major constraint for crop production in both areas.

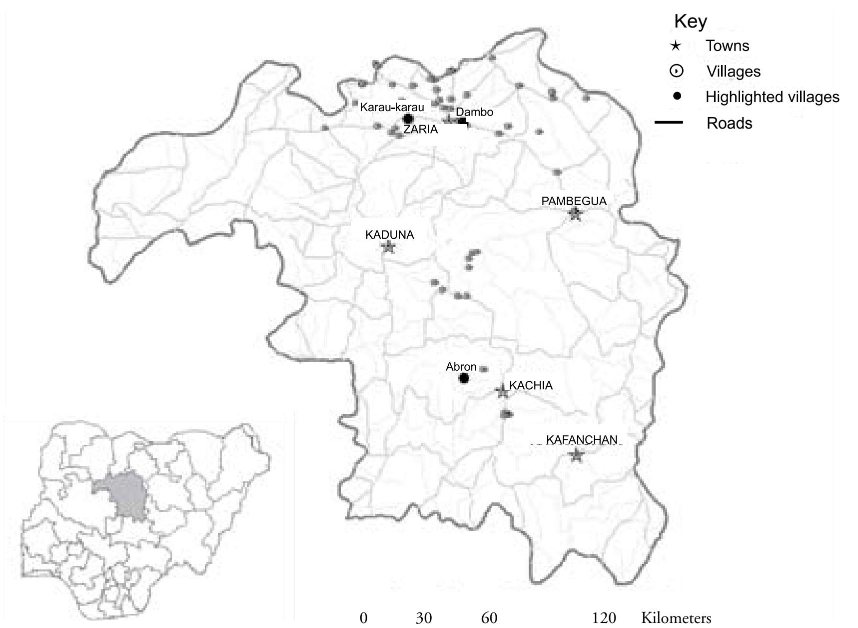

Figure 1. Kaduna State, indicating the villages where lead farmers were located.

On-farm trials

Before the establishment of the trials, following community workshops, the farming communities selected 148 lead farmers. The workshops allowed the assessment of livelihood strategies, natural resource problems and their prioritization, major crops, household resources, local institutions, problems arising from *Striga* infestation, local coping mechanisms, and identification of the control methods farmers saw as priorities for field testing (Emechebe et al. 2004). All communities ranked *Striga* infestation, along with poor soil fertility, as one of the main biophysical constraints for crop production. Each community typically selected two or three lead farmers who usually represented an existing farmers' group or another institution within the community.

Lead farmers testing ISC could choose between a variety trial and a rotation trial. The variety trial included the cultivation of *Striga* tolerant maize variety (Across 97 TZL Comp. 1-W) for 2 subsequent years (2002–2003) which was compared with farmers' traditional cereal-based systems. The cereal in the farmers' practice plot (FP) could be a traditional variety of maize, sorghum, or millet. These were occasionally intercropped with grain legumes such as local groundnut, soybean, and cowpea varieties. In some cases, farmers cultivated a recently released improved maize variety, such as Oba Super 2. In the second year, all farmers cultivated local maize on the FP plot to allow comparison with the maize in the ISC plot. In the rotation trial, a similar FP plot was compared with a 2-year grain legume–maize rotation. In the first year (2002) in the ISC plot of the rotation trial, farmers were given the choice of growing groundnut (variety RMP12), soybean (TGx 1448-2E or TGx 1864), or cowpea (IT-90K-452-2). In the following year (2003), farmers cultivated the *Striga* tolerant maize variety (Across 97 TZL Comp. 1-W) in the ISC plot as in the variety trial. Instead of a legume monocrop, some farmers chose to strip-crop maize and a legume on the ISC plot in 2002. Recommended seed quantities and fertilizer application rates were changed according to the ratio legume:maize strips. Some farmers relayed cowpea into the cereals at the end of the growing season; this is a common practice among some of the participating farmers.

Groundnut, soybean, and cowpea varieties used in the ISC plot were new varieties in this area selected for their good growth characteristics in the NGS and their ability to stimulate suicidal germination of *Striga* seeds. Groundnut, cowpea, and soybean variety TGx 1864 are dual-purpose varieties, providing both grain and fodder yields, while soybean variety TGx 1448-2E is a grain variety. The improved maize variety (Across 97 TZL Comp. 1-W) is an open-pollinated, long-duration maize variety.

Lead farmers received a set of specific recommendations on the field management of both plots from the extension agents. The trials were farmer-managed, therefore they did not necessarily follow the recommendations, as shown in the Results and Discussion section. The recommended trial plot size was 20 × 20 m (400 m^2). All crops were to be grown on ridges, a

Table 1. Details of recommended crop varieties and field management of ISC and farmers' practice plot in 2002–2003.

Crop	Variety	Planting distance (m)	Seed density (seeds/ha)	NPK fertilizer application rate (kg/ha)
Soybean	TGx 1448-2E, TGx 1864	0.75 × 0.10	133 000	40P
Groundnut	RMP12	0.75 × 0.20	67 000	40P
Cowpea	IT-90K-452-2	0.75 × 0.25	107 000	40P
Maize (ISC)	Across 97 TZL Comp. 1-W	0.75 × 0.50	53 000	120N 20P 39K
Maize or other cereals (FP)	Traditional	0.75 × 0.50	53 000	120N 20P 39K

common practice in the area, using a ridge distance of 0.75 m (Table 1). Soybean seeds were drilled at 0.10 m distance (133 000 seeds/ha). Groundnut was sown at a stand distance of 0.20 m, using one seed per stand (67 000 seeds/ha). Cowpea grown as a sole crop was sown at a stand distance of 0.25 m using two seeds per stand (107 000 seeds/ha). Cereals were grown at a stand distance of 0.50 m using two seeds per stand (53 000 seeds/ha). The extent to which farmers followed these management recommendations was monitored through a field survey.

Before planting legumes, farmers were requested to apply SSP at a rate of 40 kg P/ha and 53 kg S/ha. In maize, fertilizer was to be line-applied before sowing at a rate of 47 kg N/ha, 20 kg P/ha, and 39 kg K/ha, in the form of NPK 15-15-15, which actually contained 15% N, 6.5% P, and 12.5% K. Additional nitrogen fertilizer in the form of urea was to be spot-applied at a rate of 73 kg N/ha; 50% was to be applied at the first weeding, 2 WAP, and the remaining urea fertilizer at the second weeding, 6 WAP. In 2002, the only commodity the Project provided to the lead farmers was crop seed for the ISC plot. In 2003, the Project also provided NPK 15-15-15 and urea fertilizer for both the ISC and farmers' practice plot.

Hoe-weeding was conducted in both cereals and legumes at 2 and 6 WAP. Emerging *Striga* seedlings in cereals were hand-rogued at 12 WAP. This was, if necessary, repeated before harvest. Soil cultivation operations prior to planting legumes or maize were conducted manually or with ox-drawn tools. Other field operations were carried out manually.

Observations

Data on farmers' actual trial management practices (planting, spacing, and densities, fertilizer application rates, weed management), *Striga* infestation levels, and final cereal and legume grain yields were collected through a field observation sheet in 2002 and 2003. Extension agents collected the data for the field observation sheets with technical backstopping from project scientists and technicians. At 12 WAP, *Striga* density was assessed and *Striga* damage on cereals was rated at a scale of 1 to 5, where 1 corresponded to no damage and 5 corresponded to severe damage. Extension agents determined final grain yield. The total cereal harvest of grain and cobs was determined in the field. Subsequently, a representative sample of 20 cobs was shelled and grains were dried to constant weight at 65 °C to determine grain moisture content. Grain yields were converted to 12% moisture. Legume grain yield was determined by weighing the entire grain yield in the field and a representative sample of 200–300 g was dried to constant weight at 65 °C for dry matter determination.

Secondary farmers, i.e., farmers who wanted to test ISC using the experience from lead farmers, set up their own trials in 2003. Lead farmers typically had 3–4 secondary farmers, giving a total of approximately 450 secondary farmers. Field management and crop yields of secondary farmers were monitored in 2003 using a field observation sheet similar to that used for the lead farmers. The data were collected by a single technician and, due to logistic constraints, not all secondary farmers could be monitored.

Economic analysis

The economic analysis was based on the following:

1. A comparison of the grain yields of the different crops grown over the 2-year period.
2. A partial budget analysis deducing the main costs (fertilizer) that varied among treatments. This was primarily inorganic fertilizer as land preparation, seed, labor, and crop protection costs were similar among crops. For instance, most farmers planted soybean at a wider row spacing than recommended, often at the same spacing as maize to reduce labor costs in crop establishment and weeding. In addition, inorganic fertilizer was often the main household cash expenditure item, with other inputs being supplied by the household. Seed was often retained from the previous crop and labor was provided by the household. Few households purchased crop protection chemicals.

Comparisons were made between the different *Striga* control options, both individually and on a weighted average basis against the farmers' practice of local cereals followed by local maize. Local cereal is a weighted average of local maize, sorghum, and millet. Unfortunately, few farmers chose local legumes, either groundnut or soybean, in the first season and results were not statistically significant.

Three scenarios were considered, to examine the effects of different crop values and fertilizer prices (Table 2).

Table 2. Value/cost assumptions (US$).

		Cost at harvest time			Scenario 1 (baseline scenario)	Scenario 2	Scenario 3
					Average maize Average legume Average fertilizer	High maize Low legume Low fertilizer	Low maize High legume High fertilizer
Grain prices	US $	2001	2002	2003			
Maize	tonne	197	223	141	187	200	140
Groundnut	tonne	339	468	506	438	150	500
Soybean	tonne	153	192	285	210	150	300
Fertilizer prices		Prices at planting time					
NPK/urea	kg	0.24	0.29	0.40	0.31	0.20	0.50

Scenario 1 (the base case), based on average values and costs over the last three seasons

In this baseline scenario, crop values were based on the mean farm-gate price over the last three seasons at harvest time (2001, 2002, and 2003), when most farmers sell their crops. Prices varied considerably both among and within years. Prices were at their lowest at harvest time and increased gradually until the next harvest, reflecting their relative scarcity at this time. If farmers were able to keep their grain for consumption or store it for sale later during the year, they would realize considerably higher prices. Unfortunately, relatively few were able to do this, with many selling at low prices and repurchasing at higher prices later in the year for home consumption.

Fertilizer prices were also based on the mean price on the farm at planting time, as this is when most farmers purchased their fertilizer. Unfortunately, this coincided with the time when fertilizer prices were highest. Few farmers purchased out of season when prices were lowest.

Scenario 2, based on high maize prices, low legume prices, and low fertilizer prices

This assumed that maize prices increased due to shortages and increased demand, legume prices fell due to the lack of demand, and fertilizer prices declined, either as a result of an increasing supply or a possible Government subsidy.

Scenario 3, based on low maize prices, high legume prices, and high fertilizer prices

This assumed that maize prices decreased due to oversupply or falling demand, legume prices rose because of supply constraints or an increase in demand, and fertilizer prices rose, as a result of either a decrease in supply or shortages.

Results and discussion

Agronomic performance of lead farmer trials

Out of 148 lead farmers, 92 were based in northern Kaduna State, while the remaining 56 farmers were located in southern Kaduna State. Forty lead farmers selected a variety trial and 108 chose a rotation trial (Table 3). The variety trial was chosen by 35 farmers in northern Kaduna, and 5 farmers in southern Kaduna. Out of 57 farmers who selected the rotation trial in northern Kaduna, 15 farmers strip-cropped the legume with maize in the ISC plot. None of the farmers in southern Kaduna chose a rotation trial with strip-cropping. This suggests that more land was devoted to cereal production in northern Kaduna than in southern Kaduna. In the FP plot in 2002, 83 farmers chose local maize, 56 selected local sorghum, and 4 chose local millet, as their local cereal. Farmers chose local soybean (4 farmers) or local groundnut (one farmer) as their local legume in 2002. In northern Kaduna, 77% of the farmers preferred to grow maize as their local cereal in the FP plot, while in southern Kaduna, 75% of the farmers opted for sorghum. All farmers who selected strip-cropping for their ISC plot chose soybean as a legume crop. None of the farmers selected improved cowpea as a main crop. However, 92

Table 3. Choice of field management and number of plots on farmers' practice (FP) plot and integrated *Striga* control (ISC) plot in Zaria and southern Kaduna State in 2002–2003.

	2002		2003	
Rotation type	Crop	No.	Crop	No.
FP	Local cereal	143	Local maize	148
	Local legume	5		
ISC-variety trial	*Striga* tolerant maize	40	*Striga* tolerant maize	40
	Improved soybean	71		
ISC-rotation trial	Improved groundnut	22	*Striga* tolerant maize	108
	Soybean–maize strip-cropping	15		

farmers relayed cowpea into the cereals in the FP or ISC plot at the end of the growing season in 2003. This was usually a local cowpea variety.

Part of the ISC strategy was to increase the stand density of legumes and maize crops and to reduce the number of plants/stand to ensure sufficient root coverage of the legumes to stimulate suicidal germination and to maximize legume and cereal yields. While the recommended 0.75 m row distance for all crops and the stand distance for the legumes were closely followed by farmers, stand distance for maize was usually well above the recommended 0.25 m (Table 4). Average number of maize plants/stand in 2003 was 1.8 in both local and improved maize, while the recommendation was 1.0 maize plant/stand (Table 5). Farmers thus compensated for the lower stand density with a higher number of maize plants/stand (1.8 instead of 1.0). Likely reasons for this lower stand density are the high labor requirement associated with a high stand density, and the difficulty in relaying cowpea into maize at the end of the growing season when the stand distance is 0.25 m. Also farmers had the belief that cereals cultivated at a high stand density require more fertilizer than cereals sown at a low stand density, irrespective of the number of plants/stand.

Farmers closely followed the recommended fertilizer rates for cereals (Table 6). In 2002, when the farmers provided the fertilizer, the rates applied in cereals were slightly below the recommended rate; in 2003, when the Project provided the fertilizer, applications were at the recommended rates. In 2002, the yields of cereals in some plots may have been limited by the lack of inorganic fertilizer; in 2003, yields were unlikely to be limited by nutrient application rates in most fields. Improved maize received approximately the same fertilizer dose as local cereals within a year. In improved soybean, farmers often did not follow the recommended fertilizer application rates, applying more nitrogen and potassium and less phosphorus than recommended. There might have been a combined effect of lack of knowledge among farmers on soybean nutrient requirements and the poor availability of P-based fertilizers, such as single superphosphate and triple superphosphate. Most farmers used NPK 15-15-15 and urea as inorganic fertilizers for both soybean and cereals.

Table 4. Recommended and observed row distance (m) in lead farmers' plots in 2002 and 2003 and in secondary farmers' plots in 2003.

Rotation type	Recommended (m)	Lead farmers 2002	Lead farmers 2003	Secondary farmers 2003
FP	–	0.86	0.77	0.86
ISC	0.75	0.81	0.74	0.83

–: no data

Table 5. Recommended and observed stand distance (m) in lead farmers plots in 2002 and 2003 and in secondary farmers' plots in 2003.

Crop	Recommended (m)	Lead farmers 2002	Lead farmers 2003	Secondary farmers 2003
Local cereal	–	0.46	0.49	0.50
Local legume	–	0.23	–	–
Improved soybean	0.10	0.13	–	0.20
Improved groundnut	0.20	0.20	–	0.19
Improved maize	0.25	0.46	0.42	0.39

–: no data

Table 6. Recommended and observed average application rates (kg/ha) for nitrogen, phosphorus, and potassium in various crops in 2002 and 2003.

Crop	Recommended (m)	Lead farmers 2002	Lead farmers 2003	Secondary farmers 2003
Local cereal	–	79N 12P 17K	117N 14P 27P	108N 12P 22K
Improved soybean	40P	62N 8P 19K	–	107N 12P 22K
Improved groundnut	40P	–	–	107N 12P 22K
Improved maize	120N 20P 39K	81N 12P 19K	151N 21P 39K	108N 11P 21K

–: no data

The yields of local cereals in FP plots were well below those of the improved maize varieties (Table 7). Planting methods and fertilization regimes of the local cereals and the improved maize were not very different, therefore the observed high yield of improved maize would be likely to be related to the genetic characteristics of the new maize varieties. These include *Striga* tolerance and high nitrogen-use efficiency. Perhaps there were also differences in field management practices other than planting techniques and fertilization. In 2003, maize yields in the ISC–variety trial were higher than yields in the ISC–rotation trial. This is likely to be related to the relatively high number of farmers who selected the variety trial in northern Kaduna compared to southern Kaduna. The differences in yield may reflect the more fertile soil conditions in northern Kaduna, because of a higher use of fertilizer and organic manure in the past, rather than from an improved performance of a continuous maize system, compared with a legume–maize system.

The improved groundnut and soybean varieties did not outyield the local legumes. Also, local maize yields following a local legume were in the same range as the maize yields after an improved legume. However, given the low number of farmers that cultivated a local legume in 2002 (five farmers), it is impossible to draw any conclusions from this result.

The ISC–variety and rotation trials were both highly effective in reducing the *Striga* density and damage on cereals (Table 8). The rotation trial using soybean or groundnut as a full season crop resulted in slightly less *Striga* infestation and *Striga* damage on maize than the variety trial with 2 years of *Striga* tolerant maize. The highest *Striga* damage rating was recorded in the FP plot with local cereals in 2 consecutive years. *Striga* density observed in 2003 was positively correlated with *Striga* damage rating but this correlation was not very strong. For example, average *Striga* density in the ISC–rotation trial with soybean was approximately twice that of the rotation trial with groundnut, while the damage rating was approximately equal for both rotations. This suggests that *Striga* field density alone is not a good indicator of the damage on maize and consequently of the expected loss in grain yield due to *Striga*.

Table 7. Legume and maize grain yields (t/ha) of lead farmers' plots in 2002 and 2003 for various rotations.

Rotation type	Rotation (2002–2003)	2002 grain yield (cereal or legume)	2003 grain yield (maize)
FP	Local cereal–local maize	1.50 (0.22)	1.59 (0.12)
	Local legume–local maize	1.04 (0.54)	2.65 (0.63)
ISC-variety trial	Improved maize–improved maize	3.08 (0.30)	3.52 (0.32)
ISC-rotation trial	Groundnut–improved maize	1.06 (0.09)	2.75 (0.33)
	Soybean–improved maize	1.19 (0.09)	2.94 (0.19)
	Strip-cropping–improved maize	0.96 (0.42) maize 0.85 (0.19) soybean	2.54 (0.47)

Values in parentheses represent standard errors of the means.

Table 8. *S. hermonthica* plant density (plants/ha) and damage rating at 12 WAP in cereals in 2002 and 2003.

Rotation type	Rotation (2002–2003)	2002 Damage rating[1]	2003 Damage rating[1]	2003 *Striga* density (no. plants/ha)
FP	Local cereal–local maize	3.10 (0.07)	3.17 (0.12)	13789 (1971)
	Local legume–local maize		2.00 (0.32)	18261 (3663)
ISC-variety trial	Improved maize–improved maize	1.85 (0.12)	1.70 (0.13)	6810 (1410)
ISC-rotation trial	Groundnut–improved maize		1.40 (0.21)	2541 (1501)
	Soybean–improved maize	1.87 (0.26)	1.44 (0.10)	5837 (1908)
	Strip-cropping–improved maize		2.67 (0.33)	7368 (4206)

[1] Rating from 1 to 5, whereby 1 corresponds to no damage and 5 to severe *Striga* damage.
Values in parentheses represent standard errors of the means.

Agronomic performance of secondary farmer trials

At the beginning of the growing season in 2003, lead farmers typically guided 3–4 secondary farmers in setting up ISC trials. However, out of these 500–600 farmers who were initially interested, only 267 managed to complete the first year of the ISC trial. Reasons farmers gave for not completing the trial included a lack of access to fertilizer and the poor availability of improved seeds. Out of the 267 secondary farmers who completed the first year of the ISC trial, agronomic data were collected from 162 farmers (Table 9). A majority of these farmers (85%) opted for the ISC–rotation trial, with improved soybean being the most popular legume trap crop.

Observed row and stand distances in secondary farmers' plots were approximately similar to those observed in lead farmers' plots in the first year of the rotation (2002) (Tables 4 and 5). Row distance was slightly larger than the recommended 0.75 m, but less than the farmers' common row distance of 0.9–1.0 m. Farmers did not follow the recommended narrow stand distance for cereals and soybean. Fertilizer application rates were approximately at recommended rates for cereals (Table 6). However, improved soybean and groundnut varieties on secondary farmers' plots received higher doses of nitrogen and potassium and less phosphorus than recommended. Farmers were apparently unaware of the fertilizer requirements of grain legumes, and applied urea rather than NPK 15-15-15 or single superphosphate because the unit price of urea in the area is below that of other fertilizers.

Grain yields of *Striga* tolerant maize were well above the yields of the local cereals in secondary farmers' fields (Table 10). Nevertheless, the grain yields of *Striga* tolerant maize were below the yields observed in lead farmers' plots. The same trend was observed for the grain yields of groundnut and soybean varieties in the ISC–rotation trials. *Striga* damage rating and *Striga* field densities were lower in the ISC plots than in FP plots of secondary farmers (Table 10). The relative difference in *Striga* damage rating and *Striga* field density between the FP and the ISC plots was less in the plots of secondary farmers than in those of lead farmers. The results suggest that a transfer of the ISC technology from lead farmers to secondary farmers occurred and secondary farmers obtained higher yields and lower *Striga* densities through the use of ISC technologies. However, the performance of the ISC technology in secondary farmers' plots was not as good as it was in lead farmers' plots.

Table 9. Secondary farmers' choice of field management of ISC trials.

Rotation type	2003	No.
FP	Local cereal	162
ISC-variety trial	*Striga* tolerant maize	24
	Improved groundnut	16
ISC-rotation trial	Improved soybean	105
	Soybean–maize strip-cropping	17

No. represents the number of monitored secondary farmers who selected a type of rotation.

Table 10. Legume and maize grain yields (t/ha), *Striga* density (plants/ha) and *Striga* damage rating (relative scale) at 12 WAP in secondary farmers' plots in 2003 for various crops.

Rotations type	2003 crop	Grain yield (cereal or legume)	*Striga* damage rating[1]	*Striga* density
FP	Local cereal	0.83 (0.07)	2.53 (0.09)	5308 (458)
ISC-variety trial	*Striga* tolerant maize	2.05 (0.32)	1.92 (0.26)	3956 (1159)
	Improved groundnut	0.66 (0.07)		
ISC-rotation trial	Improved soybean	0.93 (0.07)		
	strip-cropping	1.43 (0.14) maize	1.71 (0.29)	2272 (861)
		0.65 (0.07) soybean		

[1]Rating from 1 to 5, whereby 1 corresponds to no damage and 5 to severe *Striga* damage.
Values in parentheses represent standard errors of the means.

The lack of direct support from extension agents and scientists to secondary farmers is likely to have resulted in poor field management of ISC plots and subsequently lower yields and higher *Striga* densities than in the lead farmers' plots.

Economic analysis of lead farmers' trials

Results from Scenario 1 are shown in Table 11. Integrated *Striga* control provided an 82% increase over local cereals followed by local maize (LC–LM), being 65% greater in the first season and 106% greater in the second season. All the *Striga* control options outperformed farmer practices based on crop values. The LC–LC option provided higher crop values than other farmer practices (local sorghum, millet, and legumes) because maize received much more inorganic fertilizer in both seasons than in other farmer practices. Farmers indicated that maize yields are very low without fertilizer and always prefer to apply fertilizer to maize than to other crops.

When the *Striga* control options are compared, maize followed by maize provides a greater crop value than either soybean or groundnut followed by maize. This is attributed to the high maize yields achieved in both seasons and the relatively high rates of fertilizer application in the first season relative to other crops. Legumes such as soybean and groundnut usually receive little or no fertilizer and are often grown when fertilizer is unavailable or prices are high. Although yields of soybean and groundnut were similar, groundnut attracted a higher price, making the groundnut–*Striga* tolerant maize (Gn–StM) option more attractive than soybean–*Striga* tolerant maize (Sb–StM). The intercrop of StM and soybean in the first season followed a common practice that outyielded both the soybean and groundnut options grown sole, and provided farmers with a measure of risk reduction if one of the crops failed.

All fertilizer applications in the second season were considerably higher than those in the first season, both for local and *Striga* tolerant maize. Rates were higher for *Striga* tolerant maize than for local maize. Increased fertilizer application is attributed to the fact that fertilizer was not only considered essential to obtain a good yield but was also made available as loans to farmers.

Table 11. Summary of average crop yields, crop values, fertilizer used, and costs and margins of crop values over fertilizer costs.

				Yields t/ha		Crop values US $/ha			Fertilizer applied kg/ha			Fertilizer cost US$/ha			Margins US$/ha			% over LC–LM	
	2002	2003	No.	2002	2003	2002	2003	Total	2002	2003	Total	2002	2003	Total	2002	2003	Total	Base	Rank
FP	LM	LM	83	1.80	1.93	336	361	697	223	372	595	69	114	183	267	246	514	35	4
	LS	LM	56	0.43	0.98	79	183	262	80	187	267	24	58	82	55	125	180	–53	9
	Lmi	LM	4	0.59	1.81	110	338	448	51	169	221	16	52	68	94	286	380	0	7
	LSb	LM	4	1.33	1.33	279	248	527	80	373	453	24	115	139	255	134	388	2	5
	LGn	LM	1	0.15	0.57	66	106	172	0	468	468	0	144	144	66	–37	28	–93	10
	LC	LM	143	1.23	1.56	229	290	520	162	291	453	50	89	139	179	201	381	0	8
ISC	M	M	40	3.08	3.52	575	658	1233	271	475	746	83	146	229	492	512	1004	164	1
	Sb	M	71	1.17	2.94	246	550	796	50	517	568	15	159	174	231	391	622	63	3
	Gn	M	22	1.06	2.88	465	537	1002	0	446	446	0	137	137	465	400	865	127	2
	M/Sb	M	15	0.96/0.84	2.54	180/	176474	829	223	634	857	68	195	263	111	279	390	3	5
			148	Average (ISC)		379	569	948	120	507	627	37	156	193	324	413	738	94	
				Difference (ISC-FP)		150	279	428	–42	216	174	–13	66	54	145	212	357		
				% difference (ISC-FP)		65	96	82	–26	74	39	–26	74	39	81	106	94		

LM = local maize, LSb = local soybean, Lmi = local millet.
LGn = local groundnut, LC = local cereal, SB = soybean.
M = maize, GN = groundnut, M/Sb = maize–soybean.

All loans to farmers were repaid, either in cash or kind, at the end of the season. Hence, there were no problems of availability and affordability that may normally limit farmers' use of fertilizer.

Although 26% less fertilizer (by quantity) was applied in the first season to the *Striga* control options due to the high proportion of legumes grown, similar amounts were applied to the local and *Striga* resistant maize options. However, in the second year, for reasons already explained, 74% more fertilizer was applied. This has had a significant effect on the margin of crop values over fertilizer costs. In the baseline scenario, *Striga* control options outperformed farmer practices by 94%, being 81% greater in the first season and 106% greater in the second season when compared with LC–LM. Within the *Striga* control options, StM–StM outperformed both Sb–StM and Gn–StM**,** despite the increased fertilizer costs, due to the high yields achieved and the relatively high price of maize. Interestingly, LM-LM outperformed *Striga* control with strip-cropping of maize and soybean followed by maize in the second season. This is attributed to the high rate of fertilizer application on the *Striga* control option in the second year.

The value of the crop and price of fertilizer will both have a marked effect on the appropriateness of the different *Striga* control options (Table 12). When the price of maize is high relative to that of legumes, and fertilizer prices are low (scenario 2), it becomes increasingly more attractive to grow maize, even if these are local varieties, because farmers are likely to increase fertilizer applications. Long-term sustainability of continuous maize is a concern. Stimulating the demand for legumes through encouraging alternative home use and oil extraction, as well as not subsidizing fertilizer and allowing prices to rise, is likely to favor legumes. In the scenario where the maize price is low relative to legumes and the price of fertilizer is high, legume–maize rotations for *Striga* control become increasingly attractive (Scenario 3).

Conclusions

The study reported in the paper suggested as follows:

i. A two-season integrated *Striga* control (ISC) period resulted in greater cereal yields and lower *Striga* densities in lead farmers' plots than farmers' traditional, cereal-based practice.
ii. The ISC technology increased both the value of crops and crop margins over fertilizer costs and traditional farmer practices of continuous cereal production with local varieties.
iii. As the price of maize is reduced to that of legumes and the price of fertilizer increases, it becomes increasingly attractive to adopt the use of a legume crop in the season before growing *Striga* tolerant maize.
iv. To encourage legume production, it is important that alternative home uses and oil extraction are encouraged and the price of fertilizer is not subsidized.
v. Transfer of the ISC technology from lead farmers to secondary farmers occurred and secondary farmers obtained higher yields and lower *Striga* densities through the use of ISC technologies.
vi. The performance of the ISC technologies in secondary farmers' plots was below that of lead farmers' plots, probably due to a lack of direct support from extension agents and scientists.

Table 12. Crop values and margins over fertilizer price (% over LC–LM and rank).

	Season			Crop value as % of LC–LM and rank					Crop margin over fertilizer as % of LC-LM					
	2002	2003	No.	Base (%)	Rank	High M, Low L, High F (%)	No.	Low M, High L, Low F (%)	No.	Base (%)	Rank	High M, Low L, High F (%)	No.	Low M, High L, Low F (%)	No.
FP	LM	LM	83	34	4	34	4	34	6	35	4	35	4	38	5
	LS	LM	56	–49	9	–49	9	–49	9	–53	9	–51	9	–61	8
	Lmi	LM	4	–14	7	–14	7	–14	8	0	7	–6	7	38	5
	LSb	LM	4	2	5	–16	8	119	5	2	5	0	8	283	3
	LGn	LM	1	–67	10	–75	10	–60	10	–93	10	–91	10	–149	10
	LC	LM	143	0	8	0	6	0	7	0	8	0	6	0	7
ISC	M	M	40	137	1	137	1	137	3	164	1	151	1	238	4
	Sb	M	71	53	3	37	3	157	1	63	3	0	2	338	1
	Gn	M	22	93	2	32	5	140	2	127	2	39	3	336	2
	M/Sb	M	15	60	5	48	2	133	4	3	5	13	5	–62	9
		Total	148												

Base = Average value/price over last three seasons. M = maize, L = legume, F = fertilizer.

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Agronomic and economic performance of researcher–managed integrated *Striga* management strategies

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Summary

The root parasitic angiosperm *Striga hermonthica* parasitizes cereal crops, often causing 70–100% crop losses on farmers' fields. Past researches have identified several effective control technologies. To promote farmer testing of the technologies, a participatory extension and research approach was used to encourage farmer involvement in improving *Striga* management. Integral to the research were two researcher-managed "mother" trials conducted for a 3-year period (2001 to 2003) at Samaru in the Guinea savanna of Nigeria. The first investigated the effect of maize cultivar, type of legume trap crop, and legume–maize rotation on incidence and severity of *S. hermonthica* in maize. The treatments consisted of two maize cultivars, three legume trap crops, 1 or 2 years' rotation, and a natural fallow plot. The second trial evaluated the interaction between resistant and susceptible maize cultivars and nitrogen rates on the incidence and severity of *Striga*. The treatments consisted of the same maize cultivars as in the first trial and five N levels (0, 40, 80, 120, and 160 kg N/ha). The improved *Striga* tolerant maize cultivar Across 97 TZL Comp. 1-W produced higher grain yield, supported fewer *Striga* plants, exhibited more vigorous growth, and hence had less severe crop damage than the susceptible cultivar, TZB. Maize grown after 1 or 2 years' fallow or legume trap crop had greater crop vigor and was less damaged by *Striga* than continuous sole maize. Compared with yields in continuous sole maize or maize after natural fallow, yields were up to 28% higher after 1 year's rotation with soybean, cowpea, or groundnut and 56% higher after 2 years. Maize vigor and grain yield were lowest where no N was applied and increased with higher N rates. *Striga* incidence and crop damage were higher where no N was applied and decreased with higher N rates. Application of 120 kg N/ha appears adequate for *Striga* control and improved maize yield.

Economic analysis has shown that the use of *Striga* tolerant maize and legume trap crops grown in rotation with maize can provide better returns than continuous maize. However, if maize prices increase relative to legumes and fertilizer prices decrease, continuous maize can become more profitable. Affordability and availability of fertilizer, especially for poorer households, remain key problems. Decreases in maize price relative to that of legumes and increases in fertilizer price are likely to encourage legume production and could benefit poorer households in improving nutrition and reducing the need for fertilizer.

Introduction

The root parasitic angiosperm *Striga hermonthica* parasitizes cereal crops, often causing 70-100% crop losses on farmers' fields (Emechebe et al. 2004); losses of up to US$ 3 billion would occur if all the host cereal crops in sub–Saharan Africa were to be infested. Sauerborn (1991) estimated the actual *Striga* area in Africa at 21 million ha (with 44 million ha potentially at risk). Lagoke et al. (1991) considered that about 50 million out of about 73 million ha were already severely or moderately infested. *Striga* has its greatest impact in low-input subsistence farming systems and farmers have attributed increasing *Striga* damage to continuous cropping of host crops, poor soil fertility, lack of capital, and infestation of previously uninfested fields by *Striga* seeds (Kureh et al. 2003; Schulz et al. 2003; Emechebe et al. 2004).

Past researches have identified several effective control technologies (Parker and Riches 1993). Examples include planting resistant host crop cultivars, using leguminous trap crops (which stimulate suicidal germination of *Striga* seeds and therefore reduce the seedbank), and improving and maintaining soil fertility.

In the context of this paper, the term "resistant" refers to host cultivars that are less attacked in terms of damage and number of emerged *Striga* plants (Parker and Riches 1993). Schulz et al. (2003) found that resistant maize following a soybean trap crop yielded 1.58 t/ha of grain and outyielded farmers' maize variety following traditional practices by more than 80%.

The effectiveness of leguminous trap crops was demonstrated by Sauerborn (1999) in field experiments in Ghana where annual double cropping of trap crops (soybean, sunflower, and cotton) reduced the seedbank by about 30% each year. Similarly, Schulz et al. (2003) achieved 50% seedbank reduction after one year's rotation with soybean and cowpea under farmer-managed conditions. Carsky et al. (2000) reported that *Striga* incidence in maize after soybean, compared to maize after sorghum, was significantly reduced from 3.2 to 1.3 emerged *Striga* plants/maize plant, resulting in greatly improved grain yields.

In addition to host plant resistance and legume trap crops, a substantial amount of work has been carried out to study the effect of soil fertility on *Striga* infestation. The effect of *Striga* is more pronounced on crops grown under low chemical input agriculture (Mumera and Below 1993; Kim et al. 1997). Hence, improved soil fertility conditions are likely to lead to reduced infestation (Debra et al. 1998). Adequate application of N, especially urea, at N rates between 120 and 280 kg/ha is effective in reducing *Striga* damage and emergence (Mumera and Below, 1993; Kim et al. 1997). However, the effect of N fertilizers is not always apparent and in very infertile soils N fertilizers may stimulate *Striga* infestation. Thus, a complete understanding of the effect of N fertilization on *Striga* plants and their interaction with the host cultivar is needed (Mumera and Below 1993; Cechin and Press 1993).

Most *Striga*-infested areas already have high levels of parasite seeds in the soil. It is essential to encourage the adoption of control measures that aim at reducing the level of *Striga* seed inoculum in the soil. It is widely recognized that sustainable control of *Striga* through single control options is unlikely (Berner et al. 1996; Carsky et al. 2000; Schulz et al. 2003). *Striga* control is more likely to be achieved by combining a range of individual component technologies into integrated packages that will provide flexible and sustainable control over a wide range of biophysical and socioeconomic environments (Berner et al. 1996; Schulz et al. 2003). The researcher-managed "mother" trials reported here are part of a participatory research and extension approach (PREA) that has encouraged farmers' exchange visits and on-farm testing of "daughter" trials of selected alternative *Striga* control options under their conditions.

Materials and methods

Experimental design and agronomic practices

Two researcher-managed "mother" trials were conducted for a 3-year period (2000 to 2003) at Samaru (11 °11′N, 7 °36′E: 686 m above sea level) in the Guinea savanna of Nigeria (Table 1). A fourth year, 2004, is presently being analyzed.

First, the effect of maize cultivar, type of legume trap crop, and legume–maize rotation on the incidence and severity of *Striga* in maize was investigated. The treatments consisted of two maize cultivars (Across 97 TZL Comp. 1-W, a tolerant cultivar, and TZB, a susceptible cultivar),

Table 1. Three-year *Striga* control trials at Samaru.

		2001	2002	2003
Trial 1	Maize varieties	TZB Across 97 TZL Comp. 1-W	TZB Across 97 TZL Comp. 1-W	TZB Across 97 TZL Comp. 1-W
	2-year rotation	Fallow	Maize	–
		Maize	Maize	–
		Cowpea	Maize	–
		Groundnut	Maize	–
		Soybean	Maize	–
	3-year rotation	Fallow	Fallow	Maize
		Maize	Maize	Maize
		Cowpea	Cowpea	Maize
		Groundnut	Groundnut	Maize
		Soybean	Soybean	Maize
Trial 2	Nitrogen treatments (kg/ha)	0 N	0 N	0 N
		40 N	40 N	40 N
		80 N	80 N	80 N
		120 N	120 N	120 N
		160 N	160 N	160 N

three legume trap crops (soybean cv. TGX 1448-2E, cowpea cv. IT93K452-1, and groundnut cv. RMP 12), 1 or 2 years' rotations, and a fallow control plot.

The treatments were arranged in a split plot design with sequence nesting in the cultivars replicated three times. In 2001, the experimental plot was sprayed with Touchdown® herbicide at the rate of 5 L/ha to destroy established weeds. Then the land was plowed, harrowed, and inoculated with about 3000 *Striga* seeds, broadcast after harrowing but before ridging, using *Striga* seeds/sieved sand mixture, and ridged at 75 cm. In 2002 and 2003, the land was ridged manually at 75 cm. Maize, cowpea, and groundnut were planted at an intrarow spacing of 25 cm. Two seeds of each crop were seeded/stand and thinned 2 weeks after planting (WAP) to one plant/stand. Soybean was drilled and thinned to an intrarow spacing of 5 cm. Maize plots were hoe-weeded at 2 WAP and earthed up at 6 WAP. Weeds other than *Striga* were hand-pulled. Legumes were hoe-weeded at 3 and 6 WAP.

Fertilizer was applied at the rate of 120 kg N/ha, 26 kg P/ha, and 50 kg K/ha using NPK (15:15:15) and urea. All P and K and half of the N were applied at 2 WAP while the remaining N was top-dressed at 6 WAP. The legumes were fertilized at the rate of 20 kg N/ha, 18 kg P/ha, and 17 kg K/ha using NPK (15:15:15) mixed with single superphosphate (P_2O_5). Cowpea was sprayed with a mixture of 30 kg a.i./ha of Cypermethrin and 250 kg a.i./ha of Dimethoate (BASF Corp.) and with Benomyl (Dupont Agricultural Products) at flowering and podding to control diseases and insect pests.

The second trial evaluated the interaction between resistant and susceptible maize cultivars and nitrogen rates on the incidence and severity of *Striga*. The treatments consisted of the same maize cultivars as in the first trial and five N levels (0, 40, 80, 120, and 160 kg N/ha). All plots received 27 kg P/ha using single superphosphate and 26 kg K/ha using muriate of potash at planting. Half of the N was applied at 2 WAP and the rest at 6 WAP. Field operations and data collected were undertaken as in the first trial.

Analytical procedures

Data collected included soil sampling for baseline information on the *Striga* seedbank in 2001 and the *Striga* seedbank in 2002 and 2003, *Striga* count (at 9 WAP), crop vigor score, and grain yield. The data were analyzed using Mixed Model procedures in SAS (1999). Means were separated using the standard error of the means. Farmers visited the trials to evaluate and choose treatments for their experimentation.

Economic assessment

Economic analysis was based on quantification of the benefits and costs over the 3-year period valued at the average of 2001–2003 market prices. This was designated the base case scenario. Variations in these average prices were used in a sensitivity analysis.

Partial budget (PB) analysis was used to compare the effects of the *Striga* control practices with farmers' traditional practices or varieties over the period. PBs took into account the increased gross benefit (crop yield × farm-gate market price) resulting from the *Striga* control practices over the 3-year period and the increase (or decrease) in costs from using these practices compared to farmer practices. Cost differences were largely related to quantities of seed and fertilizer actually used. Although legume trap crop seeds are not yet commercially available, they were valued at 10% more than local seed varieties. The PB excluded all items that did not vary among treatments. This included costs of land preparation, planting, and weeding costs, as farmers had indicated that there were no significant differences among treatments, even when *Striga* populations varied.

Net Present Benefits (NPB), being the present value of future benefits, were determined by adding the net benefits for each year, initially not discounting the second and third year benefits, although 5% and 20% discounts were used in a sensitivity analysis. The 20% discount rate, although high, was used to reflect a possible farmers' view of the value of future benefits.

The NPB obtained from applying each treatment can be expressed mathematically, as:

$$NPB = \sum_{f=1}^{N(t)} \sum_{t=1}^{2} d^{t-1} \left[\left(Y_s(f,t) P_s(f,t) - C_s(f,t) \right) - \left(Y_F(f,t) P_F(f,t) - C_F(f,t) \right) \right]$$

where NPB = Net Present Benefit (US\$ ha^{-1}),
d is the discount factor,

$Y_s(f,t)$ = Yield from the *Striga* control system at plot *f* in year *t*,
$Y_F(f,t)$ = Yield from the farmer practice at plot *f* in year *t*,
$C_s(f,t)$ = Cost associated with growing the crop under a *Striga* control practice at plot *f* in year *t*,
$C_F \; f,t$ = Cost associated with growing the crop under the farmer practice at plot *f* in year *t*,
$P_F(f,t)$ = Market value of the crop grown in the farmer practice system at plot *f* in year *t*,
$P_s(f,t)$ = Market value of the crop grown in the *Striga* control system at plot *f* in year *t*.

A sensitivity analysis, based on a 30% increase or decrease in maize and legume prices as well as a 30% increase or decrease in fertilizer prices and variations in the discount rate (0%, 5%, and 20%), was used to establish the robustness of the findings over the base case.

Results

Cultivar effects on *Striga* infection and maize performance

The improved *Striga* tolerant maize cultivar (Across 97 TZL Comp. 1-W) produced higher grain yield, supported fewer *Striga* plants, exhibited more vigorous growth in the 3 years, and had lower crop damage severity than the susceptible cultivar in 2002 and 2003 (Table 2). The *Striga* seedbank was 60% higher in soils collected where the tolerant maize was grown than after the susceptible cultivar. The grain yield of Across 97 TZL Comp. 1-W was 26% higher than that of TZB in 2001, 16% in 2002, and 26% in 2003.

Rotation effects on *Striga* infection and maize performance

Maize grown after 1 year of legume trap crops had greater crop vigor and was less damaged by *Striga* than continuous sole maize (Table 3). The *Striga* seedbank did not vary among the treatments. Maize grain yield after soybean, cowpea, or groundnut was up to 28% higher than that in continuous sole maize or maize after a natural fallow.

Similarly, maize grown after 2 years of fallow or legumes produced higher grain yield, was more vigorous in growth, and less damaged by *Striga* than continuous maize (Table 4). Surprisingly, maize grown after 2 years of continuous cowpea supported more *Striga* plants than maize grown after 2 years of groundnut, but this was similar to all other treatments. The grain yield of maize after 2 years of continuous fallow or legumes was more than 56% higher than that after 3 years of continuous maize

Nitrogen effects on *Striga* infection and maize performance

During the 3 years, maize vigor and grain yield were lowest where no N was applied and increased with higher N rates (Table 5). In 2001, the incidence of *Striga* and crop damage did not differ at the different rates of N applied. In 2002 and 2003, *Striga* incidence and crop damage were higher where no N was applied and decreased with higher N rates. Application of 80 kg N/ha and above significantly reduced crop damage and increased grain yield more than zero N; 160 kg N/ha produced the highest grain yield in 2001; 120 kg N/ha produced the highest grain yields in 2002 and 2003 and appears adequate for *Striga* control and improved maize yield.

Table 2. Effect of maize cultivar on *Striga* seed bank and infestation, crop vigor score, damage severity, and grain yield at Samaru, Nigeria, 2001–2003, wet seasons.

Cultivars	Crop vigor score*			*Striga* count/plot			*Striga* seed bank No./100 g soil	Crop damage score**			Grain yield (kg/ha)		
	2001	2002	2003	2001	2002	2003		2001	2002	2003	2001	2002	2003
Across 97 TZL Comp. 1-W	7.0a	8.5a[1]	9.2a	7a	12b	5a	10.6a	5.0a	3.2b	2.4b	3363a	4236a	3657a
TZB	6.0b	7.8b	8.4b	16b	23a	7b	6.5b	6.7a	3.7a	3.2a	2660b	3745b	2891b

*Crop vigor score using a scale of 1–10; where 1 = completely damaged plants and 10 = healthy plants.
**Crop damage severity using a scale of 1–9; where 1 = healthy plants and 9 = completely damaged plants.
[1]Means followed by the same letter(s) are not significantly different at 5% level of probability.

Table 3. Effect of 1-year rotation with legume trap crops on *Striga* seedbank and incidence, crop vigor score, damage severity, and grain yield of maize at Samaru, Nigeria, 2002, wet season.

Type of rotation	*Striga* seedbank No./100 g soil 2003	Crop vigor score* 2002	*Striga* count/plot 2002	Crop damage score** 2002	Grain yield (kg/ha) 2002
Continuous sole maize	8.7a	7.5b[1]	32a	4.1a	3402b
Maize after fallow	13.2a	8.2ab	24ab	3.6ab	3480b
Maize after soybean	6.2a	8.5a	16ab	3.1b	4273a
Maize after cowpea	6.2a	8.7a	16ab	3.0b	4359a
Maize after groundnut	8.7a	8.4a	12b	3.0b	4087a

*Crop vigor score using a scale of 1–10; where 1 = completely damaged plants and 10 = healthy plants.
**Crop damage severity using a scale of 1–9; where 1 = healthy plants and 9 = completely damaged plants.
[1]Means followed by the same letter(s) are not significantly different at 5% level of probability.

Table 4. Effect of 2-year rotation with legume trap crops on *Striga* seedbank and incidence, crop vigor score, damage severity, and grain yield of maize at Samaru, Nigeria, 2003, wet season.

	Crop vigor score*	*Striga* count/ plot	Crop damage score**	Grain yield (kg/ha)
Type of rotation	2003	2003	2003	2003
Continuous sole maize	7.6c[1]	8ab	4.0a	2047c
Maize after 2 years fallow	8.8a	8ab	3.0b	3195b
Maize after 2 years soybean	9.8a	7ab	2.1c	4082a
Maize after 2 years cowpea	8.6b	16a	2.5b	3776ab
Maize after 2 years groundnut	9.2ab	5b	2.5b	3247ab

*Crop vigor score using a scale of 1–10; where 1 = completely damaged plants and 10 = healthy plants.
**Crop damage severity using a scale of 1–9; where 1 = healthy plants and 9 = completely damaged plants.
[1]Means followed by the same letter(s) are not significantly different at 5% level of probability.

Table 5. Effect of nitrogen rate on *Striga* infestation, crop vigor score, damage severity, and grain yield maize at Samaru, Nigeria, 2001–2003, wet seasons.

	Crop vigor score**		*Striga* count/plot			Crop damage (kg/ha)			Grain yield (kg/ha)		
Nitrogen	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
0	5.3b	2.4d	9.0a	14.0a	1.4ab	4.2a	7.7b	7.5b	72d	669c	121c
40	7.3a	2.8a	11.3a	4.3b	1.5a	4.2a	4.5b	5.8a	684cd	1454bc	592b
80	8.2a	2.8a	2.6a	5.5b	0.8c	1.8a	2.7c	4.6c	931bc	2320ab	949ab
120	8.5a	2.7b	10.3a	4.2b	0.9bc	2.8a	3.2c	3.8c	1624ab	2673a	1183a
160	7.7a	2.6c	10.3a	2.2b	1.3ab	2.2a	2.8c	3.2c	2149a	1480bc	956ab

*Crop vigor score using a scale of 1–10; where 1 = completely damaged plants and 10 = healthy plants.
**Crop damage severity using a scale of 1–9; where 1 = healthy plants and 9 = completely damaged plants.
[1]Means followed by the same letter(s) are not significantly different at 5% level of probability.

Economic analysis

Net benefits

Nearly 90% of farmers attending field days at Samaru in 2003 showed a preference for soybean amongst the legumes in the rotation. In the following year, when only maize was grown, 50% of farmers preferred maize following cowpea and 30% preferred maize following soybean (Fig. 1).

The base case or most likely scenario has been based on the average price for the last 3 years for grain sales, seed, fertilizer, chemical, and labor costs (Table 6). Benefits from the second and third year have not been discounted. Results are summarized in Table 7 and detailed in Figures 2–5.

Striga tolerant maize outperformed the *Striga* susceptible variety over the 2-year period by 41%.

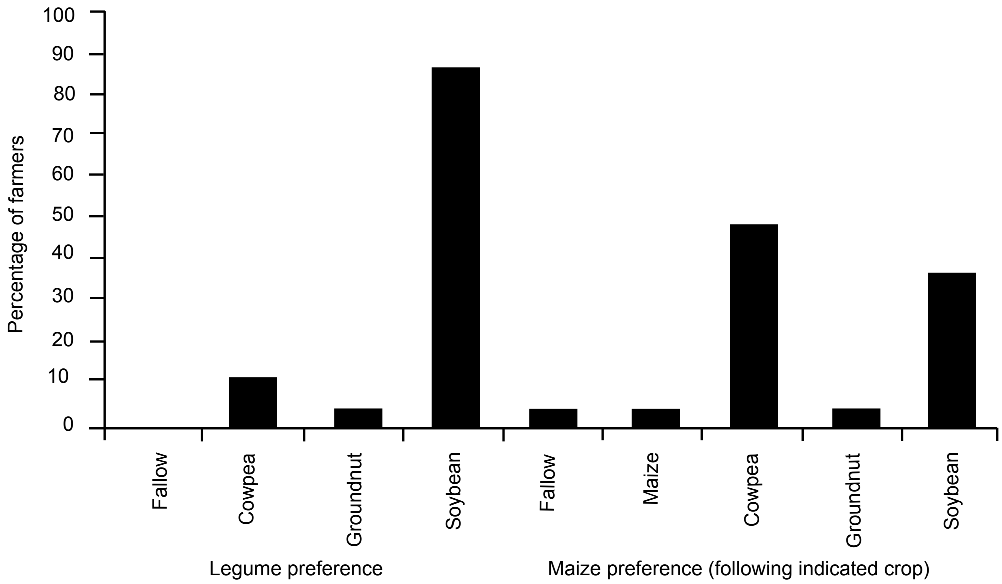

Figure 1. Farmer preference for legumes at field days held at Samaru.

Table 6. Input and output prices (Naira).

		Cost/unit (Naira)			
Item	Unit	2001	2002	2003	3-year average
Grain sale prices					
Maize	kg	27.54	31.16	19.74	26
Cowpea	kg	46.42	43.79	43.72	45
Groundnut	kg	47.52	65.52	70.79	61
Soybean	kg	21.38	26.82	39.93	29
Seed maize	kg	110	110	125	115
Cowpea	kg	120	120	120	120
Groundnut	kg	250	250	200	233
Soybean	kg	100	100	100	100
Fertilizer					
NPK	bag	1550	1900	2700	2050
Urea	bag	1650	2000	2800	2150
SSP	bag	1200	1500	1750	1483
MOP	bag	1200	1500	1750	1483
Chemicals					
Sherpa plus	liter	950	950	1300	1067
Benlate	kg	850	950	1100	967
Glyphosate	liter	1200	1200	1300	1233
Labor					
Wage rate	Day	100	100	120	107

Table 7. Economic assessment (₦/ha).

	Variety		Rotation–2 years					Rotation–3 years					N trials				
	Maize TZB	Maize Acr97	F-M	M-M	C-M	G-M	Sb-M	F-F-M	M-M-M	C-C-M	G-G-M	Sb-Sb-M	0 N	40 N	80 N	120 N	160 N
Benefit	243,059	297,601	90,990	167,692	183,840	197,627	143,452	83,539	221,214	213,731	198.981	205.201	24238	80,924	131,962	162292	142682
Cost	110,412	110,412	36,804	73,608	60,190	64,935	61,273	36,804	110,412	83,575	85,648	78,325	94287	118,388	129,611	140,834	152,057
Net benefit	132,647	187189	54186	94084	123651	132693	82179	46735	110802	130156	113333	126876	–70049	–37464	2351	21458	–9375
Margin over FP	0	54,542	–113,505	0	16,148	29,936	–24,240	–64,067	0	19,354	2,531	16,074	0	32,585	72,400	91,507	60,674
% margin over FP		41	–42		31	41	–13	–58		17	2	15		47	103	131	87
Benefit–cost–ratio	2.2	2.7	2.5	2.3	3.1	3.0	2.3	2.3	2.0	2.6	2.3	2.6	0.3	0.7	1.0	1.2	0.9
Returns to fertilizer	2.0	2.9	2.5	1.3	2.1	2.0	1.3	2.1	1.7	6.4	5.2	5.8	–1.4	–0.8	0.0	0.4	–0.2

F = Fallow, M = maize, C = Cowpea, G = groundnut, Sb = Soybean, FP = Farmer Practice or control, Acr97 = Across 97 TZL Comp. 1-W.

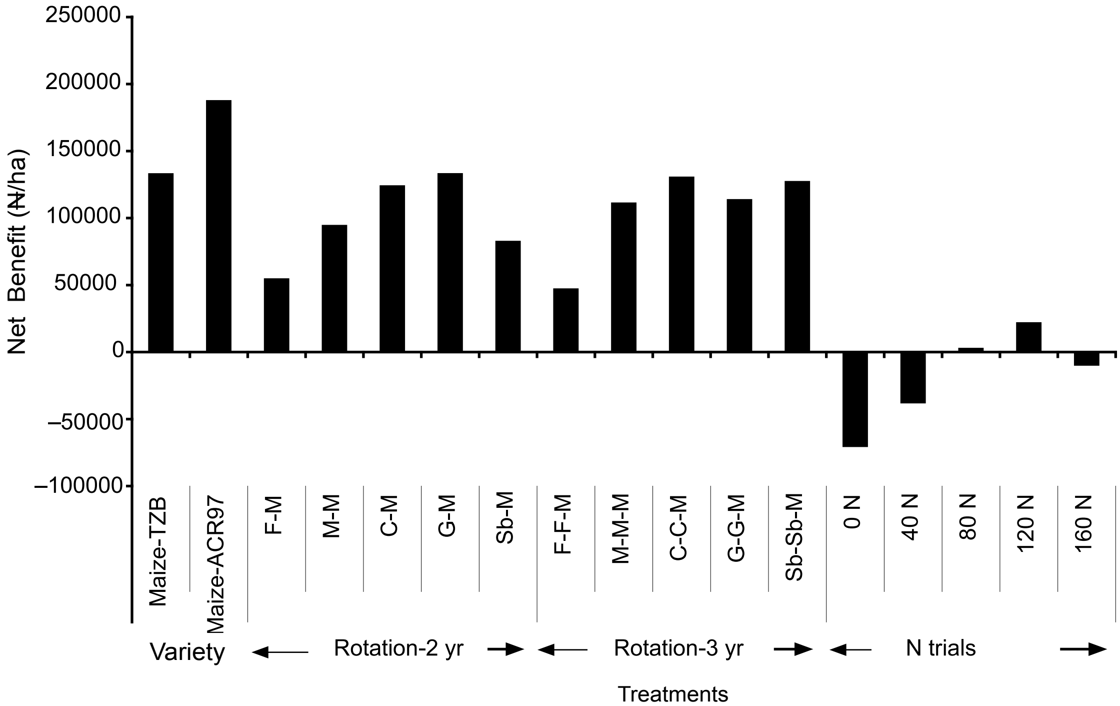

Figure 2. Net Present Benefit of each treatment.

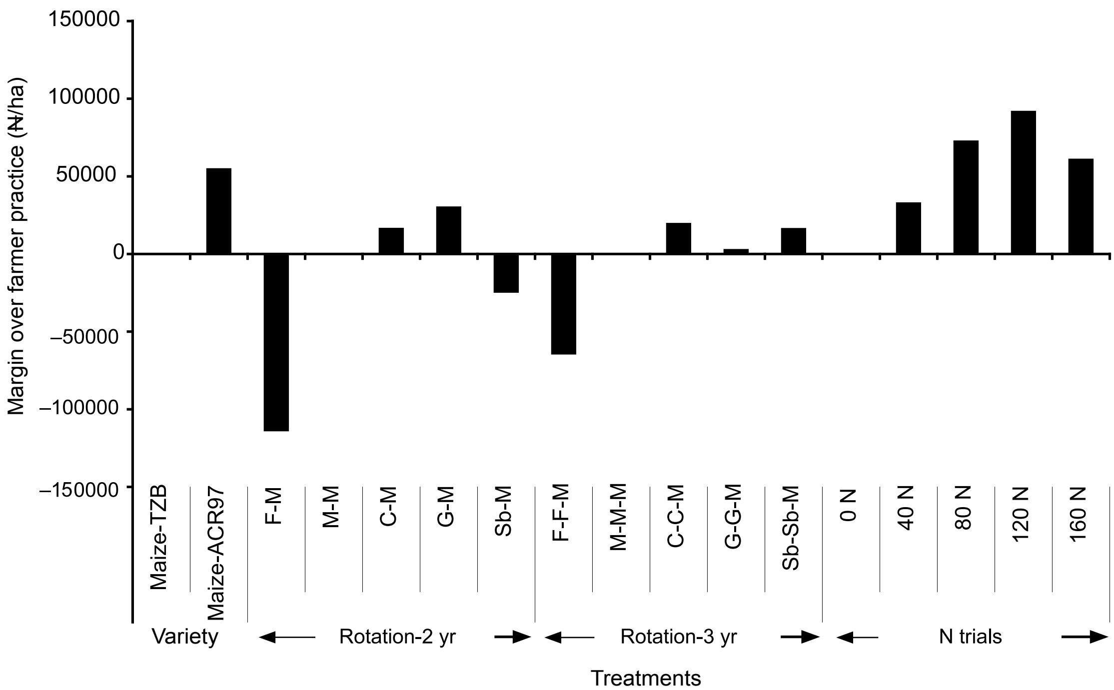

Figure 3. Margin over farmer practice.

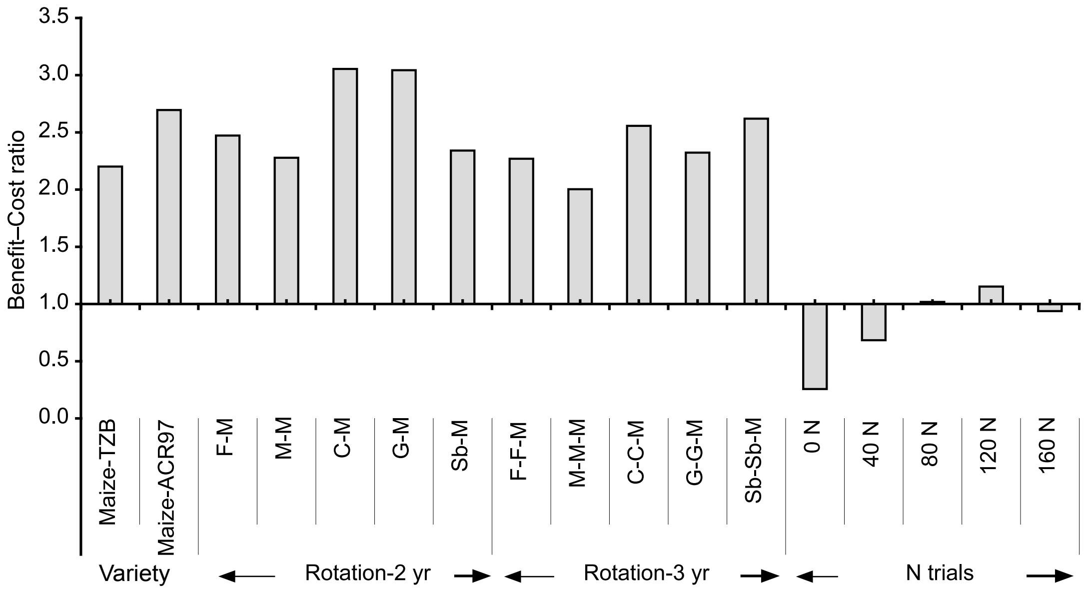

Figure 4. Benefit–cost ratio.

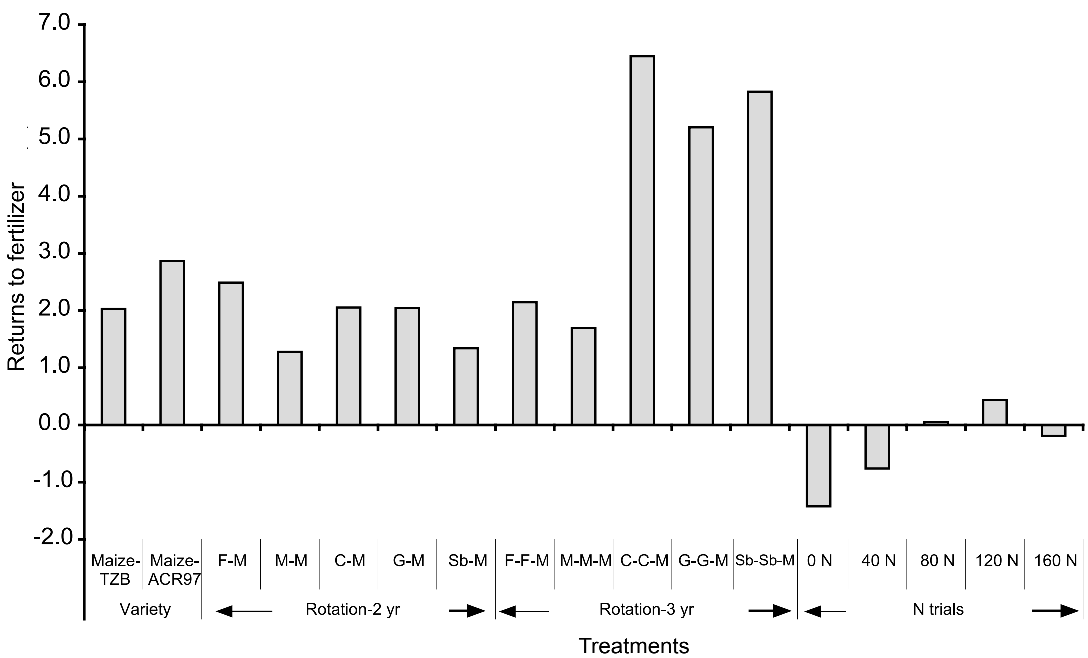

Figure 5. Returns to fertilizer.

In the 2-year rotations, legume trap crops followed by the *Striga* tolerant variety gave greater returns than both fallow–maize and maize–maize rotations, the latter being the control or farmer practice (FP). Highest returns were given by groundnut–maize (41% greater than FP) and cowpea–maize (31% greater) with soybean–maize (13% less) and fallow–maize (42% less) giving lower returns than maize–maize. The lower return from the soybean–maize rotation is attributed to low yields resulting from late planting of the soybean in the first year. Over the 3-year rotation, all the legume–cereal rotations outperformed the continuous maize rotation. Higher returns were achieved from the cowpea rotation (17% over maize–maize–maize) and soybean rotation (15%) than from groundnut (2%). However, the relative prices of maize, legumes, and fertilizer are likely to affect these results.

In the N trials, highest returns were given at 120 N application (131% higher than 0 N) but declined at 160 N (87% higher than 0 N); 0 N and 40 N applications actually gave negative returns over the fertilizer that was applied. Benefit–cost ratios mirrored the net benefits, with all treatments (including 80 N and 120 N fertilizer) except 0 N, 40 N, and 160 N fertilizer treatments, showing a ratio above one.

Overall, the greatest returns to expenditure on fertilizer were derived from the 3-year legume–legume–maize rotations, especially cowpea and soybean, with the lowest returns being achieved on the continuous maize rotations, where larger quantities of fertilizer were applied.

Sensitivity analysis

When second and third year benefits were discounted, even at the high rate of 20%, there was no effect on the overall results, although net benefits were clearly lower (Table 8).

However, when/if the maize price increases relative to legume prices, it becomes profitable to grow maize. A 30% increase makes continuous maize more profitable than a legume–maize rotation, although returns to expenditure on fertilizer remain less than on legume–maize rotations. However, if fertilizer were not available or could not be afforded, lower maize yields would make it less profitable than a legume–maize rotation. Increased prices of legume or fertilizer make legume production more attractive and maize production less profitable.

Discussion

Striga had a detrimental effect on the growth, development, and productivity of TZB, the susceptible variety, but infestation did not lower the productivity of Across 97 TZL Comp. 1-W, the resistant variety. Across 97 TZL Comp. 1-W has been previously reported to support fewer *Striga* shoots and suffer less damage than most commercial and farmers' cultivars (Kureh et al. 2003). This is consistent with our finding. This result confirmed earlier reports that improved open-pollinated (OP) maize varieties and hybrids are less damaged owing to tolerance to *Striga*. They produced higher grain yields than the susceptible cultivar and/or farmers' local maize varieties (Kim 1994; Berner et al. 1996; Kim et al. 1997; Lagoke et al. 1999). The performance of the OP maize variety is a highly encouraging development in the effort to explore host plant resistance

Table 8. Net benefit and sensitivity analysis for 2-year and 3-year rotations (₦/ha).

Scenario	Rotation–2 years					Rotation–3 years				
	F–M	M–M	C–M	G–M	Sb–M	F–F–M	M–M–M	C–C–M	G-G-M	Sb-Sb-M
Base case	54,186	94,084	123,651	132693	82,179	46,735	110802	130,156	113333	126876
High maize (+30%)	81,091	143,607	157,450	164,359	115,304	71,404	175,989	159,383	138622	158503
Low maize (–30%)	27,281	44,561	89,851	101,027	49,053	22,065	45,614	100,929	88044	95249
High legume (+30%)	54,186	94,084	143,941	159,004	91,256	46,735	110,802	163,317	145508	155536
Low legume (–30%)	54,186	94,084	103,360	106,382	73,101	46,735	110,802	96,995	81158	98216
High fertilizer (+30%)	47,654	81,019	116,006	125,048	74,534	40,202	91,204	118,324	103726	117269
Low fertilizer (–30%)	60,719	107,149	131,296	140,338	89,824	53,267	130,399	141,989	122941	136484
Maize +30%, legume –30%, Fertilizer–30%	87,624	156,672	144,805	145,694	113,871	77,936	195,587	138,054	116055	139451
Maize –30%, Legume +30%, Fertilizer+30%	20,749	31,496	102,496	119,692	50,486	15,533	26,017	122,258	110611	114302

F = Fallow, M = maize, C = Cowpea, G = Groundnut, Sb = Soybean.

or tolerance as a component for *Striga* integrated pest management. Farmers are more likely to be able to adopt and manage the OP varieties in the *Striga* control packages (Kim et al. 1997). Farmers can produce their seeds for use in subsequent years (Kim 1994; Berner et al. 1996; Kim et al. 1997). In the rotation trial, adequate fertilizer was applied to the varieties. The performance of the resistant variety is, therefore, a product of the agronomic potential, tolerance to *Striga,* and the environment (Ejeta and Butler 1993). Parker and Riches (1993) suggested three ways by which crop cultivars resist *Striga* attack: mechanical barrier by the host root cells that prevent the haustoria from attaching, anti-haustoria initiation factors, and low stimulant production. The mechanism of resistance of Across 97 TZL Comp. 1-W is not documented but may be through the low production of germination stimulant since fewer *Striga* plants were recorded.

Several studies have shown a significant reduction in *Striga* attack by adopting cropping systems that include rotation (Carsky et al. 1994; Schulz et al. 2003). Rotations with legume trap crops reduce *Striga* infestation through depletion of the seed population in the soil and through improvements in the soil nitrogen status (Kim et al. 1997). There were no significant differences in *Striga* emergence and maize grain yield among the legume trap crops in the rotation systems, suggesting that the varieties of legume crops used were efficient in reducing *Striga* parasitism on the maize crop. Thus, these legume varieties could be recommended to farmers for rotation with maize. Several authors have reported that a more effective reduction in yield and *Striga* infestation can be achieved through the application of adequate fertilizer on *Striga* resistant varieties (Mumera and Below 1993; Kim et al. 1997). Improved growth and vigor due to N fertilizer may help the maize crop to overcome *Striga* attacks.

Economic analysis has shown that the use of *Striga* tolerant maize and legume trap crops grown in rotation with maize can provide better returns than continuous maize. However, if maize prices increase relative to legumes and fertilizer prices decrease, continuous maize can become more profitable. Affordability and availability of fertilizer, especially for poorer households, remain key problems. Decreases in maize price relative to that of legumes, and increases in fertilizer price are likely to encourage legume production and could benefit poorer households in improving nutrition and reducing the need for fertilizer.

Conclusions

The trials confirmed the use of resistance as an important component of the integrated *Striga* management strategy. It also demonstrated that adequate application of N, especially urea, at the rate of 120 kg N/ha is effective in reducing *Striga* damage and increasing maize yield. Similarly, the potential of the use of appropriate soybean, groundnut, and cowpea cultivars to reduce *Striga* parasitism in subsequent maize was demonstrated.

A long-term solution of the *Striga* problem on maize would be the use of tolerant and resistant varieties combined with improved crop management practices such as legume–cereal rotation and the adequate application of N and manure. This integrated approach could be applicable to other host crops, such as sorghum, millet, and rice.

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Assessing the impact of a participatory approach for integrated *Striga* control: an *ex-ante* impact assessment and some policy implications

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Summary

This project demonstrated that agricultural development can be achieved through a process in which farmers find solutions to their problems through modifying their own farming systems to take advantage of opportunities offered by new technologies. This has been done through a process of farmer testing and modification of researcher-developed technologies. Extension agents acted as facilitators, encouraging farmers to experiment with the new technology and adapt it to their own cultural, social, economic, and agroecological conditions using a participatory research and extension approach. Research has been continued into the development phase, linking stakeholders and providing a climate for joint learning and development, the lessons of which can continue to be used well into the future. The challenge is for policymakers to create an environment for this to occur, in particular to institutionalize the use of participatory research and extension methods, promoting community production in conjunction with private seed companies, ensuring that market prices for legumes are maintained at attractive levels through household training in legume processing and preparation, and creating an environment for the establishment of processors who can contract with farmers for commercial legume production.

Introduction

Agricultural development is rarely a linear development process of researcher technology development, which is passed to extension agents (EAs), who subsequently pass it to farmers. It is a complex process, involving many iterations of experimentation, evaluation, and learning (Douthwaite et al. 2003). However, many researchers do see research as a linear process, where technology can be transferred without considering the social and economic conditions of those people for whom the technology is intended. Farmers are regarded as passive recipients of messages from EAs. Alternatively, as in this project, EAs can act as facilitators, encouraging farmers to experiment with a new technology and adapt it to their own cultural, social, economic, and agroecological conditions using a participatory research and extension approach (PREA). By this approach, research continues well into the development phase. This has important considerations for the monitoring, evaluation, and impact assessment of research.

Some key questions need to be addressed:

What do we mean by impact?

Ultimately, this means the achievement of project outputs, purposes, and goals, with households improving their livelihoods and assets through a process of community and household empowerment that leads to increased productive capacity and resiliency through a range of interventions (Fig. 1).

However, in achieving these household and community improvements, there may be an impact on other stakeholders, researchers themselves, EAs, and commercial organizations through their interaction and learning during the project.

In fact, for development to occur there is a need for the interaction of stakeholder networks in a process of communication and negotiation (Gündel et al., 2002). This is an important difference from linear technology transfers, where impact assessment focuses on economic cost–benefit assessment of technology and how many farmers have adopted the technology. This may be relatively straightforward when a new variety is being assessed but more complex when a natural resource management practice is considered. Recent approaches to impact assessment show that linear approaches are over-simplistic and do not take into account the fact that farmers test and modify technologies within their own systems, especially natural resource management practices, and such adaptations are likely to affect adoption rates. At the same time, stakeholders may promote the processes and technologies in other areas. This adds to the complexity and means there are high degrees of nonlinearity. This makes economic impact assessment to link project outputs with goals such as poverty eradication or increased food security virtually impossible (Douthwaite et al. 2003).

For this reason it is sensible that evaluation and impact assessment should be undertaken in two stages. In the first stage, an impact pathway is developed. This is a model of how the project sees itself achieving impact, mapping how project outputs are likely to lead to wider impact. Initially an *ex-ante* assessment of this impact pathway undertaken by project participants is a means of establishing early benefits from the project. A mix of formal and participatory methods including case studies can be used, blending both quantitative and qualitative data. Then at a later stage, independent impact assessors can undertake an *ex-post* impact assessment some years after project completion.

This paper is concerned with an *ex-ante* assessment and the initial policy implications of this.

How can impact be speeded up? How can more people benefit more quickly?

Improving natural resource management (NRM), including weeds, requires that farmers learn about managing their environment. What works in one environment may not work in another similar environment. NRM problems cannot be solved on-station but need to be resolved with farmers in their fields, using their knowledge and experience. In these situations, social and organizational processes become increasingly important. For example, PREA recognizes that the focus should be on developing social and organizational processes to bring about technological change rather than concentrating on technology transfer (Hagmann et al. 1999). PREA involves scaling-up as a 2-way horizontal and vertical process, scaling-out and scaling-up, to bring more benefits to more people more quickly (IIRR 2000) (Fig. 2).

- Scaling-out involves horizontal innovation spread from a trial plot on a farmer's field to the whole field or farm and subsequently to the wider landscape. This encourages spread from farmer-to-farmer and community-to-community and is comparable to an adoption process.
- Scaling-up involves vertical institutional expansion involving community-based organizations, development institutions, the private sector, donors, and policymakers concerned with development.

If technologies and management systems for controlling *Striga* and *Imperata* are to be horizontally scaled-out and vertically scaled-up, mechanisms need to be built in from the start of the project.

How can impact be measured?

Most projects use a logical framework matrix showing project goal, purpose, and outputs (Box 1) and their respective indicators as a management monitoring tool. This can be extended, showing more intermediate steps as an impact pathway that can be used to assess how far some of the project outputs and intermediate targets have been achieved (Fig. 3).

The impact pathway shows how we expect output 1 might ultimately lead to other project outputs as well as achieving the project purpose and goal of improved livelihoods of people in Africa who are affected by *Striga*. Output 1 is a product of the following.

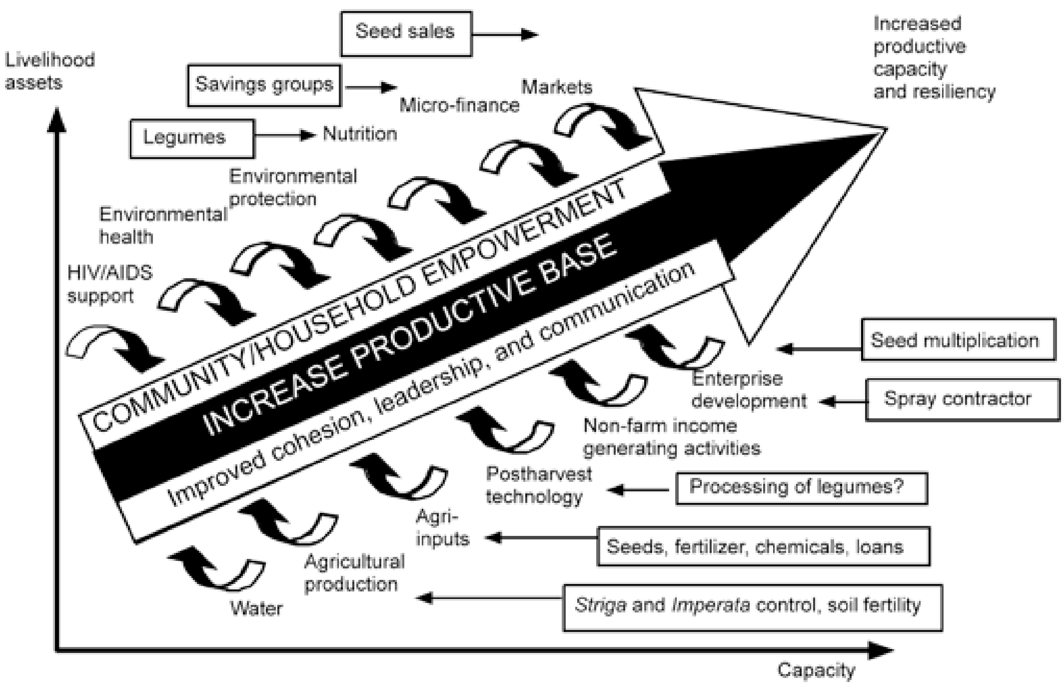

Figure 1. Improving livelihoods at a household and community level.

1. "Mother trials" at the Ahmadu Bello University, and before that, breeding trials at Ibadan. The key technologies that researchers and extension agents brought to farmers for *Striga* control were:
   - Leguminous trap crops (soybean, groundnut, and cowpea).
   - A *Striga* tolerant maize variety.
   - Growing a legume trap crop in rotation with the *Striga* tolerant maize variety.
   - To be fully effective the leguminous trap crop needs to be planted closer than farmers usually plant their legumes and should be used in a crop rotation with the *Striga* tolerant maize. At the same time, seed cleaning to remove *Striga* seed, hand-roguing or weeding of the plants before they set seed, and improving soil fertility through the use of manures and inorganic fertilizers are all needed.
2. A 4-stage PREA (Ellis-Jones et al. 2005) culminating in lead and secondary farmers implementing, monitoring, and evaluating their own trials on behalf of community-based organizations ("daughter" trials). This has resulted in many modifications and innovations, leading to increased farmer knowledge, improved ability of community-based organizations to resolve their own problems, as well as changes in farmers' attitudes and perceptions.

This in turn leads to the achievement of output 2 (diffusion and dissemination of improved weed management options) through a process of scaling-out and adoption by other farmers in the same and neighboring communities through a process of farmer-to-farmer extension. There are likely to be many iterations of farmer experimentation ("granddaughter" trials).

At the same time, output 3 (increased capability of stakeholders to facilitate adoption of improved weed management practices) is contributing to vertical scaling-up through the participation of stakeholders in the project. The facilitating and learning process leads to the use of this knowledge in other research and development activities.

The achievement of the project purpose (adopting farmers enjoy higher and more stable incomes as well as greater food security) is a product of the achievement of outputs 1–3 and the intermediate steps. However, to ensure the project goal is achieved requires the creation of an enabling policy environment.

Methodology

To measure impact, participatory and formal approaches were used (Table 1).

Participatory assessments

Participatory discussions were undertaken in March 2004 during workshops convened for this purpose with EAs and researchers. Visits were made to three communities in the *Striga* area and three in the *Imperata* area, and discussions held with the traditional leaders, the community, and representatives of each community group, usually lead and secondary farmers. The three communities in Kaduna State were Abron, Dambo, and Karau-Karau (Emechebe et al. 2004) where initial community workshops had taken place in 2002. Participants identified the

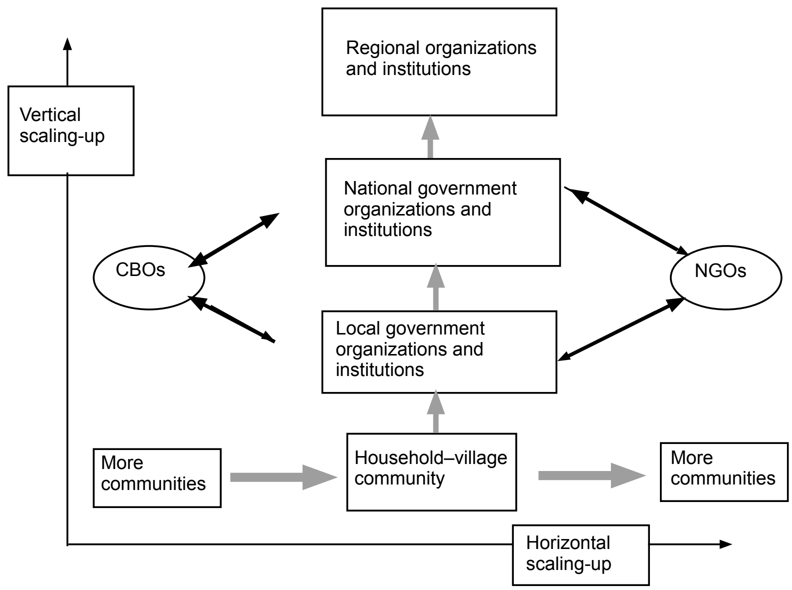

Figure 2. Scaling-up as a vertical and horizontal integration process (IIRR 2000).

Box 1. Project goal, purpose, and outputs

Goal

Improved livelihoods amongst farmers suffering from *Striga and Imperata* in Africa.

Purpose

Adopting farmers enjoy higher and more stable incomes.

Research outputs

1. Identification, evaluation, and development of methods for controlling *Striga* and *Imperata.*
2. Diffusion and dissemination of improved weed management options.
3. Increased capability of NARS/NGOs/CBOs/universities/private sector to facilitate the adoption of improved weed management practices in small-scale, disadvantaged farming communities in the moist savanna zone.

benefits received and problems they had experienced during project implementation and compiled an institutional map identifying contacts between the EAs and farmers in and outside the community. This was later followed by individual discussions with farmers (lead, secondary, and others adopting the technologies) in the same areas in July 2004, using institutional and farm maps to assist the discussion. During these meetings, adaptations to the recommended use of the technologies were also noted.

Formal assessments

Four surveys (one each for researchers and EAs and one each for farmers in the *Striga* and *Imperata* areas) were undertaken by questionnaire, with the EAs being enumerators for farmers during April and May 2004. The responses were analyzed with SNAP.

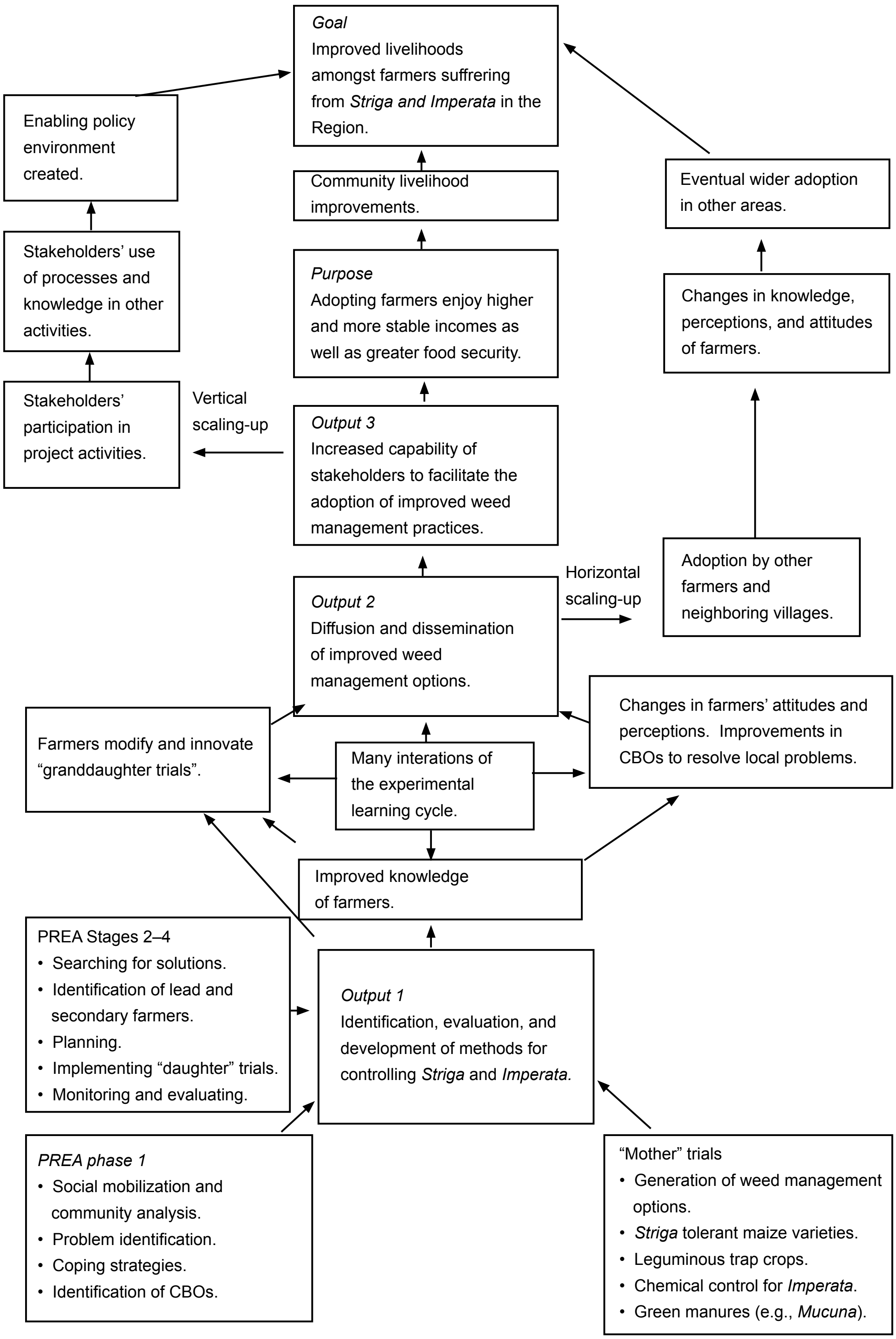

Figure 3. Impact pathway (adapted from Douthwaite et al. (2003).

Table 1. People involved in Project implementation and assessments.

		Assessment	
	Implementation[1]	Participatory	Formal
Researchers (institutions)	20 (4)		21[2]
EAs (institutions)	33 (5)	88[1]	83[2]
Communities/villages	53	3 villages[1]	
Groups and lead farmers	155		264 farmers[1]
Secondary farmers	> 600		
Other adopting farmers	Unknown		

[1]*Striga* area only. [2]*Imperata* and *Striga* areas.

Results

Participatory assessments

These clearly show that many of the PREA activities undertaken during the project have led to changes in farmers' attitudes and perceptions as well as the adoption of technologies and changes in practice. Results from the participatory assessment are summarized in Table 2. Additional benefits and/or problems are shown in Table 3.

Institutional diagrams compiled with groups within the community confirm considerable community involvement within the project, with technology spread from lead to secondary farmers and to others inside and outside the village. Some areas of concern were also highlighted.

In Abron, for example, the EA has worked with six community groups, each of whom had a lead farmer with 2–3 secondary farmers and 2–3 tertiary farmers (Figs 4 and 5). The main EA–group contact was with the lead farmer who gave support to secondary farmers. They in turn have provided support to tertiary farmers. There have also been many contacts where knowledge on *Striga* control has been extended and sales or sometimes gifts/exchanges of seed have taken place. In addition, the EA was using similar approaches in adjoining communities. Discussions with two lead farmers (Boxes 2 and 3) confirm that the technologies are being used elsewhere on their farms and seed is being given or sold to others in the group, in the village, and to adjoining areas, as well as to traders who come to the village.

In Dambo**,** the EA is also working with primarily two groups, an elders' group from the Dambo Development Association (DDA), with lead farmers from different areas in the community, and a youth group, also part of DDA, with two lead farmers as well as others outside the village (Figs 6–7). Within the elders' group, considerable support has been given to the secondary farmers by the EA with farmer-to-farmer extension being limited. However, the DDA was not involved in selecting the farmer for maize seed production. This was a failure in the participatory process with the selected farmer also failing to grow a crop. Within the youth group (67 members) this has been effective with "lead farmers acting as extension officers".

Table 2. Overall project benefits and problems in both *Striga* and *Imperata* areas.

Main benefits	Some problems
Existing farmer groups have been strengthened and are now better organized.	Some people were sceptical in the initial stages, and did not want to participate. They now feel excluded.
New farmer groups have been formed.	Arriving at group decisions can sometimes be difficult.
	Some farmers believed inputs were a gift and not a loan.
Farmers have learned new skills (technical, leadership, and communication).	Sometimes dominators in the groups influenced lead farmer selection.
Farmers feel ownership of the project.	Lead farmers can dominate at group meetings.
	Some secondary farmers do not turn up for training by either the EA or lead farmer.
Loans provided for inputs are being recovered and revolved within farmer groups.	
Communication between EAs and farmers is easier and EAs are often invited to farmers' meetings.	
Interactions between farmers from different communities have improved (especially field days).	
The use of participatory budgeting processes has helped farmers' groups to evaluate production costs and returns.	
Abandoned fields have been reclaimed and increased areas are being cultivated.	

Source: Participatory evaluations, March 2004.

Table 3. Additional benefits, specific to the *Striga* areas.

Main benefits	Some problems
Less *Striga*, increased yields, greater food security and more income.	Difficulties in ridging at close spacing, planting, and fertilizing, with more labor being required.
Knowledge created about *Striga*.	Exclusion of some people at the beginning because of lack of seed.
Individual seed producers within the community have been established.	Sometimes *Striga* was not adequately controlled.
Links have been made with private sector seed companies to support seed producers.	Some farmers have had problems in marketing seed.
Teachers have sometimes been invited to facilitate when EAs are not around.	High cost and poor availability of fertilizer, especially for maize production.
Roadside trials/demonstrations created great interest.	
Improved household welfare has been reported from increased incomes, e.g., purchase of school uniforms and books, improvements to houses, and cash available to buy seed and fertilizer.	

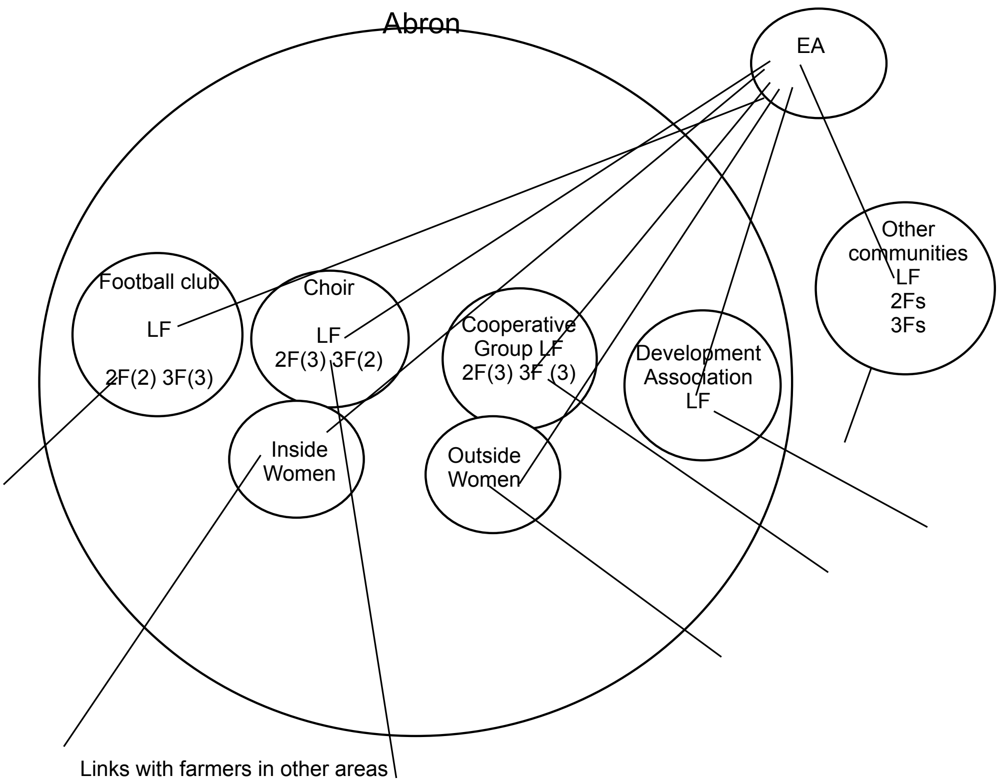

Figure 4. Institutional diagram of Abron community showing EA, group, and farmer linkages.

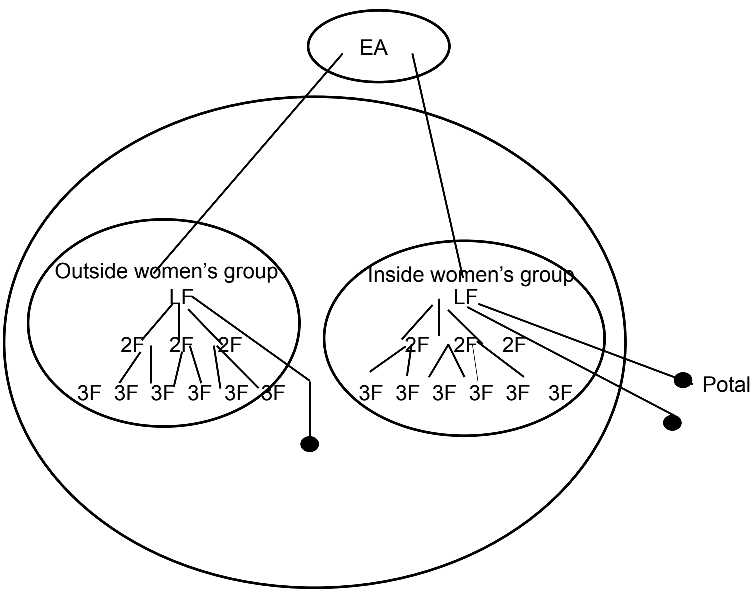

Figure 5. Institutional diagram of Abron community showing EA and women's group linkages.

Box 2: Discussion with Yakubu, a lead farmer from the Cooperative group, Abron

Yakubu has two wives and ten children, all but one at school. He indicated that he had followed a rotation of soybean–maize in 2002 and 2003 and is using both elsewhere on his farm. The soybean is closely planted in the row but the space between the rows is wider than is recommended to make ridging and weeding easier. He has also grown groundnut for seed purposes. This yielded five bags. One was used to repay a loan, one was kept for seed and home consumption, and three bags were sold or given away. He has also kept maize seed for use elsewhere on his farm. Three farmers in the village were given one *mudu* each. He sold 1–2 *mudus* each to four farmers from outside the area. Some was also purchased by a trader coming to the village to be sold as seed. In the group there are three secondary farmers, each with 2–3 tertiary farmers. He is also working directly with two tertiary farmers. He has given soybean seed to a number of other tertiary farmers in the village.

Box 3. Discussion with Asaloe Bitrus, lead farmer from the Women's Fellowship, Abron

Asaloe is married with four young children. She indicated that she had followed a rotation of groundnut–maize in 2002 and 2003, although this was on hired land, which the owner has subsequently reclaimed as the *Striga* has gone. She continues to use the groundnut seed on a small plot, but her husband uses a traditional variety elsewhere on the farm. Ten *mudus* of groundnut were kept for seed and home consumption and 10 *mudus* were sold in Kachia. In the subsequent maize crop, three *mudus* were kept for seed. She is working with three secondary farmers in the group, each of whom is working with two tertiary farmers. There is no other contact outside the village.

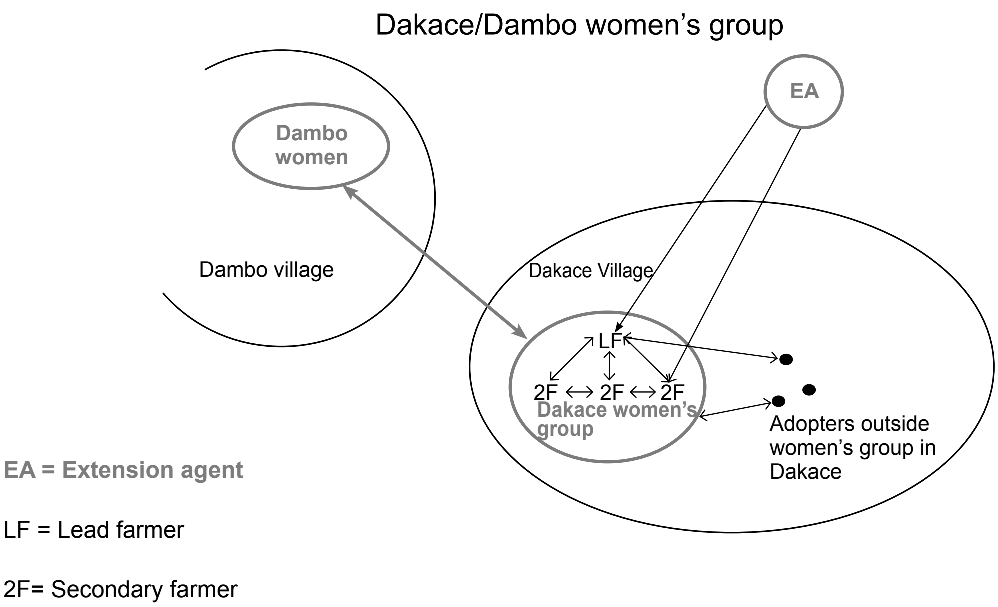

Figure 6. Institutional diagram of Dakace/Dambo women's group.

Box 4. Discussion with Aliyu Turaki, lead farmer, and two secondary farmers in Dambo

Aliyu is a counsellor to the Chief. He has two wives, and 12 grown-up children. Five married sons with their own families, including 15 grandchildren, live in the household. Three of the sons are secondary farmers with their own farms provided by Aliyu. He had opted to grow soybean–maize (TZL) in rotation on the trial plots in 2002 and 2003 and is now using the soybean seed elsewhere on his farm. He is pleased with the reduction in *Striga* and yields achieved. He kept some TZL maize seed from his 2003 trial plot, but was relying on another farmer growing seed in Dambo during 2003. This crop failed because of heavy rains. As a result, there is no TZL maize in Dambo. He gave soybean seed to four secondary farmers including his three sons and has also sold 1–2 *tiya* of seed to 15 farmers in Dambo and 15 other farmers outside Dambo. He is presently growing soybean at the recommended row width but at a much wider spacing within the row to save on seed. He has no TZL maize. He uses a hybrid maize purchased 4 years ago and controls *Striga* by applying urea at *Striga* emergence and by hand-roguing.

Two of the sons have adjoining farms, some 5 ha in extent, about 5 km away. This includes 1 ha of soybean, 1 ha of maize (not TZL, due to nonavailability) as well as 1 ha each of rice, sorghum, and groundnut. The soybean was widely spaced as cowpea was to be relay cropped. Weeds were a major problem throughout the farm. Main problems were stated to be a lack of money to buy fertilizer and hire labor for weeding.

The youth group appeared to have been proactive and innovative, assisting in loan recoveries and critical of failures. For example, they were concerned that they had not been involved in the selection of seed growers and were critical of the subsequent failure of seed producers. There has been an active women's group supported by a female EA. This consists of women farmers from both Dambo and an adjoining village, Dakace. The whole group has been active in growing a soybean–maize trial with seed now being provided by the husband of one in the group. Problems of lack of seed are reflected in discussions with an elder lead farmer and two secondary farmers (Box 4).

In the Karau-Karau area, the EA had worked in five widely dispersed villages with lead and secondary farmers in each (Figs 7–9). Sometimes his main contact was the lead farmer but often he was also in contact with secondary farmers and others outside the village areas. Although commendable in terms of coverage, there is the danger of overreliance on the EA and lack of farmer-to-farmer extension. This seems to happen in many areas among groups comprised of elders and traditional leaders who "expect service" from the EA, to the detriment of other lead farmers. In Karau-Karau, this is further hampered by the traditional lack of contact between men and women. The Nasara women's group was not receiving adequate support until Women Farmers in Agricultural Development (WIFAD) were able to play a facilitating role.

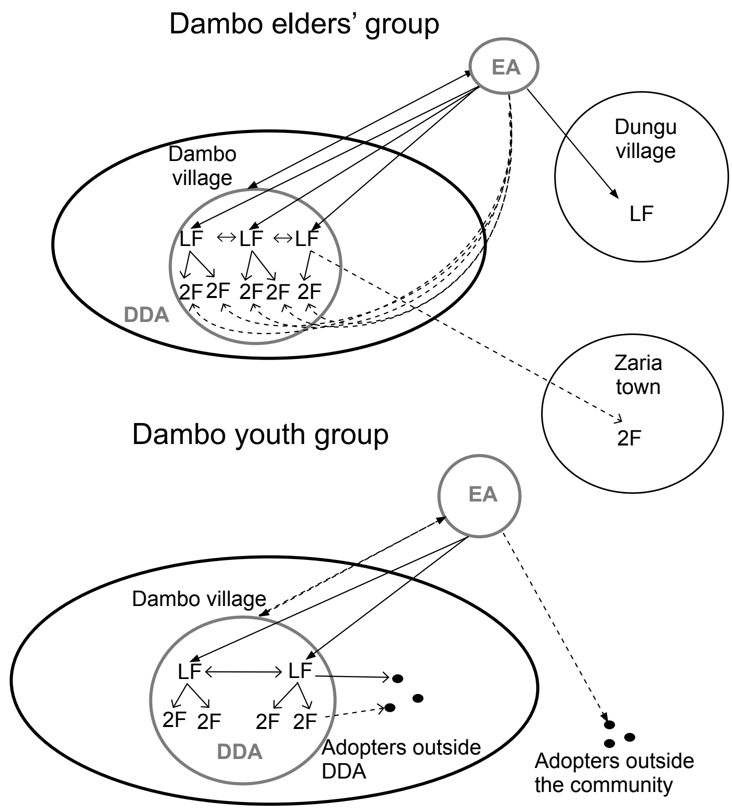

Figure 7. Institutional diagrams of Dambo Development Association, elders' and youth groups.

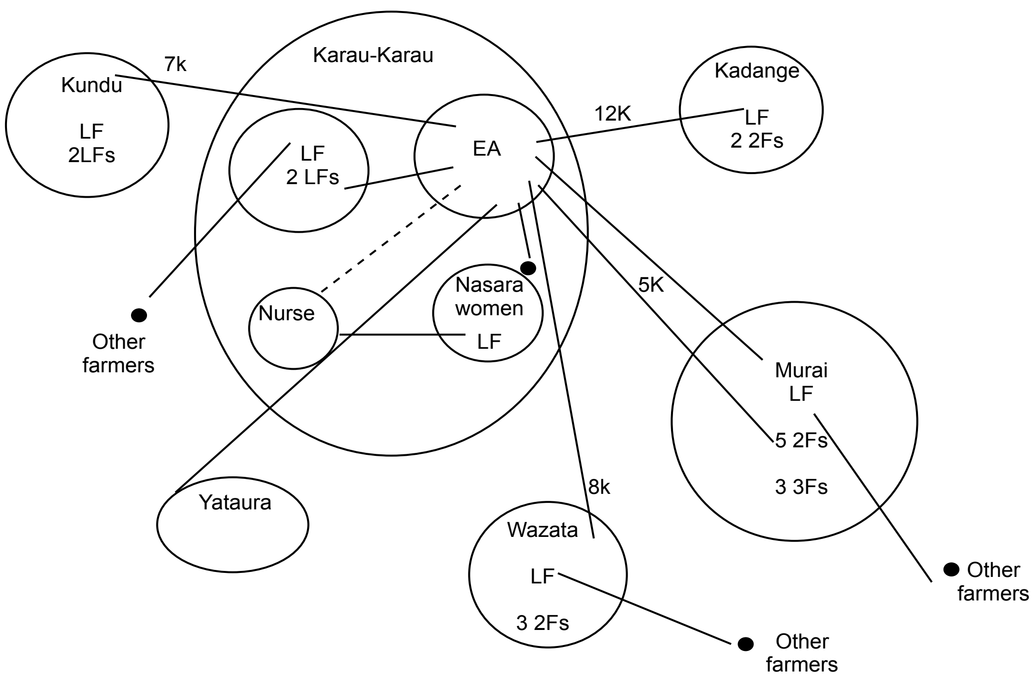

Figure 8. Institutional diagram of Karau-Karau, showing EA, group, and farmer linkages.

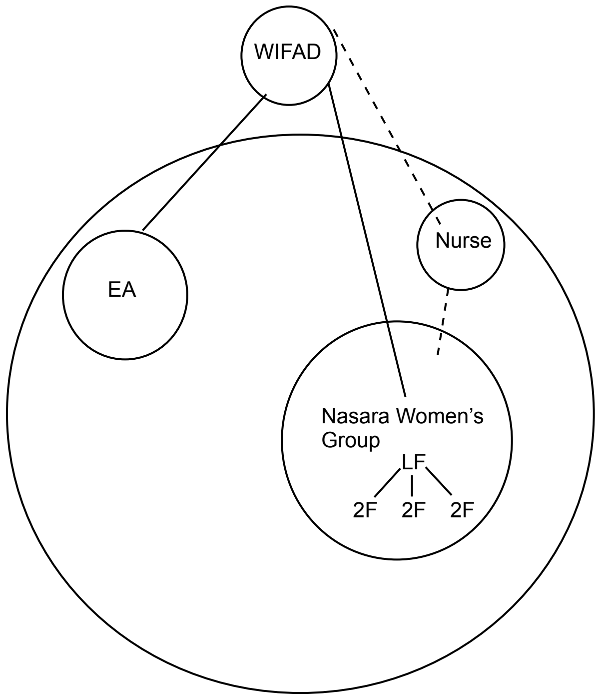

Figure 9. Institutional diagram of Karau-Karau, showing Nasara women's group and linkages.

Discussions with lead farmers from the different villages indicated that although some people had followed a soybean–maize rotation, many had opted to grow only maize. They indicated that lead farmers were originally mocked by others who indicated that the plots were too small, narrow spacing and digging in of fertilizer was too labor intensive, and no yields would be obtained. However, they also indicated that these views are now changing as yield increases are being experienced. They considered "learning by doing" very important. The strength of the groups is generally improving with some lead farmers having as many as six secondary farmers, while others complain that some secondary farmers do not attend meetings or training or have become inactive. Lack of maize seed (Across 97 TZL Comp. 1-W) and fertilizer has contributed to this (Box 5).

Adaptations to technologies

Many farmers have taken the knowledge gained on the trial plots to other fields and sometimes to their whole farm. At the same time, farmers have been seen to be undertaking modifications that more closely fit with the farming systems. These include the following.

- Growing TZL maize alone without including a legume trap crop in the rotation.
  In this case, farmers may be able to afford fertilizer and see greater benefits from growing maize rather than a legume.

Box 5. Discussion with Idi Audu, lead farmer in Kunde village, Karau-Karau

Idi has two wives and 15 children including three married sons with their own families living in the same household. The three sons work under Idi, learning from him under the *Gundu* system. Idi indicated that he had opted to grow TZL maize on trial plots in both 2002 and 2003 and was now using only seed from the trial plots elsewhere on his farm. He now appreciated the need for soybean and had planted the crop with seed purchased at the market. IITA staff indicated that this was the *Striga* trap variety. Two secondary farmers to whom he gave TZL maize seed had very low yields, as they did not apply fertilizer and no longer have access to seed.

- Using the traditional *Gichi* intercropping system of maize, sometimes TZL, sometimes a local cereal (maize, sorghum, or millet) intercropped with a legume trap crop of soybean, groundnut, or cowpea. This has been developed as a risk management strategy and farmers continue to see benefit in this.
- Strip-cropping of either maize and sorghum, or millet, or a legume.
- Relay cropping (maize followed by a legume especially cowpea and soybean, followed by cowpea).

Sometimes component parts of the technology have not been adopted for sound reasons. Management practices, especially narrow spacing in legume trap crops, have not always been adopted for the following reasons.

- An increase in labor is required, especially where land preparation and ridging are undertaken by hand.
- Difficulties in constructing ridges and weeding with local implements, especially in areas where hand tillage predominates.
- Inadequate supplies of soybean seed and the hope that, as the crop grows, it will compensate.
- Large areas and insufficient seed.
- Damage by crickets or other pests.
- Plans to relay cowpea into soybean.

Inorganic fertilizer has generally not been applied in the quantities recommended since fertilizer was not available or not affordable. Often it is applied at weeding and covered during the weeding process.

Formal surveys

The EAs interviewed 264 farmers. Of those interviewed, 38% were lead farmers, 39% secondary farmers, and 22% were other adopters; 220 (85%) were men with most (46%) being 36–50 years old. Responses to questions regarding type of house, number of fields farmed, animals owned and ownership of vehicles, equipment, etc., determined that 2% were well-resourced, 51% had average resources, and 16% were poorly resourced. Questions on education established that 51% had had a Koranic education, and 28% primary schooling. Most households were

Table 4. Main benefits of *Striga* control.

Benefit	Farmers indicating benefit (%)
Increased yield.	84
Less *Striga*.	78
New varieties of existing crops available.	47
Increased sales.	44
Improved diet.	44
New crops grown.	35
Less labor used.	34
More time available.	18

male-headed with a single wife, although 51% had two or more wives. Most of those interviewed belonged to an existing group, 62% to a men's group, 16% to a women's group, 9% to a mixed sex group, and 8% to a youth group. Successful results from the *Striga* control methods they had used were reported by 95% of farmers. Methods used in the first year consisted of soybean (66%), groundnut (14%), cowpea (6%), TZL maize (34%) as sole crops and various forms of intercropping or relay-cropping (5%), with some farmers trying more than one method. In the second year, TZL maize was grown.

The main benefits (Table 4) of *Striga* control were seen to be as follows:

Where an increased yield was obtained, 87% indicated that this was from the same area as previously cropped, although 13% said that the cropped area had been expanded. Respondents stated that part of the increased yields had been sold and part retained for home consumption. Income from increased sales had been used for many purposes, including paying school fees, buying clothing, doing house repairs, paying labor, buying agricultural inputs, and taking care of the family.

Where time was saved, this was mostly used in work elsewhere on the farm. Where an improved diet resulted, most respondents (over 80%) indicated that this benefited the entire household; 11% said young children derived most benefit. The main problem (Table 5) was an increase in labor requirements for planting, weeding, and applying fertilizer.

Most farmers (65%) indicated that they had used the knowledge gained on the trials elsewhere on their farms, with soybean and TZL maize being the most popular crops (Table 6).

Approximately 35% of the farmers had made modifications to the recommended ways of *Striga* control, as follows.

- Soybean intercropped with cereals (28%).
- Groundnut intercropped with cereals (8%).
- Cowpea intercropped with cereals (8%).
- Legumes intercropped with other legumes (2%).

Table 5. Main problems experienced in the trials.

Problems	Soybean	Groundnut	Cowpea	Maize
	Respondents (%)			
Increased labor for planting.	70	8	7	35
Increased labor for weeding.	57	27	9	41
Increased labor for applying fertilizer.	48	7	8	52

Table 6. Use of knowledge elsewhere on the farm.

Knowledge area	Respondents using knowledge (%)
Soybean–maize rotation.	40
Soybean.	37
Striga resistant maize.	29
Groundnut.	9
Inter-, relay-, and strip-cropping	4
Cowpea	2

- Others (2%), that included intercropping with vegetables.

Other methods of controlling *Striga* were reported by 32% including early planting, the use of manure, potash, ash, and urea, hand-roguing or pulling, then burying, regular weeding, and remolding the ridges.

Seed production

Just over half (51%) of the farmers indicated that they knew someone in their community who was producing seed from the new varieties. These were *Striga* tolerant maize (71%), soybean (63%), cowpea (14%), and groundnut (10%). Most respondents recognized that the original seed came from either IITA or IAR as a loan and that the loan needed to be repaid. Generally, the remaining seed was recognized as belonging either to the community (54%) or to the individual producer (46%). When the producer provided other farmers with seed, it might be given as a loan (36%), exchanged for other seed or labor (32%), sold for cash (22%), or sometimes given for nothing (5%). One or all of these methods may apply to benefiting farmers and go to people in and outside the community. Some indication of seed given or sold in 2004 is shown in Table 7.

Most farmers (61%) did not indicate any problem with seed production; 39% indicated that there had been some problems, 16% in production, 11% in storage, and 18% in marketing.

Improving community and group cohesion and relationships with stakeholders

- Relationships in the community had improved (99% of respondents).
- Relationships with the EA had improved (99% of respondents).

Table 7. Seed given or sold.

Seed	Respondents giving seed		Mean (*tiya*)
	Number	Percentage	
Maize.	49	18	43
Soybean.	68	26	28
Cowpea.	12	5	16
Groundnut.	7	3	12

1 *tiya* = 2.6 kg of maize, soybean, and cowpea; 1 kg of unshelled groundnut.

Table 8. Farmers' views on key events.

	Regarded as	
	Good (%)	Bad (%)
Selection of farmers.	100	0
Identification of research problems.	100	0
Identification of problems to be tested.	99	1
Implementation of trials.	100	0
Data collection and analysis.	98	2
Sharing of results amongst farmers.	94	6

- Research activities had left farmers in a better position (96% of respondents).

Most farmers were satisfied with the process used in the trials (Table 8). The organizations working with the project were ranked as being of great or some benefit as follows (%).

- Farmer group. 80
- Lead farmer. 92
- IITA/IAR. 92
- EA. 94
- Seed company. 35

Farmers ranked their best methods of learning as follows (%).

- Trials such as these. 74
- Field days in the community. 66
- Discussions with other farmers. 49
- Visits to research trials such as IAR or ADP. 47
- Visits to other farms. 35
- Books/leaflets. 34
- Radio. 32
- Training at a venue away from home. 26
- TV. 6
- Other. 1

When asked, "How many farmers do you know who are using the *Striga* control technologies being tested?", most respondents knew others, either in the group or inside/outside the village, who were using the technologies (Table 9).

Table 9. Farmers known to be using technologies.

	No. of farmers known	Respondents (%)	Mean number known
In your group.	179	68	10
In your village.	190	72	15
Outside your village.	134	51	10

Table 10. Level of satisfaction with key project events.

Project activity	EAs (%)	Researchers (%)
Training in PREA.	81	95
Training in weed biology and control.	87	–
Community meetings.	81	100
Lead farmer training.	83	86
Technical training for EAs.	87	88
Implementation of trials.	87	78
Midseason evaluations.	88	75
End of season evaluations.	89	84
Seed production.	78	–
Planning workshops.	–	83

The future

Most (93%) of the respondents indicated that they were interested in carrying out other trials on their own.

Researchers and extension agents

More than 80% of respondents ranked as good or excellent the overall satisfaction with key events in the project involving both the process and technical input (Tables 10–12). They appreciated the following.

- The benefits they had received from technical training and the use of PREA.
- Extension material developed and used by the project.
- Technical knowledge gained during the project.

In addition, the assessment shows that EAs believe that farmers/groups and communities have played the greatest role in problem identification and a significant role in resolving these problems through technology selection, design, implementation, management, and evaluation. Where loans were provided for input provision, farmers have been appreciative and loan repayments have largely been completed and are now being used in a revolving credit scheme. Farmers/groups and communities are also seen as the main beneficiaries of the knowledge gained from the trials. EAs have been positive in their comments about the use of PREA, with most indicating that it is a cost-effective means of extension. They intend either to use it in the future or to recommend the use of PREA to their organizations.

Table 11. Benefit from technical knowledge gained about *Striga*.

Knowledge area	EAs (%)
Biology of *Striga*.	80
How *Striga* causes crop damage.	83
The importance of crop rotations.	88
Use of *Striga* resistant maize.	86
Use of soybean.	94
Use of groundnut.	78
Use of cowpea.	76
The need for maintaining soil fertility.	84
Seed production.	83

Table 12. Benefit from knowledge gained through PREA during the project.

Training received	EAs (%)	Researchers (%)
Identifying farmers problems.	95	100
Identifying priority crops.	93	95
Learning from farmers.	80	89
Identifying groups in the village with which to work.	91	83
Seeking solutions with farmers.	91	100
Evaluating results with farmers.	90	95
Participatory budgeting with farmers.	89	72
Reviewing the season's activities.	87	100

Most researchers have already used elsewhere the knowledge they have gained on this project. Thirty examples were given.

Policy issues

The key question that needs to be addressed is what policymakers (including decision makers at Local, State, and Federal Government levels) can do to speed the process of scaling-up and to ensure the benefits can be maintained or increased as scaling-up occurs.

Speeding the process of scaling-up

The PREA used in this project has had positive results and needs to be considered for wider application. This requires institutionalization within Local, State, and Federal Government as well as NGO extension services. Private sector companies would also benefit from using PREA. This requires both theoretical and practical training that will reinforce the change from traditional top-down methods to a participatory approach. This requires a strategy that encourages community participation, local leadership initiative, and the development of human capital while avoiding paternalism and nepotism within a multi-institutional environment.

Ensuring the benefits can be maintained or increased

Conclusions from the "mother" trials (Kureh et al. 2004) as well as the "daughter" and "granddaughter" trials (Schulz et al. 2003; Franke et al. 2004; Ellis-Jones et al. 2004) have shown that the weed control options are technically and economically viable. The highest returns are achieved by growing legume–maize rotations. However, this depends on three key conditions, (1) availability of seed (TZL maize, soybean, groundnut, and cowpea), (2) a reliable market for both seed producers and seed purchasers, also for the sale of grain products, (3) the prices of legumes relative to maize being attractive to producers, and (4) the price of fertilizer not dropping too low.

Benefits of increased legume production are an improved diet, opportunities for adding value through both on-farm and off-farm processing. Production costs are reduced through the use of less fertilizer. This is often subject to regular shortages and price manipulation, and is unaffordable by poorer households. Policy needs, therefore, to look at strategies that encourage legume production by ensuring a ready market and a fair price. These will include the following.

- Providing training for on-farm processing and use of legumes, particularly soybean for household use and sale.
- Supporting the establishment of processing facilities for legumes (especially soybean) that can contract with farmers for purchase.

At the same time, demand for fertilizer is highest for maize with many farmers indicating that they would produce maize only if they could buy fertilizer. Low fertilizer prices will encourage maize production, especially when the maize price is high relative to the price of legumes (Kureh et al. 2004). Similarly high fertilizer prices when maize prices are low will encourage legume production.

In conclusion

This project has demonstrated that agricultural development can be achieved through a process in which farmers find solutions to their problems by modifying their own farming systems to take advantage of opportunities offered by new technologies. This has been done through a process of farmer testing and modification of researcher-developed technologies. EAs have acted as facilitators, encouraging farmers to experiment with the new technology and adapting it to their own cultural, social, economic, and agroecological conditions using a PREA. Research has been continued into the development phase, linking stakeholders and providing a climate for joint learning and development. The lessons can continue to be used well into the future. The challenge is for policymakers to create an environment for this to occur.

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Seed multiplication and revolving loan scheme

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Introduction

Striga hermonthica is a major constraint to agricultural development in the savanna region of Nigeria. As a result, IITA and its partners, IAR, Ahmadu Bello University, Zaria, Kaduna Agricultural Development Program, Sasakawa Global 2000, and Silsoe Research Institute initiated participatory strategies to reduce the problem of this parasitic weed with funds from the Department for International Development (DFID), UK.

A key component in the integrated *Striga* control technology is the use of improved varieties, S*triga* tolerant maize in rotation with legume trap crops (soybean, cowpea, and groundnut).

However, the Project identified the availability and quality of improved seeds as a major constraint to the wide-scale adoption of *Striga* control technologies. A course was, therefore, designed to train extension supervisors (ESs) and extension agents (EAs) on seed production techniques so that they would in turn be able to train farmers. As part of the package, inputs (seed and fertilizer) were given on loan to representative farmers and remained within the community as a revolving loan.

Course description

Extension workers were trained to acquire the skills of community seed production. They learned how to enable farmers to produce high quality seeds for planting and for sale.

Specific objectives

The EAs were trained on the agronomic practices of maize, cowpea, groundnut, and soybean seed production and how to assist farmers to acquire the skills of seed production.

Field operations

- In the 2003 planting season each EA supervised the production of 0.5 ha of *Striga* tolerant maize (Across 97 TZL Comp. 1-W) and 0.2 ha of the legumes introduced to their communities (soybean TGX1448-2E, groundnut RMP 12, and cowpea IT93K452-1).
- Representative farmers with accessible, fertile, and well-drained fields were identified in each community.
- The principle of isolation/escape in time or space was explained to the EAs. To avoid contamination of maize seed, they planted plots at least 200–500 m away from any other maize field (isolation in space), or they planted earlier or later than other farmers surrounding the maize fields to ensure that flowering did not occur at the same time (isolation in time).

- Roguing of off-types was done at all stages from seedling emergence to harvest (i.e., after emergence, at first and second weeding, at tasseling, at silking, before and after harvest) to ensure genetic purity.

Farmers were advised that harvesting at maturity should be timely, and seeds should be dried and stored in well-ventilated conditions. Farmers were also trained to use the triple bagging technique to guard against storage pests. Regular monitoring of well-ventilated rooms for seed storage was emphasized.

Inputs supplied and loan recovery

The project decided to donate some money in kind as a revolving loan to the communities for the purchase of inputs, so as to spur on community action. Seeds and fertilizers were given to farmers on loan to be recovered in kind.

Seeds:

— Maize: 12.5 kg.
— Legumes: 10 kg.

Fertilizer:

— Maize (0.5 ha): 4 bags NPK (15-15-15) + 1.25 bags urea.
— Legumes (0.2 ha): 0.5 bag NPK (15-15-15) + 0.5 bag SSP.

These rates were based on recommendations for the region (maize, 120-60-60; legumes-20-40-20, NP_2O_5–K_2O).

Loan recovery

The value of the inputs (seeds and fertilizer) was determined and farmers were to pay back either whole as seed or fertilizer + seed, as given to them. The loan recovery scheme has been successful as indicated below at 2 months after harvest:
Sector I (John Dada/Danbaba, ESs); 68% recovery; maize = 27 bags; soybean = 83 kg; NPK = 10.75 bags; SSP = 4.5 bags.
Sector II (Oguntoyinbo, ES); 74% recovery; maize = 23 bags; soybean = 2 bags + 10 kg; groundnut = 2 bags + 10 kg; NPK = 12 bags; SSP = 4 bags.
Sector III (Zango/Sadeeq, ESs); 86% recovery; maize = 26 bags; soybean = 5 bags; groundnut = 2 bags; fertilizer = 1 bag.
Total recovery: maize = 76 bags; soybean = 8 bags; groundnut = 4 bags; NPK = 24 bags; SSP = 9 bags.

Quantity of seeds available

The following quantity of seed is estimated to be available with the farmers on the assumption that 25 EAs were effectively involved in the project:
Maize: 25 farmers × 0.5 ha @ 1500 kg/ha = 18 750 kg = approximately 188 bags.
Soybean/legumes: 25 farmers × 0.2 ha @ 1000 kg/ha = 5000 kg = approximately 50 bags.

Marketing of seeds

The Project has been in contact with a number of stakeholders to assist the farmers to sell their seeds. The project has also helped to advertise the seeds to various organizations such as Project Coordinating Unit, Abuja, National Special Project on Food Security, Abuja, Premier Seed Company, Zaria, Alheri Seed Company, Zaria, farmers' organizations such as Rigasa Farmers' Cooperative Society, and other individuals.

In May 2004, the Project organized another meeting between the seed farmers and the two seed companies in Zaria. The deliberations were fruitful.

Seed diffusion

The EAs were directed to encourage their farmers to sell the seeds at affordable prices to other farmers for effective *Striga* control. However, for sustainability, other relevant government agencies must be involved to support the farmers and extension workers (inputs to farmers and incentives to extension workers).

Conclusion

The availability of quality seed is an essential part of the integrated control. Otherwise *Striga* will remain with the farmers, resulting in low yields, low income, and the misery of poor livelihood. We therefore have to think collectively of the most effective strategies.
Thank you.

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Adoption of integrated *Striga* management methods: experiences from a seed company

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Introduction

Striga, called *wuta-wuta* in Hausa, has been a limiting factor in agricultural development in northern Nigeria. It has brought poverty, low yields, and hunger to so many homes and communities. The way out of this agricultural disaster was not forthcoming so farmers abandoned their lands due to heavy *Striga* infestation.

The efforts of IITA with its collaborators, IAR, Ahmadu Bello University, Zaria, Kaduna Agricultural Development Project, Sasakawa Global 2000, and Silsoe Research Institute, and the able support of the Department for International Development (DFID) UK, have brought a great improvement in agriculture and the livelihood of many of our farmers.

Project activities

The farmer-managed "daughter" trial demonstrations started in 2002 with 20 m × 20 m plots for the improved varieties and farmers' practice. Because of the performance and benefits of the improved integrated *Striga* control method, farmers have adopted rotation practices on farm sizes of 2–4 ha. There is hardly any farmer now who grows maize on a *Striga*-infested field without planting a legume trap crop to control the weed.

The DFID project came just at the right time. The system of crop rotation introduced by the project is most commendable and the resistant maize variety enhanced the success.

Adoption and benefits

Farmers in the seed industries have since improved on their farming systems. During the first year of the project, the company did not concentrate only on the demonstration plots, but also planted soybean on larger *Striga*-infested fields.

The methods of planting and fertilizer application have also changed. Closer spacing is adopted for soybean. Fertilizer is applied by making a hole and burying it. Farmers have also adopted the use of improved *Striga* tolerant maize varieties and legume trap crops such as soybean cv. TGX 1448, groundnut cv. RMP 12, and cowpea cv. IT93k452-1.

Farmers' yields have improved greatly. Fields that had been producing 1.5 t/ha of seeds before the introduction of the technology now produce about 4 t more. Farmers' income is now improved due to higher yields; family welfare has also improved. More children are now sent to school with better uniforms and looking healthier.

Farmers living in thatched houses can afford to roof their houses with iron sheets. The PREA approach adopted has greatly improved farmer-to-farmer relationship and encouraged technology transfer. Farmers pay visits to exchange ideas and experiences on the projects. It has also strengthened the groups' relationships. The issues of social exclusion existing among farmers have since been put aside because farmers came to realize that they needed to cooperate to be able to control *Striga*.

Visit to researcher-managed "mother" trial

This aspect of the project was very commendable because, previously, many farmers never knew that scientific research work was going on and also how and where it was done. It also made the farmers know that they could take their farm problems directly to IAR for solutions. They came to realize that they could interact with scientists. Most importantly, they saw the real project work in both scientific and local practice and what the results would be after years of evaluation.

Seed multiplication

This aspect of the project has also helped the farmers to know how to produce their community-based seeds. Some of them have started to produce seeds on their own for their communities. They have even become sources of seeds for other farmers in their communities and are being linked up as out-growers for seed companies.

Role of Alheri Seed Company

Alheri Seed has since included all the lead farmers (LFs) in Kurbawa and Gadagau in its seed production work. The company plans to absorb more of the project LFs as out-growers in 2005.

The company has embarked on groundnut seed production this year and will be willing to sell some for next year's activities.

In conclusion, although the project period was short, many benefits have been derived from it. We wish all the collaborating institutes, together with DFID, long life and prosperity.

Thank you.

Adoption of integrated *Striga* management methods in northern Nigeria: experiences from a national NGO

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Introduction

It has been reported that 80% of the Nigerian population is engaged in agriculture. Out of this number, about 90% are engaged in farming using basic tools such as the hoe and cutlass and possess about 2 ha of land (Lagoke et al. 1991). This has resulted in limited crop production. The situation is made even worse by high *Striga* infestation that has spread and virtually colonized such small land holdings, resulting in important socioeconomic consequences. Before the initiative of institutionalized control of this weed, the resource-poor farmers had resigned their fate to the Almighty, hoping to harvest the little that was left over after *Striga* devastation. The resource-poor farmers depended on this little harvest to feed families exceeding ten people for a period of more than 8 months. Traditionally, the parasitic weed is controlled by hand-pulling and weeding.

Striga spp. (witch weed), locally called *wuta-wuta,* is a parasitic weed that attaches itself to the roots of the host plants, mostly cereal crops. This parasitic plant "sucks" nutrients from the host plant and "bleeds" the host to death or, at best, renders it unproductive. Host plants seriously affected are millet, sorghum, maize, rice, sugarcane, and cowpea. Maize is usually the most severely devastated/damaged crop. Losses in cereal crops are in excess of 50% (Emechebe et al. 2004). *Striga* species affect the livelihood of some 300 million people in Africa, with 17 countries being seriously affected and a further 25 experiencing moderate damage (M'Boob 1986).

In the rural communities, farmers sometimes abandon heavily infested fields in search of *Striga*-free land. A *Striga* plant can produce about 50 000 to 60 000 seeds. These seeds are then dispersed via farm implements/tools, hooves of work bulls, wind, rain, and animal faeces. The heavy losses of cereal crops incurred due to this parasitic weed will, if allowed to spread unchecked, result in the resource-poor farmers continuously suffering and wallowing in poverty and hunger. Poverty "pollutes the environment" and creates environmental stress in different ways. Those who are poor and hungry often destroy their immediate environment in efforts to maximally exploit its resources, such as by cutting down trees for firewood in order to survive.

Our experience

Research findings on the management of parasitic weeds indicated that integrated approach seemed to be the best option for the control of this weed. Adoption and transfer of these new technologies/techniques were achieved through training extension agents and equipping them with necessary facilities. The combination of resistant crop varieties and crop rotation practices that involve the use of trap crops yielded more than single methods used independently.

Approach

Participatory community analyses were held in various villages at the onset of the project activities. During the community analyses, knowledge and experiences were shared on *Striga* biology, dispersal, and control methods, and the socioeconomic effects of the weed.

Farmers identified the following as problems associated with farming: the perennial presence of *Striga*, lack of fertilizers, insufficient capital (money) for farming, lack of good quality seeds for planting, and poor storage facilities.

The opinions of the farmers were sought on how to solve the *Striga* problems. The majority of them suggested hand-pulling of the weed as the most valuable approach while others recommended the application of manure/fertilizer to infested farms. Following this dialog, a list of suggested possible control methods was presented and discussed. These were manure/fertilizer application, introduction of *Striga* tolerant/resistant seed varieties, roguing/hand-pulling, crop rotation, seed cleaning, and lastly, fallow. However, many farmers had limited pieces of land at their disposal, so the fallow method was seldom used. Control methods were ranked: fertilizer/manure and tolerant seed varieties were ranked first and second. Roguing/hand-pulling, crop rotation, fallowing, and seed cleaning were also listed.

Farmers were then told that no single control approach, by itself, was economical and effective. The integrated control approach, when properly carried out, could reduce the *Striga* seedbank in the environment and, ultimately, infestation in the long term. The combination of resistant crops with crop rotation practices involving the use of trap crops such as cowpea, groundnut, and soybean, stimulates the suicidal germination of *Striga.* This ultimately proves more effective than the use of any method independently (Akobundu and Kim 1991).

Most participating farmers (especially the women) adopted the integrated *Striga* management approach. They observed less *Striga* emergence and reduced crop damage and recorded higher yields from the 20 m × 20 m plots compared with their own practice.

The integrated *Striga* control management package included planting one seed per hole at 25 cm (close planting) spacing for maize and groundnut. Farmers also adopted the method of applying fertilizer by making holes and burying the fertilizer instead of their "usual" practice of dropping fertilizer on top of the ridges. They also adopted the rotation of legume trap crops with an improved *Striga* resistant maize variety.

Some farmers did not adopt the complete package, especially the aspect of making holes and burying fertilizers. Their major complaint was that it was more laborious than their own practice. Farmers made some modifications of the package such as planting more seeds/hole (e.g. 4–6 seeds for soybean) instead of drilling. Some mixed NPK and urea during the second application.

Plant spacing was adopted and also carried out by most of the trial farmers.

There has been farmer-to-farmer diffusion. Farmers from neighboring States, on hearing about this package, wanted to be included in the program. Some farmers even invited extension agents to organize *Striga* control training for them.

There were organized farmer's field days, exchange visits, and partial budgeting, which offered farmers the opportunity to evaluate the technologies demonstrated.

Conclusion

On the whole, farmers' perception of the acceptability and adaptability of the integrated *Striga* management package is very encouraging. Diffusion of this technology would eradicate the parasitic weed *Striga,* one of the root causes of hunger and poverty amongst small-scale farmers. The crop seeds produced were good, high yielding, and had good cooking qualities and palatability. Soybean was nonshattering. Groundnut had high oil content and also produced good quality fodder. Above all, there was the reduction of *Striga* seedbank/infestation. This translates into more income for the family and more available and varied food on the table. There will be development in the community and voices will be given to the voiceless as a result of improvement in their socioeconomic standard. This is especially true for women who can now speak out on matters affecting them, and contribute to the socioeconomic well-being of the family, community, and the society at large.

Many participating farmers have expanded the technology to their various fields. Neighboring villages/communities will also want this done in their communities. Even more women than men have embraced the technology. Perhaps the latter need to condescend to benefit from this novel practice.

I hope, with farmer-to-farmer diffusion and adoption, this package will greatly reduce, if not eradicate, hunger and poverty.

Thank you for listening so attentively.

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Adoption of integrated *Striga* management methods in northern Nigeria: experiences from extension agents and supervisors

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The on-farm Project activities started with community analyses (CAs), which were held in many villages in Northern Nigeria in 2002. The analyses allowed the assessment of livelihood strategies, natural resources, crops, household resources, and local institutions, as well as the prioritization of problems. Furthermore, problems arising from *Striga* infestation, local cropping mechanisms, and control methods were all identified. At the end of the CA, farmers were selected to represent the other farmers in the community and test alternative *Striga* control options: legume–maize rotation and the use of a resistant variety. The selected farmers were called lead farmers (LFs) who became the pioneers in this program. They were the first farmers to adopt the new technologies. Many other farmers were skeptical during the first year of the program but happy at the end, due to the superior performance of the improved technologies. Following the progress made in the first year, many farmers indicated their intention to join the program for the next cropping seasons. The partners expanded the program to include secondary farmers (2Fs) in 2003. Each LF monitored, trained, and supervised three of them. The expansion of the program was partially successful because many had joined and adopted the technologies. But it is true that the program had problems from a lack of supervision by LFs which made the 2Fs adopt only one component of the technology. Beside 2Fs, the next farmers to adopt this program were those we called other adopters. They were the farmers who bought seeds from LFs and expanded the program on their farms.

Project activities/demonstrations

As a result of the community mobilization in various villages in northern Nigeria, farmers tested the *Striga* control methods of their choice, with support from extension agents (EAs). The EAs worked with six LFs. Each LF established two treatments (integrated *Striga* control plot and farmers' practice) in plots 20 m × 20 m. The improved practices comprised the rotation of a sole leguminous trap crop, e.g., soybean, groundnut, or cowpea, with resistant maize and the evaluation of *Striga* resistant maize. The farmers' practice was local varieties of maize, sorghum, and a legume–cereal intercrop.

Midseason and end of season evaluations, facilitated by EAs, were undertaken by each group of farmers to identify the advantages and disadvantages of the integrated *Striga* management technique compared with farmers' practice.

Factors that contributed to adoption

Two factors were responsible for the adoption of *Striga* management methods in northern Nigeria: farmers' assessment of their present *Striga* control method and the exposure of other nonparticipating farmers through meetings.

Farmers' perception

It is clear that interventions aimed at reducing the *Striga* menace will have a positive effect on the wellbeing of the community. Farmers in all communities had inherited or developed various techniques to combat *Striga* to minimize the damage done to their crops. Many control techniques were used locally before the intervention. The most widely used were hoe-weeding, hand-pulling, applying manure, fallowing, and early planting.

Farmers have now learned about the relatively new control techniques that are more effective against *Striga*. Because of these, they are changing from their traditional methods of controlling *Striga* to the new approach of the integrated *Striga* management method. Examples include the application of urea fertilizer, herbicide application, cereal rotation with legumes, and double cropping.

Technology dissemination

During field days, many farmers from inside and outside the community come together; they share knowledge and experience. A proverb says: "Seeing is believing". What farmers saw with their own eyes was more convincing than something someone could tell them. Therefore, it is during such gatherings that the farmers develop an interest in adopting the new technology. Similar meetings, like the midseason and end of season evaluations actually contributed to the adoption of the new technology.

Factors that promoted adoption

During the CAs, farmers were allowed to present their problems, and *Striga* was ranked the most important. Farmers were ready to warmly welcome anything that was done to reduce *Striga* in their farms.

Farmers' field day is a very important event in the lives of village farmers. Therefore, farmers attend such field days to interact and acquire new knowledge from researchers and adopt new technologies. Visits by EAs, supervisors, and researchers actually encouraged the adoption of this technology because farmers usually consider strangers to be very important. The majority of our farmers are peasants, therefore the high prices of inputs such as fertilizer and seed adversely affect them. Giving inputs on credit motivated them to adopt the technology. There is no doubt that siting trials along the roadside attracted many farmers and therefore encouraged adoption.

Benefits of adoption

- As a result of this technology, many abandoned farmlands have been put back into use. Farmers can now grow cereals on farms highly infested with *Striga*.
- There is a closer relationship between EAs and farmers. In fact, they have now become friends.
- Farmers' groups and associations have been strengthened. Farmers' groups and associations are now more organized.
- Farmers' welfare has improved. The families of many adopting farmers now live in better conditions; they enrol their children in school, buy their school uniforms, and improve the conditions of their houses.
- Extension and lead farmers received different types of awards.

Factors inhibiting the adoption of integrated *Striga* management methods in northern Nigeria

- The prices of inputs such as fertilizer, seed, and chemicals are usually very high, especially during the planting seasons when the farmers' store is almost empty. Therefore, farmers find it very difficult to afford them.
- The prices of crops such as maize, sorghum, and rice are some times very low. Sometimes a farmer has to sell two bags of his maize before he can buy one bag of fertilizer.
- This technology is sometimes very difficult for the farmers to adopt, especially planting, ridging, and applying fertilizer. It actually requires more labor and farmers are always looking for anything cheap. This is because of their low incomes.

Conclusion

To sum up, I want all participants in this meeting to know that farmers' capacity in *Striga* management has greatly improved during this project, but farmers have very few resources. They want more input assistance, and wish to continue with seed multiplication programs, therefore, support from you is necessary.

Thanks.

May God bless you.

Scaling-up integrated *Striga* control through nonparticipating NGOs

S.A. Bako
IITA

Introduction

Striga infestation is widespread in northern Nigeria. The financial support provided by DFID for *Striga* control was of great assistance to farmers, extension agents, government and non-governmental organizations (NGOs). Technical and material support was given to NGOs to further spread the technology.

Some of these NGOs were not involved at the beginning but through publicity they got information about the technologies and indicated their interest. As a result, they were given the necessary assistance. The NGOs worth mentioning are Hadin Kai Rural Development Program (HRDP), Kontagora, and Hope for the Village Child (HVC), Kaduna.

Activities conducted

Social mobilization

Community mobilization was held in three communities (by HRDP, Kontagora) in 2003 and in four zones (by HVC, Kaduna) in 2004. The major priority problems identified in order of importance were *Striga* infestation, poor soil fertility, other weeds, and plant diseases.

Demonstration and spread of technologies

In 2003, nine "daughter" trials of integrated *Striga* control were established in three villages by HRDP. In 2004, the coordinators of the program expanded the activities from the initial three villages to over 25 villages, extending from Niger State to Zuru in Kebbi State.

The HVC started demonstrations in 2004. The organization established 18 "daughter" trials on integrated *Striga* management spread over ten villages. In all villages where demonstrations were conducted, farmers considered *Striga* the major constraint to crop production and responsible for rural poverty. Farmers were particularly impressed with the performance of the technologies demonstrated. They were happy that some solutions are being found to control the *Striga* menace.

Training and distribution of extension materials

Staff of the two NGOs were trained on trial protocols, *Striga* biology and control, use of flannel boards, extension methodologies, midseason and end of season evaluation. Extension materials such as *Striga* pamphlets and leaflets, and flannel boards were distributed after the training.

Adoption of integrated *Striga* management methods in northern Nigeria

N.I.A.J. Zazzau
District head of Karau–Karau

Introduction

Nigeria is blessed with over 60% arable land, good vegetation, and many waterways. The Nigerian coastline is made of a complex network of creeks and lagoons. The coast is bordered by beaches that give way to the mangrove swamp. Beyond these is the zone of tropical forest in an undulating country with scattered hills that give rise to the savannas. The northern part of Nigeria, which covers about one-third of the total area of the country, is characterized by brief rainfall and a long duration of the dry season. Even in the south, where water supply is generally more favorable, some areas, notably Onitsha, Owerri, and Benin, experience shortages of water.

Agriculture

Agriculture is the dominant occupation of the people of northern Nigeria. We are blessed with abundant land but lack knowledge of modern cultivation. We are faced with crop production constraints such as S*triga* and other weeds, drought, pests, and diseases, so we obtain only meagre crop yields. Adoption of improved technologies by farmers has been low because there is no close partnership established with relevant stakeholders and/or technologies are not geared towards farmers' needs and ability to manage them. For example, farmers did not readily accept chemical fertilizers when these were introduced until, after several years of demonstrations, they realized their potential and started adopting them.

Striga has been one of the most important agricultural problems in the savanna. *Striga* is harmful both to the land and the farmers, to the extent that our farmers have abandoned their farmlands, not only because they don't have the means (capital) to cultivate them but also because of the damage *Striga* has caused to crops.

Project approach and implementation

In spite of the experience farmers have acquired in agriculture from time immemorial, the *Striga* problem is now increasing at an alarming rate. The farmers' indigenous methods of *Striga* control, such as early planting of crops, use of high dosage of urea, hand-pulling, and weeding, are all found to be inappropriate for the management of *Striga*.

Karau-Karau is my home and a village under my District. I love the people of Karau-Karau and I'm always delighted to share their problems with them and find solutions. Farmers have benefited immensely from the approach and implementation of the improved *Striga* control

Project. I will first of all thank the donor (DFID), IITA, and its partners, especially the team that came to Karau-Karau village. The process started with community analysis in 2002. In the analysis, crops and community problems were prioritized. Solutions to the major problem were discussed and jointly agreed by the community, EAs, and the scientists. *Striga* was the most important problem of the community, therefore, a community action plan was developed. The project adopted the approach of working in groups, and farmers' groups were allowed to freely elect their representatives called lead farmers (LFs). The groups through the LFs decided on the crop and type of demonstration they wanted. The LFs conducted demonstrations, multiplied seeds, and took leadership roles in training other farmers to adopt the technologies. The field day provided an opportunity for farmers within and outside the area to see and evaluate the control technologies. Good progress was made in getting more farmers involved and this has increased the number of secondary and tertiary farmers testing improved technologies in Karau-Karau and its environs.

Demonstrations and benefits of the integrated *Striga* control methods

The technologies demonstrated included the use of improved *Striga* resistant maize compared with farmers' local varieties, and the rotation of improved legumes (soybean, groundnut, and cowpea) with improved maize compared with farmers' practices. After 2 years of demonstration, the farmers realized that the integrated *Striga* control plot had a lot of advantages over their own practices. For example, higher crop yield, reduced *Striga* damage and emergence, and improved soil fertility.

The benefits derived as a result of the adoption of an integrated *Striga* control method cannot be overemphasized as many things have been achieved. Farmers learned that the control of *Striga* has to be a communal activity and not done at a personal level. As a result, more groups have been formed with the emergence of a women's group. Secondly, as a result of the *Striga* Project, the relationship between inhabitants of Karau-Karau and the neighboring villages has improved at all levels. Thirdly, the *Striga* Project has brought about financial benefit as well as human development. Thanks to the training and support from this Project, the community seed schemes for the multiplication of improved *Striga* maize and legumes are still going on at Karau-Karau. In fact, the seed producers have been linked to seed companies to play the role of out-growers. Lastly, farmers in Karau-Karau are reclaiming their abandoned farmland. This was made possible because of the integrated *Striga* control project.

Factors that promoted the adoption of the integrated *Striga* control methods

There are many factors responsible for the promotion and adoption of the integrated *Striga* management methods in northern Nigeria. These include the following.

- The extent of damage *Striga* does to the land and farmers.
- The approach used in implementing Project activities (all stakeholders were involved right from the beginning of the Project). Here I must commend IITA and its partners,

especially the KADP extension agent, Mohammed N. Namadi, who was always with the farmers.

- Most of the villagers' hopes and aspirations were realized through communal efforts. Required inputs were lent to the LFs, and this facilitated the implementation of the Project.
- The training given to the LFs on improved and sustainable crop production and seed multiplication provided an impetus to technology adoption.
- The seed multiplication schemes provided pure seeds in the village for other farmers to purchase and plant on their farms.

Factors inhibiting adoption

It is a normal situation that in whatever one is doing, there must be merits and demerits. The factors inhibiting adoption of the integrated *Striga* methods include high price and the difficulty in getting fertilizers, on the one hand, and, on the other hand, the low prices of crops at the end of the harvest period. Honestly, this is where Government and all the stakeholders of this important workshop have to join hands and find a lasting solution to these problems. The other issue is that the adoption of this technology on a large scale will be labor-intensive, thus some sort of mechanization will be required to reduce fatigue.

Conclusion

To conclude, one can say that the sharing of experiences on the adoption of integrated *Striga* management methods in northern Nigeria was a good initiative. IITA and its partners have achieved a lot within a short time. At this juncture, may I remind our able scientists about the noxious grass (in Hausa we call it *Tatsinya*) that I complained to them about. The last time you visited us at Karau-Karau, you collected samples for identification and analysis. I hope very soon something positive will come out of your analysis. I would like to use this conference to urge the Federal, State, and Local Governments, and indeed all the stakeholders, to ensure the improvement and continuity of this *Striga* program. This, I believe, will not only increase our soil fertility but will also increase the financial capacity of our subsistence farmers, thereby reducing poverty. Before I say goodbye, I will once again commend the activities of the extension staff for a job well done. Therefore, their problems should be looked into with a view to solving them. I don't have to list their problems here; you know them better then I do.

To cap it all, as a traditional ruler, I want to assure IITA and all stakeholders of this conference that, whenever you are looking for support, you shouldn't hesitate. We will be ready to offer free services so that our farmers will benefit. Together we shall drive hunger out of Africa.

Thank you and God bless.

Promotion of adoption of integrated *Striga* management methods in Plateau State

R. Dung
Catholic Resource Center, Jos

Introduction

The parasitic weed *Striga* is one of the serious problems that farmers are facing in producing their crops in most parts of Plateau State. Because of high *Striga* infestation, farmlands have been abandoned and farmers have migrated to far places in search of new, uninfested lands. Now with the ethnic clashes in the State, most farmers have been forced to return to their *Striga*-infested lands, thus making them helpless. The DFID–IITA Project on integrated *Striga* management, therefore, came at the right time.

Project implementation

In 2002, IITA Ibadan, and IAR Zaria, in collaboration with other partners, started applying on-farm research for integrated *Striga* control. Catholic Resource Center (CRC) Jos, collaborated by establishing six on-farm demonstrations in 2002 (three farmers each from Kogomta, Jos south LGC, and Ngorot, Bokkos LGC, in the northern part of Plateau State).

Technologies

Each farmer maintained two demonstration plots (20 m × 20 m). One was for the integrated *Striga* management and the second for farmers' practice (control). The technology demonstrated was legume–maize rotation. All farmers preferred to grow improved soybean (because of its domestic and industrial value) in the first year, followed by an improved *Striga* tolerant maize variety to be compared with their local maize variety.

Training

The participating farmers were trained on improved crop production practices and integrated *Striga* control. The appropriate *Striga* control method discussed with farmers are outlined below:

- Rotation with leguminous trap crops.
- Strip-cropping or intercropping.
- Use of clean planting material.
- Uprooting and burying of *Striga* plants.
- Adequate fertilization.
- Use of *Striga* tolerant varieties.

Table 1. Yield of integrated *Striga* control practice compared with lead farmers' practices at Kogomta, Plateau State, 2003.

Kogomta	Crop planted		Quantity planted		Quantity harvested	
LFs	ISC	FCP	ISC	FCP	ISC	Control plot
Dachung Nyango	*Striga* tolerant maize	Farmers' local maize	2 kg 1.25 *mudus* 20×20 m^2	1 *mudu* 20×20 m^2	86 *mudus*	15 *mudus*
Dachung Gyang	*Striga* tolerant maize	Farmers' local maize	2 kg 1.25 *mudus* 20×20 m^2	1 *mudu* 20×20 m^2	82 *mudus*	7 *mudus*
Lami D. Yusuf	*Striga* tolerant maize	Farmers' local maize	2 kg 1.25 *mudus* 20×20 m^2	1 *mudu* 20×20 m^2	91 *mudus*	16 *mudus*

ISC = Integrated *Striga* control, FCP = Farmers' control practice.

The lead farmers (LFs) were also trained on how to use the *Striga* pamphlets to explain integrated *Striga* control to others. At the end of the training, the LFs were empowered to take the lead in training secondary farmers (2Fs) and others.

Farmers were also trained in Namu Parish (southern part of Plateau State) an area that had recorded the highest influx of returnees from war zones. Eleven communities were trained on integrated *Striga* control. In these areas, most farmers had left their farmlands because of the serious *Striga* problem. The outbreak of the crisis in Langtang and Shendam forced them to return to their *Striga*-infested farms.

Farmers' perception and scaling-out

Participating and nonparticipating farmers attended both the midseason and end of season evaluations. Participants evaluated the performance of the demonstrations and their perception indicated that the integrated *Striga* control plots had a good soybean crop with a canopy covering the ground (in the first year), supported fewer *Striga* plants, had less crop damage, and produced higher maize grain yields (Tables 1 and 2) in the second year than the farmers' control plots. Each of the LFs trained and supported three 2Fs. The LFs distributed seeds (improved soybean and *Striga* tolerant maize variety) to 2Fs and other members of the group to try on their farms. Similarly, the 2Fs have trained and are supporting tertiary farmers (3Fs). The soybean and tolerant maize varieties are fast spreading among farmers. Still there is high demand for the *Striga* tolerant maize variety and soybean trap crop by farmers who have a *Striga* problem on their farm. Three LFs from 11 communities in Namu Parish (southern part of Plateau State) were selected from each community and were supported with seeds of soybean, cowpea, groundnut, and a tolerant maize variety to try on their *Striga*-infested fields.

Table 2. Yield of integrated *Striga* control practice compared with lead farmers' practices at Ngorot, Plateau State, 2003.

Ngorot	Crop planted		Quantity planted		Quantity harvested	
LFs	ISC	FCP	ISC	FCP	ISC	FCP
Matthew Dallck	*Striga* tolerant maize	Farmers' local maize	2 kg 1.25 *mudus* 20×20 m^2	1 *mudu* 20×20 m^2	53 *mudus*	5 *mudus*
Markus Mayat	*Striga* tolerant maize	Farmers' local maize	2 kg 1.25 *mudus* 20×20 m^2	1 *mudu* 20×20 m^2	60 *mudus*	21 *mudus*
Julia David	*Striga* tolerant maize	Farmers' local maize	2 kg 1.25 *mudus* 20×20 m^2	1 *mudu* 20×20 m^2	40 *mudus*	0 *mudu*

ISC = Integrated *Striga* control, FCP = Farmers' control practice.

After harvest, the LFs gave the legume seeds (soybean, cowpea, and groundnut) to 2Fs and other farmers. Those that had *Striga* tolerant maize the previous year shared the seeds with other farmers. The soybean and tolerant maize seeds are fast spreading in this area because the serious *Striga* infestation is affecting the yield of cereal crops. The demand for seeds is on the increase, since people see this project as God's divine intervention.

In the Tables above, the trial plots are the experimental plots of 20×20 m^2 where the tolerant variety of maize (Across 97 TZL Comp. 1-W) was planted and the second plot (the control) was planted with a local variety of maize, showing the farmers' practice. When you look at the results from the two different plots, you will see that the quantity harvested from the trial plots is higher than from the control plots. That shows that the variety planted on the trial plots is really tolerant of *Striga* (23.4 to 68.3% successful). After the second trial, all the LFs were convinced. They were very happy to have a solution to *Striga*, which had been the major problem in growing cereal crops.

Experiences from an extension agent

I have learned much about the practical control of *Striga* using the integrated *Striga* control management approach. I have used the knowledge in training so many farmers who are facing *Striga* problems on their farmlands. I have also used the knowledge in training my colleagues and those in other NGOs.

The adoption of this technology is faster in the south of Plateau State than in the north. This is because *Striga* infestation is greater in the south, on average. The integrated approach has proved to be the only option to reduce hunger in the area. The production of legumes (soybean, cowpea, and groundnut) has increased. The green manure used (sunn hemp and

Mucuna) has also helped to suppress the *Striga* weed. The problem of *Striga* is worse than the war situation. War may end and people will go back to their homes but *Striga* burns down the land completely and brings production to zero level. The activity is sustainable since farmers exchange normal or local seeds for tolerant seeds and *Striga* control. That will make the technology spread faster through the "daughter–granddaughter" relationship of research plots. The monitoring of the research is very important but is limited by mobility.

Technology adoption

In the north of Plateau State, farmers adopted the following *Striga* control methods:

- Intercropping of legumes (soybean and groundnut) with tolerant maize.
- Use of *Striga*-free planting materials.
- Uprooting or roguing of *Striga* plants before flowering.
- Improving soil fertility by increasing the use of organic and chemical fertilizer regularly.
- Use of *Striga* tolerant varieties by farmers who have the seed already.

In the south of Plateau State, farmers adopted these *Striga* control methods:

- Rotation with leguminous trap crops such as soybean, cowpea, and groundnut.
- Regular use of organic and chemical fertilizer.
- Uprooting and burying of *Striga* plants before flowering.
- Use of *Striga*-free planting material.
- Use of *Striga* tolerant varieties.
- Use of clean farming tools.

Factors that promoted adoption

- Reduction of *Striga* plants on farmlands.
- Supply of planting materials (soybean, cowpea, groundnut, and tolerant seeds) and fertilizer on loan from researchers.
- High yield.
- Good quality seeds and early maturity.
- The eagerness felt by farmers to get a solution to their problem, especially in the south.

Problems

- Difficulty in constructing ridges spaced at 0.75 m in the improved *Striga* control plot.
- Planting soybean is tedious due to close spacing.
- The method of fertilizer application (digging and burying fertilizer) is also tedious.

Future plan

To cover more areas in the southern part of Plateau State through training on the integrated control approach and dissemination of seeds of legume trap crops and *Striga* tolerant varieties.

Vote of thanks

A.C. Odunze
IAR, Zaria

Ladies and gentlemen, I have been given the simplest but most arduous task of thanking everyone who has, in one way or another, contributed to the success of the DFID-sponsored Weed Management Project in Nigeria. First and foremost, I would like to thank the Almighty God who enabled us, with His strength and special grace, to carry out the trials to a logical conclusion.

When the Project began in 2001, it was quite impossible to ascertain the degree of success it would achieve. Today we are all living witnesses to the remarkable impact it has made in the lives of farmers in the agroecological zones covered. For this and many other reasons, I would like to thank the donor DFID, UK, on behalf of the participating or collaborating Institutes for undertaking to sponsor the project in Nigeria.

May I also thank the collaborating Institutes, IITA in particular, IAR/ABU Zaria, Silsoe Research Institute UK, the Federal University of Agriculture, Makurdi, and especially Kaduna ADP, for their commitment and unwavering cooperation that has resulted in this huge success. I would like to particularly acknowledge the logistic support of the Federal and State Ministries of Agriculture and their parastatals, the Director General IITA, Director IAR/ABU, the representative of SILSOE Research Institute, Director DFID, and Vice–Chancellors of Ahmadu Bello University, Zaria, and Federal University of Agriculture, Makurdi. Their enabling policies have enhanced farmers' income through their participation in this Project. You will agree with me that the Conference theme *Reducing poverty through improved Striga control* was achieved within the short period of the project.

There is an important set of people we cannot forget to appreciate—the traditional institution, that is, the Emirs and Chiefs in whose domain this Project was executed. Without their cooperation, we could never have gained access to the farmers or villages. For this, we would like to say thank you very much. "*mun go de*". Most importantly, we would like to thank the volunteer farmers who agreed to donate their farmlands for the benefit of the community, State, and the nation at large. This singular effort of theirs is what we are here today celebrating:

- Control of *Striga* on farmlands.
- Increased crop production/ha from *Striga*-free fields.
- Enhanced farmer income from farm produce.
- Improvement of the soil for sustainable productivity.

Finally I would like to thank all the resource persons, scientists, other support staff, that is, caterers, drivers, secretarial staff, gentlemen of the press, etc., who have variously contributed to the success of the DFID Weed Project in Nigeria.

Once again, I thank you all. Thank you! Thank you!!

Summary and recommendations: DFID Weeds Special Project. Planning meeting 2004 and handing-over strategy Communiqué

Purpose of the conference

Since *Striga* is a major cause of low crop yields, food insecurity, and increasing poverty in the savanna zones of Nigeria and surrounding countries, this Second *Striga* Management Stakeholders' Conference was convened to discuss the findings of a DFID-funded Weed Project. This has worked with partners to control *Striga* for the last 3 years (2001–2004).

Participants

Over 100 participants attended the workshop, representing researchers, extension agents, NGOs, farmers, and the private sector from 11 States (Bauchi, Gombe, Jigawa, Kaduna, Kano, Katsina, Plateau, Sokoto, Taraba, Zamfara, and the Federal Capital Territory). These areas have a combined population of 39 million people, many of whom suffer from problems related to *Striga*.

Key project results

The project has shown as follows.

- *Striga* can be effectively controlled using integrated methods, which include the use of *Striga* resistant maize varieties grown in rotation with legume trap crops (groundnut, cowpea, and soybean), as well as improved field management (use of fertilizer, planting methods, and hand-roguing).
- Participatory Research and Extension Approaches (PREA) provided the basis for multiple stakeholder participation. As a result, farmers in over 50 communities in Kaduna State, as well as adjoining areas of Plateau, Benue, and Taraba States, have successfully used *Striga* control methods to increase crop productivity and improve their livelihoods.
- The capability of project partners to facilitate uptake of improved *Striga* management practices in farming communities has been enhanced.

Workshop resolutions

Following deliberations, stakeholders made the following resolutions.

Scaling-up

1. The outputs of this project should be scaled-up to all those areas in northern Nigeria where *Striga* is a major cause of low productivity in sorghum, maize, rice, and pearl millet, environmental degradation, and poverty.

Participatory Research and Extension approaches

2. The use of PREA should be institutionalized in all those development organizations that are working with rural communities. This would involve mandatory training in PREA methods for extension staff in State ADPs, local government, and NGOs, and linked with practical application. Initial emphasis should be given to training trainers. Resources for this training could be drawn from NAERLS at Ahmadu Bello University, Zaria, the Cooperative Extension Centre at University of Agriculture, Makurdi, as well as IITA, Ibadan.

Improving the supply of quality seed

3. The key to the success of scaling-up will be improving the availability of quality seed of cereals and legumes to farmers on a sustainable basis. The project has demonstrated community-based seed production, where small-scale farmers are trained in seed production, and are able to produce for both their communities and seed companies. The role of private seed companies in this work is acknowledged.
4. Private seed companies should be encouraged to participate by providing foundation seeds, making loans to finance inputs, and purchasing seed after harvest. The seed companies should be encouraged to establish sales outlets or agents as close as possible to the communities.
5. The role of the National Seed Service for seed certification is important to ensure quality seed production and distribution.

Microcredit

6. The project has demonstrated that microcredit schemes for farmers in small-scale seed production are viable for the financiers as well as farmers. For example, over 90% recovery of input loans has been achieved in this project.

Promoting long-term sustainability

7. Legumes are an integral part of long-term sustainable land use, improving soil structure and reducing the need for inorganic fertilizer, leading to increased crop production, livelihood improvement, and poverty reduction.

Adding value to legume crops

8. Legumes are also important in improving household diet and health as well as playing an important role in *Striga* control and maintenance of soil fertility.
9. Training of women in on-farm processing and utilization of legumes within the household and for sale will assist in improving diets and provide valuable income.
10. Establishment of off-farm legume processing facilities should be supported, providing the opportunity for farmers to grow legumes on contract to processors.

Developing a proposal for reducing poverty through a *Striga* Control Initiative

11. Participants called for the establishment of a *Striga* Control Initiative encompassing all the 19 States affected by the weed. A task force was formed to develop a proposal for this purpose. This task force will consist of senior staff from IITA, IAR, KADP, SG2000, PCU, and Alheri Seeds who would consult widely in the development of the proposal.

12. This proposal would include all those States in northern Nigeria with a serious *Striga* problem.

13. The proposal would seek funding from each State as well as inviting the participation of other donors in the project.

Annex 1. Comments/Questions

First Technical Session. 8 September 2004

- Y.D. Ndirpaya—Ministry of Agriculture, Abuja
  Striga control is a complex process, considering the amount of seeds produced and how long the seed/plant can remain viable. While we appreciate the funding from DFID and IITA's technical work, I think it would be good to seek more funds for a longer period of work to effect the eradication of *Striga*.
- A.M. Emechebe—IITA
  We are not talking about eradication of *Striga*. We are talking of integrated management of *Striga*.
- D. Chikoye—IITA
  It is not possible to eradicate *Striga,* given the resources available to the project. The strategy was to promote improved *Striga* control practices on farmers' fields. Farmers demonstrated that an integrated approach gave yield advantages over farmers' methods of control. This shows that integrated *Striga* control (ISC) has positive effects on farmers' welfare. *Striga* control is a long-term strategy but within a short period, you can reduce the seedbank to levels that do not damage the cereal.
- Y.D. Ndirpaya—Ministry of Agriculture, Abuja
  Hand-pulling of *Striga* was indicated as a major control method. I think with the level of infestation on our farms, hand-pulling alone will be inadequate. We may need another option.
- A.M. Emechebe—IITA
  Roguing is a component of integrated *Striga* management. It is practicable only at low levels of infestation when it has been controlled using other control components.
- Y.D. Ndirpaya—Ministry of Agriculture, Abuja
  ISC trials are maize system-based. I think it will be good to think also of sorghum and millet systems in collaboration with other stakeholders, such as ICRISAT.
- A.I. Gatawa—Sokoto State ADP
  Kindly consider covering millet and sorghum, because Sokoto and the extreme northern part of Kebbi, Zamfara, Kano, Borno, etc., grow these crops.
- A.M. Emechebe—IITA
  Yes, we shall take into consideration, the integrated control of *Striga* in various major cereals —maize, sorghum, pearl millet, etc. We have to address *Striga* management from the systems perspective. The seeds of *S. hermonthica* that infest maize are produced on sorghum and pearl millet, so we have to address their contribution to the seedbank.

- Y.D. Ndirpaya—Ministry of Agriculture, Abuja

  It was reported that the absence of extension services was a little problem for the farmers. I think that something must be wrong with the extension system there. Maybe they are ignorant of extension work and should be linked up.
- Jim Ellis-Jones—SRI, UK

  The role of extension is very important. The challenge is to make extension services more effective. This needs to address the role of farmer-farmer extension.
- D.E. Jacob—Kaduna State ADP

  Is the National Seed Service (NSS) involved in the certification of the field for this project? The importance of seed in this project cannot be over emphasized. It is therefore pertinent that such a project should link up with the institution that has the mandate for seed issues. From the data given in the presentation, the performance of maize declined beyond 120 kg N/ha. Does this refer to absolute economic yield and why the decline?
- E.Y. Zidafomor—NSS, Zaria

  NSS is a relevant stakeholder and their involvement has been conspicuous. The designer of the project should get the NSS more involved since the project is seed-based, knowing that NSS by law has the mandate for seed multiplication, certification, and quality control in this country.
- G. Tarawali—IITA

  NSS has always been and will continue to be involved in all these projects. In fact, that is why you have been invited to be with us today. From time to time, we link up with your Director on all aspects.
- I. Kureh—IAR/ABU, Zaria

  The yield reported in the variety × nitrogen trial was economic yield. There was response to N in the 3 years to 120 kg N/ha. Beyond 120 kg N/ha, there was no yield advantage, hence the decline.
- A.Y. Kamara—IITA

  Fertilizer is not the end solution for cereal production. Yield observations show that fields that have been fertilized for over 20 years have experienced a yield decline. Legume–rotation will be useful in the long run.
- A.I. Gatawa—Sokoto State ADP

  What happens when a loan cannot be recovered because of flood? Did you consider insuring the production against natural disasters, such as flood, droughts, etc., at least for farmers' production to be at minimum risk?
- D. Chikoye—IITA

  The project wanted to make sure that farmers did not feel that they are collecting "free gifts". We had to recover "something" to enhance full commitment from farmers.

- A.Y. Kamara—IITA

  Input recovery using fertilizer may be risky because of variation in the quality of fertilizer. Please link farmers to industries to buy seeds.

Second Technical Session. 9 September 2004

- A.M. Emechebe—IITA

  CRC presenters have all apparently reported good control with intercropping host crops with legume crops (soybean, cowpea, and groundnut). Why did they not adopt cereal–legume rotation?

  Or did the farmers choose intercropping instead of rotation and, if so, why?
- R. Dung—CRC, Jos

  Farmers' population has increased. Mining activities have also increased, leaving our farmers in Plateau State with less land to practice crop rotation, as advised. Some good farmers in the southern parts of Plateau State practice crop rotation because they are aware of ISC for the control of *Striga*. Here, cowpea and groundnut have replaced the local legumes. They are fully informed that cowpea and groundnut seeds have the ability to reduce the *Striga* seedbank through suicidal germination and such rotation has continued to improve the maize yield in the farmers' fields.
- Y. Adamau—Gombe State ADP

  This report that 4 t/ha is obtainable in maize—is it referring to the variety 94 TZE Comp. 5? The time for discussion is too short. There is the need to limit the period of presentation so that we have more time for discussion.
- S.G. Hassan—Alheri Seed Nig. Ltd, Zaria

  Although I was not variety-specific about yield it is possible to obtain yields higher than 4 t/ha. Depending on management and soil fertility, 7–8 t/ha are possible.

  Farmers' improvement on yield/ha is our desire. The higher the farmers' yield, the better off they are. We are not particularly happy with the new trends of the seed multiplication of the *Striga* resistant varieties. It is pushing us out of business. We have been unable to sell our *Striga* tolerant materials since the multiplication aspects of the DFID project started.
- A.Y. Kamara—IITA

  If markets are developed, farmers will sell their produce and buy inputs without waiting for the Government.

  Crop varieties are ecoregion-specific. Late maturing crop varieties such as Across 97 TZL Comp. 1-W are suited to areas where rainfall is longer (NGS + SGS). In the Sudan savanna, we need early maturing varieties, e.g., 94 TZE Comp. 5 (*Striga* resistant). We also have early maturing soybean varieties.

- E.J. Zidafamor – NSS, Zaria

  These *Striga* resistant maize varieties used in this Project—may I know if they have been officially released for cultivation? NSS has a community seed diffusion program where this seed can be made accessible to farmers. This is where collaboration becomes important. NSS is willing to participate and make the project successful. Quality control services can be offered in the seed multiplication aspects of the project.
- N.S. Bako—Plateau State ADP

  I thank the organizers of this conference for inviting Plateau State ADP. We would like to continuously be part of this project. There are new parasitic weeds on rice and acha that need to be addressed. We request experts from IITA to help us identify them.
- Y.D. Ndirpaya—Ministry of Agriculture, Abuja

  The Federal Government is very much in the business of promoting agriculture, especially through the presidential initiatives on rice, cassava, vegetables, and oil crops, etc. Government is interested in community-based projects. We must learn to sustain the efforts of the Government and other organizations. DFID's role in sponsoring this project is well appreciated by the government and people of Nigeria.
- D. Abdullahi—Bauchi State ADP

  I wish to request the organizers of this conference to produce and make available all the papers presented to all the participants. In view of past experiences in the implementation of externally funded projects that, in most cases, collapsed after the expiration of the support, a well designed strategy should be put in place to ensure the sustainability of this Project. Bauchi State ADP is interested in this Project and would like to be included in the next line of action.
- G. Tarawali—IITA

  We plan to put together all presentations in this conference and we promise to send copies to all participants.
- Alh. S.A. Magami—ZACAREP, Zamfara State

  Zamfara Comprehensive Agricultural Revolution Program (ZACAREP) is one of the seven programs under Zamfara State Integrated Development program (ZASIDEP). The Zamfara State Government intends to spend about ₦56 000 000 in 46 months (i.e., from November 2003 to April 2007). The ZACAREP program has taken off in earnest during this rainy season. Our farmers are happy with this. To ensure the sustainability of the program, ZACAREP acts as a facilitator and uses a crop participatory approach. Zamfara State Government has also promised to be the buyer of "last resort" for farmers' produce when the need arises. Also the program is working hand in hand with First Bank of Nig. Plc. for loan disbursements.
- D.E. Jacob—Kaduna State ADP

  Counterpart funding by States should be pursued in the scaling-up of the ISC Project. This could be incorporated in the next phase of this Project. This is important, considering the role of *Striga* in crop production all over the savanna.

- A.Y. Kamara – IITA
  We should form a *Striga* Initiative for northern Nigeria. This would include support from State Governments and Local Government Councils.
- D. Chikoye – IITA
  There is a need to form a "Task Force" to pursue this concept note!
  We need the involvement of LGAs to show how demand for this Project was determined.
- A.I. Gatawa—Sokoto State ADP
  Sokoto State is interested in participating in this Project, considering the plight of our farmers who experience 60–90% loss of crops such as millet and sorghum due to *Striga* infestation. This Project will go a long way towards minimizing the effect of *Striga* in the savanna for the resource-poor farmers. The State is committed to be part of this laudable Project.
- D. Abdullahi—Bauchi State ADP
  There is no doubt that the Project has made some impact on the lives of the participating farmers. However, the impact of other existing projects in these areas need to be taken into account.
- D. Chikoye—IITA
  A large task force will require resources to function effectively! How will these activities be funded? Perhaps a small group is needed to link up with the LGAs and State Governments.
- J. Ellis-Jones—SRI, UK
  Link DFID Project with the new concept note on *Striga* control.
  Each State should contribute 80–90% of the funds.
  Our donors will appreciate seeing the Government's contribution coordinated by the Federal Government.
- B. Barde—Jigawa State ADP
  Jigawa State is severely infested with *Striga*. I would like you to write to my State Government about the need to participate in this Project. Explain the details and let us know exactly when you must begin.
- M. Shuaibu—Katsina State ADP
  Considering the agricultural potential of my State and our proximity to the Sahara, I suggest that this Project be extended to Katsina State, especially in the Funtua and Gangara LGAs as well as areas of Daura and Mai-Adua LGAs where *Striga* causes serious damage. I am pleased to identify with this Project.
- E.J. Zidafomor—NSS, Zaria
  The NSS has the statutory role of foundation seed multiplication, certification, and quality control in the seed industry in particular and in agriculture in general. We are to render our services and contributions/expertise to promote this Project. Our men are in every State and I suggest that you get in touch with us.

- I. Kureh—IAR/ABU, Zaria

  NSS has fully identified their role in this Project. Other meaningful NGOs who, like the NSS, are stakeholders should be equally identified, considered, and included as partners.

Agreement

It was finally agreed that a task force should be created. Members were to be few—about six in number. All stakeholders had to be represented thus:

1. IITA = 1 representative.
2. NAERLS/IAR = 1 representative.
3. PCU = 1 representative (S. Ngawa).
4. Program Manager—Kaduna State ADP (to represent all States).
5. NGO = 1 representing all NGOs (SG 2000).
6. Private sector = 1 representative.

Annex 2. Participants

No.	Name	Organization
1.	S. Hassan	Alheri Seeds
2.	D. Abdullahi	Bauchi State ADP
3.	Y. Adam	Gombe State ADP
4.	Y. Adamu	Gombe State ADP
5.	B. Barde (Rep Z. Abdullahi)	Jigawa State ADP
6.	M. Suleiman	Kaduna State ADP
7.	A.M. Dahiru	Kaduna State ADP
8.	A.K. Abubakar	Kaduna State ADP
9.	A.H. Zakari	Kaduna State ADP
10.	A.G. Ishaq	Kaduna State ADP
11.	S.Z.M. Abubakar	Kaduna State ADP
12.	J.K. Aliyu	Kaduna State ADP
13.	T. Mohammed	Kaduna State ADP
14.	D. Garba	Kaduna State ADP
15.	P. Paul	Kaduna State ADP
16.	I. Zango	Kaduna State ADP/SG 2000
17.	A. Danbaba	Kaduna State ADP/SG 2000
18.	I.A. Garba	Kaduna State ADP
19.	A. Usman	Kaduna State ADP
20.	A.U. Suleiman	Kaduna State ADP
21.	F. Musa	Kaduna State ADP
22.	D.E. Jacob	Kaduna State ADP
23.	T. Buba	Kaduna State ADP
24.	J.A. Kasim	Kaduna State ADP
25.	A. Sada	Kaduna State ADP
26.	M. Saleh	Kaduna State ADP
27.	A.K. Kassim	Kaduna State ADP
28.	M.A. Gwandu (Rep. Prog. Manager)	Kebbi State ADP
29.	N. Barko	Plateau State ADP
30.	A.G. Isah	Sokoto State ADP
31.	S.A. Magami	ZACAREP, Zamfara State
32.	T.F. Abdullahi	Giwa LGA
33.	H. Balarebe (Rep. Chairman Giwa)	Giwa LGA
34.	S. Salusi	Giwa LGA
35.	K.A. Balarabe	Giwa LGA (Dept of Agric. and Nat. Res.)
36.	M. Muhammed	Ikara LGA

No.	Name	Organization
37.	D.A. Hajji	Kudan LGA
38.	A. Agunu	Kajuru LGA
39.	D. Lallai	Kajuru LGA
40.	S. Danbaba	Kajuru LGA
41.	S. Shamaki	Kajuru LGA
42.	M. Sha'abu	Kajuru LGA
43.	B.D. Giwa	Kajuru LGA (ECWA Church)
44.	A.G. Muntari (Rep. Chairman)	Kubua LGA
45.	D. Sa'adu	Kudan LGA
46.	A. Umar	Sabon Gari LGA
47.	E.O. George	WIFAD, Zaria
48.	S. Musa	WIFAD, Zaria
49.	A.C. Odunze	IAR/ABU
50.	B. Adeniji	IAR/ABU
51.	F.C. Orakwue	IAR/ABU
52.	A.C. Odunze	IAR/ABU
53.	F.A. Showemimo	IAR/ABU
54.	I. Kureh	IAR/ABU
55.	S. Misari	IAR/ABU
56.	A. Sani	IAR/ABU
57.	I. Sani	IAR/ABU
58.	S.M. Misari	IAR/ABU
59	B. Adeniji	IAR/ABU
60.	O. Tunji	IAR/ABU
61.	Y. Dodo	IAR/ABU
62.	J.E. Onyibe	NAERLS/ABU
63	J.T. Amodu (Rep. Director)	NAPRI/ABU
64.	C. Ali	CRC Kaduna
65.	A. Nyango	CRC Jalingo
66.	R. Dung	CRC Jos
67.	J. Ellis–Jones	Silsoe Research Institute, UK
68.	O.O. Olufajo	ILRI
69.	D. Chikoye	IITA
70.	G. Tarawali	IITA
71.	L. Franke	IITA
72.	A.M. Emechebe	IITA
73.	A.F. Lum	IITA
74.	A. Kamara	IITA

No.	Name		Organization
75.	O. Tobe		IITA
76.	J.D. Dada		IITA
77.	A. Olanrewaju		IITA
78.	S.A. Bako		IITA
79.	B.Z. Jamagani		IITA
80.	V.O. Mosimabale	(Rep. Director)	NSS, Zaria
81.	E. Zidafamor	(Rep. Director)	NSS, Zaria
82.	D.A. Idris	(Rep. Director)	NSS, Zaria
83.	A. Fumen	(Rep. Director)	NSS, Zaria
84.	H. Idris		Sarkin Pambegwa
85.	I. Haruna		Pambegwa
86.	J. Azah		Hope for the Village Child, Kaduna
87.	R. Schwerzenberger		Hope for the Village Child, Kaduna
88.	Y.D. Ndirpaya	(Rep. Director)	Federal Ministry of Agriculture, Abuja
89.	J. Aham		PCU Sheda, Abuja
90.	J. Maigari	(Perm Sec)	Ministry of Agriculture, Kaduna
91.	S. La'Ah	(Director)	Ministry of Agriculture, Kaduna
92.	A.J. Nok		Ministry of Agriculture, Kaduna
93.	J.A. Haynok	(Rep. Head)	Department of Rural Development, Kaduna
94.	A.H. Hassan		College of Agric/Animal Science, Mando, Kaduna
95.	U.M. Taghid		Miagro Ltd, Kaduna
96.	M. Shuaibu		KTARDA
97.	A. Ismail (D/H Karau-Karau)		Emir's palace, Zaria
98.	H. Ankyang		Makafi, Zaria
99.	S. Oguntoyinbo		Samaru, Zaria
100.	M. Shai		Samaru, Zaria
101.	M.A. Hussaini		Bayero University, Kano
102.	B. Idris		Gangara
103.	A.I. Garba		ABCOA, Dambatta
104.	I. Hassan		University of Ilorin
105.	D. Hussaini		Dallaka
106.	A.A. Yaradua		Department of Agriculture, HUK Polytechnic, Katsina
107.	A. Habibu	(Rep. Director)	NIAGRO Ltd, Katsina

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