African Union

Semi-Arid Africa Agricultural Research and Development

(AU/SAFGRAD)

FOSTERING STRATEGIC ALLIANCE FOR EFFECTIVE STRIGA CONTROL IN AFRICA'S CROP PRODUCTION

Walter S. Alhassan, PhD

20th April, 2007

EXECUTIVE SUMMARY

Striga is the most pernicious weed problem of SSA. It is estimated that 22 to 40 million ha of land in SSA is infested by the parasitic weed. Yield losses range from 30-100%. FAO (1989) reports that $7 billion worth of food is lost annually due to Striga infestation. Despite the many *Striga* control initiatives put in place the problem remains intractable across Africa. Most of the initiatives have been stand alone. There is the need to harness initiatives across the various sub-regions to collectively tackle the Striga infestation menace.

Six cases of comprehensive national and sub-regional programmes for Striga control in SSA were reviewed. Out of these, two cases, namely the AU-SAFGRAD-IITA-Korean Government *Striga* Control Programme and the CIMMYT-Kenya-AATF *Striga* control were studied in greater depth to form the basis for an All-Africa *Striga* Control Programme. The selection of these two for further study for possible up scaling is due to their geographic coverage and the additional technology innovation introduced by the CIMMYT-Kenya-AATF IR-Maize project for the control of *Striga* in Kenya. An additional dimension of the IR-Maize project is the added partnership involving an agency (AATF) that has brokered a technology transfer deal between the owners of proprietary technology (BASF) and research and development institutions (CIMMYT and KARI) for the benefit of small scale farmers.

Maize has been the crop that has received the most research and technology transfer attention in *Striga* control in SSA. Although for the more semi-arid ecologies cereals other than maize should receive greater emphasis, due to the available knowledge and the far greater numbers of farmers cultivating the crop in sub-Sahara Africa the initial thrust on technology transfer will be on maize. More basic research and on-farm trials will have to be conducted on the other important cereals, sorghum, millet and rice to quickly upscale the resultant technologies in the near future. Thus the proposed programme will be a 10 year proposal in two 5-year phases. The first 5-year phase will cover herbicide (imazapyr) resistant maize (IR-Maize) and other *Striga* tolerant or resistant cereals (sorghum, millet and rice) while the second 5-year phase will involve all herbicide resistant cereals (maize, sorghum, millet and rice) in the integrated *Striga* control programme involving the use of legume crops. The integrated control program draws largely on the experiences of AU-SAFGRAD and AATF in Striga control in West and East Africa respectively. Both agencies have independently drawn their programs for up scaling in SSA in 11 (AU-SAFGRAD) and 7 (AATF) countries in SSA with a considerable overlap in the countries selected. There is therefore the need for harmonization of the two up scaled programs of the organizations.

The total 10-year budget for the All-Africa Striga Control Programme is $15,697,600.

The governance structure, activity details and success indicators are presented for the proposed up scaled All Africa Integrated *Striga* Control Program.

Sustainable funding coupled with the payment of attention to governance and management issues are needed to ensure success in *Striga* control in SSA and to address the problems of food security and poverty.

INTRODUCTION

General outline of socio-economic situation in Africa's agriculture.

It is estimated by FAO (2005) that at Africa's current population growth rate of 2.8% the population will double in 25 years. The population pressure leads to intensive land cultivation, soil degradation, worsening disease and pest build up, declining yields, chronic food insecurity and worsening rural poverty. There is the need to raise cereal yield which has been flat since 1960 (around 1 mt/ha—contrast 3.2 mt/ha for Asia and the Pacific and 3.8 mt/ha for the developed countries) (World Bank, 2005). Long-term investment in research is needed for the development of crop varieties, livestock and crop production practices for small scale farmers.

The African Union's vision adapted by NEPAD is for regional agricultural production to grow at an annual rate of 6% by 2020 from the current low levels of around 2.3%. Issues of policy and technology must be addressed to correct the gloomy picture of food insecurity and poverty for Africa. The specific problems to address relate to weather, biotic and abiotic stresses as well as policy constraints relating to input supply and marketing.

The current study report is related to the control of one of the most serious biotic constraints of grain production, namely, *Striga* infestation in Africa. *Striga* infestation is often associated with the abiotic constraints of drought and declining soil fertility. The environmental conditions favoring *Striga* infestation are degraded soils, low fertility and soils of low moisture retention capacity. The condition is exacerbated by population pressure where cereal is grown repeatedly in the same area.

The *Striga* problem and its context in the current food security problem.

Striga spp. are widely distributed root parasites that derive their mineral nutrients, water and carbohydrates from their host plants that are mainly staple crops such as maize, sorghum, pearl millet, rice, cowpea and sugar cane. A range of 4-17 *Striga* species has been identified in various countries in West and Central Africa on a wide range of hosts including cereals, grain legumes, wild hosts and pasture crops. *S. hermonthica* was most ubiquitous and was present in cereals and wild grasses. *S. gesnerioides* is present in cowpea and wild legumes. *S. asiatica* attacks maize on land adjoining river banks. *S. asiatica* was also found in rice in Côte d'Ivoire. In Togo *S. aspera* attacks lowland rice (Emechebe et al 1991).

Next to the cereals, the most important food crop infested by striga is the cowpea (*Vigna unguiculata*)
Reports by Emechebe et al (1991) indicate that in Nigeria cowpea is attacked by 2 parasitic weeds: *S. gesnerioides*, and *Alectra vogelli* with *S. gesnerioides* the more important. Symptoms of Striga attack in cowpea listed were:

- Interveinal chlorosis.

- Leaflet may be completely desiccated.

Symptoms may appear even when germinated Striga is not seen

Striga is a very prolific parasitic weed. A single plant of *S. asiatica* produces over 200,000 seeds. Seeds are small and light and thus easily dispersed. *Striga* may be spread as a seed contaminant or in the dung of animals (cattle). The seed can survive up to 15 years under favorable conditions. Subsequent to the after-ripening dormancy, most *Striga* species require pre-conditioning and adequate chemical stimuli, usually from roots of suspect hosts for germination.

Striga has been a serious problem of cereal and legume crops among farmers in sub-Saharan Africa. Its effects on crops range from stunted growth, through wilting, yellowing, and scorching of leaves, to lowered yield and death of many affected plants. The problem of *Striga*-infested fields has 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 non-adoption of integrated *Striga* management strategies.

A typical maize field with heavy *Striga* infestation is as indicated (Fig. 1)

Fig. 1. Maize with heavy *Striga* infestation (Courtesy AATF)

The economic losses from *Striga* infestation are enormous. It is estimated (FAO, 1989) that 7 billion US dollars worth of food is reported lost annually in SSA due to *Striga*. The greatest damage occurs in the savanna and sahelian zones. Higher yield losses occur in Sudan savanna and the Sahel compared to losses in Guinea Savanna and wetter areas. There is variability in crop susceptibility to *Striga* within varieties. A loss of 25-100% in crops is reported in Mali.

Varying levels of yield losses due to *striga* infestation have been reported. Losses reported in sorghum in Kenya range from 70% to total (Kiriro, 1991).

The most deleterious effects *Striga* infestation Kenya occur under maize, where about 2.5

million ha suffer grain losses of 30-80%, a setback valued at approximately US $1 billion per year. 15 countries of eastern, southern and western Africa account for 92% of the continent's *Striga* infestation in maize fields.

The *Striga* infestation problem is widespread in sub-Sahara Africa. In West Africa, it occurs significantly in the areas between latitude 8° and 12°N. In Cameroon, The Gambia, Ghana and Nigeria, 26-96% of land surveyed was infested by *Striga*. The predominant crops infested were cereals (Emechebe et al 1991). In Kenya the problem has been largely reported in the Lake Victoria basin and in the Lake region of Tanzania (Kiriro, 1991; Doggett, 1991).

Some areas of severe *Striga* infestation in sub-Sahara Africa are as indicated (Fig. 2). This information may need to be ascertained from more exhaustive surveys, however.

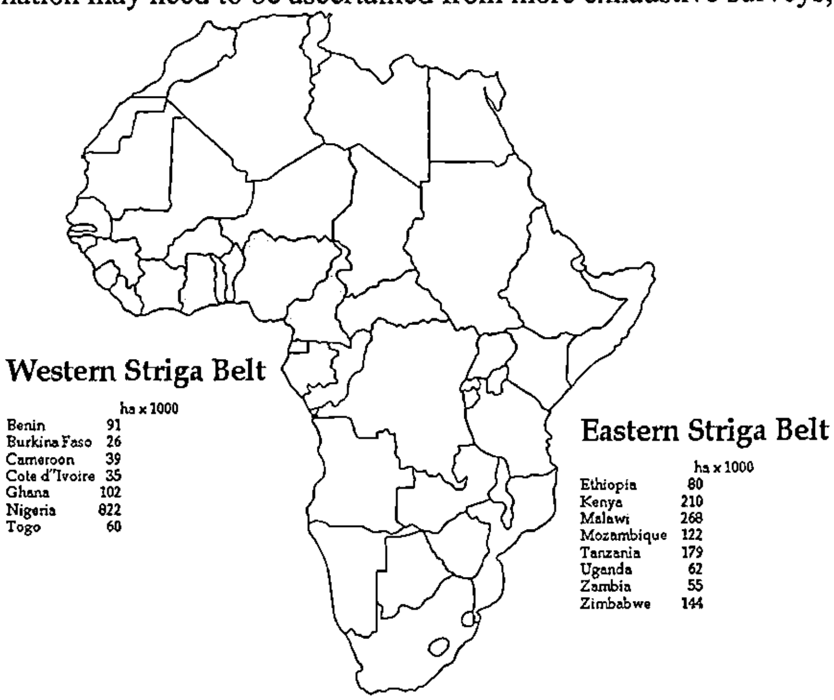

Fig. 2. *Striga* infestation belts of Africa (Source: AATF, 2006).

Early studies to define the nature of the *Striga* problem in Nigeria were undertaken by Lagoke et al. (1990) in a survey. The objectives of the survey were:

1. To obtain information on the distribution, intensity of infestation, rates of spread of *Striga* and related parasitic weeds and relate these to the farming system.
2. To obtain baseline data on the reliability and socio-economic acceptability of existing *Striga* control methods and their relationship with the distribution and spread of *Striga* and related species.
3. To produce map of the distribution of *Striga* and related species in Nigeria savannas.

The survey methodology consisted of farmer interviews supplemented with observations of farms in the Guinea and Sudan Savanna ecological zones during the cropping season when the crops were in the field and at a time the *Striga* had emerged.

The survey revealed that *Striga* infestation was worse than anticipated. *Striga* infested

96.1 and 88.7% of farms in the Northern Savannas in 1988 and 1989 respectively. This was far in excess of the 40% estimated. The underestimation was blamed on **inadequate survey procedures in the past and of the need to standardize survey procedures.** Both *S. hermonthica* on cereals and *S. gesnerioides* on cowpea were noticed. A yield loss of over 40% was reported on 58% of farms surveyed.

Striga hermonthica alone seriously infests over 40 million hectares of land in Africa, causing yield losses on cereals ranging from 40% to 80%, with the consequence that over 100 million people lose half of their crop production (AU-SAFGRAD Leaflet).

The environmental condition favoring *Striga* infestation is degraded soils, low fertility and soils of low moisture retention capacity. The condition is exacerbated by population pressure where cereal is grown repeatedly in the same area.

Considerable efforts by International Agricultural Research Centres (IARCs), and National Agricultural Research Systems (NARS) have been devoted to solving the *Striga* problem in Africa. At individual country level, achievement in Striga control has been slow. There is thus the need for collective action in the continent.

A joint FAO/OAU meeting held in Yaounde, Cameroon as far back as 1985 underscored the seriousness of *Striga* as a pan-African problem mostly affecting the small holder resource poor farmer (Parkinson et al 1991). The meeting recognized the need to:

- Coordinate activities
- Disseminate information
- Provide training
- Support priority areas for adaptive research in *Strga*/weed management on a pan-African basis through national and regional programs.

AU-SAFGRAD reviews (undated leaflet) show that progress achieved by individual sub-Saharan African countries in *Striga* control have been slow and non significant. This has been probably due to:

- The weak complementarities and synergy among NARES, IARCs, and other institutions engaged in *Striga* research and control.
- The fact that no single country in sub-Saharan Africa has the scientific capacities and resources to effectively control *Striga* infestation.
- The non-participation of farmers with multidisciplinary research teams engaged in improving agricultural production and productivity.

The current AU-SAFGRAD consultation supports the above review finding. Further justification for the current consultation is embodied in the contract document which alludes to the fact that to date, several initiatives are on-going aiming at reducing the *Striga* scourge on crops produced and consumed by the poor in Africa. Although these initiatives are working towards the same objectives and aims, the approaches are different, and very little coordination effort is put in place to ensure non-duplication of effort and pertinence of the collective action.

AU/SAFGRAD in collaboration with IITA and the Government of the Republic of Korea has been working towards enhancing the capacities of National Agricultural Research and Extension Systems (NARES) through development and implementation of a project on *Striga* research and control. This consultation will review this as well as other *Striga* control and management initiatives that could inform current control programs in sub-Sahara Africa (SSA).

The objective of this consultancy is, therefore, to take stock on existing *Striga* control programs and projects in Africa with the view to providing a framework for concerted action among these initiatives. Details of the terms of reference for the consultancy are in Appendix 1.

The Semi-Arid Africa Agricultural Research and Development (SAFGRAD) of the Africa Union was established in 1977 to advance agricultural research development and natural resource management in semi-arid ecologies of more that 30 countries of Sub-Sahara Africa. In support of its mandate to contribute to Africa's food production increase and poverty alleviation, AU-SAFGRAD proposes to launch a continent wide campaign for the control of *Striga* infestation in crops. The current study aims at assisting AU-SAFGRAD to realize this objective.

REVIEW OF *STRIGA* CONTROL INITIATIVES

Preliminary Initiatives at Striga control in Sub-Sahara Africa

Preliminary initiatives based on surveys and research on specific areas of *Striga* control has informed the sub-regional efforts to tackle the *Striga* problem. These have been reported by various NARES and IARCS and will be covered under this heading. Specific *Striga* control projects or programs of a sub-regional nature will be covered under a separate heading from which candidate case studies will be identified and recommendations for a future detailed study made. Possible areas of collaboration for a regional program on *Striga* control, success indicators and partner countries and a proposed implementation budget will be presented.

Nitrogen fertilizer effects

Increasing levels of soil nitrogen (N) have led to a decrease in *Striga* infestation in both cereals and legumes, notably, cowpea. Research on the effect of N on *Striga* did not appear conclusive (Adu et al 1986). While 30kg N/ha was effective in one location, higher levels (60-120 kg/ha) were required to effect control. It would seem that the original N status of the soil affects the response to N fertilizer application with regard to the control of the incidence of *Striga* infestation.

Kureh et al (2006) noticed that *Striga* incidence and crop damage were higher where no

N was applied and decreased at higher rates of N application. The application of 120 kg N/ha was adequate to control *Striga* and increase maize yields.

Elements for an integrated control method for Striga

Various elements for an integrated *Striga* control in Africa have been reviewed by Emechebe et al (1991) and Akobundu (1991). Integrated control measures involve various combinations of the elements for *Striga* control. The merits and demerits of the elements for an integrated *Striga* control are:

a. Destruction *Striga* plants

i) Physical

Hand pulling, hoeing or uprooting of whole plant (haustorium plus shoot) is a most common farmer practice. Hand pulling is an effective method of control done after tissues in the basal stem have become lignified. This ensures that the haustorial connections are removed with *striga* plants, thus preventing the regrowth that normally occurs when younger plants are pulled out and the haustoria re-sprout. Drawbacks of this practice are:

- *Striga* plants may produce ripe capsules before they are uprooted; such capsules subsequently dehisce to release large numbers of seeds.
- Hand pulling is ineffective for preventing loss in yield in the very season it is effected since damage to host plant occurs before *Striga* emerges from the soil.
- Hand pulling is laborious and expensive.
- Benefit from hand pulling occurs if done frequently (every 2 weeks).

ii) Biological control

This is the control or suppression of weeds by one or more organisms. Mammals, insects and pathogens are the potential biological control agents. Livestock may play a role in controlling *Striga* through grazing but this potential is realized where grazing occurs before *Striga* set seed.

Where seed has set, grazing is a major source of spreading seeds through the manure of ruminants. The use of biological control agents is an active area of research for *Striga* control.

iii) Chemical

This involves foliar application of herbicides to emerged *Striga* plants. This is effective especially if combined with tolerant or resistant crop varieties. Spot spraying with chemicals is effective. The drawback is that spraying may damage other crops in the intercrop.

b. Host plant resistance

This is the safest and most economical element for an integrated *Striga* control. Unfortunately grain yields of some resistance lines are low and efforts have been made to transfer the resistant genes into high yielding cultivars. Various *Striga* resistant sorghum and maize lines have been developed.

c. Cultural Practices

These include the use of fertilizers, crop rotation, land preparation, date of sowing and biological control.
Fertilizer: N fertilizers are most effective. Also organic manure is satisfactory. Limitation of fertilizer use is the cost.
Crop rotation: Use of non-susceptible trap crops e.g. alternating sorghum or millet with groundnuts (effective trap crop), soybean, cotton and bambara nuts when grown in rotation with a susceptible cereal host or as intercrops induce suicidal germination.
Land preparation: Deep ploughing is costly but effective.
Biological control: Some insects are known to destroy *Striga* e.g. *Smicronyx* weevil. Limitations will include the rearing and release of the predators.
Multiple cropping: Since host specificity is known to occur frequently in *Striga*, the direct effect of multiple cropping and crop rotation would be to prevent the persistence of a strain of *Striga* adapted to a particular host.

Principles of an integrated Striga management

So far no single control measure has proved successful in the control of *Striga*. There is therefore the need to understand the host-parasite ecological relationship in order to understand fully host specificity, the effect of multiple cropping, impact of crop rotations, the introduction of new crop varieties, etc. These factors are considered in an integrated management of the weed.

Technologies must be subjected to economic analysis before finally recommending to farmers.

With regard to **Research Findings** for controlling *Striga* various technologies have been presented (AU-SAFGRAD, 1999). These include the following:

- The IITA research and other advanced National Agricultural Research and Extension Systems (NARES) have generated resistant tolerant cultivars of maize and cowpea and agronomic practices including the use of nitrogen fixing legume trap crop cultivars.
- The International Agriculture Research Centers (IARCS) in collaboration with the NARES of Africa developed various agronomic practices effective against *Striga* such as intercropping with legumes or crop rotation with the appropriate *Striga* resistant and tolerant crops. This is especially so for Benin, Cameroon, Ghana, Nigeria and Kenya.
- The ICRAF has focused the use of short-term fallow of legume trees and shrubs such as *Sesbania sesban* and *Desmodium distortum* and the transfer of biomass and animal manure for improvement of soil fertility of infested fields.
- The ICIPE has emphasized N-fixing legume cover crops such as *Desmodium uncinatum* that repel the maize stem borer insect pests while controlling *Striga hermonthica* as trap crops.
- CIMMYT in East and Southern Africa has also identified improved maize inbred lines, hybrids and synthetic populations resistant to *Striga* for release. The use of low dose herbicides for control of *Striga* in host- plants developed for herbicide tolerance is included in the technologies developed by the CIMMYT.

The above research findings and other control elements mentioned earlier have formed the basis for the development of integrated *Striga* control packages for transfer to farmers for testing and subsequent adoption. The on-farm testing of technologies have been carried out in various collaborative studies funded by development partners. These special projects to be discussed include the following case studies:

- The Kenya Striga Control Initiative
- AU-SAFGRAD-Korean Government funded integrated *Striga* control project
- The FAO-Cameroon *Striga* Control Project.
- The EEC *Striga* Control Project.
- The DFID-IITA-IAR *Striga* Control Project.
- The CIMMYT-Kenya-AATF *Stritga* Control Project.

Case studies for *Striga* control in Sub-Sahara Africa

Case 1: Kenya Striga Control Initiative

Kenya had a National *Striga* Research Committee as at 1984 to develop *Striga* control methods for the country. Objectives of the *Striga* research committee were (Kiriro, 1991):

1) Survey the incidence and distribution of *Striga* species and strains in western Kenya and magnitude of the associated crop loss.
2) Classify and document *Striga spp.* and determine parasite –host specificity.
3) Select and develop *Striga*-resistant or tolerant varieties of sorghum, maize and sugar cane.
4) Identify trap crops most effective against *Striga*, especially legumes.
5) Identify efficacious herbicides especially, at the crop germination stage without damage to the crops and the environment.
6) Develop an economically viable integrated *Striga* control system for both large and small scale farmers.

The Kenya initiative lasted 3-4 years and collapsed thereafter due to funding constraints. In addition there was also an East African regional *Striga* committee at the same time but all these disappeared when financial support for the initiative was withdrawn (Odhiambo, Personal communication, 2007).

Lesson: Sustainable funding is a pre-requisite for the success of any *Striga* control initiative.

Case 2. AU-SAFGRAD-Korean Government funded integrated Striga control project.

The Africa *Striga* Collaborative Research and Control Program, funded by the by the Government of the Republic of South Korea and the then Organisation of African Unity was a response to the increasing *Striga* problem in sub-Saharan Africa. The project sought to enhance complementarities and synergy in the effective control of *Striga*. The program is implemented through partnership with participating NARS, farmers, IARI

(South Korea), IITA, CIMMYT, ICRISAT, the West and Central Africa Maize Network (WECAMAN) and the National Agricultural Extension Systems (NAES).
Through the project, various *Striga hermonthica* trials were conducted in selected countries of Western, Central, Eastern and Southern Africa in 1999 (OAU/STRC-SAFGRAD, 2001). The current report on the Collaborative *Striga* control project focuses on the work carried out in 7 countries of West and Central Africa, namely, Benin, Burkina Faso, Côte d'Ivoire, Ghana, Mali, Nigeria and Cameroon and stretches over the 2002-2004 periods.

The objectives of the collaborative programme were:

- To establish a *Striga* consultative group called the *Striga* Task Force (STF).
- To enhance on-farm adaptive evaluation of integrated *Striga* control technology packages.
- To serve as a forum for exchange of technical information as well as to articulate policy issues and build awareness from community to government levels.
- To articulate the link between *Striga* control and food security.

In the course of the trial various field visits were taken to project sites. The purpose of the field visit was to monitor implementation of the trials activities in West and Central Africa and to suggest recommendations for addressing eventual shortcomings (AU-SAFGRAD, 2005).

The AU-SAFGRAD Korean Government integrated *Striga* control project activities undertaken by participating NARS are summarized below (AU-SAFGRAD, 2005 Achievements):

- On-farm variety evaluation and demonstration
- On-farm rotation demonstration
- On-farm intercropping demonstration
- On-farm technology dissemination
- On-farm community seed production

Through these activities more than 5,180 farmers were reached in participating countries. The achievements measured over the 2002-2004 periods are as presented (AU-SAFGRAD, 2005 Achievements):

On-farm variety evaluation and demonstration

A total of 23 *Striga* tolerant or resistant (STR) maize varieties were demonstrated in 2002. Following the evaluation of the varieties, this number was reduced to 15 in 2004. Only 3 cowpea cultivars, 1 soybean variety and 1 groundnut cultivars were used during the same period as leguminous trap crop in the STR maize evaluation trials. The mean yield for STR maize was 2,131 kg/ha as opposed to 1,517kg/ha for the local maize. This corresponded to 40% grain yield superiority of the STR-maize over the local maize. This grain yield superiority varied from country to country, ranging from 29% in Cameroon to 63% in Burkina Faso. The study confirms that the farmer would be better off using the STR-maize whether or not it is infested with *Striga*. Even though sole STR maize could not reduce the *Striga* seed bank, it could at least slow down the rate of infestation.

On-farm rotation demonstration

On-farm rotation demonstration was conducted by 235 farmers in 6 countries. Grain yield obtained on STR-maize after 3 years of maize-legume rotation was 2,033 kg/ha. The local maize yielded 1,443 kg/ha. This represented 41% grain yield superiority of the STR-maize. The STR-maize grain yield superiority varied from country to country, ranging from 10% in Cameroon to 168% in Mali. This cropping system also showed a 44% less *Striga* emerged plant on plot planted to STR-maize as compared to plot planted to farmers' practices. This cropping system has the advantage of reducing the *Striga* seed bank as well as increasing the N content of the soil.

On-farm intercropping demonstration

This cropping system consisted of planting leguminous crop between maize hills or in between two maize rows at the same time or in relay cropping. Average grain yield obtained with this practice was 2,216 kg/ha and 1,700 kg/ha for STR-maize and farmers practices, respectively. STR-maize exhibited 30% grain yield superiority over the local practice. This superiority varied from country to country and ranged from 27% obtained in Benin to 105% recorded in Mali. This grain yield superiority was partly explained by the 47% less *Striga* plants emerged on STR maize as compared to farmer variety. Legume intercropping led to additional legume grain as well as gradually depleting the *Striga* seed bank.

Summary achievements of the AU-SAFGRAD-IITA Korean Government Collaborative *Striga* Control Programme.

After 3 years of on-farm verification trial using three integrated Striga control packages namely: variety demonstration, rotation demonstration and intercropping, the following observations were made:

- All the above strategies revealed at least 30% grain superiority of the improved STR technologies over the farmers' practices.
- Average grain yield obtained over the 3 years, was 2,000 kg/ha or more. This is already superior to the 1,000 kg/ha reported in sub-Sahara Africa
- The purpose of the project was to control *Striga* spp. Results summary after 3 years demonstrated that, the three strategies used by the project, resulted in 41% less *Striga* plant emerged on plot planted to STR-maize as compared to local practices.
- No significant grain yield difference was detected among the three cropping systems. However intercropping maize and legume tended to produce the least number of *Striga* plant emerged, followed by maize/legume rotation.

It could be concluded that, for long term maize production, the use of STR-maize either in rotation or intercropped with leguminous trap crop would be more sustainable. This combination has the advantage of producing additional grain legume while reducing the *Striga* seed bank. Intercropping maize/legume which seems to be the best practices is difficult to carry out when larger land area is concerned.

Other project benefits

Apart from the distinct benefits due to the introduced varietal and cultural innovations, additional project benefits were stressing are the capacity to produce quality community based seeds, successful collaborative research on *Striga* control and a positive socio-economic evaluation of the project. These are highlighted below:

Community based seed production.

In 2004, all participating countries produced at community level the seed quantity needed for their 2005 activities. A total of 11,673 kg of seed is available in participating countries. This will enable them to effectively pursue the scaling up of activities, including diffusion of seed to a larger number of farmers in 2005.

Collaborative striga research and control project

Through the trials, several promising maize varieties were identified to be further evaluated or released. In Cote d'Ivoire for example, Across 94 TZE Comp 5-W, Across TZE Comp 5-Y and IWD STR had better grain yield and less *Striga* emergence than farmers' varieties. In Benin and Ghana, *Striga* emergence was low. The trend observed is encouraging as to the effectiveness of STR maize varieties in *Striga* control.

A study on the economic analysis of the technologies also revealed that the improved technologies would yield higher net return under farmers' traditional mixed cropping than local varieties. Indeed, a cost-benefit analysis revealed a gross margin of $800/ha per farmer adopting the technology. A growing number of farmers (225 in 2003 and 1,225 in 2004) joined the project. The project has so far reached 5,180 farmers.

Only 20% of the farmers perceived that STR-maize demonstrated on farms were good to very good in reducing *Striga* incidence on maize. 67% of the farmers indicated that STR maize yielded better than their local maize and only 10% preferred their local maize to the STR cultivar.

Despite the above achievements, a number of constraints and shortcomings were observed. These, together with the achievements, are lessons to be considered in project scaling up to a continent wide *Striga* control initiative.

Constraints and shortcomings (AU-SAFGRAD, 2005 Achievements)

Constraints encountered

- Appropriate STR-maize was not always planted from the standpoint of suitability for the local growing season. For instance, planting of early maturity maize instead of intermediate maize in area with more than 1000 mm of rainfall such as in Benin, Cote d'Ivoire and Ghana or the use of intermediate season varieties instead of short season varieties in areas of less that 1000 mm rainfall as in Mali.

- Legumes used in some countries have not been tested as *Striga* trap crop. Given the fact that Benin and IITA have tested and classified many legume varieties as good *Striga* trap crops, it is recommended that STR maize varieties be used along with proven leguminous trap crop for all maize/legume inter-cropping trials.
- Annual reports from participating countries were most of the time submitted late.
- The late implementation of on-farm demonstration due to untimely funds availability, greatly reduced researchers efficiency to reach larger number of farmers on time.
- The non-availability of a project vehicle in participating NARS, did not permit timely visit on farms by the coordinating NARS scientists.
- The on-farm diffusion of the technologies will require the scaling up of on-farm community seed production.

Shortcomings

- The strategies used by the project have not been fully implemented by all countries. These strategies referred to relate to field days organization, training, video tapes film of activities and on farm diffusion of the technologies. To enhance technology transfer and participation of farmers, it is recommended that farmer's field day be organized for all successful trials.
- The project needs to cover all *Striga* endemic area of participating countries. This will require newer strategies for 2005 and beyond. These countries include Togo, Kenya, Ethiopia, and other countries in sub-Saharan Africa.
- To broaden the scope of project coverage it is then recommended to avoid planting trials too close to each other and in addition selected villages should be evenly distributed within *Striga* infested areas.
- The project needs to broaden the scope of its germplasm to include cultivars with better *Striga* tolerance as well as those showing herbicide tolerance such as tolerance to Imazapyr (IR germplasm) developed for East Africa.
- Finally, project evaluation by external committee need to be organized as well as impact assessment at participating countries.

Other shortcomings revealed by the author's review process indicated the following:

- No private sector involvement in seed production/distribution was apparent.
- Training of NARES did appear adequate. However, there is the need to train farmers before start of trials.

The project's strong points were the following:

- Sub-regional focus. 7 countries of West and Central Africa were involved.
- Strong partnership arrangement: It involved NARES, IARCS, Farmers
- Farmers were satisfied with the project.

Case 3. The FAO-Cameroon Striga Control Project.

This is one of the *Striga* control initiatives started in West and Central Africa in the mid-eighties and is reported by Parkinson et al (1991). Though country based, it has lessons

which can be emulated in a regional outscaling initiative.
The main cereals in Cameroon are maize, millet, sorghum and rice. Sorghum and millet are largely produced in northern Cameroon and feed a third of the population of Cameroon. N. Cameroon lies in the savanna and sahelian zones. Two-thirds of this land area is *Striga* infested.
Crop loss due to *Striga* is estimated at 30% and can be as high as 100% especially for maize and cowpea.
About 300,000 ha maize were severely damaged by *Striga* in 1984. This prompted the government to seek international assistance to tackle the problem. This led to a joint FAO/OAU meeting on *Striga* control in Yaounde, Cameroon in 1985. FAO played a supporting and coordinating role in the *Striga* control project which came to be known as the FAO/MINAGRI *Striga* Project.
The project was funded by the UNDP and executed by FAO. Crop Protection Agency, Ministry of Agriculture of Cameroon was the implementing agency. The project started in 1986. It is not clear when this project ended but it is likely that this was in 1990 following on the Parkinson et al (1991) report.

Project objectives were to:

1) Contribute to increase food crop production by reducing pre-harvest losses caused by *Striga*/weed complexes.
2) Ensure mastery by small scale farmers in *Striga* affected areas of acceptable technologies capable of being adapted for control of *Striga* and *Striga*/weed complexes.
3) Strengthen the Crop Protection Division of the Ministry of Agric by developing a cadre of specialist, middle level technicians and extension agents to handle the control of *Striga* and *striga*/weed complexes.
4) Develop and make available documentary information on the prevailing species of *Striga*, their economic importance and ways of coping with them.

The above project objectives are as relevant to-day as they were in 1986.

Project activities were:

1) Pre-extension evaluation of control packages in farmers' fields.
2) Survey of *Striga* infestatioin in Cameroon. This started in 1987 using questionnaires on incidence; 64 villages were surveyed.
3) Evaluate crop varieties for tolerance. This started in 1987. IITA materials were used for this.
4) Training. Training was at all levels from farmers through to technicians and post-graduate training of scientists. Training areas included biology and taxonomy of *Striga*, control principles, sprayer calibration and maintenance. Training was by weed specialists of the Institute of Agricultural Research (IAR) in Zaria, Nigeria and masters' training at Halifax, UK. Local training was at various levels offered in French, English, Hausa and Fulbe. There is little knowledge on understanding of Striga by farmers and policy makers in the sub-region. Such local training fulfilled this training need.
5) Study of possible mycological factors in host-parasite relation was undertaken. This activity also investigated trap crops. These have ability to deplete the *Striga* inoculum reserves in the soil. Trap crops induce *Striga* germination but are themselves resistant to attachment and penetration by the weed parasite. Cotton,

bambara groundnut (*Vigna subterranean*) and soybean were used as trap crops depending the location.

Various agro-chemicals including 2,4-D were investigated for effectiveness as post-emergent herbicides. Publications to complement extension efforts were to be made in French, English, Hausa and Fulfulde.
The follow up on the outcome of this project is not immediately known to this author but Parkinson et al (1991) indicate the training given in *Striga* weed management was successful among others.

Case 4. The EEC Striga Control Project.

The EEC *Striga* project which was executed over the 1985-1996 (11 year period) was led by the French government (Sallé, 1991). The objectives of the project were to:

1) Carry out basic research on *Striga* in French labs in close cooperation with West African scientists.
2) Train scientists from developing countries.
3) Build network in West Africa to coordinate all *Striga* research and extend the results to the entire region.
4) Undertake surveys on *Striga.*

Surveys were carried out by trained scientists (Mali, Burkina Faso) on various *Striga* specimens to aid future identification. During the survey, new *Striga* types, *S. aspera* on sugar cane in Burkina Faso and *S. passargei* on sorghum in Mali were identified. These *Striga* species are normally found on wild grasses but can attach economic crops.

Basic research under the EEC *Striga* initiative
This covered:

- Morphological aspects i.e. mechanical action in host penetration studied.
- Variation in host root properties. The study established that the water content did not change in parasitized sorghum but protein content of the roots increased when *Striga* was still underground. This confirmed that *Striga* is more damaging to the host during its underground life than after emergence.

Applied Research
This covered:

- Intercropping effects. 1 row millet + 4 rows groundnut was found effective against *S. hermonthica*. It reduced the number *Striga* plants per plot by 60%.
- Fertilizer effects. Use of fertilizers (100kg/ha ammonium phosphate +50kg urea/ha, 2.5 tons/ha farm yard manure or compost) did not reduce *Striga* infestation nor increase yield of millet.
- Screening of crop varieties for resistance to *Striga.*
- Field survey of *Striga* incidence was proposed. Accurate maps of the distribution of important *Striga spp* were to be drawn following surveys. A *Striga* identification manual developed will be used in the surveys.
- Manual/Posters showing the biological cycle of Striga and control measures were to be produced. This aspect required further sponsorship to be able to effect.

The EEC Project recommended the following as the composition for an effective *Striga* research team :

1) Agronomist
2) Socio-economist
3) Weed scientist
4) Coordinator/advisor

Outcome of the EEC Project on *Striga*

These can be summarized as follows:

- Basic and applied researches were conducted during the 11- year EEC Striga Project, which began in 1985 and ended in 1996. Intercropping and rotation reduced *Striga* emergence. In the intercropping studies, three rows of groundnut with two rows of millet reduced *Striga* plants by 50%. In cowpea and sorghum intercropping studies in Mali, position of the legume was important. The best result was obtained with the legume intercropped between sorghum hills and not in-between rows.

  It thus seems that cropping geometry is important in the efficacy of intercropping in *Striga* control.

- Participating national programs in Africa tested the effectiveness of many herbicides in controlling *striga*. Among the herbicides tested, the most efficient was 2, 4-D (amine form). However, herbicides will have to be applied for about three years for the level of *Striga* to be significantly reduced and yield increased.

- Crop varieties were useful as trap crops if they exhibited two properties viz. (i) if they induced germination of *Striga* seeds at a high rate, and (ii) if *Striga* seedlings were unable to effect successful attachment.

  These could be criteria for determining the efficacy of a legume as a trap crop.

- Best results in terms of yield were obtained with the local sorghum cultivars. A case was made for breeding using local cultivars for yield increase under *Striga*.

Significant genotype x environment interaction has been found in variety development studies for *Striga* control (Kim et al 1998). There is therefore the need to carry out testing in more than one location and one year. It may also be successful to screen for inbred lines that have lots of attachment but slow growth of the parasite.

Case 5: The DFID-IITA-IAR Striga control project.

DfID-IITA northern Nigeria Improved *Striga* Control Project

The Department for International Development-International Institute for Tropical Agriculture (DfID-IITA) northern Nigeria Improved *Striga* Control Project (Chikoye et al

2006) was funded following a June 2000 proposal submitted to DfID, UK by IITA and its partners on "Sustainable weed management strategies to reduce poverty and drudgery among small-scale farmers in the West African savanna". 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 project. In addition, DfID recommended their capacity building project (CBDD) as a dissemination avenue for ensuring that technologies reached the intended users, the small scale farmers.

The various stakeholders in the project and their roles in the partnership are as tabulated (Table 1). Each partner made a positive contribution to the partnership (Chikoye, 2006).

Table1. 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.
IAR (Institute of Agricultural Research, Zaria)	Coordinator of activities in the *Striga* zone.	Detailed knowledge of Kaduna State. Ongoing involvement in *Striga* research.
NGOs Sasakawa Global 2000	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 Development Program 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 group 150 farmers in 33 villages	Participation as equals in seeking sustainable ways of controlling *Striga*.	Detailed knowledge of their own environments. Existing indigenous

in the *Striga* zone were involved.		knowledge of Striga.

Source: Chikoye et al, 2006.

In the project, an Integrated *Striga* Control (ISC) technology was designed and tested on a large number of farms in the northern Guinea savanna (NGS) of Nigeria. In this zone farmers have traditionally adopted 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.

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 (Franke, 2006). The "mother" trial was carried out on-station by researchers at the Institute for Agriculture Research in Zaria, while the on-farm "daughter trials were managed by lead farmers who were selected by farming communities and represented institutes or groups within the community. The granddaughter trials were undertaken by secondary farmers who in turn copied and tried technologies on their own volition from the lead farmers. Such farmers were mentored by the lead farmers.

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.

In this study a Participatory Research and Extension Approach (PREA) was chosen to encourage farmers to test alternative *Striga* control options under their conditions. The process consisted of community analysis, problem diagnosis, action planning, experimentation, monitoring and evaluation using a "mother-daughter-granddaughter" approach to the research described above.

Design and conduct of on-farm trials

All communities ranked *Striga* infestation, along with poor soil fertility, as one of the main biophysical constraints for crop production. This was done before the conduct of the on-farm trials.

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). This was compared with farmers' traditional cereal-based systems. In the second year, all farmers cultivated local maize on the farmer practice (FP) plot to allow comparison with the maize in the ISC plot.

Results of on-farm trials

The yield of local cereals in FP plots was well below those of the improved maize varieties (Table 2). 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 characteristics included *Striga* tolerance and high nitrogen-use efficiency. 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.

Table 2. 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 Local legume-local maize	1.50 (0.22) 1.04 (0.54)	1.59 (0.12) 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 Soybean-improved maize Strip-cropping-improved maize	1.06 (0.09) 1.19 (0.09) 0.96 (0.42) maize 0.85 (0.19) soybean	2.75 (0.33) 2.94 (0.19) 2.54 (0.47)

Values in parentheses represent standard errors of the means
Source: Franke et al. 2006.

Deductions from the field trials

The following were deduced from the outcome of the field trials:

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. This recommendation would seem to have a policy implication.

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.

The overall achievement of the DFID-IITA *Striga* Control Project as determined by Ellis et al (2006) is as follows:

- 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 DfID-IITA *Striga* Control Project is a success worthy of emulation by new proposals.

Case 6: The CIMMYT-Kenya-AATF Striga control project.

Striga has infested over 210,000 ha of otherwise high potential cropland in west Kenya, placing the nation's food security at risk. At the request of local farmer organizations in 2004, and with assistance from the Rockefeller Foundation, national scientists and NGO partners developed a set of "best-bet" management options to combat *Striga*. These options developed and tested on farmers' fields comprised a number of *Striga* control technologies described in the text below (AATF 2006).

1. IR maize. This new approach is based on inherited resistance to a systemic herbicide (imazapyr), a method referred to as imazapyr resistance (IR). When IR maize seed is coated with the herbicide, germinated *Striga* seed attempting to parasitize the resulting plant are destroyed. Imazapyr is marketed under the trade

name STRIGAWAY®. Only 30 g of imazapyr coated onto seed is sufficient to protect one hectare of maize from *Striga* for 6-8 weeks.

2. Push-pull. Push-pull is an agro-ecological approach to resist *Striga* by establishing a *Desmodium* understory beneath maize. Root exudates of *Desmodium* induce dormant *Striga* seeds to germinate, a mechanism known as suicidal germination. They also exude substances that are allelopathic (harmful) to *Striga* plants. The push-pull system recommends planting alternate rows of maize and *Desmodium* and establishing *Napier* (elephant) grass around the field margins to also lure stem borer insect pests away from maize. This system was originally developed by ICIPE.

3. *Striga* tolerant varieties. These are available as open pollinated varieties (OPVs) or hybrids. These lines evade *Striga* by producing more roots below the *Striga* seed bank within the soil plough layer and by expressing less phytotoxicity in response to *Striga* parasitism. Resistant varieties may, however, become overwhelmed under severe *Striga* attack.

4. Intercropping (MBILI). This is based on staggering every other maize row and growing legumes in the resultantly wider inter-row. The legumes suppress *Striga* through suicidal germination while also procuring higher value legume intercrops.

5. Legume smother. This involves the use of legume in rotation with maize. The legume smother relies upon the suppressive effects of legume root exudates on *Striga*. Two grain legumes, groundnut and soybean, are grown in rotation with maize by planting them in alternating rows. This allows their roots to thoroughly explore the soil. Since neither legume is a host of *Striga* no parasitism is expressed and the seed bank is decreased.

6. Herbicides. The use of broadleaf herbicides, in both pre-emergent and post-emergent field application, is a valuable control measure of *Striga* but one that is beyond the pocket of most small-scale farmers. Many African farmers practice cereal-legume intercropping, a practice that is incompatible with field spraying.

The advantages and disadvantages of the above *Striga* control technologies are as presented (Table 3).

By 2006, field tests were installed in over 9,400 farms in western Kenya. After only 3 seasons of intervention, impressive gains were being realized. All the *Striga* control practices demonstrated potential benefits but IR maize resulted in the highest maize yield improvement and largest suppression of *Striga* (Table 4).

On farm testing in western Kenya has demonstrated that the application of only 0.7mg of herbicide coating per maize seed before planting protects STRIGAWAY maize cultivars from attack by *Striga* for 8 weeks, reducing Striga infestation by 86% and more than doubling maize yields or an additional 1.7 tons of maize per ha. In other words, an additional investment in herbicide of US$20 per ha by farmers offers additional returns of US$ 305 per ha. Intercropping or crop rotation with legumes also offers a great opportunity for controlling *Striga*, improving household nutrition and expanding market opportunities.

HOWEVER, *Striga* suppression technologies cannot work alone; they must be nested into rural development efforts that ensure farmers' access to input and output markets (AATF, 2006).

How the IR technology works: Maize that is specially bred for resistance to the systemic herbicide, Imazapyr, has its seeds coated with minute quantities of the systemic herbicide. When the maize germinates, the herbicide is absorbed by the roots. Upon germination the maize attracts the germinating *Striga* seed which are killed upon contact with maize roots. The IR Maize technology when combined with the known technologies for combating *Striga* has produced the most dramatic results in *Striga* control to date under tests carried out in western Kenya (Table 4).
The IR Maize is marketed under the trade name STRIGAWAY®. The STRIGAWAY® technology is owned by the agro-chemical company BASF that has licensed it to CIMMYT through the intermediation of the African Agriculture Technology Foundation (AATF) based in Nairobi, Kenya. CIMMYT and the Kenya Agriculture Research Institute (KARI) collaborate to build the IR trait into superior lines of maize and in the production of the foundation seed for hybrids of such maize.

It should be noted that each of the above *Striga* control measure has specific advantages and disadvantages thus presenting opportunities to combine the technologies within locally adapted *Striga* Eradication Initiatives (SEI's). No *Striga* control practice is applicable to all situations; rather each has its comparative advantages. Different technologies may be combined to control *Striga* in an integrated manner. The STRIGAWAY® technology is easily integrated with the other control systems for a very potent control tool for *Striga.*

AATF has developed a $12 million proposal to introduce the STRIGAWAY® technology into 10 countries of sub-Sahara Africa over a 6 year period. These countries are Kenya, Malawi, Tanzania, Uganda, Zambia, Ethiopia, Ghana, Mozambique, Nigeria and Zimbabwe.

Table 3 . Advantages and disadvantages of different Striga control technologies.

Control	Advantages	Disadvantages
IR maize	Improves maize yield while reducing *Striga* biomass and seed bank in the soil.	Currently available only for maize, requires accompanying technologies.
Tolerant varieties	Maintains maize yield under modest *Striga* infestation	Does not reduce *Striga* infestation, overwhelmed under severe Striga infestation.
Push-pull	Compatible with IR and tolerant varieties, reduces stem borer, lasts	Difficult and slow to establish, more difficult

	several seasons and provides livestock feed	to weed, no opportunity for grain legume intercropping, lowers net return.
MBILI (Intercrop)	Compatible with IR and tolerant varieties, increases options for intercropped pulses.	More difficult to plant and weed, requires several accompanying technologies.
Legume Smother (Rotation)	Produces higher value oil seed, reduces *Striga* biomass and its seed bank in the soil.	Requires large amounts of legume seed and maize must be grown in rotation, increases phosphorus requirement.
Herbicide Application	Compatible with IR and tolerant varieties, kills Striga shoots; suitable for different cereal crops	Expensive, seed bank unaffected, precludes legume intercropping, requires several accompanying tools and technologies.

Source: AATF. 2006. Booklet

Table 4. Benefits obtained from Striga control practices compared to the recommended maize hybrid H513 over 3 seasons in west Kenya

Striga control measure	maize yield improvement	economic return	Striga suppression
Imazapyr resistant maize	+44%	+50%	70%
Striga tolerant variety KSTP94	+41%	+61%	35%
Push-pull w/WH502 & *Desmodium*	+35%	-18%	41%
MBILI w/WH502 & groundnut	+40%	+65%	41%
Legume smother w/soya & g'nut	na	+84%	na

Source: AATF, 2006 Booklet
H513 average yield= 1.67 t/ha. H513 average net return $241/ha/season. H513 average Striga infestation = 5.4 stems of Striga per maize plant.
Seed price is $2.01 per kg (imazapyr treated). Seed rate is 20kg/ha. Striga affected area 210,000 ha.
Average adoption rate is 38%. Proven yield increase due to IR Maize= 44% (Table 4).

It has been shown from economic analysis that IR maize could become an important product among Kenyan seed producers and that the maize surpluses resulting from planting IR maize can greatly contribute to the rural economy of west Kenya.

CASE STUDY ANALYSIS AND THE SELECTIONS FOR IN-DEPTH STUDY

All the 6 cases reviewed offer useful lessons that can be introduced into the two case studies for further in-depth study. Maize is the crop that has received the most research and technology transfer study in all case studies. Although for the more semi-arid ecologies cereals other than maize should receive greater emphasis, due to the available knowledge and the far greater numbers of farmers cultivating the crop in sub-Sahara Africa the initial thrust on technology transfer will be on maize. More basic research and on-farm trials will have to be conducted on the other important cereals, sorghum, millet and rice to quickly upscale the resultant technologies in the near future.

Three of the cases studied stand out for possible upscaling in view of the general success. These are the AU-SAFGRAD-Korean Government funded integrated *Striga* control project, the DFID-IITA-IAR *Striga* control project and the CIMMYT-Kenya-AATF *Striga* control project. All the programmes offer good examples of inter-institutional collaboration involving national systems, CGIAR centers and local farmers. They have all used the common approaches of an integrated control involving resistant varieties, legume intercropping and rotation involving cereal-legumes. They have all led yield increases and positive economic returns to participating farmers. Farmers have generally been satisfied with the technologies. However, for the detailed study of selected initiatives, the AU-SAFGRAD-Korean Government led project and the CIMMYT-Kenya-AATF *Striga* control project have been selected. The selection of these two for further study for possible up scaling is due to their geographic coverage and the additional technology innovation introduced by the CIMMYT-Kenya-AATF IR-Maize project for the control of *Striga* in Kenya. An additional dimension of the IR-Maize project is the added partnership involving an agency (AATF) that has brokered a technology transfer deal between the owners of proprietary technology (BASF) and research and development institutions (CIMMYT and KARI) for the benefit of small scale resource poor farmers.

AU-SAFGRAD-Korean Government Striga control project.

Positive elements

The positive elements of the project such as the strong sub-regional focus (covered 7 countries in West and Central Africa), the strong partnership arrangement (NARES, IARCS and farmers) and the satisfaction with the outcome expressed by participating farmers should be rolled into a future upscaling initiative. The project reached over 5,180 farmers. However the project's weaknesses (shortcomings and constraints) identified above (AU-SAFGRAD 2004 Achievements) will need corrective action to enforce the very positive outcomes.

Issues to be addressed for future upscaling

- **Appropriateness of germplasm deployed:** Numerous *Striga* tolerant or resistant varieties were developed that did not march the growing seasons. Follow up study will need to develop STR-maize varieties that would suit the length of the growing season of the places it is to be deployed. Responsibility: NARS, IITA, AU-SAFGRAD (coordinating). Research duration will be about 3 years.

- **Appropriateness of legume trap crops:** In the use of legume varieties for use as *Striga* trap crops there is the need to screen various legumes for efficacy before use in maize-legume rotations or intercrops. Suggested test duration: 2 years concurrent with maize germplasm development for appropriate growing season lengths.
- **Delayed reporting:** Delays in the submission of annual project reports should be addressed to enhance timeliness of reporting. There is the need to determine causes for this during the follow up survey. The delay could be related to governance if there is no active sub-regional coordinator to prompt national coordinators or there are pervasive delays in the release of resources for the collaborative study (on-farm demonstrations) as experienced in the course of this project or that national teams are not harmonizing their efforts in addressing the workplans developed. The study review questionnaire will hopefully identify the course for the delays and recommend corrective actions.
- **Project vehicle:** In general, participating NARS complained about the lack of an appropriate project vehicle for timely visits to farms. Follow up studies on this project will need to address the transportation constraints. The feasibility of providing additional financial support for the use of vehicles belonging to participating countries will need to be examined. The possibility of purchasing dedicated appropriate vehicles for regular field visits will also need to be determined.
- **Seed supply:** Innovations in *Striga* resistant seed production will need to be introduced to enhance seed availability. Linkages between community seed growers and commercial seed producers and distributors should be examined to enhance seed production and distribution in a future project scale up phase. Appropriate questionnaires will be developed to gather the relevant information to strengthen the seed system.
- **Training:** Training related activities for farmers such as the organization of field days, the development of training videos and the production of brochures in the local languages and the official language should be undertaken. These activities were not accomplished in all cases. Follow up project design should include a

time-bound program for farmer field days in all participating countries. The researcher and extension involvement in the field days should be defined. A study visit should examine the constraints associated with the organization of this activity in participating countries. A template for video film development of activities should be developed and budget drawn for the localized production of the videos.

- **Technology diffusion:** To ensure the wide diffusion of technologies, selected participating villages should be evenly spread out within the key *Striga* endemic areas. Participating farmers identified for the follow up project should receive some basic training on issues of *Striga* control before embarking on the on-farm trials.
- **Sourcing germplasm:** The project should continue to source germplasm with better *Striga* tolerance coupled with drought tolerance and resistance to herbicides against *Striga*.
- **External project evaluation:** An external project evaluation committee should be constituted to independently assess the project after a stated time frame. It is proposed that this be a 5-year time frame and a 10-year final project evaluation.

CIMMYT-Kenya-AATF *Striga* control project

Positive elements

This project, also known as the IR-Maize project incorporated all the integrated *Striga* control elements of the introduction of a resistant variety and appropriate cultural practices. The value added technological innovation is the introduction of the imazapyr resistant (IR) maize (STRIGAWAY®) which further enhanced the *Striga* resistance and tolerance of maize. Yield increases in excess of 40% and a higher economic return from investment in the IR-Maize technology are the strong points of this technology. It is significant that these positive attributes were established following extensive farmer participation in field trials. Over 9,400 farmers in western Kenya participated in the programme. There is however the need to address project shortcomings in a future follow up study to further enhance the value of the IR-Maize technology to small scale farmers.

Issues to be addressed for a future upscaling

- **IR-Maize seed supply:** The major challenge to the IR-Maize technology is in the supply of the treated maize seeds at a price farmers can afford. It requires the facilitation of seed treatment and packaging for the small scale farmers. Extensive and continuous farmer education is required in the handling of treated seed from the stand point of health of the farmer and the loss in viability of seed not bred for resistance to the herbicide following contact with the herbicide. Future study should address the challenge of handling the treated seed to ensure safety and an affordable product by resource-poor farmers. The technology lends itself to the use by farmers who can afford to purchase inputs.

- **Produce marketing:** An NGO is currently involved with the assistance of farmers to market their produce through linking of farmers with buyers. There is the need to study and improve grain marketing that will result from large numbers of farmers adopting the technology. Follow up studies will examine the avenues available for product marketing to absorb expected increases in maize production.
- **Integrated legume based technologies:** The other legume based *Striga* control technologies developed with the IR-Maize as an integrated control approach have some disadvantages identified by the project (Table 3)such as seed supply and physical constraints to weeding and of the need to integrate livestock for use of forage biomass.

Questionnaire for further evaluation of the AU-SAFGRAD-Korean *Striga* control initiative and the CIMMYT-AATF-KARI IR-Maize project (Appendix Table 1) is attached. These questionnaires will be administered through advanced submission to identified respondents in the project countries and personal visits to assess the situation on the ground as well as direct discussion on issues of the questionnaires. A personal visit to the follow up project countries is necessary for any meaningful responses.

PROPOSAL FOR AN ALL-AFRICA INTEGRATED *STRIGA* CONTROL PROGRAMME.

A proposal for an all-Africa Integrated *Striga* Control Programme (AASCOP) must address the problem of food security and poverty reduction through a sustainable, cost effective control of the parasitic weed. As for the AU-SAFGRAD-Korea *Striga* project, the AASCOP will work closely with National Agricultural Research systems as well as with International Agricultural Research Centers such as IITA and CIMMYT to ensure that farmers will have access to crop varieties that are resistant to Striga.
Farmers' involvement in the project will be as equals with researchers and shall act as decision-makers, rather than research subjects or passive components of the farming system under investigation. It is envisaged that the execution of the project will be totally participatory. The "mother-daughter-granddaughter" participatory concept that was so successful in the DFID sponsored *Striga* control project in northern Nigeria will be introduced into the new programme. This will facilitate the adoption of new technologies generated.

The All Africa *Striga* campaign or project is considered in two phases, namely, an IR-maize integrated *Striga* control phase in the first 5-years of technology deployment (also included STR-sorghum, millet and rice) and a second 5-year phase of development and deployment of IR-sorghum, millet and rice integrated *Striga* control concurrently with the IR-maize technology as routine. STR-sorghum, millet and rice (non-IR) will arise from normal breeding and selection for resistant or tolerant material from the local germplasm in collaboration with IARCs (IITA and CIMMYT). These ordinary STR materials will be used pending the development of IR varieties. The budget drawn is for the AU-SAFGRAD component which will concentrate largely on 11 countries in West and

Central Africa (Table 5) in the two phases (Tables 8 and 9). AATF has its own budget developed independently to cover 10 countries most of which is for activity in Eastern and Southern Africa. In the short term (2-3 years).AATF intends to cover some countries in West Africa, namely, Ghana and Nigeria. The countries AATF is covering in the short to medium term are:

1. Kenya-pilot country. To be covered in 2007.
2. Malawi- 2008
3. Tanzania-2008
4. Ugnada-2008
5. Zambia-2008
6. Ethiopia-2009
7. Ghana-2009
8. Mozambique-2009
9. Nigeria-2009
10. Zimbabwe-2009

Eventually, AATF intends to cover all African countries with the *Striga* problem. A harmonization of the two initiatives is crucial now.

An AU-SAFGRAD AATF coordination plan is proposed subject to negotiations with the AATF. Activity timelines for the execution of the project is tabulated (Table 7).

Farmer selection for participation in the project:

For each country, participating farmers will be selected from the key *Striga* endemic zones. The selection will be executed by the collaborating research institution of the country in consultation with the extension or other appropriate agencies of the ministry responsible for agriculture, farmer-based organizations and agricultural supporting NGOs. Intensive public awareness campaign should precede the start of the project for both fresh participating countries and follow up countries. Baseline data on the current prevailing socio-economic status of farmers in *Striga* endemic areas should be conducted in the season preceding the start of technological interventions. For countries that have experienced a *Striga* control programme before, such data will be an update of the socio-economic data (area of infestation, current farmer production levels, farmer perspectives on the problem, farmer suggestions for dealing with the problem, current control initiatives, etc) earlier collected. A more extended sensitization will be required in countries or farming areas participating in the control initiative for the first time.

The countries to be involved in the program would be those with known severe infestation challenges (Fig. 2) identified for the AATF intervention as well as the additional ones within the AU-SAFGRAD mandate area. These countries are as tabulated (Table 5).

Table 5. Major *Striga* endemic to be considered in the all-Africa *Striga* control program

Western *Striga* Belt hax100	Eastern *Striga* Belt hax100

Benin	91	Ethiopia	80
Burkina Faso	26	Kenya	210
Cameroon	39	Malawi	268
Côte d'Ivoire	35	Tanzania	179
Ghana	102	Uganda	62
Nigeria	822	Zambia	55
Togo	60	Zimbabwe	144
Mali	na		
Niger	na		
Chad	na		
Senegal	na		

Modified from AATF (2006)

The programme's common goals and objectives are:

- Contribute to increased food production and poverty reduction by reducing the pre-harvest losses caused by *Striga* infestation.
- The development and transfer of methodologies for the sustainable control of *Striga* to farmers in sub-Sahara Africa (SSA).
- Build network of researchers, extension agents and policy makers to control *Striga* in SSA.
- Train a broad range of stakeholders from scientists to farmers in *Striga* research and general control methodologies. These will be in the official language and in the local dialects.
- Undertake *Striga* surveys on a continuing basis to assess distribution of *Striga* and extent of economic damage. This will also authenticate the *Striga* prevalence map of SSA.
- Develop and make available documentary information on the prevailing species of *Striga*, their economic importance and ways of controlling them.

Mechanisms for collaboration or Strategies for the all-Africa programme.

- For each country constitute a research team and a general *Striga* Task Force (STF). The research team should comprise the following:
    - Agronomist
    - Plant breeder
    - Socio-economist (Secretary to the task team)
    - Weed scientist
    - Coordinator/advisor

  The STF should comprise the following:
    - The country research coordinator
    - Two representatives of the Ministry responsible for agriculture- one from the Extension Service as Secretary to the task team and a representative of the Crop Services Division as STF coordinator.
    - A farmer representative
    - An agri-based NGO representative. The NGO will provide support to farmers in the areas for which they have primary responsibility. Such

support should include the identification of marketing channels for farm produce.
- Private sector seed distribution representative
- Private sector agro-chemical distribution representative. The private sector representatives will contribute to the determination of effective ways to distribute improved *Striga* tolerant or resistant seeds and agro-chemicals to farmers.

Sub-regional STF composition

At the sub-regional level (West and Central Africa or Eastern and Southern Africa) the STF shall comprise:

- *Striga* control project coordinator at AU-SAFGRAD as STF Chair for West and Central Africa (WCA) and the coordinator at AATF as Chair for Eastern and Southern Africa (ESA) STF.
- *Striga* research coordinator for each participating country in the sub-region
- Private seed company representatives (two) from the sub-region. For WCA one should be Anglophone and the other francophone.
- Farmer based organization representatives (two) from the sub-region. For WCA one should be Anglophone and the other francophone.
- Extension officers (two) from the Ministry responsible for food and agriculture. For WCA one should be Anglophone and the other francophone.
- NGO representatives (two). For WCA one should be Anglophone and the other francophone.
- Sub-regional research organization (SRO) representative. For WCA this will be CORAF/WECARD.
- Representative of IITA or CIMMYT operating in the sub-region

At the regional level the STF shall comprise:

- Director of AU-SAFGRAD as Chair
- Executive Director of AATF as Vice-Chair
- Two research coordinators selected from among members of the sub-regional STF
- One farmer based organization representative from each sub-regional STF
- One seed company representative from each sub-regional STF
- One NGO representative from each sub-regional STF
- SRO representative from each sub-region.
- One representative from each IITA and CIMMYT.
- One representative of FARA

Project coordination

An All-Africa *Striga* Control Agency (AASCA) is proposed for the All-Africa Integrated *Striga* Control Program (AASCOP) with headquarters at AU-SAFGRAD. The Director of AU-SAFGRAD will be the Chair of the Agency with the Executive Director of AATF as the Vice-Chair. AU/SAFGRAD would coordinate the activities of participating countries in consultation with AATF and ensure a regional perspective as well as ensure routine reporting, fund disbursement, general monitoring and organizing sub-regional meetings to assess progress of Striga control and to recommend remedial measures as necessary. A special coordinator should be appointed in the regional coordinating agency,

AU-SAFGRAD and AATF, for coordinating activities in West and Central Africa (WCA) and Eastern and Southern Africa (ESA) respectively.
In the AU-SAFGRAD and AATF partnership, **AU-SAFGRAD will**:

- Deploy the integrated *Striga* control program developed under the AU-SAFGRAD-IITA-Korean Government initiative in WCA.
- Negotiate with AATF for access to the herbicide tolerance gene for incorporating by IITA into the appropriate maize germplasm of the sub-region.
- Coordinate a test treatment of herbicide tolerant maize with imazapyr (STRIGAWAY®). This is to be done by the NARES and pilot Seed Companies of the sub-region with IITA oversight.
- Engage the NARES to test IR-maize in the sub-region in consultation with AATF and IITA.
- Scale up the IR-maize technology in the sub-region in consultation with AATF and BASF.
- Link up with AATF and BASF to facilitate the development of herbicide tolerant sorghum, maize and rice by the NARES and IITA.
- Deploy the tested IR-sorghum, millet and rice in consultation with AATF, NARES of the sub-region and BASF and interested seed companies in WCA.
- Hold various meetings with AATF and stakeholders on the progress of *Striga* control in Africa.

AATF will:

- Upscale the IR-maize in Eastern and Southern Africa and monitor success.
- Contact BASF and CIMMYT to develop appropriate IR-sorghum, millet and rice varieties for on-farm testing and deployment.
- Upscale the IR-sorghum, millet and rice in the appropriate regions of Eastern and Southern Africa.
- Facilitate the transfer of developed IR- cereal technologies to WCA through AU-SAFGRAD.
- Harmonise with AU-SAFGRAD activities in *Striga* control

Suggested coordinating agencies/leaders for the research team and *Striga* Task Force (STF) in proposed participating countries are indicated (Table 6).

Responsibility of the research team and STF:

The research teams will perform the following tasks:

- Undertake diagnostic study of the problem of *Striga* infestation and together with farmers design the control measures to be researched into in entry zones.
- Development and release of *Striga* tolerant or resistant seeds which will also suit the length of the growing season of participating project sites.
- Undertake economic analysis of the efficacy of control schemes.
- Develop appropriate integrated control measures for *Striga* in collaboration with participating farmers.
- Training of a broad range of stakeholders in Stiga control methodologies in collaboration with the agricultural extension services. Grassroots farmer training which shall involve the extension services will be in both the official language

and the local dialect as appropriate. Both the coordinating research institute and the extension agency will develop training brochures and a compact disc (CD) on *Striga* and its control. The coordinating research institute shall coordinate this activity.

- Undertake *Striga* surveys on a continuing basis to assess distribution of *Striga* and extent of economic damage. This will also authenticate the *Striga* prevalence map of SSA as well as contribute to the development of a regional *Striga* prevalence map to be undertaken by the regional coordinator (AU-SAFGRAD, AATF or FARA).

The STF at the country, sub-regional and regional levels will perform essentially a monitoring role of the progress of the *Striga* control schemes being implemented and make suggestions on combating emerging problems. They will receive and deliberate on the reports from each country or sub-region on the *Striga* control initiative. Farmer constraints with regard to access to inputs and market channels will be discussed by the STF.

Role of IITA and CIMMYT

The International Agricultural Research Centers (IARCS), IITA and CIMMYT shall work closely with the NARES in *Striga* resistant seed breeding and development and in specialized training of researchers on diagnostics, characterization of the *Striga* or socio-economic surveys and analysis.

Special role of BASF and the AATF

The German chemical company, BASF which holds proprietary rights on the herbicide tolerant gene and the herbicide (imazapyr), will register the chemical for seed treatment in target countries. The coordinating research institute and the ministry responsible for agriculture will facilitate BASF in this effort. Negotiations for the use and release of the herbicide tolerance gene in the country should be mediated by the AATF who will in collaboration with the NARES deploy the IR maize technology.

AATF will also liaise with AU-SAFGRAD, BASF, the NARS and the appropriate IARC in the development and deployment of the IR sorghum and millet for West and Central Africa as part of an integrated *Striga* development program for these crops.

There will be the need to create a forum for exchange of technical information as well as to articulate policies issues and build awareness from community to government levels. This may be through farmer field day activities, tours within the sub-region by farmer groups, researchers and policy makers, media support services like radio and television discussions and distribution of brochures and activity reports in the national language and major local dialects. This crucial task should be undertaken by the research coordinating institution with the collaboration of the extension services of the ministry in charge of agriculture in the country.

Frequency of meetings.

The national research team and the national STF will meet as required for 2 – 3 times in a year. These will be before the start of the cropping season, during the season and after the harvest. The sub-regional STF will meet once in a year while the regional STF shall meet every other year.

Raising the AASCOP campaign to a continental wide level by AU-SAFGRAD

AU-SAFGRAD shall:

1. Call meeting of experts to review the draft document on *Striga* control commissioned by it (AU-SAFGRAD).
2. Present the approved strategy document to AU/ NEPAD for endorsement.
3. Seek support of sub-regional economic unions (ECOWAS, ECCAS, COMESA, and SADC) to contribute funds to the campaign.
4. Present the proposal to bilateral donor agencies such as the EU, Gates Foundation, DFID, USAID, BMZ, and CIDA for support.
5. Present the proposal to multilateral donor agencies like the World Bank and the African Development Bank for support.

Components of the strategy document/technical proposal:

Project summary with problem definition and expected outputs/outcomes

It is estimated (FAO, 1989) that 7 billion US dollars worth of food is reported lost annually in SSA due to *Striga*. The greatest damage occurs in the savanna and sahelian zones under conditions of drought and poor soil fertility.
Varying levels of yield losses due to *striga* infestation have been reported. Losses reported in sorghum in Kenya range from 70% to total (Kiriro, 1991).
The most deleterious effects of *Striga* infestation documented has been on maize. In Kenya for instance, grain losses of 30-80% have been reported with an annul loss of about $1 billion (Kiriro, 1991). Mean yield loss in SSA is about 40%.
Many initiatives have been put in place to control the problem of *Striga* infestation in crops. Despite these efforts, the scourge of *Striga* infestation still ranges on. There is the need to harness resources and collate lessons learnt from various stand alone programs

for an all out Africa initiative to control *Striga.*

An All-Africa *Striga* Control Program with an estimated budget of $15,697,600 and lasting 10 years is proposed to execute the program. It is expected that over the first 5 years of the project, a sustainable *Striga* control program for maize will be in place at the level of the farming community, especially, the resource poor farmer in the near term. In the long term (5-10 years) a sustainable program shall be developed to cover the other key cereals, namely, sorghum, millet, rice and cowpea. The outcome of the program will be an enhanced food security in SSA and improved livelihood of farmers from the added income from the sale of farm produce.

Type of partnership desired

There will be a strong partnership between AU-SAFGRAD and AATF in the execution of the program. Both agencies have implemented pilot scale control programs for *Striga* with varying degrees of success and are at the point of out scaling the technologies developed and tested on farmer fields. The coordinating agency proposed for the program is AU-SAFGRAD but with both AU-SAFGRAD and AATF having independent budgets with clearly defined tasks for disbursement. Other partners for the execution of tasks are the national agricultural research and extension systems (NARES), farmers and their organizations, agric based NGOs, sub-regional research organizations and the IARCS (IITA and CIMMYT) and private sector agencies (seed companies and agro-chemical dealers and international seed and agro-chemical producing agencies, namely, BASF).

Financial elements/Budget

The proposed budget is $15,697,600 to be sourced from various agencies, namely, intergovernmental organizations (IGOs) such as ECOWAS, COMESA, ECCAS, SADC), bilateral sources (the EU, USAID, Gates Foundation, BMZ, CIDA, and DFID) and multilateral sources such as the World Bank and the African Development Bank.

Political dimension

AU-SAFGRAD will ensure that the program is submitted to the technical agency of the AU for its endorsement under the Comprehensive Africa Agriculture Development Programme (CAADP) pillar 4 initiative which deals with agricultural research, technology dissemination and adoption under NEPAD. Some harmonization with FARA's research support activities under its SSA Challenge Programme (SSA-CP, 2004) will be sought. One of the pilot learning sites of FARA under its SSA Challenge Program is the Kano-Katsina-Maradi pilot learning site (covers Nigeria and Niger) of West Africa where the problem of *Striga* infestation is endemic.
The endorsement of the IGOs of Africa will be sought to pave the way for funding support following their endorsement

Expected output and key indicators for measuring progress

The activities to be executed are as a result of the 2 case studies examined above for the AU-SAFGRAD-IITA-Korean Government *Striga* control programme and the AATF-KARI-CIMMYT IR-maize project. The objectives of the All Africa Integrated *Striga* Control Programme will inform the outcome or indicators for measuring success. These are summarized below alongside the expected output and partners (Table 6). The partners to lead various activities are also indicated.

Table 6 All Africa Integrated *Striga* Control Activities, Outputs and Outcomes

Activity	Partners	Output	Outcome/Success Indicators
1. Pre-project launch issues verification in participation countries	Consultant-leader NARES Farmer organizations	Appropriate questionnaires administered and analyzed. Verification visits to 4 Western and 3 Eastern *Striga* belts done. Visit reports	Enhanced project design and management
2. Conduct of baseline socio-economic studies in participating study areas.	NARES-leader Farmer organizations	Baseline socio-economic data published.	Basis for determining project impact determined.
3. Selection of villages and participating farmers in project countries	NARES-leaders Farmer based organizations	Farmers and villages in 11 participating countries of Western Striga belt and 7 Eastern Striga belt identified	Farmers sensitized and ready to start project.
4. Partnership building and Project Management Enhancement	AU-SAFGRAD-Leader WCA AATF-Leader ESA IARCS NARES NGO Farmer based organizations Seed companies	Network of researchers, extension workers, farmers, IARCS, IGOs, SROs exists in 18 countries and in the sub-regional offices. Various *Striga* management task forces in place and meeting regularly.	Collaborative efforts in *Striga* control visible at the country and sub-regional levels. Project objectives met.
5. Training of broad	NARES	Training modules	Farmers well

range of stakeholders- scientists, extension agents, farmers, seed companies, govt. officials.	IARCS-Leaders Farmers Policy makers	developed Video on *Striga* and its control developed. Farmer field days organized for each participating group of farmers once a year.	informed about *Striga* control issues. Scientists familiar with *Striga* biology and control. Policy makers integrate *Striga* control issues in national development agenda for food security.
6. Development of STR maize germplasm suited to the growing seasons of WCA	IITA-Leader NARES Farmers	STR maize foundation seed available for various growing season lengths in participating countries in 3 years of project inception.	Certified seed readily available to participating farmers in project countries.
7. Identification and screening of legume seeds for use as *Striga* trap crops.	IARCS-Leader NARES Farmers	Appropriate legume seeds for integrated *Striga* control in 11 countries of WCA and 7 of ESA identified for seed production.	Number of farmers seen integrating screened legume varieties into cropping schemes with cereals in participating countries noted..
8. Community seed growers and commercial seed producers identified for certified seed multiplication and distribution	NARES-Leaders NGOs Seed Grower Associations	x tonnes of certified maize seed and x tones of legumes produced for about x number of farmers in the participating countries	STR maize and screened legume seeds routinely planted in integrated *Striga* control schemes in 18 countries in SSA.
9. Release of IR herbicide tolerant gene for introgression into local maize varieties	BASF-Leader AATF IITA NARES	STR maize with herbicide tolerant gene developed and deployed as foundation seed in 18 countries of SSA.	IR-Maize readily available and being planted in integrated *Striga* control schemes
10. Registration of imazapyr herbicide and IR-maize	BASF-Leader Seed dealers Agro-input dealers	IR-maize certified seed readily available to farmers. Seed companies have seed treatment and packaging	IR-Maize readily available and being planted in integrated *Striga* control schemes

		facilities. Trained seed dealers in seed dressing and packaging present in 18 countries of SSA.	
11. Deployment of IR-maize integrated *Striga* control technology	NARES-Leaders IITA AATF Farmer based organizations Seed companies and Community seed growers	(No.?) participating farmers practicing integrated *Striga* control on farms in 18 countries of SSA (11 from Western *Striga* belt and 7 from Eastern *Striga* belt).	About 200,000 farmers in West and Central Africa and 100,000 in Eastern and Southern Africa will benefit the integrated IR-maize technology. At least 70% reduction in *Striga* incidence in farms and at least a 30% increase in maize production in participating countries.
12. Livestock incorporation into integrated *Striga* management schemes.	NARES-Leaders Farmers	Over 180 mt. of legume straw for cattle feeding in the 18 participating countries produced.	Increase meat and milk production in project areas noted.
13. Develop IR technologies for sorghum, millet and rice	BASF-Leader AATF IARCS NARES	IR-sorghum, millet and rice developed and deployed in participating countries.	Enhanced food security in semi-arid areas growing sorghum and millet seen. Increased rice production from *Striga* infested areas visible.
14.Periodic *Striga* prevalence surveys	NARES	Report update on *Striga* prevalence	*Striga* prevalence map available. Targeted interventions in *Striga* control facilitated.
15. External Project Evaluation	NARES Private Sector Consultants	5-year evaluation report. 10-year evaluation report.	Review of project management after 5 years. Comprehensive report on project. Guide to future projects.

The timelines for various activities are indicated in the Ghent chart below (Table 7) over the 10-year time span.

Table 7. Activity Timelines (Ghent Chart)

Activity	Yr0	Yr1	Yr2	Yr3	Yr4	Yr5	Yr6	Yr7	Yr8	Yr9	Yr10
1.Pre-project launch issues											
2. Conduct of baseline socio-economic studies in participating study areas.											
3. Selection of villages and participating farmers in project countries											
4. Partnership building and Project Management Enhancement											
5. Country coordinators active											
6. Sub-regional coordinators active											
7. Regional coordinator active											
8. Training of broad range of stakeholders-scientists, extension agents, farmers, seed companies, govt. officials.											

9. Development of STR maize germplasm suited to the growing seasons of WCA											
10. Identification and screening of legume seeds for use as *Striga* trap crops.											
11. Community seed growers and commercial seed producers identified for certified seed multiplication and distribution											
12. Release of IR herbicide tolerant gene for introgression into local maize varieties											
13. Registration of imazapyr herbicide and IR-maize											
14. Deployment of IR-maize integrated *Striga* control technology											
15. Livestock											

incorporation into integrated *Striga* management schemes.											
16. Develop IR technologies for sorghum, millet and rice											
17. Periodic *Striga* prevalence surveys											
18. External Project Evaluation											

Program budget proposed.

A special budget and activity reconciliation meeting is proposed between AATF and AU-SAFGRAD as part of the expert review of this consultancy report. This is because as mentioned above the AATF has developed a comprehensive all Africa *Striga* control project for which it is seeking funds. The AU-SAFGRAD AATF meeting is crucial to avoid needless duplication in efforts all of which have budgetary implications.

The Phase I budget (Table 8) is for the first 5 years and covers activities related to the development and deployment of IR-Maize and STR-Sorghum, Millet and Rice integrated *Striga* control technologies. This is worth US$7,237,600.

The Phase II budget (Table 9) covers the next 5 years after Phase I and covers activities related to the development and deployment of IR-Sorghum, Millet and Rice and IR-Maize integrated *Striga* control. It is worth US$8,460,000.

The total project value (Phase I and II) is US$15,697,600.

Table 8. IR-Maize Phase and STR-Sorghum, Millet and Rice Phase (Phase I) Budget (US $).

Activity	Yr1	Yr2	Yr3	Yr4	Yr5	Total
	-----------------X10^3-----------------					
1. Pre-project launch issues.	26.6	0	0	0	0	26.6
2. Conduct of baseline socio-economic studies,	120	30	0	0	0	150
3. Selection of villages and participating farmers.	30	0	0	0	0	30
4. Partnership building	50	50	50	50	60	260
5. Country coordinator (research)*	100	100	150	200	250	800
6. Country coordinator (STF)*	60	60	70	80	80	350
7. Sub-regional coordinator (SAFGRAD)*	120	120	200	250	400	1,090
8. Training	100	100	100	100	200	600
6. Development of STR maize for length of growing season.	400	400	0	0	0	800
7. Screening of legumes for *Striga* trap efficacy.	88	88	88	0	0	264
8. Identification of seed growers and distributors.	20	20	20	0	0	60
9. IR gene introgression into local maize varieties.	350	350	80	20	0	800
10. Herbicide and IR-maize seed registration.	15	12	0	0	0	27
11. Deployment of IR-maize integrated *Striga* technology.	100	100	50	20	20	290
12. Livestock integration	60	60	100	100	120	440

13. *Striga* prevalence survey	220	220	220	220	220	1,100
14. External project evaluation	0	0	0	0	150	150
Totals	1,859.6	1,710	1,128	1,040	1,500	7,237.6

*Salary/allowance, travels, meetings, administration

Table 9. IR-Sorghum, Millet and Rice and IR-Maize Phase (Phase II) Budget (US$).

Activity	Yr6	Yr7	Yr8	Yr9	Yr10	Total
	---------------------X10^3------------------------					
1. Partnership building	80	80	80	80	80	400
2. Country coordinator (research)	120	120	250	250	300	1,040
3. Country coordinator (STF)	100	100	100	120	200	620
4.Sub-regional coordinator (SAFGRAD)	140	140	250	300	400	1,230
5. Training	100	100	100	100	250	650
6. Identification of seed growers and distributors.	30	30	0	0	60	120
7. Deployment of IR-maize integrated *Striga* tech.	80	80	80	40	0	280
8. Livestock integration	100	100	120	200	250	770
9. Development of IR techs. for sorghum, millet and rice.	400	400	450	450	200	1,900
10. *Striga* prevalence survey.	250	250	250	250	250	1,250
11. External project evaluation.	0	0	0	0	200	200
Totals	1,400	1,400	1,680	1,790	2,190	8,460

Total for Phases I and II is US$15,697,600.

SUMMARY AND CONCLUSION

Striga is one of the most devastating weeds of cereal crops and some legumes in sub-Sahara Africa. Annual crop losses due to Striga in excess of $7 billion have been recorded for sub-Sahara Africa.

In support of its mandate to advance agricultural research, development and natural resource management in semi-arid ecologies of more that 30 countries of Sub-Sahara Africa and to contribute to Africa's food production increase and poverty alleviation, AU-SAFGRAD has commissioned the study on the review of various initiatives in SSA to enable the up scaling of the initiatives into an All-Africa Striga Control Programme. Previous initiatives have chalked varying degrees of success but the problem has remained intractable. The proposed campaign draws on the previous Striga control programs to develop the up scaled programme.

The 10 year program is set in two 5-year phases dealing with integrated IR-Maize and STR sorghum, millet and rice in the first 5 year phase and IR technologies for all cereals in the second 5 year phase. The budget total is $15,697,600. The integrated control program draws largely on the experiences of AU-SAFGRAD and AATF in Striga control in West and East Africa respectively and suggests the need to harmonize the two up scaled programmes.
It is hoped that the innovative partnership and technologies proposed in the All-Africa *Striga* Control Program, if it receives adequate and sustainable levels of funding support over the 10 year project life span will greatly enhance the course of *Striga* control in SSA and address the problem of food security and poverty so endemic in the drought prone infertile soils of the savannas of SSA.

REFERENCES

AATF , 2006. Empowering African farmers to eradicate *Striga* from maize croplands. The African Agricultural Technology Foundation. Nairobi, Kenya. 17 pp.

Adu, J.K., O. Leleji and A.M. Emechebe. 1986. N fertilizer effects on Striga attack of cowpea in Northern Nigeria. Internal Communication. IAR, Samaru, Zaria, Nigeria.

Akobundu, I.O., 1991. Integrated weed management for Striga control in cropping systems in Africa. In: S. K. Kim (edtd). 1991. Combating Striga in Africa. Proceedings, International Workshop organized by IITA, ICRISAT and IDRC, 22-24 August 1988. pp 122-125.

AU-SAFGRAD. Undated. Enhancing Food Security through Control of parasitic weeds (Striga spp.) in Africa's Crop Production. CONCEPT NOTE. AU/SAFGRAD Leaflet.

AU-SAFGRAD. 1999. Task Force meeting report on *Striga* research and control. 4-5 March, 1999. Abidjan, Cote d'Ivoire. PP 27

AU-SAFGRAD. 2005. African Union. Semi-Arid Africa Agricultural Research and Development. 2005. Scientific Monitoring Tour of the Collaborative Striga Research and Control Project in Africa. 22 October; 7 November, 2004.

AU-SAFGRAD. Semi-arid Africa Agricultural Research and Development. 2005. Collaborative Striga research and control project. 2002-2004 Achievements. 34 pp.

Chikoye, D., 2006. Project description and purpose of the conference. In: Chikoye, D., J. Ellis-Jones, G. Tarawali, and A.F. Lum. (Editors) 2006.Reducing poverty through improved striga control. Procs. of the Second Striga management stkeolders' conference. 8-9 September, 2004. Zaria, Kaduna State, Nigeria. Pp 9-12.

Chikoye, D., J. Ellis-Jones, G. Tarawali, and A.F. Lum. (Editors) 2006. Reducing poverty through improved striga control. Procs. Of the Second Striga management stkeolders' conference. 8-9 September, 2004. Zaria, Kaduna State, Nigeria. 120 pages.

Doggett, H. 1991. Coordination of Striga research. In: S. K. Kim (edtd). 1991. Combating Striga in Africa. Proceedings, International Workshop organized by IITA, ICRISAT and IDRC, 22-24 August 1988. pp 126-133.

Ellis-Jones, J, S. Schultz, D. Chikoye, P. Kormawa, and D. Adedza. 2006. Participatory research and extension in *Striga* and *Imperata* control in Kaduna, Benue, Cross River and Kogi States, 2001-2004: an overview. In Chikoye, D., J. Ellis-Jones, G. Tarawali, and A.F. Lum. (Editors) 2006. Reducing poverty through improved striga control. Procs. of the Second Striga management stkeolders' conference. 8-9 September, 2004. Zaria, Kaduna State, Nigeria. 120 pages. Pp 13-29.

Emechebe, A. M., S.T.O. Lagoke and J.K. Adu. 1991. Research towards Integrated Control of Striga in West and Central Africa. 1991. Procs. Of the SAFGRAD Inter-Network Conference held at the Palais des Congres, Niamey, Niger. 7-11 March, 1991.

Emechebe, A.M., B.B. Singh, O.I. Leleji, I.D.K. Atokple and J.K. Adu. 1991. Cowpea Striga Problems and Research in Nigeria. In: S. K. Kim (edtd).Combating Striga in Africa-Proceeding of International Workshop organized by IITA, ICRISAT and IDRC. 22-24 August 1988. IITA, Ibadan, Nigeria. Pp18-28.

FAO. 1989. *Striga* in Africa-Introduction. In: *Striga* Improved Management in Africa. In: Emechebe, A. M., S.T.O. Lagoke and J.K. Adu. 1991. Research towards Integrated Control of Striga in West and Central Africa. 1991. Procs. Of the SAFGRAD Inter-Network Conference held at the Palais des Congres, Niamey, Niger. 7-11 March, 1991.

Franke, A.C., J. Ellis-Jones, M.A. Hussain, I. Kureh, G. Tarawali, D. Chikoye, S. Schutze, B.D. Oyewole and R. White. 2006. Dissemination of integrated *Striga hermonthica* control technologies through on-farm trials in the savanna zone of northern Nigeria. In: Chikoye, D., J. Ellis-Jones, G. Tarawali, and A.F. Lum. (Editors) 2006. Reducing poverty through improved striga control. Procs. Of the Second Striga management stkeolders' conference. 8-9 September, 2004. Zaria, Kaduna State, Nigeria. 120 pages. Pp 30-45.

Kiriro, F.H., 1991. The Striga Problem in Kenya. In: S. K. Kim (edtd).Combating Striga in Africa-Proceeding of International Workshop organized by IITA, ICRISAT and IDRC. 22-24 August 1988. IITA, Ibadan, Nigeria. pp15-17.

Kureh, I., D. Chikoye, J. Ellis-Jones and A. Sanni 2006. Agronomic and economic performance of researcher-managed integrated Striga management strategies. Pp 46-61. In D. Chikoye et al 2006.

Lagoke, S.T.O, J.Y. Shebayan, J. Adeosun, E.N.O. Iwuafor, J. Olkosi, J.K. Adu, O. Olufajo, A. Emechebe, M. Zaria, A. Adeoti, J. Onyibe and S. Chobe. 1990. Survey of Striga problem and on-farm testing of intergrated Striga control package and evaluation on various Striga Control Methods in Maize, Sorghum and Cowpea in the Northern Savanna. Pan Africa Striga Control Network Workshop, IITA, Ibadan, Nigeria. March 10-14, 1990.

OAU/STRC-SAFGRAD, 2000. Collaborative Striga Research and Control Program in Africa: Report on field visit to on-farm striga demonstration sites in West and Central Africa. Submitted to the Government of the Republic of Korea. Implementation Report:SAF/STR No. 001. pp 28.

OAU/STRC-SAFGRAD, 2001. Collaborative Striga Research and Control Program in Africa . Annual Report 1999/2000 Funded by the Government of the Republic of South Korea through Kyungpook National University and the Organization of African Unity through SAFGRAD

Parkinson, V., S. Njinyam, G.O. Ayongwa and L. Ngawu. 1991. The FAO Striga project in Cameroon. In. S.K. Kim (edtd). Combating Striga in Africa. Proceedings, International Workshop organized by IITA, ICRISAT and IDRC. 22-24 August 1988. IITA, Ibadan, Nigeria. pp 111-121.

Sallé, G. 1991. Striga research for West Africa sponsored by the European Economic Community. In S.K. Kim. (Edtd.). 1991. Combatting Striga in Africa. Pp 117-121.

SSA-CP, 2004. Building Sustainable Livelihoods through Integratd Agricultural Research for Developmnt. "Securing the Future for Africa's Children". Sub-Saharan Africa Challenge Programme (SSA-CP). Programme Proposal. Volume 1, June 2004. FARA Secretariat, Accra, Ghana.

Appendix 1. Terms of reference for the AU-SAFGRAD *Striga* control study.

The terms of reference for the consultation are the accomplishment of the following tasks:

1. Desktop review of on-going and previous *Striga* control initiatives by regional and sub-regional institutions in Africa, and document lessons learned (success and/or failure). This review will cover the area of focus, geographical coverage, institutional networking, approaches, outcome, areas of possible collaboration with other actors in the same field, existing collaboration mechanisms etc.
2. Among these initiatives, select the two most effective initiatives for further in-depth study through appropriate means (mail interview using detailed questionnaire, eventual consultation visit etc.). (Case study).
3. Based on the study, determine the shared interest, common goals and objectives that could serve as a basis for collaboration and outline the most plausible mechanisms to put in place for such collaboration to be materialized.
4. Propose a strategy for AU/SAFGRAD to effectively raise this campaign to a continental wide level including but not limited to type of partnership, technical, financial and political.
5. Determine the expected output and key indicators for measuring progress.
6. Propose cost for the initiation of such program for making *Striga* a continental wide campaign

2007-04

FOSTERING STRATEGIC ALLIANCE FOR EFFECTIVE STRIGA CONTROLIN AFRICA'S CROP PRODUCTION

Alhassan, Walter S.

AU-SAFGRAD