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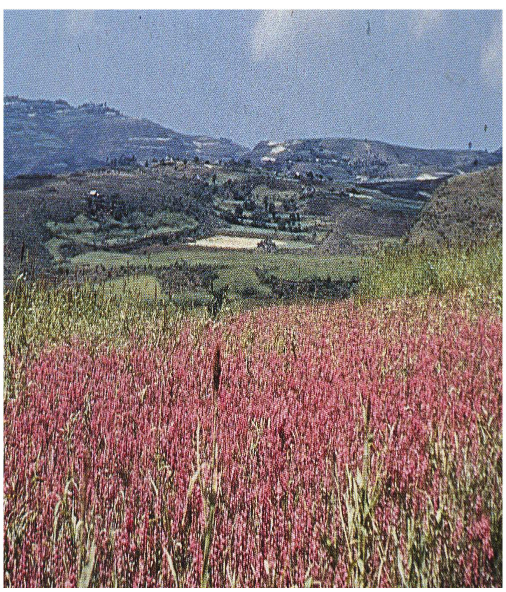
PARTICIPATORY *STRIGA* MANAGEMENT IN AFRICA: A TRAINING GUIDE



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FOREWORD

Food production in sub-Sahara Africa is severely affected by *Striga*. In the sub-humid and semi-arid zones where the bulk of the cereals and grain legumes is produced, and which already suffer from erratic rainfall and degraded soil conditions, parasitism by *Striga* can cause yield losses of up to 40% to complete crop failure.

The seriousness of the problem was repeatedly reaffirmed in many fora however, to the dismay of those suffering from the plague, efforts are still pursued in isolation, save the limited, but praiseworthy strives of the Pan-African *Striga* Control Network (PASCON). As if encouraged by the lack of concerted action but also due to the declining natural resource base, the *Striga* problem is growing from bad to worse. As the problem increases, favored by low fertility and unreliable rainfall, it is affecting the small-scale farmers who are least productive and least able to afford any inputs for its control.

Over the years, FAO, OAU, SAGRAD, and global and regional networks have created an awareness of this alarming problem. Unfortunately, the international community has not yet fully recognized its seriousness to farmers in Africa, who still lack the means to control *Striga* effectively.

SAFGRAD will continue to consider the *Striga* problem as one of the priorities to be solved in Africa. It believes that the implementation of a coordinated, continent-wide *Striga* program, directed towards enhancing networking activities, national research and extension programs is essential in overcoming this problem. This concern is also part of the serious approach of the organization to upgrade the status of food production in Africa. Each year, *Striga* reduces yield and production of important food grains that are consumed by the people in sub Sahara Africa. It is important therefore that the best *Striga* control measures be made available for use by farmers and Government institutions of these countries and help alleviate the incessant food shortages experienced.

One way of achieving this is through tailor made awareness creation and knowledge sharing functions. Focusing on training, which is an important component of such functions, SAFGRAD has produced this training guide for wide use by resource persons of African NARES assigned to provide action oriented training on Striga. It is hoped the publication will also be found useful by a wide array of potential users from research, extension and the academia. The ultimate aim is to contribute towards the desired goal of creating farming communities, and extension and development agents equipped with practical knowledge to make informed decisions and contribute towards bringing the ravages of the noxious weed under control.

Director, SAFGRAD

PREFACE

Arguably, *Striga* is the greatest biological constraint for food production in Africa, threatening the lives of over 100 million people. It is an economically important problem in 59 countries. Despite the enormous magnitude of the problem, efforts targeted against the scourge are fragmented and poorly coordinated. Access of farmers and development agents to new developments in research is very limited. A coordinated effort needs to be done to set up effective networking mechanism to facilitate free flow of information within and between countries. A series of organized awareness raising functions, and appropriate training programs are needed to create the level of understanding required to deal with the complex problem of *Striga*. The latter is particularly important to instill new thinking and galvanize the desire of stakeholders to come together, to pool their resources and face up to the challenge. Unfortunately, training guidelines that could be used by resource persons to help execute the task successfully are in short supply and hard to come by. A training guide that is handy and action oriented is thus developed and presented.

In the introductory part of the document, the major *Striga* species occurring in the continent, their distribution and importance is briefly described. The proposed training course comprises seven sessions. Efforts were made not to make the sessions loaded with bulky information that is hard to follow for non technical person. It was opted for a course that would pass a concise message, with some practical examples, to people on the ground. Three modules are developed that would allow to adopt the course to three groups of trainees i.e. farmers, extension and development agents, and junior researchers. The practical aspects of *Striga* control, participatory approaches, case studies and success stories are emphasized in the training module for farmers. It is recommended that the formal training is followed by measures to organize farmers in groups for participatory technology development and extension using for e.g. farmers field schools or farmers research groups to ensure continuity. Aside from the applied aspects, theoretical knowledge about *Striga*, and participatory research and extension approaches constitute the module for extension and development agents. In depth treatment of the biology of the parasitic weed, host-parasite interactions, new advances in science, research methodologies and integrated *Striga* management are the areas which received greater coverage in the training module for junior researchers.

Although the main thrust is to have a training guide with full fledged action oriented program on *Striga* biology and control, attempts have been made to make the document appealing and interesting to a wide array of users from extension to academia and, thus, description is given of some of the noteworthy endeavors on *Striga* management in Africa, new advances in *Striga* research and extension, participatory approaches and the success stories that have to be shared across NARES.

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and

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ACRONYMS AND ABBREVIATIONS

ASARECA: Association for Strengthening Agricultural Research in East and Central Africa

CIDA: Canadian International Development Agency

CIMMYT: International Center for Maize and Wheat Improvement

EARSAM: Eastern African Sorghum and Millet Improvement Network

ECARSAM: East and Central African Sorghum and Millet Improvement Network

EEC: European Economic Commission

EIAR: Ethiopian Institute of Agricultural Research

FAO: Food and Agricultural Organization

ICRISAT: International Crops Research Institute for the Semi-Arid Tropics

IITA: International Institute for Tropical Agriculture

INTSORMIL: International Sorghum and Millet Research Support Program

IRAT: Institut pour la Recherche Agronomique (Cameroon)

ISM: Integrated *Striga* management

MINAGRI: Minister Agricole (Cameroon)

NARES: National Agricultural Research and Extension Systems

OAU: Organization of African Unity

PASCON: Pan-African *Striga* Control Network

RTI: Royal Tropical Institute

SAFGRAD: Semi-Arid Food Grain Research and Development

STD: Science and Technology for Development

STRC: Scientific, technical and research commission

SWG: Scientific Working Group

UN: United Nations

UNDP: United Nations Development Program

UPMC: Universite Pierre et Marie Curie (France)

USAID: United States Agency for International Development

WASIP: West African Sorghum Improvement Project

1. **INTRODUCTION**

1.1 MAJOR *STRIGA* SPECIES, THEIR DISTRIBUTION AND IMPORTANCE

In the plant kingdom parasitism evolved independently occurring in at least 17 different plant families. But the families, which include species of importance as weeds number not more than eight. One family is known to contain parasitic members: Orobanchaceae. The family contains more than 45 genera and 1650 parasitic species, and, also, exhibits the entire range of trophic conditions found in parasitic plants - hemiparasites to holo-parasites (Nickrent and Duff, 1996).

Of the more than 30 known species three cause the greatest damage to crops in sub-Saharan Africa, namely, *S. hermonthica*, *Striga asiatica* and *Striga gesnerioides. S. hermonthica* mainly attacks sorghum, finger millet, and maize in tropical and sub-tropical regions spreading across from West Africa to Ethiopia. It is also a growing problem on rice in West Africa. *S. hermonthica* is the most important pest in crops throughout its geographical range. *S. asiatica* parasitizes sorghum, millet and maize in South Africa, maize and sorghum in East Africa and maize in West Africa; and *S. gesnerioides*, is a parasite of broad-leaved dicotyledonous plants including cowpea in West Africa, tobacco in South Africa.

Striga represents the greatest biological constraint for food production in Africa with greatest diversity in the savannas and grasslands north of the equator and it is an economically important problem in 59 countries (Mboob, 1989). It is estimated that *Striga* threatens the lives of over 100 million people in Africa. Two-thirds of the 73 million hectares devoted to cereal crop production in Africa is seriously affected. A conservative estimate of 40% crop loss is believed to occur due to *Striga* in Africa, representing an annual loss of cereals worth US $7 billion (Sauerborn, 1991). The overall loss in grain production amounts to over four million tons. Research reports further indicate that another 44 million ha grain producing area could be at risk. In East Africa, the parasite is a serious pest that threatens subsistence cereal production. *Striga* has recently been reported to extend to areas where it had not previously been present in the region.

1.2 NOTABLE PAST EFFORTS ON *STRIGA* MANAGEMENT IN AFRICA

1.2.1 Research collaboration and networking

Food crop production in sub-Sahara Africa is severely affected by parasitic weeds particularly *Striga*. Parasitism by *Striga* is the most important biotic constraint to food production in sub-Sahara Africa. Despite the general recognition of the *Striga* problem, most efforts to control these parasitic weeds were pursued in isolation. However, following the recommendation of the FAO-OAU All-Africa Government Consultation on *Striga* Control, held in Maroua, Cameroon, in 1986, efforts were made to promote more active collaboration for *Striga* research and control. Consequently, the Pan-African *Striga* Control Network (PASCON) was established at the FAO-OAU Workshop on *Striga* control in Africa, held in Banjul, The Gambia, in December 1988. The objectives of the network were to promote and facilitate exchange and dissemination of information, experiences and ideas on *Striga* research and control among institutions and *Striga* workers within and outside the Africa region; strengthen the capabilities of National Agricultural Research and Extension Services

(NARES) in the areas of *Striga* research and control; promote collaborative research for the development of appropriate and cost effective *Striga* control strategies; and promote their adaptation and implementation by the African farmers. The four founding NARES of PASCON in 1988 were Burkina Faso, Cameroon, Nigeria and Zimbabwe. In later years, PASCON managed to enroll 27 countries as active members and publish a newsletter, organize workshops and provide direct technical assistance to its members. Coordination at national and sub-regional level has been improved, and regional trials were formulated and promoted for on-farm testing in participating NARES. Since the inception of PASCON in December 1988, FAO has played the lead role in the promotion of collaborative *Striga* research and control activities in Africa. The Technical Secretariat of PASCON was based at the FAO Regional Office for Africa in Accra, Ghana, thus providing technical and administrative support to PASCON on continuous basis. The PASCON General Workshop was a major forum for facilitating exchange of information, experiences and ideas on *Striga* research and control. By publishing and distributing proceedings, PASCON and FAO were making latest knowledge on *Striga* research accessible to *Striga* workers in Africa. However, lack of sustained source of funds, which is the prime constraint to greater and wider-based network activities started to seriously affect PASCON since its infancy. Formal agreement of participating countries for participation in and contribution to the operations of the network did not exist to closely knit the network with national programs through institutional linkages. This would have allowed for better coordination, based on geographical commonality of the *Striga* problem, and membership would have expanded to enlist the support and leadership of strong national programs. Nevertheless, the attempt to forge a functional continent wide network on *Striga* through PASCON was praise worthy. Even though, it has not attained the desired status and set out objectives due to a plethora of reasons.

In the mean time, the *Striga* problem as massive as it is continued to draw attention of research and development organizations. Hence, a number of regional and sub-regional initiatives and networks, international agricultural research centers, UN agencies strived to fill the gap by rendering support to NARES at various levels. FAO was one of the main sponsors of *Striga* research projects across the continent. Apart from the wide support rendered to PASCON, the UN organization funded *Striga* control projects in Tanzania and the Gambia in the early 1990s. FAO also co-sponsored the UNDP/FAO/MINAGRI *Striga* control project in Cameroon during the same period. SAFGRAD operating several sub-regional commodity networks on maize, cowpea and sorghum in west and central Africa established scientific working groups to help coordinate *Striga* research in the region. Furthermore, recognizing the continent-wide responsibilities of PASCON, it rendered un-reserved support to strengthen the network's activities over years. SAFGRAD promoted region wide evaluation of resistant varieties and other control measures through its collaborative linkages (EARSAM/ICRISAT/SAFGRAD and OAU/STRC/SAFGRAD).

Two crops each under the mandates of IITA (cowpea and maize) and ICRISAT (sorghum and millet) are severely affected by *Striga*. In the early years (after 1988), aside from the main task of development and provision of diverse genetic materials, ICRISAT expanded its program to include development of *Striga* control technologies and training NARES scientists and technicians. ICRISAT devoted much of its *Striga* research efforts on host plant resistance. On the other hand, research on cowpea *Striga* was started by the IITA/SAFGRAD project in the late 1970s. During the course of the project, outstanding varieties with broad-based resistance to *Striga gesnerioides* were identified. With respect to maize *Striga* (*S. hermonthica*), IITA begun work in the early 1980s. However, early work only produced tolerance sources in several hybrids and open-pollinated varieties. IITA took measure in the 1990s to intensify its maize *Striga* research by recruiting more scientists and managed to step up and widen its contribution by working on a range of topics including biology, biological control and cropping systems. Intensive effort was done by the institute to strengthen the capacity of collaborating NARES. Training opportunities were offered by IITA scientists on a range of topics including *Striga* research techniques. The international research center was also working with national programs in the region through networks such as PEDUNE, PRONAF on cowpeas; and WECAMAN on maize to develop and disseminate *Striga* control technologies.

Financed by the French Ministry of Research and Technology, Mali National Program and the Universite Pierre et Marie Curie (UPMC) were engaged in a wide array of collaborative activities including agro-ecological and agronomic studies, and training of technicians and researchers under the tripartite arrangement between IRAT/ICRISAT/WASIP. In addition, UPMC, with financial support from the EEC, continued to work in collaboration with a number of West-African national programs including Burkina Faso, Mali and Senegal on *Striga* biology, taxonomy and bio-chemistry. Further, UPMC teamed up with USAID, ICRISAT and the Royal Tropical Institute (RTI) of Amsterdam on what was then called the Science and Technology for Development (STD) projects to support research and capacity building activities in that same region.

In the east, the East African Regional Sorghum and Millet Network (EARSAM) was the first to launch activities on *Striga* at regional level with the support of ICRISAT. The network was established at the 1986 East African Sorghum and Millet Workshop in Bujumbura, Burundi, by sorghum and millet scientists of the NARES in the region. The overall objectives of the network were to strengthen ties among NARES scientists in the region; promote free exchange of scientific information and germplasm; develop collaborative research on regional priority constraints; and establish a coordinated regional testing network for elite cultivars in the region. Since its inception, the network has made positive and significant contribution on sorghum and millet research in the region. Particularly notable are the effort the network made to promote free flow of elite germplasm including sources of resistance to *Striga*; improve the scientific skills of both NARES scientists and technicians in the network by organizing short courses and in-service training; provide a forum for NARES scientists to freely exchange research information and germplasm, and promote scientific interaction among the scientists through regional workshops, research monitoring tours, scientific working groups etc. With the support of the network, the Regional Scientific Working Group on *Striga* Research (SWG) was meeting regularly to review and approve *Striga* research and extension activities to be implemented at regional level, set regional priorities, plans and strategies. Unfortunately, because of lack of funds, EARSAM activities were suspended in the early 1990s. CIMMYT East African program with financial support from CIDA came in to fill the void and provide assistance to the SWG. The SWG reinitiated suspended activities and started identifying *Striga* control packages for region-wide testing well into late the

1990s. Regional networking suffered a setback again for a while and, in 2003, the East and Central African Sorghum and Millet Network (ECARSAM) came in to being. ECARSAM operating under the auspices of ASARECA has identified *Striga* as one of the most important constraints in the region. This network is currently funding two regional projects on *Striga* control with financial support from the European Union. The main emphasis of these projects is wide scale promotion of available *Striga* control packages in the region.

Research support programs, training institutes and advanced laboratories from Europe and North America have also played an active role in the area of *Striga* research and extension in Africa over the years. Their contribution ranged from generation of valuable information from basic studies to provision of technical support, training and human resource development. Notable among those were UPMC of France, RTI of the Netherlands, Long Ashton Research Station of UK, Purdue University and INTSORMIL of USA.

1.2.2 Training and capacity building

Many national programs were beneficiaries of the above described collaborative engagements with international research institutions, regional and global networks, advanced laboratories and research support programs. Consequently, many of them have managed to upgrade and equip their laboratories, and train their staff up to high level of qualification. One of the early projects was the FAO and USAID supported IPM project of the early 1980s. About nine countries vis. Cape Verde, Senegal, Gambia, Guinea Bissau, Mauritania, Mali, Burkina Faso, Niger and Chad took part in that successful venture, which significantly contributed towards strengthening research in the participating countries in terms of facilities and training. Universite Pierre et Marie Curie of France has been active for over ten years in Mali, Senegal and Burkina Faso offering capacity building and research support with funds obtained from the European Community. The more recent project, jointly supported by the Republic of Korea Government and African Union through SAFGRAD, has been and is still making a telling contribution in a number of West and Central African countries. The project renders its assistance for on farm implementation of *Striga* control measures, training of farmers, field days and scientific monitoring tours. As a result, consistent progress in *Striga* research and control has been achieved by participating countries. Furthermore, the project led to enhanced complementarity, synergy and partnership in research between the NARES, farmers, extension agencies, IARCs, IARI (South Korea), WECAMAN and SAFGRAD. Similarly, the International Sorghum and Millet Research Support Program (INTSORMIL) helped a number of East and West African national programs in terms of human resource development. Quite a number of researchers particularly from Niger and Sudan obtained higher degree training through INTSORMIL. A TCP project from FAO involving Benin, Burkina Faso, Mali, Niger, Senegal and Togo on IPM for *Striga* control, using the improved research and extension approach of FFS, has come to conclusion recently. The project created an opportunity for farmers, from the participating countries, to experiment themselves and select and adapt technologies suitable for their circumstances.

Considerable efforts were made by regional and global networks, UN and government agencies, advanced laboratories and research support programs to strengthen African NARES and contribute towards the alleviation of the *Striga* problem in the continent. But, most of the assistance focused on the implementation of joint research activities and training of researchers for higher degrees. Very little attention has been given to finding ways of making gains made in research known by the end user through training and other appropriate means. There still is paucity of appropriate training manuals and guidelines for conducting training to convey knowledge and information generated by research to the people on the ground i.e. extension agents and farmers. Even though, there are some encouraging developments of late. Manuals such the ones on weed management for developing countries (FAO), *Striga* research methodologies (IITA), research and extension on parasitic weeds (by Kroschel of Hohenheim University, Germany) have come out, and, these will definitely serve useful purpose and help bridge some of the gaps. However, as yet unaddressed major issue still remains and that is a tailor made action oriented training module specifically on the subsistence farmers' worst enemy in sub-Sahara Africa – *Striga*. Most of the manuals produced so far are either on parasitic weeds in general or research per se, and not designed to convey information of practical significance to the farmers plagued by the scourge.

2. OBJECTIVES OF THE TRAINING

Training of farmers, extension staff and young researchers is of paramount importance if they are to make visible contribution in the implementation of integrated control strategy and approaches. It is indispensable that these groups know about the ecology and biology of parasitic weeds. It is equally important to be able to recognize and discuss the relation of parasitic weed control with ecological, economical, social and cultural factors relevant to farming. It is absolutely necessary to create the necessary awareness that only the long term application of a combination of control methods can substantially reduce the threat by parasitic weeds to crop production.

The course that is going to be given using the described guideline will be action oriented, hands on training for farmers, extension agents and junior researchers. Deliberate effort has been made to make course contents easy to understand and adopted by local resource persons (probably often non Striga experts) who will be recruited to conduct the training.

Specific objectives are:

- To help farmers and development agents get an in-depth and comprehensive knowledge of the most practicable, feasible and low cost *Striga* management technologies
- To contribute towards wide dissemination of basic knowledge on the biology and ecology of *Striga*
- To review the most notable advances and achievements made in *Striga* research and extension in Africa and make them widely known and then used as an input in future endeavors
- To demonstrate, to the wider public, the paramount importance of community approaches and partnership for effective control of parasitic weeds

3. TRAINING SESSIONS

3.1 PLANT PARASITIZM: SOME IMPORTANT TERMINOLOGIES

Parasite: An organism depending on another host organism for part or all of its nutrition

Hemi-parasite: A plant which is only partially parasitic, possessing its own chlorophyll (green colour) and photosynthetic ability. (May be facultative or obligate - see below)

Obligate parasite: A plant which cannot establish and develop independently

Facultative parasite: A plant which normally behaves as a parasite for some of its nutrition, but is able to grow independently if necessary

Holo-parasite: A plant that is totally parasitic, lacking chlorophyll

Haustorium: The `bridge' of tissue connecting the host and parasite, usually a swollen mass consisting of both host and parasite tissue

3.2 DESCRIPTION OF *STRIGA* AND RELATED SPECIES

Alectra vogelii

Alectra vogelii is identified by its narrow, dull-green leaves and short, uniformly hairy calyx. This species attacks mainly legume species and is a serious parasite of cowpea and groundnuts in parts of western, central and southern Africa, especially in Botswana.

Alectra vogelii

Buchnera hispida

This is an erect plant up to 1 m high, rough to the touch (hispid), with simple lanceolate leaves up to 5 cm long and small (0.5-1 cm diameter) bright blue flowers. This is a facultative hemi-parasite, which can if necessary, establish and continue to grow without a host. If other plants are present, however, it can make attachments to the roots of almost any other species. It is a characteristic of the facultative parasites that they show a very wide host range. It occurs very widely in Africa in natural grassland, apparently parasitizing mainly grass species. It has not been recorded on any crop except in West Africa where it is occasionally reported damaging sorghum and millet.

Buchnera hispida

Ramphicarpa fistulosa

This is also an obligate hemi-parasite with very small seeds but with finely divided foliage and a large pure-white flower, 1-2 cm in diameter which opens in the evening. It occurs sporadically under wet soil conditions. In West Africa, it is known to parasitize and cause some damage to rice under partially flooded conditions.

Ramphicarpa fistulosa

Striga asiatica

Striga asiatica is a self-pollinated species. It is a much smaller plant than *S. hermonthica*, normally growing only up to 15 to 30 cm high. Leaves are green and entire, but smaller than those of *S. hermonthica*. Flower color varies greatly but the commonest are orange, yellow, red and white.

Striga asiatica

Striga aspera
Striga aspera is a cross-pollinated plant and it is similar to *S. hermonthica* in all other aspects except that it is smaller. The major distinguishing characteristic being, that the corolla tube has glandular hairs and extends beyond the tip of the calyx before it bends.

S. aspera *S. hermonthica* (left) *and S. aspera* (right)

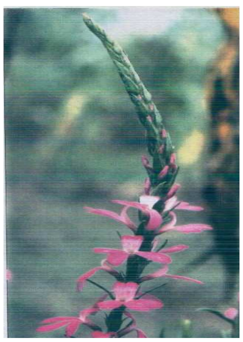
Striga forbesii
Striga forbesii is an erect herb, intermediate in size between *S. asiatica* and *S. hermonthica*, often 30-40 cm high, and differing from both those species in the shape of the leaves which are broader. Flowers are large, comparable with those of *S. hermonthica* and pink, scarlet or yellow in color. The species can be distinguished from *S. hermonthica* by the presence of two flowers only open on each inflorescence and lobed leaves. *S. forbesii* occurs in wetter situations. Although rarely reported attacking any crops, it is damaging to maize and sorghum in Zimbabwe and Tanzania, and to rice in West Africa.

Striga forbesii

Striga gesnerioides
Striga gesnerioides, unlike other *Striga* species, forms a very large tuberous haustorium, which may reach up to 3 cm in diameter. On crop hosts, the plant is usually extensively branched, with stems growing 15 to 20 cm high. The reduced scale-like leaves are pressed to the stem. The flowers vary from light pink to a dark purple. In rare cases may be white or yellow. The flowers are packed together up the stem. Cowpea is the most extensively attacked crop in West Africa, but the species is also known to be damaging to tobacco in Southern Africa.

Striga gesnerioides

Striga hermonthica
Striga hermonthica is the largest of the species occurring commonly as weeds. It is an annual, cross-pollinated and erect herb, usually at least 30-40 cm high and sometimes 100 cm or more. In *S. hermonthica,* wide variation has been recorded for plant type, corolla shape, size, and color. However, the color of the flower is normally bright pink although white flowered plants are occasionally found.



Striga hermonthica

3.3 BIOLOGY AND ECOLOGY
To introduce trainees to the main parasitic weeds in Africa, description of *Striga* and related species is given in the above chapter. The subsequent chapters are on biology and control of *Striga*, as it is the most serious pest in African agriculture.

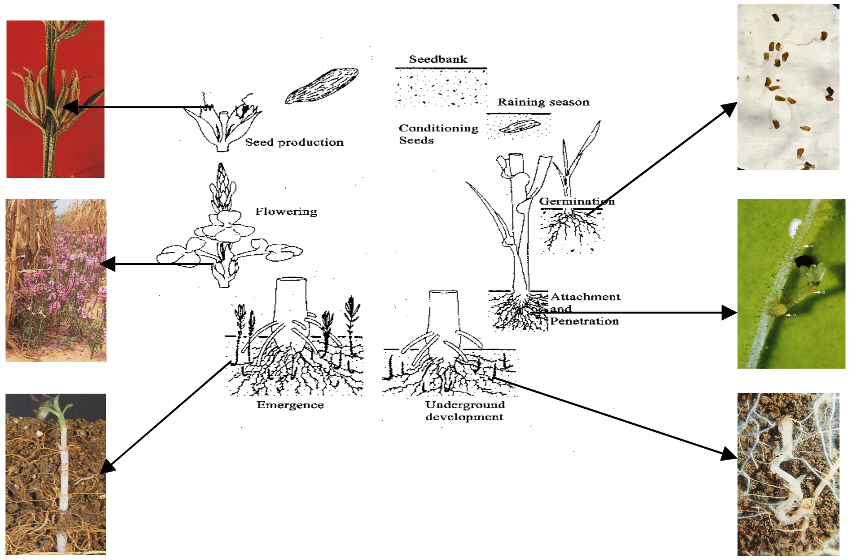
3.3.1 LIFE CYCLE
It is pertinent to begin the training sessions with an introduction to the biology of *Striga*. Here the main purpose is to give a general description of the process, which starts with explanations about the seed in the soil up to the formation of mature plants. The intimate relationship between host and parasite, and the exchange of signals between the two is worth mentioning without going to great technical details about the nature and biochemistry of the whole complex interaction.

MATERIALS

As regards to materials required in this session, a poster or a good drawing depicting the lifecycle (see figure below) of *Striga* is all that would be needed.

PROCEDURE

- It is useful to start this session by explaining about *Striga* seeds, that they are produced in enormous numbers (50000 to 200000 seeds/plant). The seed is very minute (0.2 mm) and can remain viable in the soil for 15-20 years. (It would be helpful to show for e.g. the size difference between *Striga* and maize seeds to make trainees observe how tiny and numerous the seeds are).
- The obligate nature of *Striga*, that it is capable of only limited seedling growth before the seed resources/seed reserves are exhausted.
- The seeds are usually dormant for a few months after harvest before they acquire the capacity to germinate. Once dormancy requirement is satisfied, the seeds need a period of conditioning.
- The need for conditioning of *Striga* seeds. The inability of *Striga* seeds to germinate, even in the presence of a stimulant, until they have been imbibed (kept in wet conditions) for at least few days, and ideally 1-2 weeks, at a suitable temperature. The seeds have to be very close to the host root (within 10 mm) to be stimulated. At favorable temperature of 30-35 ^{0}C, seed germination occurs within 24 hours.
- The optimum temperature for *Striga* seeds to germinate is 30 ^{0}C, although seeds are capable of germinating over a wide range of temperatures from 20 ^{0}C to 40^{0}C.
- Once the seeds have germinated in response to chemical stimulant from the host, they have to make contact with the host root in order to parasitize it. There appears to be chemotropic behavior that assists the parasite's root to grow in the direction of and make contact with the host root. Up on contact with the root, the tip of the *Striga* radicle transforms itself into a haustorium (a round and swollen attachment organ). Sticky hairs develop on the young haustorium, which help the parasite to adhere to the root. *Striga* then produces enzymes that assist it to penetrate the host root.
- After establishment, the parasite damages the host by withdrawing photosynthates (food) and affecting its hormone balance. Young *Striga* seedlings are completely parasitic while they are under-ground, at this stage, they cause maximum damage. After emergence from the ground, they, develop green leaves that produce their own photosynthates. However, there is a continued flow of carbohydrates, water and minerals from the host, which disrupts normal growth.
- After germination and attachment, *Striga* takes a few weeks to emerge, depending upon the depth of the seed in the soil. After emergence, it takes about 4-8 weeks to complete its life cycle. Thus, 2-4 months are required from germination to seed production. It is often observed that *Striga* can complete its life cycle on the crop stubble after the host crop has been harvested and removed from the field.
- *Striga* is a pest of warm and dry climates, and it is more of a problem in areas with poor and depleted soils. Appreciating the latter is particularly important, because building the fertility of soils is considered so critical in controlling *Striga*.



***Striga* life cycle**

3.3.2 SURVIVAL AND DISPERSAL MECHANISMS

The shear number of seeds produced by each plant (up to 200000/plant) and tiny nature of the seeds (0.2 mm) are certainly the factors contributing to the invincibleness of *Striga*. The small seed size is associated with the obligate nature of the parasitism. Unless, the seed gets chemical signal from a very nearby host it can lay dormant but viable for up to 20 years.

Therefore the prolific seed setting ability and consequently the ability to create a huge seed bank in the soil in a short period of time, coupled with the longevity of the seeds and the very light nature of the seeds that make them easily dispersed by wind, water, cattle, man and other agents make *Striga* one of the most troublesome weeds in agriculture.

PROCEDURE

- Show the very unique seed setting ability of the parasitic weed. Taking a mature *Striga* plant, the trainer can show the very large number of seed capsules (up to 60 per plant) produced by an individual plant. Making trainees observe the numerous seeds contained in each capsule (up to 700 per capsule) by breaking one open is very informative.
- Further, using the plant samples indicate how seed production progresses from the lower capsules. The capsules at the top could be green and immature, while the ones at the bottom are already mature and shattering, and this is one of the factors that should be taken in to consideration to effectively control *Striga*.
- Have a display of samples of seeds of *Striga*, maize and sorghum for size comparison. Mix seeds of *Striga* with sorghum and maize and demonstrate how the *Striga* seeds are so invisible in the crop seed.
- The longevity and hardiness of the seeds. Note that the seeds can pass through digestive system of animals un-harmed, and stay viable for 20 years and more.

- The spread and dispersal mechanisms. Wind, farm implements, animals are some of the agents but stress that the major means of dispersal is contaminated crop seed.

NOTE

- With the regular movement of seed on sale, exchange or donation within and between countries; and of breeding lines and promising new varieties between research programmes, it is vital that every precaution is taken to ensure that seed batches are not contaminated.
- To be completely safe, any seed due for export to as yet un-infested regions should be produced from un-infested sites.
- Research on *Striga* should only be carried out at sites which are already infested.
- Parasite seed should not be collected in one region to be used at an infested research site elsewhere in the same country until the host range of the sample being moved is fully understood.

3.4 PRINCIPLES AND PRACTICES OF STRIGA CONTROL

3.4.1. PREVENTION

Proper sanitation measures are essential especially when dealing with noxious weeds like *Striga*. The major focus has to be placed in protecting less and non-infested areas as it is more practical to manage new parasitic weed incursions. Once it is established it is nearly impossible to get rid of *Striga*. In already infested fields, weeds in the perferial areas have to be also removed in order not to allow weed seed production and dissemination.

PROCEDURE

- Stress the need to conduct survey or use available information to map out the infestation distribution in an area
- For non infested or newly infested parts, strict sanitation and quarantine measures have to be enforced to prevent introduction of contaminated seed and farm implements. The movement of livestock also needs to be restricted and monitored. Seed that is used in such areas has to originate from non infested areas
- For moderately/highly infested areas care has to be taken to prevent introduction of more virulent races. Use of clean and certified seed is also of immense value in such areas. Particularly, all efforts should be made not to allow aggressive *Striga* populations, capable of attacking new crops spread to new ecologies and set seed
- Care must be taken to ensure that traditional harvesting and post harvest handling methods do not lead to contamination of grain by *Striga*. E.g. Majority of farmers in Burkina Faso put the harvested crop on the ground and such practice should be discouraged to minimize the risk of contamination of crop produce

3.4.2 HAND WEEDING

Hand weeding of *Striga* plants is the most feasible control approach for the small-scale subsistence farming community in Africa. However, effectiveness largely depends on proper timing of the operation. Experience showed that hand pulling could be efficiently and economically done late in the season (during flowering) with less than one-half of the labor input required for early season weeding (at vegetative stage, farmer's practice). Furthermore, late pulling is less tedious and more manageable as one has to pull out only the flowering *Striga* shoots. However, care must be taken to weed out all flowering *Striga* plants before they set seed, and continue the weeding operation up to and beyond harvest.

PROCEDURE

- Take freshly collected *Striga* plants at different growth stages to show the difference in fleshiness of the stems. Indicate the fact that it is not only easy to pull out a mature and flowering *Striga* plant which has woody stems but also more effective.
- Pulling out young plants at early vegetative stage is often a futile exercise as it induces re-sprouting of more shoots from underground buds.
- Rigorous weeding is particularly encouraged where infestation is very localized and the density is very low; and in areas where a new population, capable of infesting new crops, is suspected of developing
- After pulling, stress the need for drying of plants, in pits, and burning to prevent seed dispersal
- Indicate the need for managing un-necessary expectations of the farmer associated with use of this particular method. He/she has to be informed that it is nearly impossible to get immediate return from hand pulling. Experience shows realizing improved crop yields, in the first season, is difficult to accomplish, as most of the damage is done before *Striga* emergence. The ultimate aim of employing such practice must be to prevent seed setting and realize better economic returns as a result of diminished infestation in the long run

3.4.3 HOST PLANT TOLERANCE/RESISTANCE

A huge amount of resource was spent on research to identify tolerance/resistance sources against *Striga* worldwide. The outcome has been largely discouraging and very variable across crops and *Striga* species and populations. Nevertheless, notable advances have been made in sorghum, maize (horizontal resistance from IITA and IR technology of BASF/CIMMYT) and cowpea lately. It is worth pointing out the available tolerant and resistant varieties, their potentials and limitations. As a method, which, can be easily adopted and practiced by the great majority of small-scale farmers, use of resistant crop varieties should receive much attention in technology extension and transfer programs.

PROCEDURE

- Introduce and explain the concept of tolerance and resistance. Tolerant crops support as many *Striga* plants as susceptible varieties, and the only difference is that tolerant varieties manage to produce substantial yield while the susceptible ones fail. Conversely, resistant varieties support few and significantly low number of *Striga* shoots.

- In principle, sole use of tolerant and even resistant varieties should not be encouraged unless used in combination with other methods that help to curtail seed setting in *Striga*. Further, the method has to be combined with fertilizer use, moisture conservation and weeding to maximize benefits
- Organize field visits to an area where *Striga hermonthica* and *Striga asiatica* resistant or tolerant maize and sorghum; or *Striga gesnerioides* resistant cowpea varieties are grown for farmers to appreciate the differences. Some IITA maize and cowpea varieties and Purdue University (USA) sorghum varieties have demonstrated good level of tolerance/resistance across regions and *Striga* populations, and if demand is there it would be worth trying those varieties
- Make a list of the resistant/tolerant varieties and give description about good and not so good attributes of those varieties other than *Striga* resistance (agronomic, grain quality etc.) Resistant/tolerant varieties produce yield where others fail, but at times one observes those same varieties are inferior in certain aspects: threshability, emergence and stand establishment, stalk size etc
- Stimulate discussion to know whether there are known local landraces retained and used by farmers for their resistance/tolerance to *Striga*. Identifying and promoting such cultivars could be much easier as they are often well adapted and productive
- If possible run a small germination assay (see laboratory methods section 3.6) to explain about resistance for e.g. based on low germination stimulant production

3.4.4 CROP ROTATION

Rotation of infested land into non-susceptible crops or into fallow is theoretically one of the simplest solutions, but also one that is neither simple nor acceptable. Farmers are usually reluctant to break the cereal production cycle. The many number of years that would possibly be required to bring about impact and exhaust the *Striga* seed bank in the soil further complicates the situation. However, promoting use of crop rotation is advisable, if nothing, to improve productivity and help sustain fertility of the soil. If the fertility of the soil is improved significantly, it could eventually lead to reduced parasitic weed infestation.

PROCEDURE

- Define the concept of trap cropping. Trap crops induce *Striga* seed germination but the seed soon dies because such crops do not support further development.
- Trap crops are preferred as suitable rotation crops in *Striga* endemic areas because they contribute to reduction of *Striga* seed bank.
- Among the crops known to have trap cropping effect are: soybean and pigeon pea for cowpea strain of *Striga gesnerioides*; cotton, cowpea, haricot bean for *Striga hermonthica*
- Crops have to be screened for their potential as trap crops. For e.g. not all cowpea varieties are equally effective trap crops against *Striga hermonthica*, the same is true for the other crops. Thus, initially evaluation of existing germplasm of potential trap crops has to be conducted to identify the ones that are likely to work against a given *Striga* population(s)
- If long term secession of cereal crop (sorghum and maize) cultivation is not going to be acceptable due to pressure for food grain production or other reasons, alternate cropping could be usefully employed. A five-year experiment was conducted in

Ethiopia to explore at least the possible benefits of alternate cropping of sorghum and annual legumes over the existing system of cereal monoculture, under *Striga* infested conditions. Results showed that the yearly rotation of sorghum with either cowpea or haricot bean resulted in significantly higher cereal yields but failed to lead to concomitant reduction in *Striga* infestation. The lesson learned from this exercise was that short term (yearly rotation) may not result in significant decline in infestation (at least in the short run), however, it can serve to improve the system in terms of increased crop productivity per unit area

3.4.5. FERTILITY MANAGEMENT

Striga is less damaging and often less severe in fertile soils and the critical element among the nutrients is widely believed to be nitrogen (N). One effect of N could be through reduction in stimulant exudation by the host. Nitrogen fertilizers are believed to delay and reduce infestation by *Striga*, although this is not always the case. In fact, in certain situations aggravation of the problem (increase in infestation) could be observed especially in areas with low inherent fertility. The response of *Striga* to fertilizers from different sources could also vary. A report from Tanzania indicated animal manure was relatively more effective than fertilizer from inorganic sources. Inconsistent results were observed on cowpea *Striga* in West Africa. Similarly, mixed results were obtained in Ethiopia. No benefit was attained from use of full recommended rate of fertilizer in the dry, north-eastern highlands with depleted soils. On the other hand, in another site with better edaphic and weather conditions, the exceptionally good response to the input led to dramatic improvement in the productivity of sorghum even though there was no concomitant reduction in infestation, possibly because of the short duration of the trial. Nonetheless, building the fertility of the soil should be considered as the central component of any *Striga* control strategy, because it is on a land with good fertility that a viable agricultural enterprise can be developed. Furthermore, applying fertilizers enhances resistance/tolerance of varieties.

PROCEDURE

- Introduce the different sources of fertilizers (organic and inorganic) and the advantage and disadvantage of using those
- Organic sources - animal manure, green manure (live mulch and plant biomass), and inorganic sources - urea, di-ammonium phosphate (DAP) etc.
- Explain the varietal difference in response to fertilizers. The fact that some varieties are more responsive than others.
- Environmental factors have impact on effectiveness of fertilizers. For e.g. availability of moisture, inherent soil fertility, weather etc
- Integrated water, soil and nutrient management provides a more holistic option. *Striga* is a problem in drought affected areas with depleted soils. Adopting and promoting packages that integrate technologies needed to improve the soil structure and fertility, and conserve moisture is of paramount importance to make the difference. For e.g. a farmer using manure and chemical fertilizers, and tied ridging for moisture conservation coupled with hand weeding could stand a better chance of getting a better crop as a result of suppressed *Striga*

3.4.6. CROPPING SYSTEMS APPROACH

In the past, most of the recommended control measures failed short of being practical in the low capital and labor intensive subsistence agriculture systems of Africa. A potentially viable technology should be low-cost and within reach to the small scale farming community, and address at least the two highly inter-related problems of low soil fertility and *Striga*. Cropping systems approaches i.e. intercropping and relay cropping could satisfy those two important concerns. A substantial amount of research information exists that can be put to use to alleviate the scourge of *Striga*, improve productivity per unit area and mitigate risk that is a prevalent problem in the dry and fragile environments.

3.4.6.1. INTERCROPPING

Even though considerable reduction in *Striga asiatica* from intercropping maize with cowpea was reported as early as the 1930s, intercropping has received less emphasis as a useful method for reducing the parasitic weed infestation. In many instances, intercropping was found promising. Many researchers have showed that intercropping can result in improved yield of sorghum and greater reduction in *Striga* incidence.

PROCEDURE

- Introduce the crops that can be used in intercropping arrangement with cereal grains. These include: groundnuts, cowpea, soybean, dolichos lablab, sesame and haricot bean.
- Explain the benefits of intercropping – sustained soil fertility and improved soil environment, improved yield per unit area and spreading risk. Explain further that such method is mainly used to introduce legumes to improve the traditional cereal mono-cropping system. But, also indicate that competition between component crops could lead to reduced yield of the main cereal crop under drought conditions, which might not be acceptable to farmers. To prevent such incidences it is recommended that intercropping be promoted along with moisture conservation methods e.g. tied-ridging particularly in very dry and harsh environments
- In selecting the appropriate companion crops and planting arrangements, care must be taken not to compromise the productivity of the main crop, mostly the cereal grain. Farmers have difficulty in accepting a system which puts their main crop, very often sorghum or maize, at a disadvantage. One can minimize such undesirable consequences by using proper spatial and temporal arrangements. Using less intimate planting arrangement (e.g. alternate row planting rather than within row intercropping and broadcast planting) and having a staggered planting time (planting the legume 2-3 weeks after the cereal to give the cereal a head start) could be advisable in dryland environments where competition for moisture, between component crops, could be severe. Changing the seeding rate of the crops could be considered to minimize competition e.g. using full seed rate of the main crop and half of the recommended seed rate of the companion crop was shown to be beneficial on several occasions

- Intercropping should be used to improve an existing, unproductive system. Therefore, looking for legumes compatible with popular local cereal crops should receive priority attention.
- Legumes which have effective trap cropping potential (capable of inducing very high seed germination of available *Striga* populations) should be selected for the purpose. Conducting simple germination assays to identify legume varieties with the highest potential could be a worthwhile exercise before selecting the companion crops for intercropping. Small verification trials can be planned to select appropriate intercrops that are adapted and compatible with the main cereal. Cowpea was found to be most effective among a range of crops tested in intercropping experiments in Ethiopia and Cameroon. *Dolichos lablab* and groundnuts were proven superior in Sudan and the Gambia, respectively.
- While selecting a companion crop, care must be taken not to select a crop which helps minimize a problem with one species of *Striga* only to aggravate a problem with another species. E.g. in areas where *S. hermonthica* and *S. gesnerioides* occur, selecting susceptible cowpea varieties to *S. gesnerioides*, as intercrops, may not be advisable

3.4.6.2 RELAY CROPPING

Relay cropping and improved fallow systems, which involve the use of perennial legume shrubs are receiving increased research attention as promising methods for resource poor farming communities. Improved fallow requires interruption of cereal production, which may not be favorably accepted by subsistence farmers. But, relay cropping could be an attractive option in areas where human population density is high, fallow periods are decreasing, and additional land is unavailable. Legume shrubs can be valuable sources of scarce commodities (fodder, fuel wood, etc.), and improve soil nutrient status, particularly nitrogen, through biological nitrogen fixation and nutrient recycling.

PROCEDURE

- Introduce legume shrub species which can be used as relay crops. These include: *Sesbania*, *Leucaena* and *Cajanus*.
- Initial adaptation trial may be conducted to select the best legume shrub species that will be subsequently promoted widely. In the dry land environments of northern Ethiopia, *Sesbania sesban* was the best performing and effective relay crop
- Explain the benefits of relay-cropping – sustained soil fertility and improved soil environment, improved yield per unit area, spreading risk, alternative source of feed and fuel wood.
- Staggered planting is recommended in relay cropping to minimize competition between companion crops. The legume shrub seedling (3-4 month old) is transplanted at least three weeks after planting of the cereal. As the shrub gets established, the cereal crop reaches advanced stage to escape competition from the legume shrub. After the cereal harvest, the legume shrub is allowed to continue growing, until the next cropping season, and produce biomass that can be used as source of fuel wood, animal feed and green manure.

- A tree nursery needs to be available in the vicinity to grow seedlings of the legume shrub. It may not be necessary to establish a separate one if there are nurseries used by the farming communities for other purposes e.g. re-afforestation programs
- Most of the beneficial effects of inter-cropping described above apply for relay cropping.
- Combined use of relay cropping, agronomic and water harvesting methods has to be encouraged to maximize benefits. Especially in dry lands where moisture is limiting, tied ridging could be very helpful
- The legume shrubs are harvested just before the on set of the next season, and the biomass divided in to parts that are used as animal feed (leaves and twigs), green manure (branches) and fuel wood (stalk)

NOTE

- Inter and relay cropping technologies have to be adapted to local conditions. There is no specific recommendation that works across environments. For e.g. sorghum and cowpea appear to be compatible for intercropping in diverse dry land agro-ecologies. However, it is advisable to carry out a small verification trial to look at the best compatible crops and the optimal temporal and spatial arrangements in areas where these methods need to be promoted.

3.4.7 BIOLOGICAL CONTROL

Training farmers about biological control might be seen as a far fetched idea. But, it is a fast growing science, and, before too long, a formulation with bio-agents (e.g. pathogens) might be available for wider use in Africa. Biological control is increasingly being considered as useful and viable component of an integrated management strategy. Therefore, embarking on programs that would help the farmer and development agents get basic knowledge of the method is essential. Regrettably, there was very little effort, to date, to pursue and exploit this rather promising control measure by African NARES.

PROCEDURE

- Indicate that a wide range of insects and pathogens are known to be damaging to *Striga*. Most of them are, however, polyphagous and not host specific and, thus, not fit for biological control. Collect diseased and insect damaged plants and assist the trainees observe whether some known bio-agents are causing damage
- The insect of great interest for biological control is *Smicronyx* (weevil), the gall forming weevil, capable of damaging the seed bearing capsules preventing seed production
- Research on biological control of weeds with fungi has spanned over twenty years. The myco-herbicidal (using live exotic pathogens) approach is the most promising to date. This involves the periodic application of massive doses of inoculum of phytopathogenic fungi to create a high infestation level when conditions are favorable for disease development and weed control. Very significant advances have been made recently with *Fusarium oxysporium*. Researchers are working to develop effective delivery system (easy to use formulations) and improve the feasibility of the method in African agriculture.

- One option is using pathogens in the form of myco-herbicides as described above. The other theoretically plausible alternative is mass production and release of locally available bio-agents. The latter would demand close collaboration of research, extension and development agencies, farmers and farmers' associations.

NOTE

- One reservation most often expressed, as related to biological control, is the fact that it is about dealing with live organisms which could potentially evolve and develop new behavior, over time, to become harmful to economically important crops. For many developing countries where the regulatory systems are often very weak, the existence of such possibilities, however remote, could be source of serious concern

3.4.8 CHEMICAL CONTROL

The prospect for wide scale application of chemicals for *Striga* control is not very high in Africa. There are two reasons for this: 1. the fact that farmers are resource poor and unable to afford the cost. 2. Lack of fully effective herbicides, which are capable of arresting early development of the parasite and prevent crop loss. However, herbicides (post emergence chemicals for targeted spray) will remain an essential component of an integrated *Striga* control method, particularly in vast agricultural areas where employing labor for control could be impractical. Furthermore, new promising leads are emerging such as the imidazolinone resistant (IR) varieties of maize being promoted by CIMMYT, which allow use of the herbicide as seed dressing treatment to prevent *Striga* attack. One hitch in relation to the IR technology is that it presupposes the existence of organized and efficient national seed system, capable of providing fresh supply of seed of the IR variety, which is rarely the case in most parts of sub Sahara Africa.

PROCEDURE

- Introduce chemical control concept, and the potentials and limitations of the technology as related to parasitic weed management.
- Explain about herbicides which have contact and systemic mode of action, the growing concern about health and environment
- The simplest use for herbicides is as an alternative to hand pulling for killing emerged parasitic plants. The cheapest and most widely used herbicide for this purpose is 2,4-D. It is applied at the rate of 1 kg product/ha, as directed spray between cereal crop rows, repeated as necessary throughout the season
- Before applying herbicides, the size of the field to be sprayed should be known. Calibrate the knapsack sprayer to determine the time needed to spray the area based on the speed of the spraying individual.
- Calculate the amount of herbicide required and mix with pre-determined amount of water (assuming the amount of spray solution needed is 250 liters/ha)
- Know about the necessary precautions that have to be observed. Do not spray during windy weather or when rainfall is expected shortly. Avoid spray drift especially 2,4 – D to susceptible crops such as cotton and pulse crops
- With the IR technology, seed of the resistant maize variety is soaked in a solution containing the herbicide, before sowing, to protect the growing crop seedling from

Striga attack. Where possible the IR maize varieties have to be tested for adaptation and acceptability, and be promoted

- The advantage of the IR technology is that very low amount of herbicide is used with little or no negative effect on environment

3.4.9. INTEGRATED CONTROL

No single method that is completely and fully effective against *Striga* has ever been discovered. It is increasingly realized that logical integration of effective management measures can only provide a holistic solution to the problem. Research results demonstrated that the integrated use of *Striga* control and proper crop husbandry practices (proper cultivation, row planting, timely planting and use of appropriate seed rates) could enhance productivity and help alleviate the problem. The integrated *Striga* management (ISM) intervention that can be effectively used across agro-ecologies could vary depending on a number of environmental and socio-economic factors, but most importantly on the level of *Striga* infestation. The trainers have to make sure that trainees are aware of these facts. In any case, farmers have to be encouraged to use a combination of methods, with proven effectiveness under their circumstances, to prevent seed set and the evolvement of more virulent races. Implementing a holistic approach is the only way forward in the battle against the diverse and highly complex problem of *Striga*. Two separate strategies have to be followed for highly/moderately and less/newly infested areas.

PROCEDURE

3.4.9.1. ISM FOR SEVERLY/MODERATELY INFESTED AREAS

- The main focus in this kind of situation would be to use ISM measures targeted at reducing the *Striga* seed bank in the soil
- Rotating the field out of susceptible hosts, especially in severely infested fields, is probably the simplest but not very readily acceptable. The long number of years that would be required to bring about impact on *Striga* adds to the complication. In areas where it is possible to employ the method, it needs to be integrated with soil fertility building measures, sanitation practices and hand weeding of *Striga* growing on alternate hosts (weeds).
- The other more plausible alternative is to use ISM program, which combines use of resistance varieties (e.g. Purdue sorghum varieties and IITA *Striga* resistant cowpeas), and crop and *Striga* management practices (row planting, tied ridging, fertilizers, hand pulling/2,4-D herbicide). In Ethiopia integrated use of row planting, mineral fertilizer (42 kg N/ha) and 2,4-D herbicide (1 liter product/ha) led to 40% increase in cereal yield and appreciable reduction in *Striga* infestation, compared to the control (broadcast planting, no fertilizer and early weeding; farmer's practice). Combined use of row planting, fertilizers and hand pulling (during flowering) registered 48% higher grain yield and over 50% reduction in *Striga* shoot counts compared to the farmer's practice at a more drier location. Similarly, in Burkina Faso, integrated control involving resistant variety, inorganic fertilizer, hand weeding or 2,4-D herbicide significantly improved sorghum yield and led to substantial reduction of *Striga* infestation.

3.4.9.2. ISM FOR AREAS WITH LOW INFESTATION

- Less infested areas should be of top priority concern for agricultural development and extension agencies. Every possible effort has to be made to prevent further spread and build up of infestation. It is mightily difficult to bring *Striga* infestation down, once the parasitic weed is allowed to reproduce and build up. However, in areas where there is low infestation, and where *Striga* has just been introduced it could be feasible to arrest the advances of the weed.
- Training and improving awareness of the farming community and the general public is one of the key functions that need to be accomplished initially.
- Hand weeding, at the proper time (at flowering but before seed setting) and frequency (several times in the season), could be the only method that needs to be employed in an organized manner. However, even though hand weeding is the main component, integrating that with sanitation and quarantine measures (prevention of in flow of contaminated seed, and use of clean and certified seed) could help to attain complete control.

3.5 PARTICIPATORY APPROACHES FOR AWARENESS CREATION AND STRIGA CONTROL

Experience unequivocally showed that headway in the fight against parasitic weeds can only be made through community based approaches. Aggressive programs have to be put in place to create a fully sensitized community on the potential threats, and on the gravity and magnitude of the problem to lay the ground work for the development and implementation of a holistic, long term strategy that could bring about a lasting solution. Here below the activities required in the awareness area and in participatory technology generation and transfer are outlined.

3.5.1. AWARENESS CREATION

The value of raised awareness can not be over emphasized. It is absolutely crucial to help people fully grasp the enormity of the problem, and galvanize the level of determination required for sustained and well coordinated community action against *Striga*.

PROCEDURE

- A series of well thought out awareness creation activities have to be conducted concurrently, involving all concerned from public and private institutions
- Schools, and religious worshiping places can be used as a venue for awareness creation functions
- Think-thank and lobby groups (e.g. a committee involving local elders, religious leaders etc.) can initiate open discussions about the role of the public in general and the different sectors of the society (youth associations, farmers etc.) in particular.
- Published and electronic media can be used to reach as wide audience as possible. Concise and to the point information on the required course of action can be passed using television and radio programs, posters and fliers, and news papers
- Organizing a series of training of trainers sessions could be helpful to convey knowledge and information from research and academic institutions through development agencies down to the grass roots level

3.5.2. PARTICIPATORY TECHNOLOGY DEVELOPMENT AND EXTENSION

Once *Striga* is established, it instantly becomes too big a problem and beyond the control of the affected farming community. That is why holding awareness creation functions described above becomes so essential. Such programs can help make the general public raise to the task, render every assistance necessary and play its part in an all out campaign to combat *Striga*. At the local, village level, improved extension systems such as Farmer Field Schools (FFS) and Farmer Research Groups (FRG) can be employed to help the farmer get organized, get trained, make informed individual and collective decision that would eventually lead to impact oriented team action.

It is being increasingly realized that conventional extension methods are inadequate to help farmers get organized and make informed decisions on crop and pest management. One way of bridging such gap is to reach out for and empower farmers through self-teaching through for e.g. FFS or FRG using weekly sessions to create an opportunity where by they can participate and recognize the factors that affect crop performance. The most important part of using the participatory approaches is that farmers use techniques that would enable them to visualize the aspects that affect the establishment, development and spread of pest such as *Striga*. Appreciate the edaphic and climatic factors, and traditional practices contributing to the build up of parasitic weed infestation, and learn about the various means used to alleviate the situation. The farmers will learn through exercises based on self discovery. These include, field exercises, share of experiences, need based training sessions. Employing participatory research and extension approaches help with fast diffusion of information, knowledge and technologies to make the difference at grass roots level. The tentative curriculum for FFS on *Striga* management is presented in annex 4. The curriculum comprises series of practically oriented sessions which have to be administered in the field with the farmers and by the farmers. Development agents and researchers could serve as facilitators. The FFS could run for several seasons, as the case may be, since it involves continuous learning by doing process. Employing FFS or any other participatory method is presented as an option to be considered by national programs interested to pursue and follow on gained knowledge through the proposed training course.

3.6 STRIGA RESEARCH METHODOLOGIES

3.6.1. SURVEY

3.6.1.1 ASSESSING DISTRIBUTION AND IMPORTANCE OF *STRIGA*

Knowing the occurrence and severity of the *Striga* problem is a prerequisite for a successful research and control intervention. But this is often not realized and wastage of resources is observed in trying to implement a uniform approach across areas with different sets of conditions. A comprehensive survey needs to be conducted to map out the distribution of the weed and thus devise appropriate strategy depending on specific situations.

In general field surveys are an important tool, especially in integrated *Striga* management, to get better understanding about the nature of the *Striga* problem and its magnitude. The objectives of the survey activity are:

- To determine the geographical distribution of *Striga*

- To obtain data on the magnitude of the infestation and crops infested
- To monitor change in infestation level over a period of time through repeated surveys
- To create database for ecological and yield loss studies
- To obtain information on areas under threat from possibility of new parasitic weed incursions

MATERIALS

- Map
- Identification guide
- Herbarium press

PROCEDURE

- Randomly select fields (approximately every 5 to 10 km) to be surveyed along the road
- Select fields where *Striga* has not yet been removed. Fields with a crop that has reached reproductive stage are specially preferred.
- Conduct visual assessment on the parasitic weed and the effect it has on the crop
- Field inspection method depends on the nature of the crop and crop husbandry followed. However, for ease of implementation walking in a crisscross fashion and stopping every 20 steps to make the assessment from a 1m x 2m area would be recommended. At every stop, count the number of parasites per crop plant or hill.
- Be aware that all the parasitic plants being counted are growing on the crop plant and not on weeds. Occasionally, uprooting the plant might be advisable to look for un-emerged *Striga* seedlings. Counting emerged plants at times may not reflect the true picture. In fields with extremely severe infestation, *Striga* plants may fail to emerge due to severe intra-specific competition.
- Use pre prepared data sheets to record the data and observation

DATA TO BE COLLECTED

- Infestation rate: Percentage of infested fields (%)
- Infection intensity: Percentage of infected plants

NOTE

- The level of infestation can be highly variable between years. Factors like weather conditions, time of planting, soil fertility, influence the parasite's emergence.

3.6.1.2 SEED AND HERBARIUM SPECIMEN COLLECTION

Having carefully preserved reference collections of different morphotypes (different flower color, branching and stem structure) of *Striga* for future use by students, researchers and trainers is something that has to be encouraged. Similarly, having clean and good quality seed (few hundred grams from each species) is essential for basic studies. Occasionally, big quantity of seed may be collected when need arises to have enough seed to establish a uniformly infested *Striga* sick plot for experimental purposes.

MATERIAL

1. Herbarium press, used news papers for specimen collection
2. For seed collection: paper and plastic bags, sieves, plastic container for seed storage and dry and cool store

PROCEDURE

1. Herbarium collection
   - Fresh plants, preferably green and at initial flowering stage, are placed between sheets of paper
   - The paper sheets containing the plants are placed between stiff flat cardboard. A number of paper sheets and flat boards can be pilled together and pressed using a herbarium press.
   - The paper sheets containing plant specimens have to be regularly checked and changed until the plants dry up maintaining their natural color
   - Finally, dried up plants are carefully glued to card-board, labeled and placed in herbarium cabinets
2. Seed collection
   - Seed collection should start 2-3 weeks after flowering
   - A plant is considered mature when there are none or only few apical flowers
   - Each collection has to be from the same host
   - The plants are transported in paper bags and then sun dried
   - After drying capsules are threshed by hand in paper bags or sacks. The bigger plant parts are separated and the remaining parts passed through sieves. *Striga* seeds will be deposited at lower mesh size of 100 µm
   - The clean dry seed can be stored in plastic containers at room temperature.
   - Careful labeling of the containers is essential. The label contains species name, host, date and place of collection, any other observation deemed necessary.
   - Samples should be regularly checked for viability

NOTE

- Seeds have to be collected at least one season before they could be used for experiments because of the after-ripening requirement of *Striga* seeds

3.6.2. LABORATORY AND GLASS-HOUSE STUDIES

Field experiments have been carried out over many years. Unfortunately, the results from such experiments have often been inconclusive, due to variability in *Striga* infestation, loss of trials to drought etc. This necessitates that the field work be supplemented by experiments from controlled conditions.

OBJECTIVES:

- To have better understanding of *Striga* biology especially its germination behavior and its interaction with environmental factors – nutrient, temperature, wetness etc., which could help in devising better agronomic approaches for control
- To determine possible variation in behavior/ host range of different *Striga* populations, which is not feasible to do in the field

- To compare promising varieties for their resistance to *Striga* under controlled conditions
- To understand, if possible, the mechanisms of resistance and hence perhaps devise simplified screening methods, which would help accelerate selection of promising materials from among variety collections or breeding material

MATERIALS

- Petri dishes, clear plastic cup, distilled water, glass fiber filter paper (GFA), markers, digital counters, incubators set at 32 ^{0}C for root exudates testing in the laboratory (see picture below)
- One liter plastic pots, sterilized soil, labels, watering hose for the glass house experiments

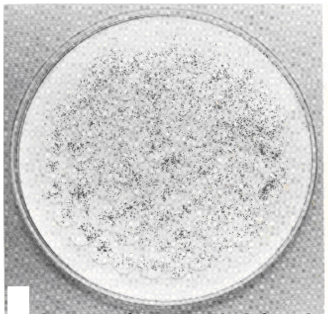
PROCEDURE

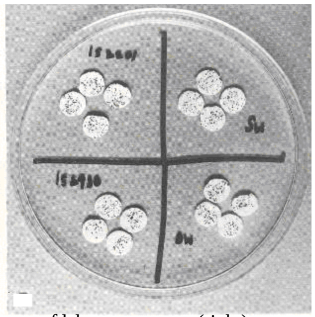
- LABORATORY STUDIES
  - Host crop seedlings are grown for four days at 32 ^{0}C between a layer of wet filter paper and the wall of a clear plastic yoghurt container. The terminal 1.5 cm of each root tip is then cut, rinsed and incubated in distilled water equivalent to 0.5 ml per tip for 24 hours at 32 ^{0}C. During this time the root segments exude stimulant and then the solution is used for germination studies.
  - Conditioned *Striga* seeds, usually 2 weeks at 32 ^{0}C under moist conditions, are used for the laboratory assays. *Striga* seeds are sprinkled on to small (2 mm) and round GFA discs in a Petri dish. Three discs containing approximately 50-60 seeds each represent one treatment and are thus wetted with solution obtained from a specific test entry (see fig. below).
  - After 48 hours germination count is performed under microscope using digital counters to determine percentage of seeds induced to initiate radicle growth.
- GLASS HOUSE STUDIES
  - Pots are half filled with sterilized soil and seed of *Striga* (about 1000) mixed in to the top half of the pots. Depending on the type of experiment, fertilizer (Diamonium phosphate) could also be applied into the top half of the pots at the rate of 1 g/pot. Seeds of the crop or other hosts (e.g. host-range study) are sown shallowly and later thinned to a standard number per pot. The experiments can be set up in RCBD and watered regularly.
  - During the experiment, emergence of *Striga* is counted at weekly intervals. Roots of crop plants without emerged *Striga* are washed to detect un-emerged parasites.
  - Further data can be taken on the crop such as height, stage of growth and biomass yield.

NOTE

- Using the laboratory assay procedure, screening of large number of breeding lines and varieties for low-stimulant production, the best characterized resistant mechanism known in cereals, can be conducted. Further research can be done on germination biology and ecology of *Striga* to determine ecological requirements of the different species and races.

- Advanced stage evaluation of promising genotypes for resistance across virulent races of *Striga* can be done in the glasshouse on pots. Furthermore, host range studies of *Striga* populations collected from different hosts and locations can be performed on selected, major crop and weedy species.





Conditioning of *Striga* seeds (left) and set up of laboratory assay (right).

3.6.3. FIELD INVESTIGATIONS

A wide range of field experiments is conducted on different aspects of *Striga* control. However, results, particularly data on *Striga* shoot counts, are often inconsistent partly because of the sporadic nature of parasitic weed infestation. Since host plant resistance is the main component of integrated *Striga* management intervention, appropriate infestation and field plot techniques need to be adopted to get meaningful results from screening experiments.

PROCEDURE

- Select a site with history of heavy and uniform *Striga* infestation
- Use the simple and uniform field infestation technique developed for maize at IITA (Kim 1991) or a modified “checker-board” layout (see fig. below) for sorghum and millet with susceptible checks repeated every two test entries. The IITA method involves placing 20000 germinable seeds per m^2 (approximately 3000 germinable seeds per maize plant). The crop is planted on ridges. Two maize seeds are sown per hill with a spacing of 50cm. The wider spacing is used to cut the labor input for Striga infestation. Infested and non infested plots can be placed adjacent to each other for comparison. The checker board layout was developed by ICRISAT in the 1980s. The repeated check plots give indication of the nature of the *Striga* infestation. For e.g. if low *Striga* emergence is observed on one test entry one can use the adjacent check plot to verify whether the low incidence is due to genuine resistance or just absence of *Striga* in that particular spot.
- All agronomic data including crop emergence, stand establishment, plant height and yield should be collected. *Striga* shoot counts can be performed by counting and removing flowering plants. Very valuable data can be generated by computing percent of *Striga* plants growing on each test entry compared to the adjacent check plot.

NOTE

- To prevent crop failure, which, occurs rather frequently in the drought prone areas where *Striga* is a major constraint, using water conservation methods (e.g. tied ridges) could be considered.

A model of a variety screening experiment

Rep. I	1 **C**	2 **1**	3 **2**	4 **C**	5 **3**	6 **4**	7 **C**
Rep. II	14 **C**	13 **8**	12 **7**	11 **C**	10 **6**	9 **5**	8 **C**
Rep. III	15 **C**	16 **9**	17 **10**	18 **C**	19 **11**	20 **12**	21 **C**

Note: Rep. – replication, c – check plot, 1 – 12 bold numbers are test entries, 1 – 21 are plot numbers

3.7 RECENT ADVANCES IN STRIGA MANAGEMENT IN AFRICA: LESSONS TO BE LEARNED

The desire to have a continent-wide organized effort may have not been realized, but there were quite a number of regional initiatives and collaborative engagements between international research centers, UN agencies, advanced laboratories in western countries and the NARES in Africa that have made visible contributions. We have described those in some detail in the previous sections. Future *Striga* management undertakings have to capitalize and build on those and the host of little known success stories that are out there with the national programs in the continent. An attempt is made below to briefly review some exemplary and telling endeavors by African NARES so that they can be picked up and implemented by others.

3.7.1 MASS CAMPAIGNS FOR *STRIGA* CONTROL IN ETHIOPIA

The first attempt to implement a nation-wide mass mobilization, involving different sectors of the society, against *Striga* was done in the Gambia with the support of FAO in the late 1980s. It is not known whether the impact and the final outcome of the program has been fully assessed and made public, nevertheless, the information about the campaign itself was a source of inspiration for some national programs. Among those was the Ethiopian National Program. The Ethiopian Institute of Agricultural Research and the Ethiopian Weed Science Society used publications and all available means to widely publicize the experience and make a case about the need for launching a similar initiative in the Country. Consequently, two regional states in northern Ethiopia (Amara and Tigray) managed to come up with a plan and execute eradication campaigns. No systematic assessment was done to quantify the impact of the program, which was conducted for a number of years rallying the general public for repeated weeding campaigns every season. However, regardless of the outcome, the general understanding, which has developed as a result on the massiveness and complexity of the problem has served to change public and policy makers' attitude.

3.7.2 COMMERCIALIZATION OF A *STRIGA* TOLERANT VARIETY IN UGANDA

Epuripur, a variety originally selected for its *Striga* tolerance, has become an instant success and it is now grown on over 40000 ha for its good quality grain that is in high demand by the brewing industries in the country. Selecting, promoting and commercialization of such varieties could go a long way to improve income and change the livelihood of farmers and motivate them to make investment to counter the damaging effects of *Striga*.

3.7.3 WIDE SCALE PROMOTION OF INTERCROPPING SORGHUM WITH STRIGA GESNERIOIDES RESISTANT COWPEA IN MALI AND BURKINA FASO

Highly encouraging results were registered in Mali and Burkina Faso recently with wide scale promotion of the intercropping approach involving *Striga* resistant/tolerant sorghum varieties (Seguetana in Mali and F2-20 in Burkina Faso) and *S. gesnerioides* resistant cowpea (Sankaranka in Mali and KVX-61-1 in Burkina Faso).

3.7.4 INTEGRATED *STRIGA* MANAGEMENT PROJECT IN ETHIOPIA

The collaborative project between the Ethiopian Institute of Agricultural Research (EIAR) and the Sorghum and Millets Research Support Program (INTSORMIL) was launched in 2002. It involved three activities: seed multiplication of the two resistant varieties (Gubiye and Abshir), popularization of those varieties on farmers' fields and wide scale demonstration of an integrated method (resistant varieties, water conservation and fertilizer use). The project which started with handful of farmers has now reached over 10000 farmers from four regional states (Oromiya, Amara, Southern state and Tigray). The lesson learned from the experience was that for any resistant variety promotional activity to succeed, a functional seed supply systems has to be in place. The inclusion of moisture conservation practice (tied ridging) enhanced the performance of the varieties in the dry areas where weather patterns are rather erratic.

4. IMPLEMENTATION PLAN

The course is developed for training of trainers including farmers, development and extension agents and junior researchers. The content of the course varies for the different group of beneficiaries (see module in annex 1). For e.g. for farmers, the sections that are too technical are omitted to devote more time for the practical part i.e. control options and case studies. Those that have been trained are expected, if necessary, to adapt and modify the course according to local conditions and use it to disseminate the knowledge to wider community of farmers affected by the *Striga* problem. The people, who are going to be entrusted with conducting such training, using the module, after receiving training of trainers themselves, would be able to successfully accomplish their task if they had prior exposure on how to conduct adult training. What is envisaged is to execute a hands-on training that is action oriented mainly intended for farmers, who are not used to formal type of training but rather feel comfortable with more interactive and participatory programs in an informal setting. And this requires a special skill.

Generally, the length of a training course should not exceed four days. A three days course is proposed for farmers, and four days for development agents and researchers. Whether the course is conducted before or during the growing season depends on the availability of adequate time for the trainees and trainers and the availability of *Striga* in the field.

Otherwise, observation on the parasitic weed and the effect of control interventions on *Striga* would not be possible. Conducting the training early enough enables trainees employ newly gained knowledge during the progressing season. The training could be handled as practical demonstration at the training site or at farm level with discussions and evaluations of for e.g. control options. The contribution of working groups, and presentations by participants should not be underestimated. Working in groups facilitates interaction and thus better exchange of knowledge and experience. Participants' presentations offer opportunity to express and share different views. During the course, farmers and extension staff could be invited to describe the difficulties faced in the real world.

Prior to the organization of the training course, resource persons should be identified and contracted to help with adaptation of the course content and training material to the local needs and conditions. Researchers actively involved in applied research could serve as resource persons. They could take a part that is related to their field of expertise. Prior discussion should be held between course organizers and the researchers to explain to the latter that the information to be provided should be relevant to farmers and extension staff, and understandable to non academic personnel. Innovative farmers and development agents who have received prior training could also serve as resource persons. It would be essential to ensure that the trainers have adequate field experience, and an experience of working with farmers to be able to effectively contribute to adaptation of course content according to needs and specific requirements. The preparation and adaptation of the course content and the materials together may require some weeks depending on the communication facilities.

The presentations/lectures must be distributed in the form of handouts. The handouts must be prepared in simple languages, easy to understand and free of jargon and complicated scientific terms. Other printed material can supplement the manual e.g. technical leaflets and guidelines. The information should be presented as much as possible in a visual form. Sketches and graphics of all relevant aspects related to the life cycle and the relation of the parasite and its hosts could be presented orally. Other information like seed dispersal and control measures should be presented in the form of text. Oral presentation should be supported with actual presentation of specimens and samples e.g. specimens of the different *Striga* species and their hosts accompanied with viewing under microscope.

Trainers should try and stimulate discussion and create friendly environment. Dialogue and interaction should be the norm for better communication of knowledge and experiences. Conducting a benchmark test helps under such circumstances to determine the level of basic knowledge of participants (annex 2). The same test can be used at the end of the course to assess whether trainees have fully grasped the knowledge and information. It is advisable that the training process is evaluated every day, in a participatory manner, to get feedback and constantly review and adapt course contents. Conducting final evaluation is considered part of the training to have trainees express their views and offer suggestions for future improvement of program content (annex 3).

During the course the use of the following materials is required:

- Power point/multi media projectors and computer, slide projector and screen. If these are not available transparency sheets and overhead projector can serve the purpose

- Pin boards and markers
- Brochures/leaflets and other publications
- Writing pads/note books and pens
- Demonstration materials: seeds of *Striga*, dried and fresh plants
- Microscope and magnifying lenses
- Samples of extension material
- Petri-dishes, plastic pots (one liter pots), glass fiber filter paper, distilled water, sterilized seeds
- Knapsack sprayer, bucket, measuring cylinder, stop watch

Following the above described formal training, it is recommended that farmers are organized for group training using appropriate research and extension method i.e. either FFS or FRG. Using such methods provides an opportunity to follow on and ensure gained knowledge is internalized and used on sustainable basis. Furthermore, farmers have to learn and work together to constantly improve their know how if they are to succeed against the highly variable and complex problem of *Striga*. Draft training program and curriculum for *Striga* FFS are shown in annex 4.

5. BUDGET

The required budget out lay for each training program could significantly vary depending on the number and origin (local or from abroad) of trainees/trainers, and on where the training is scheduled to take place because these have budget implications. A budget proposal is presented below with the assumption that as an action oriented training course, the program can be implemented locally for the three groups of trainees using resource persons.

5.1 TENTATIVE BUDGET OF A TRAINING COURSE FOR FARMERS

Item/function	Description	Cost (US$)
DSA for trainer	Two weeks for preparation and three days training, 17 days @ USD 50/day	850
DSA for support staff (Facilitator, secretary, driver)	3 people, 3 days @ USD 20/day	180
DSA for trainees	25 trainees, 5 days (1 day each to travel to and fro duty station and 3 day training) @ 10 USD/person/day	1250
Food & refreshment	Lunch, and refreshment during the morning & afternoon sessions, 29 participants including trainers, 3 days @ approx. USD 7/person/day	609
Meeting hall rent	3 days @ USD 50/day	150
Fuel & lubricants	Lump sum amount of USD 300	300
Transport fees	Farmers coming from distance places an approx. amount of USD 250	250
Stationery	Flip charts, marker pens, note books @ an approx. amount of USD 100	100
Printing & duplication	Lump sum amount of USD 150 for printing and duplicating handouts	150
Internet, fax and communications	Payment for telephone charges, fax and internet communications during the time of organization and during the course of the training	150

	@ USD 150	
Contingency (10%)		399
Total		4388

5.2 TENTATIVE BUDGET FOR THE ESTABLISHMENT OF FFS (OPTIONAL)

The process of establishing a functioning FFS takes at least two whole cropping seasons. With the help of the facilitator, farmers are continually engaged in a learning-by-doing process, following up on the phonological developments of the crop and the pest over a period of three to four months each year. The sessions are conducted on farmers fields in their village, therefore, the expenses shall only include the salary of the facilitator, who would be recruited for a period of four months every year at a monthly rate of USD 2000 and miscellaneous expenses (stationery, fuel, car rent, allowance for support staff) at a lump sum amount of USD 500 per month, which brings the total budget (including salary and other expenses for 8 months) to USD 20000

5.3 TENTATIVE BUDGET OF A TRAINING COURSE FOR DEVELOPMENT AGENTS AND JUNIOR RESEARCHERS

Item/function	Description	Cost (US$)
DSA for trainer	Two weeks for preparation and four days training, 18 days @ USD 50/day	900
DSA for support staff (Facilitator, secretary, driver)	3 people, 4 days @ USD 20/day	240
DSA for trainees	25 trainees, 6 days (1 day each to travel to and fro duty station, 3 day training) @ 20 USD/person/day	3000
Food & refreshment	Lunch, and refreshment during the morning & afternoon sessions, 29 participants including trainers, 4 days @ approx. USD 7/person/day	812
Meeting hall rent	4 days @ USD 50/day	200
Fuel & lubricants	Lump sum amount of USD 300	300
Transport fees	Trainees coming from distance places an approx. amount of USD 250	250
Stationery	Flip charts, marker pens, note books @ an approx. amount of USD 100	100
Printing & duplication	Lump sum amount of USD 150 for printing and duplicating handouts	150
Internet, fax and communications	Payment for telephone charges, fax and internet communications during the time of organization and during the course of the training @ USD 150	150
Contingency (10%)		610
Total		6712

6. EXPECTED OUTPUT

The expected outputs of the training course are:

- To have increased number of farmers, extension and development agents and researchers equipped with practical knowledge on *Striga* and its control, and the participatory approaches necessary to improve the likelihood of success against this formidable problem.
- Help African NARES conduct targeted and action oriented training and sensitization programs through wide use of the training module
- Make new advances in research and hitherto little known success stories of African NARES publicized for wide scale adoption and promotion

The indicators of the accomplishments that have been realized will be the number of trainees in each NARES trained and practicing gained knowledge to make the difference on the ground. Quantified information on the level of dissemination of the integrated *Striga* management technologies across NARES could also shade light on the success and acceptability of the training module.

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8. ANNEXES

ANNEX 1. A DRAFT MODULE OF A TRAINING COURSE ON *STRIGA* MANAGEMENT

1.1 A MODULE OF A TRAINING COURSE FOR FARMERS

Session	Day I	Day II	Day III
Early morning (2 hrs)	• Opening & welcome • Self introduction of participants • Myths & perceptions about *Striga* • Major species, their distribution and importance • Introduction to biology with emphasis to seed production & dispersal	Group discussions on the feasibility of different control methods. Which type of ISM and why?	Participatory approaches for awareness creation and *Striga* control • Awareness raising functions • Community based approaches • Introduction to participatory rapid appraisal (PRA) & participatory technology development (PTD)
Late morning (2 hrs)	Practical on biology in groups: • Study the floral & reproductive parts • Seed production (no capsules/plant, seeds/capsule) • Role play (have farmers try and explain *Striga* biology using a their own drawing)	Group presentations	• Participatory approaches (contd.) • Discussions
Early afternoon (2 hrs)	Control methods and their integration • Sanitation & quarantine • Use of resistant varieties • Time & frequency of hand weeding • Crop rotation & cropping systems • Integrated *Striga* management (ISM)	Success stories in African NARES on *Striga* management	Field visit: demonstration plots & research station
Late afternoon (2 hrs)	Control methods (contd.)	• Group discussions on the success stories & how they can be implemented • Group presentations	• Field visit (contd.) • General discussion • Course evaluation • Closing (Certificates)

1.2 A MODULE OF A TRAINING COURSE FOR EXTENSION AND DEVELOPMENT AGENTS

Session	Day I	Day II	Day III	Day IV
Early morning (2 hrs)	• Opening • Self introduction of participants • Expectation • Benchmark test	Control methods and their integration	• Success stories of African NARES in *Striga* management • Discussions on possibilities for adoption & scaling up of the successful approaches	• Practical (contd.) • Group presentations
Late morning (2 hrs)	• Major species, their distribution and importance • Life cycle • Survival & dispersal mechanisms	Control methods (contd.)	Participatory approaches for awareness creation and *Striga* control • Awareness raising functions • Community based approaches • Introduction to participatory rapid appraisal (PRA) & participatory technology development (PTD)	• Facilitation skills • Extension materials and their use
Early afternoon (2 hrs)	Practical on biology in groups: • Identification of specimens • Study the floral & reproductive parts • Seed production (no capsules/plant, seeds/capsule) • Role play (have trainees try and explain *Striga* biology using a their own drawing)	Group discussions on ISM (What type of ISM and why?), personal experiences with farmers (locally applied methods their weaknesses & strengths) etc.	Participatory approaches (contd.) • FFS principles and practices • Curriculum development for FFS • Successful case studies on FFS	Field trip: visit farmers fields, demonstration plots, research station
Late afternoon (2 hrs)	Practical (contd.)	Group presentations	Practical in groups • Climate setting for FFS • Participant and site selection • Agro-ecosystem analysis • PTD • Collection, processing & presentation of data	• Benchmark test • Evaluation • Closing (Certificates)

1.3 A MODULE OF A TRAINING COURSE FOR JUNIOR RESEARCHERS

Session	Day I	Day II	Day III	Day IV
Early morning (2 hrs)	• Opening • Self introduction of participants • Expectation • Benchmark test • Major species, major hosts their distribution and importance	Control methods and their integration	Research methodologies • Survey • Laboratory (lab. assays for screening germplasm) • Pot experiments (variety evaluation, host range studies) • Field experiments (sick plot, proper layout)	Field visit: visit farmers fields, demonstration plots, research station
Late morning (2 hrs)	• Identification key for major species • Life cycle • Chemical & physiological interaction between host & parasite • Host specificity & physiological races • Seed production, survival & dispersal mechanisms	• Control methods (contd.) • Success stories from African NARES in *Striga* management	Methodologies (contd.)	• Field visit (contd.) • Evaluation of field trip
Early afternoon (2 hrs)	Practical on biology in groups: • Identification of specimens • Study the floral & reproductive parts • Seed production (no capsules/plant, seeds/capsule) • Role play (have trainees try and explain *Striga* biology using a their own drawing)	Group discussions on control methods & ISM (What type of ISM and why?), what lessons can be drawn from success stories?	Practical (methodologies) • Determining distribution & importance of *Striga* • Specimen/seed collection • Simple germination tests using root exudates • Setting up pot experiments • Field layout	Participatory approaches for awareness creation and *Striga* control • Awareness raising functions • Introduction to FFS
Late afternoon (2 hrs)	Practical (contd.)	Group presentations	Practical on methodologies (contd.)	• Benchmark test • Evaluation • Closing (Certificates)

ANNEX 2. BENCHMARK TEST

TITLE: TRAINING COURSE ON BIOLOGY AND CONTROL OF *STRIGA*

Name: Score:

Date:

Instruction: Answer the following by marking the right answer. Note that there can be more than one correct answer

1. Which of the following are parasitic on cereal crops?
   - *Striga asiatica* ____________________
   - *Striga gesnerioides* ________________
   - *Striga forbesii* ________________
   - *Striga hermonthica* ________________
2. Which of the following crops are hosts of :

	S. hermonthica	*S. gesnerioides*
2.1 Cotton	_____________	_____________
2.2 Soybean	_____________	_____________
2.3 Maize	_____________	_____________
2.4 Groundnut	_____________	_____________
2.5 Sorghum	_____________	_____________
2.6 Millet	_____________	_____________
2.7 Cowpea	_____________	_____________
2.8 Rice	_____________	_____________

3 How does *Striga* reduce the yield in cereals?

3.1 Shading of the host plant ____________________________________

3.2 Competition for space and light ______________________________

3.3 Uptake of water and minerals from the soil _____________________

3.4 Reduction of size and weight of the host _______________________

3.5 Uptake of water and minerals direct from the host _______________

4 How does *Striga* reproduce?

4.1 By roots ____________________

4.2 By seeds ____________________

4.3 By tubers ____________________

4.4 By rhizomes ____________________

5 How does *Striga* spread?

5.1 By animals ____________________

5.2 By wind ____________________

5.3 By water ____________________

5.4 By men ____________________

5.5 By crop seeds ____________________

5.6 By tools ____________________

6 What is the size of *Striga* seed?

6.1 1 cm ____________________

6.2 0.5 cm ____________________

6.3 0.2 mm ____________________

7 How many seeds can a *Striga* plant produce?

7.1 50 ____________________

7.2 500 ____________________

7.3 5000 ____________________

7.4 50000 & more ____________________

8 For how many years can *Striga* seed survive in the soil?

8.1 1 year ____________________

8.2 5 years ____________________

8.3 10 years ____________________

8.4 50 ____________________

9 Where is *Striga* more serious problem?

9.1 Soils with high fertility ____________________

9.2 Mono-cropping ____________________

9.3 Rotation between cereals & legumes ____________________

9.4 After a long fallow period ____________________

9.5 Fields with low soil fertility ______________________________

10 Why is hand weeding important?

10.1 To prevent yield loss ______________________________

10.2 To prevent *Striga* reproduction ________________________

11 When is the recommended time of weeding?

11.1 Immediately after emergence ______________________________

11.2 At flowering ______________________________

11.3 After crop harvest ______________________________

12 How should you dispose of uprooted *Striga* plants?

12.1 Leave in the field as green manure ________________________

12.2 Feed animals ____________________________________

12.3 Bury & burn in a pit ____________________________________

13 What is a trap crop?

13.1 A plant which stimulates germination of *Striga* seed but does not allow its development ______________________________

13.2 A plant which stimulates germination of *Striga* seeds and supports further growth ______________________________

13.3 A plant which produces toxic exudates but does not stimulate germination of *Striga* ______________________________

14 What is intercropping/relay cropping?

14.1 Cereal and legume mixed planting ________________________

14.2 Cereal/cereal mixed cropping ________________________

14.3 Both ________________________

15 What are the benefits of intercropping and relay cropping?

15.1 Improve yield ______________________________

15.2 Reduce *Striga* infestation ______________________________

15.3 Build fertility of the soil ______________________________

16 When is the appropriate time for planting the legume intercrops/relay crops in dry land environments? Why?

16.1 Simultaneously with the cereal ________________________

16.2 Few weeks after the cereal crop ________________________

17 Give an example of a good rotation program? Why?

17.1 Sorghum-sorghum-sorghum ____________________________

17.2 Sorghum-cowpea-wheat-sorghum ______________________

17.3 Sorghum-maize-wheat ____________________________

17.4 Sorghum-cowpea-cotton-sorghum ______________________

18 How do you think should the control methods be integrated? Why?

18.1 Row planted resistant variety, fertilizer, water harvesting _________

18.2 Broadcast planted resistant variety, fertilizer __________________

18.3 Row planted resistant variety, fertilizer, water harvesting, weeding ______

18.4 Broadcast planted local susceptible variety, no fertilizer, weeding _______

19 Should you follow the same control strategy for low, moderate and highly *Striga* infested areas? Why?

Yes ___________ No ___________

20 What constitutes right strategy for low infested areas?

20.1 Hand weeding ___________________________________

20.2 Eradication ___________________________________

20.3 Abandoning sorghum production _______________________

21 What constitutes right strategy for heavily/moderately infested areas?

21.1 Hand weeding alone ___________________________________

21.2 Eradication ___________________________________

21.3 Rotation ___________________________________

21.4 Integrated control ___________________________________

ANNEX 3. EVALUATION OF THE TRAINING COURSE

- During the training (e.g. each day before closing) the expectations of the participants, as expressed on the first day, could be looked together and asked whether they have been met so far. This permits to adapt and modify the program if necessary
- The results of the first benchmark test already gives hints where the knowledge of the participants is limited or is already quite good. This should help the trainers to specially pay attention to the week points revealed by the test
- The evaluation of the workshop has two purposes:
    - The evaluation of the content, program and the organization done by the participants and,
    - An evaluation of the improved knowledge on *Striga* through a second benchmark test.
- The evaluation of the course can be done using cards and visualization on pin boards
        - What did I like about the workshop?
        - What should be improved?
- To know whether the presented information was assimilated by the participants the comparison of the benchmark tests can be used.

ANNEX 4. TRAINING PROGRAM AND CURRICULUM FOR FARMER FIELD SCHOOL ON *STRIGA* MANAGEMENT

4.1 TRAINING OF TRAINERS ON ESTABISHMENT OF FFS FOR PARTICIPATORY TECHNOLOGY DEVELOPMENT AND EXTENSION

Program

Date:

Venue:

DAY I

9:00 – 9:30	Registration
9:30 – 9:45	Welcome
9:45 – 10:00	Climate setting and TOT organization
10:00 – 10:30	Break
10:30 – 12:00	*Striga* - Biology & control
12:00 – 12:30	Discussion
12:30 – 14:00	Lunch
14:00 – 16:00	Experience in *Striga* research and extension
16:00 – 16:30	Break
16:30 – 17:15	Discussion
17:15 – 17:30	Evaluation of Day I program and announcements

DAY II

9:00 – 10:30	Participatory farmer training on the control of *Striga*
10:30 – 11:00	Break
11:00 – 12:30	Introduction to FFS
12:30 – 14:00	Lunch
14:00 – 15:30	FFS methodology
15:30 – 16:00	Break
16:00 – 17:00	FFS methodology (contd.)
17:00 – 17:30	Discussion

FIELD EXERCISE DAY III - XII

DAY III
AM - Concept of agro-ecosystem analysis (AESA)
PM – Group work & group discussion

DAY IV
AM – Conditions for successful FFS, selection of participants & sites
PM – Organization and management of FFS (school schedule)

DAY V
AM - Field visit
PM – Field visit & group presentation

DAY VI
AM – facilitation skills
PM – Discussions

DAY VII
AM – Participatory technology development (PTD)
PM – Group exercises & discussions on PTD

DAY VIII
REST DAY

DAY IX
AM – Visit to FFS
PM – Processing, presentation & discussion on FFS (field day)

DAY X
AM - Discussion on leadership & folk media
PM – Visit to FFS

DAY XI
AM – Discussion on report writing & documentation,
PM – Discussions on group organization & team building

DAY XII
AM – Strength & weakness of FFS & solutions
PM – Action/work plan

DAY XIII
AM – Evaluation of TOT & preparation for graduation
PM – Graduation Ceremony & closing

4.2 CURRICULUM FOR FFS

The curriculum includes nine sessions. The sessions are formulated and designed for the farmers to own and implement them themselves. Experts may lead the initial introduction of the program and serve as facilitators. One FFS comprises a maximum of 25 farmers. A number of FFSs can be formed in a given village. Joint programs and exchange visits have to be regularly organized to facilitate experience sharing. Innovative and influential farmers can help organize the schools and help convince more farmers to join the schools but care must be taken to ensure that such people do not dominate the training and experimentation sessions. It is absolutely essential that the farmers feel relaxed, not dominated and capable of participating and contributing freely.

The first session is important since it will serve as motivation for participants to continue to assist the school. In addition to that there will be discussions and agreements on the manner in which the activities of the FFS will be implemented. The commitment and responsibility of the facilitators will be established at this time and it is hoped that it will serve a useful purpose beyond the completion of the activity. Furthermore, the first session will be used to establish the benchmark on current knowledge of the farmers about *Striga* and other weeds, pests, diseases and their control

SESSION I

TITLE**:** Introduction to farmer field school (FFS) concept and practices, participatory rapid appraisal (PRA)

OBJECTIVE:

- To facilitate the conceptualization of the FFS approach
- To identify and prioritize the production and resource management problems
- To create team spirit

MATERIALS: flip charts, pens, pencils, note books

PROCEDURE:

- The session to be conducted separately for each separate FFSs
- Get to know each other and find out about farmers expectation from involvement in FFS
- Introduction to adult and hands-on training (FFS)

SESSION II

TITLE: Knowledge on and attitude of farmers towards *Striga*, and control measures practiced by farmers

INTRODUCTION

- Before the commencement of FFS activities, the facilitator should determine the level of knowledge and perception of farmers on *Striga*.
- Better done by conducting question and answer sessions.

OBJECTIVE

- Determine existing knowledge, perception, attitude and practices on weeds especially *Striga* and other pests.

- Enable farmers share knowledge and ideas.

NOTES FOR FACILITATORS

- Do not forget that farmers have abundant knowledge and experience. Try to listen to what they have to say and learn from their experiences. Direct the discussions so that greater focus is rendered to weeds specially *Striga* and other biotic constraints. This can provide an opportunity to reorient the FFS based on the issues and topics that would interest the farmers much.
- Since making detailed diagnosis is not the objective of this session, the activities should be done so as to promote the discussion in a dynamic and pleasant manner using examples, samples, photographs, drawing etc.
- It is advisable to use two facilitators to handle the activity. One can lead the discussion while the other takes notes of the proceedings.

MATERIALS

- Survey questionnaire, checklist, flip charts, markers & pens, adhesive tape, different photographs and drawings appropriate for the session, specimens of major weed species, samples of diseases and pests

PROCEDURE

- Form groups consisting of 3 – 6 member farmers. Groups need to be uniform in terms of age distribution, status and gender representation
- Each group should be assigned a name
- The facilitators present questions or topics of discussion one by one. The small groups are allowed to discuss each question/topic for a specified period of time (10-15 minutes) and make presentation to illustrate their deliberations. A representative from each group summarizes the findings of the group's discussion in five minutes. The discussion on the presentations should be open with full participation of all members. The facilitators should encourage people to contribute to the discussions and refrain from offering opinions and information.

SESSION III

TITLE**:** Basic concept of experimentation: Randomization, replication and sampling. Create better understanding of FFS experiments.

INTRODUCTION

One of the objectives of the field school is that the farmers improve their ability to do their own experiments. To do this, farmers need to be familiarized with the concepts and purpose of doing research. They have to have basic knowledge of treatments, randomization and replications. Farmers will participate in a number of experiments during the crop growing period. The main purpose of conducting the experiments is to allow and enable farmers correctly apply treatments, differentiate the treatment responses and learn how to conduct observations and assessments.

OBJECTIVE

- Help farmers have an idea on the basic aspects of experimental design
- Encourage farmers to raise questions and design experiments to find the answers

At the end of this exercise farmers are expected to get an idea on the value and importance of conducting experiments.

NOTES FOR THE FACILITATOR

The farmers are testing new ideas/technologies. It is important that they understand the basic concept and principles of field experimentation, data collection and interpretation. First, it has to be realized that an experiment is designed when there are several possible alternative solutions (treatments) to a problem where the best treatment is not known. For e.g. there may be five varieties of sorghum and it is not known which one of them is more resistant to *Striga*. The treatments are the alternatives that we want to compare. For instance each of the five varieties of sorghum would constitute a treatment. Furthermore, it is worth explaining that the replications are there to verify that the results are not due to accident or chance but due to treatment differences i.e. because certain treatments are better than others. The plot area (block) is assumed to be uniform. The next step is to allocate treatment at random which is called randomization. This is done to allow treatments get equal exposure to the environment, facilitating fair comparison among them.

SESSION IV

TITLE**:** Site selection, seed-bed preparation, trial layout and planting

OBJECTIVE

- Introduce farmers to basics of trial management
- Reach agreement on responsibility sharing
- Select treatments and appropriate site for experiment

PROCEDURE

The history of the field to be used for sorghum production is very important. Select trial site based on history of *Striga* infestation. Preferably the preceding crop on the trial plots selected for the purpose should be the same. The soil should have a history of no serious soil borne diseases. Participants should be encouraged to observe and determine soil types suitable for sorghum production and know how soil type and management affect crop growth. A good seed-bed preparation is a pre-requisite for quality seeding which is in turn a key factor for good yield. Unlike conventional experimental setup procedures, each treatment has to be applied on a separate plot.

MATERIALS

Hoe, plough, pegs, meters, sisal strings

ACTIVITY

- Farmers should collect soil samples from different parts of the farm land (top of hill, valley bottom etc)
- Allow farmers to observe the soil samples and classify them based on color
- Can they distinguish good soil type based on color or texture?
- Which of the soils do they think are suitable for sorghum cultivation?
- What inputs and materials do they use in field preparation?

SESSION V

TITLE: Use of clean and good quality seed

INTRODUCTION

In this session the quality of seed and its impact on the spread of *Striga* will be dealt with. The idea is that they discover and understand that the quality of seed is important in avoiding the introduction of parasitic weed seeds to farms. The presence or absence of *Striga* seed in crop seed lots will be examined by farmers. Seed sales and exchange as the main factor of dissemination of parasitic weed seed will be discussed.

OBJECTIVE

- Improve awareness on the importance of use of clean seed
- Production, storage and handling of good quality seed

EXERCISE: Experiments in selecting clean, good quality seed

MATERIALS

- Samples of seed from different farmers, plastic containers and magnifying glasses. The seed samples can come from storage houses of farmers, markets and experimental stations.

PROCEDURE

Divide the participants into groups of 4 to 6 people. Every group should be requested to examine the seed quality using magnifying glasses. Inspect the seed lot for disease and insect damage, see if any impurities exist and if the crop seed is plump and good quality. Generally, a "five percent rule" applies to any seed lot. A seed lot with five percent or more total defects is considered too risky to use. With parasitic weeds any contamination level is not tolerable. Farmers should strive to use the highest quality seed obtainable, know the source, history of a seed lot. Let the group members grade the seed lots for seed health and contamination, and decide which they consider is suitable for planting.

SMALL POT EXPERIMENT ON USE OF QUALITY SEED

The farmers can run a small experiment with samples of the seed lots they have at hand. Use one-liter pots. Fill with sterilized soil or soil collected from *Striga* free areas. Plant seeds and observe and determine whether seed lots used as seed source were contaminated with *Striga* and/or other diseases/pests.

- Collect contaminated and clean seed samples
- Plant the seeds in non contaminated soil in clay pots
- Water the pots regularly and place under close supervision by group of farmers
- Discuss observation and take notes for presentation to group discussions

SESSION VI

Title**:** Crop management and its effect on the cereal crop and *Striga* (row planting, tied ridging, fertilizer application, thinning, mid season cultivation, weeding, disease and pest control)

INTRODUCTION

Appropriate care is needed to create an environment for the crop to realize its potential and for it to be in a position to defend itself or tolerate disease and pest attack. Hence proper seed bed preparation, use of clean seed and optimal seed rate during planting, use of recommended fertilizer rate and measures required to protect the crop from biotic constraints deserve due consideration. In hilly areas with undulating topography terracing and other appropriate land management measures may need to be implemented.

1. CROP EMERGENCE

INTRODUCTION

Crop emergence is an important aspect of plant growth. Poor emergence could be indicative of the poor status of seed health or the presence of soil-born diseases. Delay in seedling emergence could also be due to poor seed-bed preparation. E.g. hard or crusted soil or lack of rainfall. Generally farmers should be aware of all the conditions related to seed bed or field preparation, timing of planting etc. Of particular importance to seedling emergence are diseases and insect pests that affect seed germination and emergence. Pathogens and insect pests are some of the important causes of delayed or uneven emergence

MATERIALS

Flip charts, hand lens, markers, pens, pictures and diagrams of plants damaged by diseases and pests, vials, swift net etc

ACTIVITY

- The farmer should be encouraged to observe and take note on the rate of seedling emergence and establishment. This could give clue as to the health of the seed used during planting.
- Un-emerged seedlings have to be dug out and examined for *Striga*, pathogens and pests.
- Initiate discussion on the causes of poor emergence.

2. WEEDING

OBJECTIVE: to make farmers aware of the proper time and frequency of weeding.

INTRODUCTION

Weeds compete with crops for light, nutrients and water as a consequence yields can be severely reduced. Parasitic weeds can furthermore induce physiological disturbances hampering crop growth. The level of damage can vary depending on weed infestation intensity and competitive ability of the weed species present. Weeds can harbor pathogens and pests and inflict indirect damage. The value of the crop produce can be seriously compromised due to contamination by weed seeds. Field preparation, time of planting, seed rate and planting arrangement, soil and crop type, and weather conditions can all affect weed dynamics but most importantly proper time and frequency of weeding is required to manage weeds.

ACTIVITY 1. Facilitator should initiate discussion on the time and frequency of weeding practiced by farmers.

- First weeding: Generally crops are sensitive to weed competition during the initial growth stage and first weeding has to be performed within the first four weeks. In some cases, if crop is planted after onset of rain the first weeding probably needs to be done early, may be two weeks after planting.
- Second weeding: This operation is normally performed between six and eight weeks after planting. At this time hilling or ridging may also be conducted. While doing this operation care must be taken not to damage the root system of the crop.
- Removing *Striga* is more effectively accomplished after flowering but before seed setting.

ACTIVITY 2. Facilitator initiates exchange of idea and knowledge on existing weed species.

- Form groups, with 4-6 member farmers each.
- Farmers observe, collect and identify the different weed types.
- Classify the weeds according to their type (annual/perennial, noxious/not noxious, parasitic/non parasitic etc).
- Discuss the possible factors affecting weed dynamics.

3. SOIL FERTILITY MANAGEMENT

OBJECTIVE: to improve knowledge of farmers in integrated fertility management

INTRODUCTION

Fertility management is one of the very critical elements in crop production and in parasitic weed management. Use of optimal dose and combination of organic and inorganic fertilizers, and proper and timely application of the input can lead to successful crop production. Farmers have to acquire basic knowledge of integrated crop and nutrient management. Soil and fertility management is one of the neglected aspects of crop production by small-scale farmers.

PROCEDURE

- Stimulate discussion on integrated crop and nutrient management concept.
- Help trainees develop a holistic view, explain that addressing crop and soil related problems in an integrated manner is one very helpful way to improve productivity of the system and combat biotic constraints such as *Striga*
- Have farmers discuss the pros and cons of using fertilizer from different sources in variable set of conditions (e.g. in wet climates and in arid areas)
- Encourage farmers to discuss the prevailing problem on natural degradation in general and soil fertility depletion in particular, and how traditional farming practices

are contributing to the problem. Constant mining of the soil (complete removal of crop residues) is the rule than an exception in the subsistence agriculture of tropical Africa

- Compost preparation from locally available materials should get adequate coverage supported by practical demonstration
- Appropriate use of farm yard manure after drying and decomposition helps to limit spread of parasitic weeds and it is important that farmers do appreciate the importance of such an operation

SESSION VII

TITLE**:** Symptoms and diagnosis of *Striga*, other crop diseases and pests

INTRODUCTION

This session gives the farmer the opportunity to recognize different types of symptoms of *Striga*, diseases (e.g. leaf diseases) and pests on crop plants in the field, and study them with the aid of a hand lens. In addition, the farmers shall incubate leaves and other plant parts with different symptoms in moist chambers (plastic containers) for observation.

Activity I: Diagnosis of *Striga* and plant diseases

- Divide participants into small groups of 4 or 5 members for field visit and agro-ecology analysis
- Determine if farmers can distinguish between symptoms of *Striga*, major diseases and pests
- Identify the major *Striga* sp, diseases and pests in the area and how many farmers know about such pests as well as their management
- Encourage farmers to learn more about the biotic constraints, learn to recognize and differentiate the typical symptoms of *Striga* and, various classes of pests and diseases
- Let each group explain what they observe based on their assessment of diseased and healthy plants and having taken note of what environmental factors caused the problem(s). The explanation could include *Striga*/disease/pest symptomology (where do the symptoms start? What do they look like?), and biology (means of spread and reproduction)
- Have each group produce drawings of symptoms, including important contributing factors

MATERIALS

Crop plants with symptoms (one per *Strig,* pest, or pathogen type), colored markers, magnifying lenses, flip charts, plastic containers and petri-dishes

NOT FOR FACILITATORS

This is a practical way for farmers to diagnose *Striga*, common diseases and pests, and it is also a good team building exercise. Participants should form small groups to permit active involvement of all. Groups should study and draw affected plants, present and compare findings. Drawing allows people to internalize what they observe.

SESSION VIII

Title**:** *Striga* infestation in relation to the environment

INTRODUCTION
The principal part of each session from now on will be the agro-ecological analysis or detailed observation of the farm. In this session, environmental factors that influence *Striga* development and the concept of integrated *Striga* management will be introduced.

AGRO-ECOLOGICAL ANALYSIS
The objective is to observe and analyze the agro-ecosystem and diversity of crop fields
NOTES FOR THE FACILITATOR
This session will be conducted to create awareness and interest on the part of the farmer to conduct detailed observation and monitoring of his/her fields. With good field observation the farmer can reach better management decisions and acquire problem solving ability at local level.
MATERIALS
Paper, pencil/pen, flip charts, markers, plastic bags, small plastic trays for sample collection

PROCEDURE

ACTIVITY 1
The participants will form 4-6 member groups. Each group will be assigned a specific spot or plot of land. The farmers are expected to make their observation, draw and categorize the weeds, the soil types, insects (classified as good or bad according to criteria set by farmers). The farmers should try to draw everything that they observe, collect samples and record symptoms. The farmers are expected to do their own assessment of the overall situation, the biotic and abiotic factors and their interaction within, and between themselves and the environment.

After pre-specified time, the groups come together to present their findings. When one group presents, members of the other groups should be encouraged to pose questions and ask for clarifications. The facilitators can provide support in terms of clarifying doubts or in terms of proposing tests to verify observations. By the end of the exercise enough exchange of ideas and opinions would be made to draw conclusions on the management of fields.

ACTIVITY 2
This part will focus on elaborating the factors contributing to *Striga* build up. Farmers know the conditions that are favorable for parasitic weed infestation however they are unable to tell the relative contribution of each factor. The farmer groups should try and deliberate on the possible edaphic and weather factors playing role in weed/pest dynamics. Farmers should be encouraged to list out the factors, which will in turn be separated depending on whether they cause “more *Striga*” or “less *Striga*”. Questions to be answered could include: Why is there more/less *Striga* in water logged soils, dry seasons, light soils, mono-cropping conditions, different varieties, and different management practices? It is expected that farmers can

deduce from the discussions that *Striga* is favored by land degradation, moisture stress and other factors that could weaken the crop's natural defense system.

SESSION IX

TITLE**:** Integrated *Striga* management (ISM) through integration of resistant/tolerant varieties, good land preparation, use of clean seed, optimal crop husbandry including fertilizer use and moisture conservation practice, right time and frequency of hand weeding

ACTIVITY 1

A simple exercise to help farmers appreciate the size of *Striga* seed, the tiny almost microscopic seed, and the fact that *Striga* is an obligate parasite which can not germinate and grow unless there is a suitable host nearby. The fact that the parasite is a prolific seed setter and that only few plants can produce and shed millions of seeds in one go. Hence, the primary target of any viable control and management intervention should aim at the gradual depletion of the seed bank in the soil.

To demonstrate the process use the following steps:

- Place seeds of *Striga* and some crops on a plate and show the contrast in size
- Place the seed samples on grass fibre paper in Petri-dishes and add water and demonstrate that unlike the seeds of crop and other weed seeds *Striga* seeds do no germinate in water unless they receive root exudates stimulants from host plants
- Show under magnifying lens the seeds of *Striga* are equipped with structures that help them get easily disseminated
- Later in the season, uproot a crop, another weed and *Striga* plant and compare the amount seed produced by each plant. This helps farmers realize how important it is to keep fields free of even a single plant of the parasitic weed

ACTIVITY 2

Set up an experiment to compare the advantages of integrated crop and *Striga* management and farmers' traditional practices. The improved package should include:

- Good seed bed preparation
- Use of clean seed, optimal seed rate and fertilizer
- Proper weeding and other crop husbandry practices
- Recommended control practices (resistant varieties, row planting, moisture conservation, timely hand pulling and/or herbicides)

Groups will be assigned to make follow up, take notes and data, interpret and write report and make presentation about their findings.

2007

PARTICIPATORY STRIGA MANAGEMENT IN AFRICA: A TRAINING GUIDE

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