A REFERENCE MANUAL ON STRIGA DISTRIBUTION AND CONTROL IN TANZANIA

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Farmesa
Sida

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CONTENTS

PREFACE

Striga, a small weed with delicate, purple flowers, annually robs African grain producers of more than four million tons in yields.

Striga attaches to the roots of maize or sorghum, and saps nutrients and water, thus reducing yields dramatically. Also known as witchweed, *Striga* is amazingly prolific - a single plant can produce tens of thousands of pollen-like seeds that pepper the soil. It causes considerable yield losses throughout most agroecological zones of sub-Saharan Africa (excluding mountainous and forested areas) and has raised serious concern in southern Africa.

Thus, two countries of the FARMESA programme have identified *Striga* as one priority to work on. FARMESA (the Farm-level Applied Research Methods for East and Southern Africa programme) is a collaborative Programme of countries in East and Southern Africa (Kenya, Tanzania, Uganda, Zambia, Zimbabwe, in association with Botswana, Malawi, Mozambique and South Africa) with the objective of, inter alia, identifying, testing and disseminating improved methods and technologies for small holder agriculture.

In Uganda FARMESA supports on farm trials designed to assess improved cultural practices.

In Tanzania, researchers have confidence in a set of cultural practices which will reduce the impact of *Striga*, especially on poor farmers. Thus, researchers and extension workers have compiled and tested this extension package with farmers. We look forward to widespread adoption of these improved practices.

J. Dixon and T. Kirway
Programme Coordinator and Chairman
National Coordinating Committee

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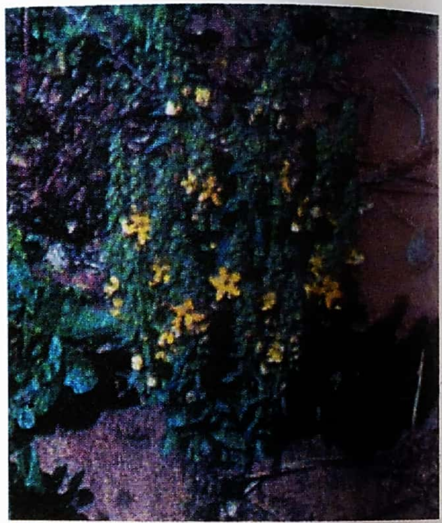
STRIGA AND ALECTRA SPECIES OF ECONOMIC IMPORTANCE OBSERVED IN TANZANIA

Plate 1

Striga asiatica

Alectra vogelii



Striga forbesii

Striga hermonthica

Plate 2

Maize highly infested by *S. asiatica.*

Cowpea infested by *Alectra vogelii.*

1. Introduction

Striga species (Scrophulariaceae family) are obligate root hemi-parasites of cereals and legumes meaning that *Striga* plants are only partially parasitic with their own chlorophyll and photosynthesis, but the plants cannot establish and develop independently. Several Striga species attack different food crops including sorghum, maize, upland rice, millets, sugarcane and cowpea, especially in the Sahelian and Savannah zones of Africa (M`boob 1986). They have also been observed on wild grasses, such as *Chloris* species.

Striga, also called witchweed, represents the greatest biological constraint to increased food production in sub-Sahara Africa (M`boob 1994, Sauerborn 1991), and it is a more serious problem than insects, birds or plant diseases (Ejeta and Butler, 1993). *Striga* species affect the livelihood of some 300 million people (M`boob 1989, 1994). Many African countries including Benin, Burkina Faso, Gambia, Ghana, Mali, Niger, Nigeria, Senegal, Togo, Cameroon, Sudan, Ethiopia, Kenya, Malawi, Madagascar, Tanzania, Zimbabwe are highly infested with *Striga* causing serious yield losses that are as high as 100% at some sites (Lagoke et al. 1991, 1994). Many farmers are forced to continue growing crops on heavily infested fields and harvest low yields. Few are able to move to *Striga* free fields as arable land has become limited due to population pressure (Kim et al. 1985b, Parkison 1985). About 2/3 of the 73 million ha. of land devoted to cereal production in Africa are situated in ecological zones where *Striga* is already present and it can easily spread to *Striga* free areas if no control measures are taken (M`boob 1989, Lagoke et al. 1991, 1994, Sauerborn 1991).

Most *Striga* species are originally from Africa and a few have their origin in Asia. Currently, 41 species of *Striga* are known to be parasitic on wild hosts of which 11 can attack cultivated crops. Only three *Striga* species are known to cause serious damage to food crops including *Striga hermonthica, S. asiatica* and S. *gesneriodes* (Roynal-Roques 1991, 1996).

There are many alternate hosts for *Striga,* mostly grasses and legumes (Musselman 1987), making it very difficult to eradicate *Striga* species from Africa. However, eradication may not, be necessary or even desirable. Co-survival and maintaining low levels of *Striga* infestation with less effect on reduction of cereal yields sounds more applicable and feasible (Kim et al. 1994b).

2. *Striga* species and distribution in Tanzania

Striga species reported in Tanzania include *Striga asiatica* (L) Kuntze, *S. aspera* (Willd) Benth., *S. elegans* Benth., *S. euphrasioides* Benth; *S. forbesii* Benth., After establishment, the parasite extracts sugars and inorganic minerals from the host plant. Recent studies have shown that as a result of *Striga* infestation , growth reducers (inhibitors) in the host plant are increased and growth promoters are decreased. Young *Striga* seedlings are completely dependent on the host while they are still underground and especially at this stage they cause the maximum damage to the host plant. When *Striga* seedlings emerge above ground they develop green leaves and produce their own photosynthates. However, there is a continuous flow of carbohydrates, water and minerals from the host.

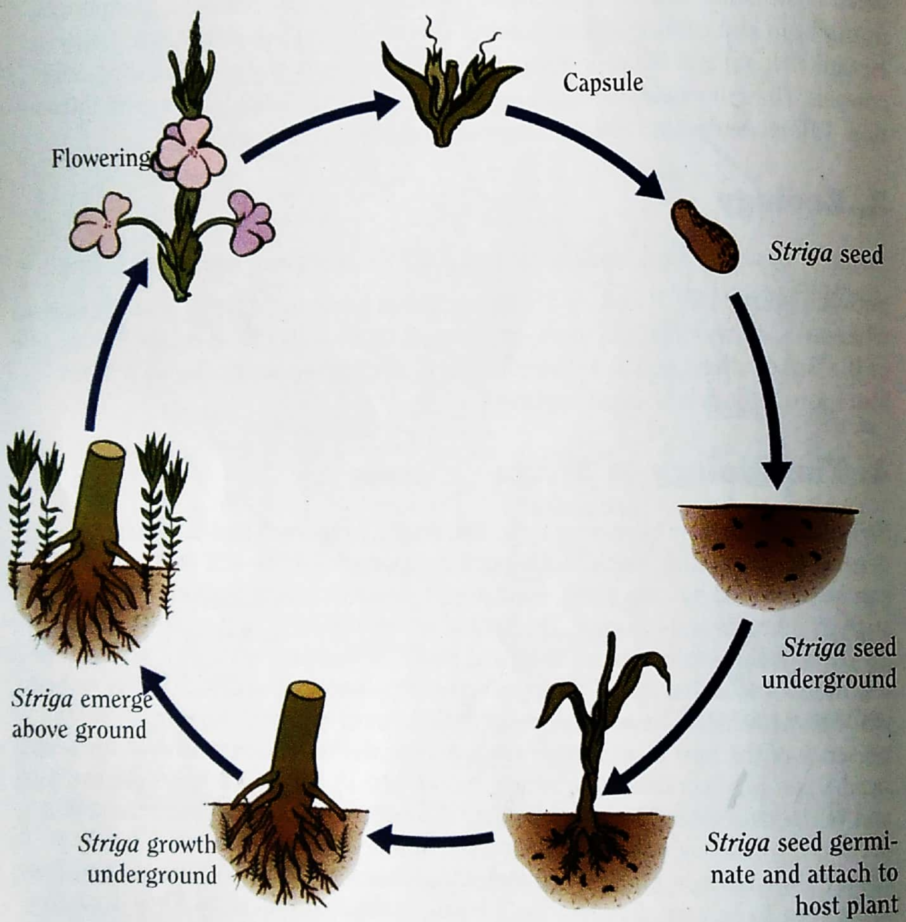


Fig. 2. *Striga* life cycle

After germination and attachment, *Striga* takes 4 - 7 weeks to emerge, depending on the depth of the seed in the soil. After emergence it takes about 4-10 weeks to complete the life cycle. Thus 2-4 months are required from germination to seed setting. The most active *Striga* seeds are found at 0 - 15 cm deep in the soil with reported germination up to 95 %.

5. Control of *Striga* in relation to its biology

Striga biology as described in section 4 differs from normal weeds and shows specific characteristics which have important implication for it's control.
The main damage to the host occurs underground before *Striga* emerges and can be observed.
Striga seed remain viable for more than a decade in the absence of the host plant.

Control measures have therefore to be applied continuously over a large period (up to 10 years) to reduce significantly the number of *Striga* seeds in the soil.
Striga plants produce extensively high number of seeds. Sprich (1994) counted about 23000 - 50000 viable seeds per *Striga* plant. Consequently it must be ensured that *Striga* is not allowed to produce new seeds in order to prevent an increase in soil seed population.

For prevention of *Striga* seed production, weeding needs to be done at emergence of the *Striga* plants or before flowering, which does not coincide with the "normal" weed control practices of farmers. In addition weeded *Striga* plants need to be collected at the field border and burnt since they are able to mature and set seed even though they have been uprooted.

6. Symptoms on the host plant

After successful attachment, development occurs underground for 4-7 weeks prior to emergence. Most of the damage to the host plant occurs at this stage making it difficult for a farmer to determine the actual cause.

Direct symptoms from *Striga* infestations on the host plant include stunted growth, scorching of leaves and wilting, yellowing and barrenness (without setting cobs/heads).

Under high infestation the host plant may die before flowering and symptoms may even be observed before the *Striga* emerges from the soil. *Striga asiatica, S. hermonthica* and *S. forbesii all* cause stunting of the host shoot and affect panicle formation, which can lead to 100 % crop yield loss, but other symptoms are different for different *Striga* species. For example, *S. asiatica* attack induces symptoms similar to those induced by drought - like leaf wilting and leaf rolling even though the soil is saturated with moisture. *S. hermonthica* and *S. forbesii* do in general not cause drought symptoms but cause chlorotic lesions; these may not always be clear and are quite often confused with symptoms caused by leaf diseases. *Striga* may completely destroy the crop if this occurs because this adds to the water stress already created by *Striga*.

7. 1 Farmers knowledge about *Striga*

Farmers recognise *Striga* as one of the major constraints to cereal production in Tanzania (Mbwaga, 1996). Each tribe has a special name for *Striga* which is usually associated with its damage to the crop and the nature of the attack which is seen as mysterious (Table 1). Farmers have reported crop yield losses due to *Striga* damage up to 90 % - 100%. The existence of *Striga* goes back as far as the 1930s (the earliest they can remember). During the colonial period, extension staff were given the mandate to punish any farmer (by fines, jail or beatings) whose field was found to be infested with *Striga*. The farmers consider that the problem of *Striga* has increased since independence because extension had ceased to follow-up on the problem. Other possible explanations for the increase of the *Striga* infestation are the accelerating decline in soil fertility, under conditions which *Striga* becomes more pronounced, reduced fallow periods, introduction of new cultivars e.g. sorghum variety Tegemeo, which are highly susceptible, mechanisation in land preparation which encourages the spread of the seeds of the weed; limited crop rotation caused by shortage of arable land and use of seed harvested from *Striga* infested fields as planting material, which has been reported as the major source for spread of *Striga* to *Striga* free fields by Berner (1994).

Striga control measures observed to be practised by farmers include hoe weeding/uprooting, leaving *Striga* plants on the soil surface in the field to dry. This is the most common control measure. Other measures are crop rotation with non cereal crops such as cowpea, green gram, cassava, sweet potato, tobacco, groundnuts and sesame; leaving land fallow where possible for 2-3 years; mixed cropping systems such as maize/sorghum, sorghum / cassava / maize, maize/pigeonpea, maize intercrop with upland rice to reduce the risk of crop failure. Few farmers transplanted rice and sorghum to escape severe *Striga* infestation. Early crop planting has higher *Striga* infestation than late, and has been reported and practised by farmers as a measure for the crop to escape severe *Striga* damage. Late planting of crop results in few *Striga* counts but also poor crop yields. From farmers experience none of the control measures offered a significant control of *Striga*. This is due to lack of knowledge by farmers about *Striga* biology, and the opti-

mum time to carry out *Striga* control measures such as critical stage to weed the witch weed.

Table 1. Local names for *Striga*

Local name	**Ethnic group (tribe)**	*Local name*	**Ethnic group (tribe)**
Kiduha	Sukuma, Jita, Nyamwezi (Shinyanga, Mwanza, Mara)	Kisahani	Zigua (Tanga)
Ilambito, Mahanga, Mhiriri, Kiduhi	Gogo (Dodoma)	Chihavi, Kafwiti	Ngoni (Ruvuma)
Sani	Luguru, Kaguru (Morogoro)	Kansimba	Fipa (Rukwa)
Motomoto	Bondei (Tanga)	Chiluri	Rangi (Singida)
Chiluba	Mwera (Mtwara/Lindi)	Chilori	Burunge (Kondoa)
Lundimu,	Makonde	Senengee	Sandawi (Kondoa)
Nanchilanga	(Mtwara/Lindi)		
Chikungulu	Makua and Yao (Mtwara/Lindi)	Ebitoha (sing. Egetoha)	Zanaki. Kuria and Ngoreme (Mara)
Kyumika	Nyakyusa (Mbeya)	Kalozi	Bungu (Mbeya)
Chiavi	Makua (Mtwara/Lindi)	Ukankala	Nyiha (Mbeya)

7.2 Farmers knowledge about the biology of *Striga*

Several studies have been conducted in African countries on farmers knowledge of the biology of *Striga*. Farmers in Ethiopia identified several ways of *Striga* dispersal, including equipment during cultivation, seeds, crop root systems, manure, runoff water, wild plants, migratory birds, body hairs of livestock, crop residues, stored grain and human beings. In Ghana farmers know that *Striga* is reproduced by seeds, but only few have actually seen *Striga* seeds. Farmers attribute symptoms like yellowing or falling leaves of any plant, not only host plants, to the presence of *Striga*. Some farmers in Southern Mali know that Striga is a parasitic weed and a few of them know that it attaches to the roots. Farmers know that it produces seeds because it has flowers. The seed can be spread by wind, water and animals, where only few farmers indicate that it can spread by human beings, crop seeds and ploughing equipment. Farmers have observed that *Striga hermonthica* also occurs in fallow, but the intensity decreases with an increasing fallow period. Farmers in other areas know very little about the biology of *Striga*. Farmers in Tanzania believe that *Striga* is propagated by means of stolons and hence leave weeded *Striga* plants on the soil surface to dry. Also farmers know in general that *Striga* occurs on less fertile soils and they see *Striga* as an indicator plant for reduced soil fertility.

Therefore a better understanding on the biology and ecology of *Striga* will enhance farmers understanding of, and willingness to execute control measures, since most of them have no direct effect on the crop yield in the current season.

8. Uses of *Striga* in Tanzania

The *Striga* plants have been reported by few farmers to have some medicinal uses. It has been reported by few farmers in Dodoma to be used for human treatment against headache, stomach ache, scabies and skin disease and some women use *Striga* flowers for decorative purposes. The other use of *Striga* plants mentioned by farmers from Chunya in Mbeya is to protect the stored harvest against witchcraft.

9. Socio-economic implications of the *Striga* problem

A direct socio-economic implication of crop yield losses due to *Striga* damage, which is estimated in Tanzania up to 90 % depending on the *Striga* infestation, is the migration of farmers to *Striga* -free areas. This is limited due to shortage of arable land, shifting cultivation, farm abandonment or change of cropping pattern (Riches et. al. 1987). The accessibility to (quality) fallow land is not equal among all farmers, because the founding families of the village retain traditional ownership and decide on the allocation of land to new arrivals who usually get marginal fields.

10. Host specificity of *Striga*

There has been evidence that host specific strains of *Striga* exist. In Botswana it has been reported that maize is not attacked at first, when planted into fields where sorghum has been infested by *S. asiatica,* in subsequent years maize may gradually show increasing infestation.

Similarly Parker and Reid (1979) confirmed the existence in West Africa of distinct host specific strains of *S. hermonthica* that attack either sorghum or pearl millet, each strain being almost totally unable to parasitize the other host. At Mwele Seed Farm in Tanga region, maize has been observed to be seriously infested by *S. asiatica*, but when sorghum was planted on the same fields, it was observed to be completely free of *Striga* infestation (Mbwaga1993 and 1995 unpublished). Trials conducted at Ukiriguru and Hombolo for *Striga* host specificity at a hot spot for *S. hermonthica* and *S. asiatica* respectively, it was observed that pearl millet was free of *Striga* infestation, but maize and sorghum were attacked (Tables 2 and 3). The specificity could be explained by different germination requirements, the pearl millet root exudates failing to stimulate the germination of the strain from sorghum/maize and vice versa. The strains of major *Striga* species found in Tanzania do not infest pearl millet but finger millet is attacked.

Table 2.
The development of *Striga hermonthica* on three cereal crop at Ukiriguru (1988/89 - 1990/91)

Crop species	Variety	Percentage *Striga* infestation / host plant 1988/89	1989/90	1990/91
Pearl millet	Serere 17	0.0	0.0	17.0
	Ukiriguru local	0.0	0.0	3.0
Sorghum	Serena	9.3	4.0	284.0
	Tegemeo	277.0	116.4	335.7
Maize	Staha	45.0	97.0	350.7
	TMV-1	102.7	5.0	259.3

Mbwaga and Obilana (1993)

Table 3.
Development of *Striga asiatica* on three cereal crops at Hombolo, Dodoma (1988/89 - 1990/91)

Crop species	Variety	Percentage *Striga* infestation / host plant 1988/89	1989/90	1990/91
Pearl millet	Serere 17	0.0	0.0	0.0
	Ukiriguru local	0.0	0.0	0.0
Sorghum	Serena	125.7	0.0	73.3
	Tegemeo	492.0	434.0	58.3
Maize	Staha	13.0	129.0	29.0
	TMV-1	4.0	93.0	6.3

Mbwaga and Obilana (1993)

11. Methods for *Striga* control

The present recommended methods for *Striga* control are based on a fundamental understanding of the germination, establishment, growth and the host-parasite relationship. The prime consideration in any *Striga* control strategy is to prevent seed formation, dispersal and to encourage fatal germination. Through removing normal weeds at an early stage crop losses can be prevented within the same cropping season, but in the case of *Striga* infestation, farmers cannot prevent yield losses even though they apply various available control methods. Therefore, farmers have to employ a long -term approach which includes investments in control measures with marginal short-term returns.

11.1: Hand pulling and hoe weeding

Hand pulling and hoe weeding should be done before *Striga* flowers; this prevents the production of *Striga* seeds, which might otherwise accumulate in the soil for future cropping seasons. The hand pulled or hoe weeded *Striga* should be collected and burned, especially when the *Striga* plants have flowers. Where infestation is light, weeding before *Striga* sets seeds has been reported to be a most effective method of *Striga* control (Saunders 1933). *Striga* is not very difficult to weed,

because the roots are brittle and easily to break from the host. Farmers are already practising *Striga* control either by hoe weeding or uprooting *Striga* but they lack the knowledge about *Striga* that it produces and disperses by seed (Section 4), because they leave weeded *Striga* plants on the soil surface to dry. It is not practical to hand pull dense infestations. Hand pulling or hoe weeding and burning prevents the production of *Striga* seed, and this should continue beyond crop harvest if necessary. The crop ratoon should also be uprooted or burned to prevent the continued growth and seeding of *Striga*.

11.2: The use of *Striga* free seed.

In *Striga* infested areas, planting materials is frequently contaminated with *Striga* seeds as a result of harvesting, threshing and drying processes (Berner et al. 1994b). Harvesting is frequently done by cutting the crop plant at ground level and laying the whole plant or cobs to dry on the soil surface in the field. When collecting the crop from the field, any *Striga* seeds which are interspersed with the drying crop are also collected and taken to the threshing area where *Striga* seed contamination crop seed may easily occur. After winnowing the seed lots are either stored or taken to the market for sale. Seed purchased from the markets are used for food and planting material for the next season as are household-stored seeds. Thus newly infested fields can quickly result through contamination, sale and distribution of crop seeds. Therefore the use of *Striga*- free planting material is the most important step in preventing new infestations or re-infestations. This can be made sustainable if it can be ensured that planting seeds are harvested only from *Striga* - free fields or by harvesting the crop without allowing it to come in contact with the ground in *Striga* infested fields, and drying and threshing harvested seeds in *Striga*- free areas. In *Striga* infested fields farmers are advised to use containers during harvesting to avoid seed coming in contact with *Striga* seeds.

11.3: Early planting

An early sown crop usually has higher *Striga* emergencet compared to a late sown crop and high yields are realised from the early planted crop (Table 4). Farmers in Tunduru district for example reported that early planted crops escape severe *Striga* damage, because they realise better yields from early than from late planted maize (Mbwaga et al.1998). Similar observations have been reported by Lagoke et al (1991) and Singh et al (1991).
It has to be noted that from the late planted crop not all *Striga* plants emerge above the ground due to hard soilpan and crop yields are significantly lower due to unfavourable growing coditions, including *Striga* infestation underground.

Table 4.
Effect of Sowing date on emergence of *Striga*

Sowing date	Maize		Sorghum	
	Striga Number/ plant	Yield kg/ha	*Striga* Number/ plant	Yield kg/ha
Early sowing	7	333.4	9	1508.0
Late Sowing	3	35.6	7	757.0

Mbwaga (1996)

11.4: Intercropping of Cereals with legumes

Intercropping of cereals with cowpea in the same row has been observed to reduce *Striga* infestation significantly (Tables 5 and 6). This is thought to be due to the soil cover of cowpea creating unfavourable conditions for *Striga* germination. If it germinates, emerged *Striga* plants do not produce many capsules hence reducing the total seed production per plant. Intercropping cereal with cowpea in the same row gave the highest grain yield and similar results were reported by Sing et al. (1991) in Cameroon and by Reda (1996) in Ethiopia. This practice can easily be adopted by farmers as they are already mix-cropping cereals with legumes. Another advantage of intercropping in the same row is that it reduces Striga growth and makes weeding easier. Intercropping cereals with groundnuts has shown to give similar results.

Table 5.
Maize and cowpea intercrop for the control of *Striga*

Treatment	*Striga* number/host plant	Grain yield (kg/ha)
Maize sole crop	5	107.6
Maize in alternate row with cowpea	6	214.4
Maize in the same row with cowpea	2	672.0

Table 6.
Sorghum and cowpea intercrop for control of *Striga* at Ukiriguru, Mwanza.

Treatment	*Striga* number/ host plant	Grain yield (kg/ha)
Sorghum sole crop	9	1351
Sorghum in alternate row with cowpea	8	1431
Sorghum in the same row with cowpea	5	1742

Mbwaga, (1996)

11.5: The use of trap crops in rotation with cereals

Trap crops produce exudates which induce the germination of *Striga* seed but they cannot support *Striga* development. Germination in the absence of a host plant results in the death of the *Striga* seedling, which is named suicidal germination. Inclusion of trap crops in a rotation system can result in reduction of the *Striga* seedbank in the soil significantly (Riches et al 1986, Terry 1988, Lagoke et al 1991).

Trap crops include cotton, legumes such as cowpea, soybean, bambaranuts, pigeon-pea and oil seeds such as groundnuts, and sunflower. A four year rotation of groundnuts / cowpea has been reported to result in a significant reduction of *Striga* seedbank in the soil. Rotation of nitrogen fixing legumes such as soybean and cowpea with cereals not only reduce the *Striga* seed population in the soil but also increases cereal yield because of the availability of nitrogen in the soil. Cultivars of legume species vary significantly in their ability to stimulate *Striga* seed germination (Alabi et al 1994, Parkinson et al 1987). Hence, it is necessary to screen suitable legume cultivars with high efficacy in *Striga* seed germination.

Research findings from Sprich (1994) indicate that soybean has the highest efficacy to deplete *Striga* seed in the soil followed by sunflower and cowpea (Table 7) and from our findings cowpea variety Fahari and Marejea (sunhemp) had the highest stimulating effect on seed of *S. hermonthica*.

The substantial and relatively rapid effectiveness of legume cultivar rotations with cereals and the side benefits of improved soil fertility have also been demonstrated with cowpea (Carsky and Berner 1995). However, certain soybean and cowpea cultivars are parasitised by *S. gesnerioides* and / or *Alectra vogelii.*

Table 7.

The *Striga* seed bank in soils in northern Ghana as affected by two year cropping with selected crops or fallow (Sprich, 1994).

Treatment	Change of Striga seed bank (%) 1990	1991	mean
Conventional cropping			
maize-sorghum	+513.2	+116.6	+314.9
maize-groundnut	+180.0	+59.2	+119.6
fallow	-17.3	-6.4	-11.9
Trap cropping			
cotton	-33.6	-29.7	-31.7
cowpea	-25.3	-19.7	-22.5
groundnut	-18.7	-23.4	-21.1
soybean	-35.2	-34.1	-34.7
sunflower	-37.5	-32.8	-35.2
Catch cropping			
maize-sorghum	-44.8	-40.2	-42.5

1 calculated *on the basis of the seed content per 100g air dried soil taken up 0 to 15 cm soil depth.*

11.6: The use of inorganic nitrogen fertilizer and animal manure

The use of urea both on station and on - farm has been shown to suppress *Striga* germination and on the other hand to increase crop yield compared to no fertiliser. The effective nitrogen rates of urea were between 50 and 75 kg N/ha. CAN (calcium ammonium nitrate) has shown to have no effect on *Striga* germination, instead it promotes *Striga* growth.

Animal manure has been shown to suppress *Striga* germination on farmers field but the rates are still to be established. The access to animal manure is very limited as not all farmers posses cattle and also transportation of the manure from the homestead to the fields is a problem due the bulkiness of manure, the distance to the fields, as well as shortage of transport. Therefore any use of animal manure should be targeted on heavily infested fields.

11.7: Host Plant resistance

From the farmers point of view host plant resistance offers the cheapest and most effective method of *Striga* control. At present the situation is not very promising since it has been difficult to find truly resistant lines of maize. Better progress has been made in developing *Striga* - resistant sorghum varieties. Resistance in this case is defined as the ability of the same variety to produce satisfactory grain yield when grown in *Striga* infested fields, supporting at the same time markedly fewer flowering *Striga* than a susceptible variety under similar conditions. Resistant sorghum varieties identified are SRN 39, SAR 29, P9405, P9406 and Serena. A tolerant variety produces higher grain yields compared to a susceptible variety, but supports also many flowering *Striga* plants. Tolerant varieties have been identified to be Weijita - a local sorghum variety from Mara region and rice variety "Mwangulu" -a local variety from Kyela. Some problems such as lodging in Weijita and poor threshability in Mwangulu are receiving the attention of the breeders.

11.8: Green manure

The leguminous plants which show great promise as green manure are Velvet bean (*Mucuna pruriens*) and sunnhemp (*Crotalaria juncea, C. ochroleuca*).
The use of green manure has been suggested to increase soil fertility and hence reduce *Striga* infestation. However, use of *Crotolaria* (Marejea) has not been well adopted by farmers because of lack of information about the alternative uses of *Crotolaria*. Research is looking into best and profitable ways of integrating *Crotolaria* in the farming system of the small scale farmers. Marejea has been promoted by Peramiho Mission in Songea, Southern Tanzania, where seed is available. Marejea is known to be good fodder for livestock as well as leaving the soil enriched with nitrogen. It is also claimed to repel insects and can be used for spinach at younger stage. Because of its potential, on-farm trials are now being established on *Striga* infested fields.

11.9: The use of herbicide 2, 4-D amine for Control of *Striga*

The herbicide 2, 4-D amine was applied on sorghum variety Tegemeo (susceptible) to control both *S. asiatica* and *S. hermonthica* at a rate of 2 kg a.i./ha. The nozzle was directed to the area between rows so that the spray liquid touched only the lower stalks of the crop.

The best *Striga* control was observed from the treatment where 2, 4-D amine was applied twice at 8 and 10 weeks after crop emergence (Table 8). Similar results have been reported elsewhere (Edgerton 1955, Setty and Hosmani 1987 and Sigh et al. 1991). The technology has greater chances of being adopted in maize and upland rice farming systems than in sorghum, because sorghum is not a market crop.

Table 8:
Control of *Striga* using herbicide 2, 4-D amine in sorghum

Treatment	Mean *Striga* number/plant	Grain yield (kg/ha)
Hoe-weeding (no pre-emergence herbicide)	2.5	26.7
Hoe-weeding (with pre-emergence herbicide)	5.0	155.6
2, 4-D amine applied once	0.7	222.2
2, 4-D amine applied twice	0.2	800.0

Mbwaga (1996)

11.10: Tied ridges and Mulch

High soil moisture reduces or delays *Striga* emergence. Tied ridges to conserve soil moisture have been reported to double the crop yield and at the same time to reduce *Striga* infestation. *Striga* does not attack rice with high soil moisture or under irrigation (Steeramula 1959).

11.11: Transplanting on the Control of *Striga*

Under the stress of *Striga* attack, transplanting of cereal especially sorghum or upland rice has been observed to improve host growth compared to directly sown crop. Transplanting of 3-4 weeks old sorghum seedlings significantly reduced *Striga* damage and increased crop yield (Dawoud, 1996). Sowing of sorghum for example after the advancement of the rainy season was found to reduce *Striga* infestation but crop yield was also reduced (Mbwaga 1996, Bebawi 1987, Parker and Riches 1993).

11.12: The use of catch crops

Catch crops are highly susceptible cultivars, which are grown in advance of the main crop and are ploughed under or used as fodder before the *Striga* flowers and set seeds. Susceptible cultivars like sorghum variety Tegemeo or maize variety Staha could be used. This method is further improved when applied in dense stands and would be especially useful in areas where the growing season allows a preceding crop for 6-8 weeks or to restore fields which are abandoned due to high *Striga* infestation. Limitations are the extra labour and planting material required, and unreliable rains. Therefore, few farmers will apply this *Striga* control method and it may be more practical on large farms like seed farms.

11.13: The use of synthetic stimulants

The first indication of the possible use of trap crops was the synthesis of strigol, a compound extracted from the roots of cotton (*Gossypium hirsutum L.*). Strigol is capable of inducing *Striga* seeds to germinate but such germination is suicidal in the absence of host plants. Strigol can cause 50% suicidal germination of *S. asiatica* at very high dilution (10^{-12} M).

Strigol and other synthetic stimulants could be injected into the soil to induce suicidal germination of *Striga* seeds. Ethylene injected into the soil has been reported to be effective in the USA (Eplee 1988), but the equipment needed is beyond the reach of most small scale farmers and ethylene itself may not be readily available in the country. Other synthetic stimulants have been tested, but at present these compounds are not of practical and economical use (Eplee et al 1991).

11.14: Biological Control

The practical control techniques are still being developed and potential useful organisms have been identified. These include the gall-forming weevil (*Smicronyx sp.*) which are laying eggs in the flower buds; the grubs feed on the ovules and effectively reduce seed production. The butterfly Precis (Junonia orithya), its larvae feed on leaves, buds and capsules of *Striga* species.

A range of fungi have also been identified and the most promising are *Fusarium nygamai* and *F. oxysporum*. These cause wilting of *Striga* plants, girdling of stem and varying degrees of damage. Effect of soil borne pathogens on *Striga* and/or *Striga* seeds are currently being investigated.

12. Integrated *Striga* Control

An integrated approach is an effort to combine more than one (preferably many) control measures into one control strategy (Fig. 3), with some background knowledge of the expected contribution of each component to the control strategy. The use of the control strategy is currently handicapped because of the non-availability of resistant varieties especially in maize, rice and finger millet. In sorghum, some tolerant/resistant varieties have been identified and it is possible to integrate these varieties with other management practices. Control strategies could consist of resistant varieties which support significantly less *Striga* plants compared to susceptible varieties, combining with hand pulling or spraying with 2, 4-D amine.

A few other examples of integrated *Striga* control strategies are:

1. Resistant sorghum variety, like SRN 39, intercropped with cowpea in the same row plus animal manure;
2. Sorghum variety P9405 plus animal/green manure combined with hand pulling/hoe weeding
3. *Striga* free planting material plus resistant variety plus manure and combined with hand pulling/hoe weeding.

However it has to be emphasised that the gross value of some of the crops grown by farmers is too low to justify high input methods. Furthermore the methods should be applicable or adapted to the local circumstances. For example, in Dodoma cowpea is attacked by *Alectra vogelii,* a parasitic weed of cowpea, is not a good choice as a trap crop; groundnut however is not susceptible so it provides farmers with alternative intercrop. Small scale farmers will be better able to adopt *Striga* control measures to their local circumstances if they understand the biology of *Striga*. Therefore, extension staff, being close to the farmers, should also be aware of the biology of *Striga*, means of dispersal and possible control options.

13. Summary:

Striga species of economic importance (in terms of crop damage) in Tanzania are *Striga asiatica, S. hermonthica* and *S. forbesii* infesting cereals. *Alectra vogelii* is another parasite infesting cowpea.

The biology of *Striga* is complicated compared to normal weeds, it produces numerous seeds which can remain viable in the soil for 15-20 years in the absence of a host plant. Symptoms on the host plant can be easily confused with drought and diseases.

Farmers recognise *Striga* as one of the major pests on cereal crops but they lack knowledge about its biology, hence they fail to realise good results when applying some control measures like weeding.

There is host specificity observed in *Striga* species found in Tanzania. Pearl millet for example is not attacked by any of the *Striga* species.

Striga control measures:

1. Hand pulling/hoe weeding before *Striga* set seeds and burning prevents the production of seed by *Striga.*
2. The use of *Striga* - free planting material is one of the most effective methods of preventing *Striga* re-infestation and spread to new fields.
3. Early sown crops escape severe *Striga* damage and better yields are realised than from late sown crop.
4. Intercropping of cereals with legume in the same row reduce *Striga* infestation significantly.
5. Crop rotation of cereals with nitrogen fixing legumes such as soybean and cowpea reduces the *Striga* seed population in the soil and increase crop yields.
6. The use of fertilizer - Urea suppress germination of *Striga* especially when applied at a rate of 50-75 kg N/ha. Animal manure has also been observed to suppress germination of *Striga* but the rates are still to be determine.
7. *Striga* resistant sorghum varieties have been identified which include SRN 39, P9405 and P9406. Tolerant varieties are sorghum variety Weijita and rice variety Mwangulu. So far no maize variety has been found to be resistant to *Striga.*

8. Green manure such as sunhemp (Marejea) increase soil fertility and hence reduce *Striga* infestation.

9. The use of 2,4-D amine at a rate of 2 kg a.i./ha controls *Striga* significantly when applied twice at 8 and 10 weeks after planting.

10. Tied ridges conserve soil moisture and hence create unfavourable condition for *Striga* germination.

11. Transplanting sorghum or upland rice in *Striga* infested fields reduce *Striga* infestation and hence improve crop yield.

12. The use of catch crops such as a susceptible sorghum variety like Tegemeo reduce *Striga* seed population in the soil especially when it is densely sown and ploughed under before *Striga* set flowers.

It is obvious that there is no single method that can effectively control *Striga* under small scale farmers` conditions. The approach should be integration of possible control options aiming at reduction or depletion of the *Striga* seed reserve in the soil and growing a healthy crop. This includes physical removal of the weed, use of post emergence herbicide, use of catch and trap crops either in rotation or intercropping, use of manure/inorganic fertilizer, timely sowing, use of tolerant/resistant crop varieties and water management practices. It has to be recognised that benefits of *Striga* control cannot be obtained in a short term, particularly on highly infested fields, but can only have positive results in the long run.

Fig. 3. Integrated *Striga* control.

Demonstration

Section 2: Live materials of the different *Striga* species and *Alectra* occurring in Tanzania.

Section 4: Show a hand full of *Striga* plants, as well as a capsule containing seeds. This will give an impression of the tinyness and huge amount of seeds per plant.

Section 6: Live material of maize, sorghum, finger millet and upland rice affected by *Striga* showing the different symptoms as described in the text.

Section 11.4: Intercrop in the same row (cereal-cowpea) compared to intercropping in alternate rows (1 row cereal + 1 row cowpea and sole cropping. Observations throughout the cropping season on *Striga* emergence + crop yield.

Section 12.2: Planting material from Striga prone regions (seeds from the market or storage) + bucket of clean water + white cloth. Wash planting material in water; Remove seeds; Filter remaining water through white cloth and look for Striga seeds.

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A Reference manual on *Striga* distribution and control provides a comprehensive review on the extent of the *Striga* problem in Tanzania, farmers knowledge about *Striga*, *Striga* biology and control options of the major *Striga* species. These include *Striga hermonthica*, *S. asiatica* and *S. forbesii* infesting mainly cereals and *Alectra vogelii*, a parasitic weed on cowpea. We hope that the manual will furnish young research scientists, extension staff, and tutors at agricultural colleges, universities and those involved in seed production with some knowledge about *Striga*.

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