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FARMERS' PERCEPTION OF THE *STRIGA* PROBLEM AND ITS CONTROL IN NORTHERN NIGERIA

By A. M. EMECHEBE†, J. ELLIS-JONES‡§, S. SCHULZ†, D. CHIKOYE†, B. DOUTHWAITE†, I. KUREH¶, G. TARAWALI†, M. A. HUSSAINI¶, P. KORMAWA† *and* A. SANNI¶

†*International Institute of Tropical Agriculture, P.M.B. 5320, Ibadan, Nigeria;* ‡*Silsoe Research Institute, Wrest Park, Silsoe, Bedford, MK 45 4HS, UK and* ¶*Institute for Agricultural Research, Samaru, Ahmadu Bello University, P.M.B. 1044, Zaria, Nigeria.*

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SUMMARY

The parasitic angiosperms, *Striga hermonthica* and *S. gesnerioides*, obligate root parasites endemic in sub-Saharan Africa, constitute severe constraints to cereal and legume production in West and Central Africa. Over the years, a range of effective component technologies has been identified for *Striga* control in Africa. The potential of these technologies has been demonstrated under researcher-managed conditions. To promote farmer testing of the technologies, community workshops were conducted in 42 rural communities in Kaduna State, northern Nigeria. These revealed that agriculture was the main source of livelihood for most households. The three most important crops, maize, sorghum and pearl millet are attacked by *S. hermonthica*, regarded as the major constraint to crop production, often causing 70–100 % crop loss. Farmers recognised two types of *Striga* damage (underground and aboveground), with greater damage being caused by underground *Striga*. Farmers attributed increasing incidence and severity of *Striga* damage to lack of capital, poor soil fertility, infestation of previously uninfested land by *Striga* seeds, and continuous cropping of host crops. The most widely used among the 15 existing *Striga* control techniques identified by the farmers were hoe weeding and hand pulling, application of inorganic fertilizer and manure, crop rotations, fallowing, and early planting. In assessing possible control measures farmers considered increased crop yield, reduced *Striga* reproduction and *Striga* emergence, greater crop vigour, and increased soil fertility as positive attributes. Negative attributes comprised increased labour requirement, higher costs, increased risk of crop damage or yield reduction, and lower quantity and quality of produce. Overall, a legume-cereal rotation was the most highly rated control option for *S. hermonthica* management evaluated by the farmers. The implications of these results are examined with respect to farmers' adoption and adaptation of *Striga* control options beyond the experimental plots.

INTRODUCTION

The parasitic angiosperm, *Striga*, is an obligate root parasite which infects cereal and legume crops in sub-Saharan Africa, often causing yield losses in excess of 50 % (Parker, 1991). *S. hermonthica*, endemic in Africa, constitutes the most important biological constraint to cereal production in sub-Saharan Africa (M'Boob, 1989; Lagoke *et al*., 1991). The infested area has been variously estimated. Thus, while Sauerborn (1991) estimated the actual *Striga* infested area in Africa at 21 million ha (with 44 million ha potentially at risk), Lagoke *et al*. (1991) considered that about 50 million out of about

§ Corresponding author: jim.ellis-jones@bbsrc.ac.uk

73 million ha were already severely or moderately infested, respectively. Sauerborn (1991) estimated an annual cereal grain loss of more than 4 million tonnes (worth about US$480 million); losses of up to US$3 billion would occur if all the host cereal crops in sub-Saharan Africa were to be infested. These losses adversely affect the lives of about 300 million people in sub-Saharan Africa (M'Boob, 1989). *S. gesnerioides* causes considerable yield reductions in cowpea in more than 29 sub-Saharan African countries (Emechebe *et al*., 1991; Kroschel, 1999).

Striga research in Africa has a long history and a range of effective component control technologies has been identified (Parker and Riches, 1993). Examples of control options for *S. hermonthica* include use of trap crops (which stimulate suicidal germination of *Striga* seeds and therefore reduce the seed bank), resistant host crop cultivars and improving soil fertility. Good control of *S. gesnerioides* in cowpea in West and Central Africa is obtained by growing a range of cowpea varieties resistant to several strains of the parasite (Singh and Emechebe, 1997). However, it has been generally accepted that *Striga* control in cereals is more likely to be achieved by combining a range of individual component technologies into integrated programmes to provide more flexible and sustainable control over a wide range of biophysical and socio-economic environments (Berner *et al*., 1996). The potentials for *Striga* control options have been demonstrated under controlled researcher-managed conditions and trials are currently being undertaken to establish if these technologies work efficiently under farmer-managed conditions (Schulz *et al*., 2003). The real test of whether *Striga* control options are appropriate is whether farmers adapt and adopt them beyond the experimental plots (Douthwaite *et al*., 2001; Sumberg *et al*., 2003).

In promoting further farmer testing of these technologies, it was important to establish:

- What contribution agriculture and in particular crop production made to local peoples' livelihoods in the target areas.
- The most important crops for both food security and cash incomes, and which of these crops are most affected by *Striga*.
- How the *Striga* problem or damage was prioritised compared with other agricultural problems communities were faced.
- What *Striga* control methods farmers were already using for coping with *Striga*, and the effectiveness of these methods.

Three workshops held in 2002 helped to explore, learn and share knowledge with three communities on the problems affecting them, particularly with regard to *Striga*. In particular the workshops were designed to ascertain the importance of agriculture in the livelihoods of rural communities, their priority crops, priority problems affecting crop production, the incidence of *Striga* infestation in the area and to assess existing *Striga* control strategies. A further 39 village meetings involving discussion groups facilitated by local extension workers (who had attended a short course on participatory extension methods) helped to confirm priority problems, and *Striga* coping strategies in addition to identifying local institutions and farmers to take ownership and undertake *Striga* control trials on a wide basis. This participatory process stimulated great interest

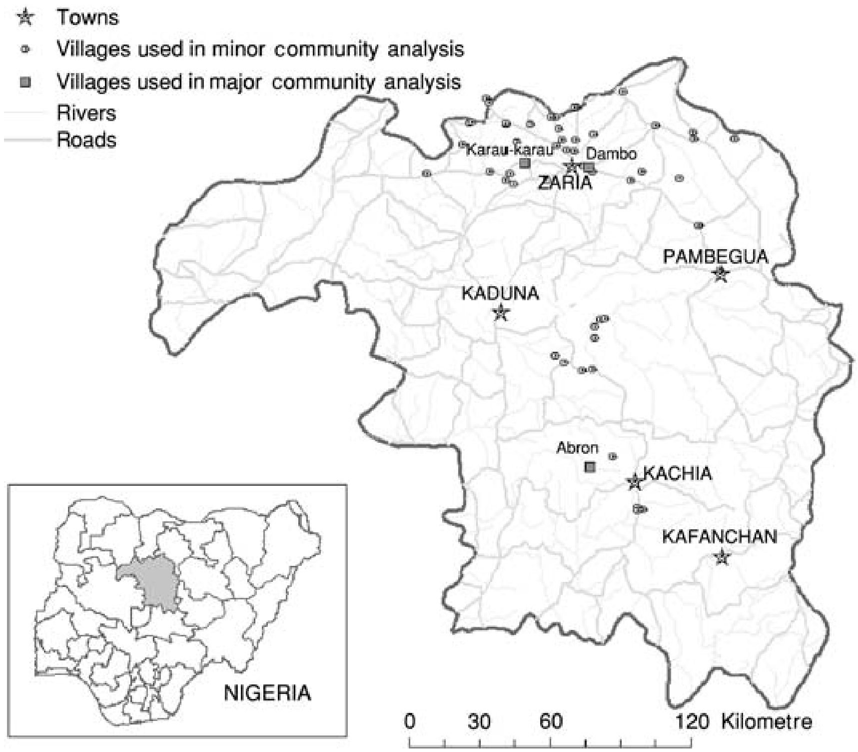

Figure 1. Location of villages, where farmer workshops took place.

in more effective *Striga* control and laid the foundations for the establishment of local farmer managed *Striga* control trials, whose ownership was vested in the local community, providing potential for wider adoption within the communities.

As a result of the work reported in this paper, local institutions and farmers were selected in each community to choose alternative *Striga* control options, namely legumes causing *Striga* suicidal germination, *Striga* resistant/tolerant maize varieties grown as a legume-cereal rotation, to be compared with local practices. Some initial work has been reported (Schulz *et al.*, 2003) and further ongoing work will be reported to this Journal.

METHODOLOGY

Three community workshops were held each over a three-day period in Abron (9.93°N, 7.78°E), Dambo (11.07°N, 7.78°E), and Karau-Karau (11.09°N, 7.53°E) villages (Figure 1 and Table 1). The villages in Kaduna State were selected on the basis of proximity to market as this was likely to affect both input availability and output sales, and to include both religious groups, Christian and Moslem. Participants included traditional leaders, men and women (where local tradition permitted), both young

Table 1. Community workshops, location, market characteristics and participants.

Village	Religion	Location	Market characteristics		Number of participants		
			Outputs	Inputs	Men	Women	Total
Abron	Predominantly Christian	12 km from small market centre, Kachia	Wide range of crops sold in Kachia	Inputs available, but shortages common	92	47	119
Dambo	Moslem	5 km from main town, Zaria	Wide range of crops sold in Zaria	Inputs easily available at most times	70	10	80
Karau-Karau	Moslem	50 km from the nearest market centre, Zaria	Most crops marketed locally	Inputs difficult to obtain	131	1	132

and old. The workshops provided an opportunity to use a participatory learning approach to research and extension work (Hagmann *et al.*, 1999; Defoer, 2002), involving building common knowledge, participatory learning and action planning. The following participatory analyses were undertaken with participants.

Livelihood analysis. Brainstorming enabled participants to establish their main means of deriving a living. Specifically, they listed all livelihoods, estimated the extent of community involvement in each livelihood activity, determined the trends in the performance of these livelihoods over the years and identified the reasons for such trends.

Resource analysis. Brainstorming enabled participants to identify their criteria for assessing their own livelihood or asset status so as to determine possible strategies for alleviating their poverty. In particular, they identified characteristics of different resource (or wealth categories) existing in their communities and determined the distribution of resources that could assist in *Striga* control.

Crop priority ranking. Brainstorming and participatory ranking exercises enabled farmers to identify and rank each crop grown in the area either for food security and/or for cash sales.

Problem identification, prioritisation and causes of Striga *problem.* Participants were helped to identify and prioritise their main agricultural problems to determine the relative importance of *Striga*, using matrix-ranking techniques. Participants then identified the causes of increasing *Striga* infestation in the form of a causal diagram in order to assist in determining possible options for control.

Mapping. Farmers were helped to identify the distribution of *Striga* in their communities to allow them to identify suitable sites for locating control trials. This was based on: i) mapping present *Striga* infestation in their communities, showing the relative intensity of *Striga* infestation at the different locations, ii) establishing the likely trends in relative intensity over years through drawing a map of *Striga* as far back as people could remember, usually 10–25 years, and iii) visioning future *Striga* problems through mapping 10–15 years into the future.

Striga *coping strategies and their evaluation.* Farmers were assisted to identify how they presently coped with *Striga* in their fields, the source of this knowledge, the advantages and disadvantages of each control method, whether their use was increasing or decreasing and the percentage of the community actually using each method. From this, farmer evaluation criteria were identified and a comparative evaluation of each control method undertaken.

Institutional analysis. Farmers were assisted to identify the main institutions, both within and outside the community, which could play a lead role in solving the *Striga* problem. At the end of the session, farmers identified local institutions and elected lead farmers from each institution that would take ownership of the *Striga* trials.

Discussions took place in group sessions comprising men and women. Further discussion and consensus occurred during plenary feedback sessions held after the group sessions. As a result of these three community workshops, local institutions were identified and farmers were elected to establish *Striga* control trials of their choosing.

In addition to the three community workshops, local extension workers from the State, Local Government and NGOs met in an additional 39 villages with members of their respective communities. They used similar methodologies to establish priority agricultural problems and farmers' *Striga* coping strategies and identified local institutions and farmers to take ownership and undertake farmer managed trials on *Striga* management.

RESULTS

The importance of agriculture in the livelihoods of local communities

The study revealed that although there were up to 20 livelihood sources in each of the three rural communities, agriculture was the main source for most households. In Abron, 100 % and 47 % of the households are engaged in arable crop production and livestock rearing, respectively; the corresponding statistics for Karau-Karau were 90 % and 30 %. By contrast, 100 % of households in Dambo produce livestock, while 80 % are arable crop producers. In addition, several other occupations are dependent on agriculture. For example, agriculture-dependent activities of Karau-Karau villagers include food vending (30 %), contract activities using animal traction (30 %), and food processing (10 %).

In these rural communities, relative well-being is determined by access to resources, the most important of which are the area of land owned by a farm family, livestock ownership, food security and availability of cash to pay for agricultural inputs and to purchase assets, such as bicycles and motor cycles. In Dambo, a poor family usually owns very little arable land, if any, while a family is considered rich if it owns 7–8 ha of arable land. In Abron and Karau-Karau, poor families own 3–4 ha while the rich ones

Table 2. Crop priority ranking by farmers in Abron, Dambo and Karau-Karau Communities of Kaduna State, northern Nigeria (1 = highest).

	Rank given to crop in:					
	Abron†		Dambo‡		Karau-Karau§	
	Men	Women	Men	Women	Men	Reasons for rank given to crop
Maize	2	2	1	2	2	Food and cash crop; high yielding; easy to weed
Sorghum	1	1	2	4	3	Food and cash crop; high yielding; easy to weed; does not require much fertilizer
Pearl Millet	6	7	3	7	–	Food crop; does not require much fertilizer; easy to weed
Cowpea	8	4	4	1	4	Food, fodder and cash crop
Groundnut	5	3	–	6	1	Food and cash crop; does not require fertilizer; well adapted to the area
Yam	4	6	7		5	Food and cash crop; improves soil
Rice	7		5	2	8	Food and cash crop
Soyabean	9		6	4	9	Cash crop
Ginger	3	5	–	–	–	Food and cash crop

†17 crops listed, ‡23 crops listed, with sweet potato as the 8th crop in the men's ranking, §9 crops listed, tomatoes and pepper as the 7th and 6th crops in the men's ranking, – Crop not listed.

possess more than 15 ha (in Abron) or more than 30 ha (in Karau-Karau). Although other differences such as type of house, clothing and education were also deemed important in wealth differentiation, access to land, livestock, labour and cash tended to influence *Striga* control practices.

With most household heads being engaged in crop production, a wide range of field (mostly cereals, legumes, root and stem tubers, and fibre) and horticultural crops are produced, mostly under rain-fed or wetland (*fadama*) conditions. The largest number of crops is produced by farmers in Dambo village, with 23 crop species, compared to 17 in Abron and nine in Karau-Karau. This pattern reflects village proximity to markets and the demand for a wider selection of crops.

Farmers' perception of the importance of Striga

During the study, farmers were asked to rank their crops in order of importance either as food and/or cash crops. In priority order the five most important crops in the three communities for both food security and cash sales were as follows: sorghum, maize, ginger, yam and groundnut (in Abron); maize, sorghum, pearl millet, cowpea and rice (in Dambo); and groundnut, maize, sorghum, cowpea and yam (in Karau-Karau) (Table 2). Some differences between men and women were noted. For example, the women in Abron rated groundnut, okra and sorghum as the three most important crops, in descending order of importance, compared to the men who rated sorghum, maize and ginger as the most important. Similarly, while the men in Dambo considered maize and sorghum as the two most important crops, the women rated cowpea and rice as the two most important crops.

All the five most important crops in Dambo are attacked in varying degrees by *Striga hermonthica* (maize, sorghum, pearl millet and rice) or *Striga gesnerioides* (cowpea).

Table 3. Problem prioritisation by farmers in Abron, Dambo and Karau-Karau communities of Kaduna State, northern Nigeria. (1 = highest).

	Rank given to problem:				
	Abron		Dambo		Karau-Karau
Problem	Men	Women	Men	Women	Men
Striga damage	1	1	3	2	1
Lack of fertilizers (= Low soil fertility)	2	–	2	1	2
Non-parasitic weeds	3	8	–	–	5
Yam insect pests	4	–	–	–	–
Downy mildew in maize, sorghum or millet	5	2	5	4	–
Groundnut diseases	6	4	–	–	–
Cowpea diseases and insect pests	7	9	–	–	–
Lack of capital	–	–	1	3	–
Lack of implements	–	–	4	5	4
Lack of knowledge about improved technologies	–	–	–	–	4
Lack of improved seed	mnr	mnr	mnr	mnr	3

– = Not mentioned; mnr = mentioned but not ranked.

Similarly the two most important crops in Abron and the second and third most important crops in Karau-Karau (sorghum and maize) are attacked by *S. hermonthica*, while the most important crop in Karau-Karau, groundnut, is affected by a related parasitic flowering plant, *Alectra vogelii*, which the farmers also regard as '*Striga*'.

It was not surprising, therefore, that farmers in two of the villages (Abron and Karau-Karau) considered *Striga* damage as the most important constraint to crop production (Table 3). Female farmers in Dambo rated *Striga* damage as the second most important constraint to crop production after low soil fertility, while the male farmers listed it as the third most important constraint, after lack of capital and low soil fertility. In the other 39 villages, farmers identified a wide range of crop production constraints (Figure 2) of which the top five were *Striga*, fertilizer shortages (low soil fertility), crop diseases, lack of implements (including tractors) and lack of seed.

Farmers in these communities indicated that severe *Striga* damage can cause 70–100 % crop loss in maize and sorghum; indeed some have stopped producing maize and sorghum in heavily infested land, which was subsequently abandoned or planted to legumes. A quantitative assessment of *Striga* damage was given by two farmers in Karau-Karau village. One of them reported that in 2000, he obtained only one bag of maize from the same piece of land that yielded five bags in 1997, a yield loss of 80 %. A female farmer reported obtaining less than one bag in 2000 from a plot that yielded at least five bags five years earlier, representing at least a 80 % yield loss. Consequently both farmers reportedly did not grow cereals in those plots in 2001. Farmers in Karau-Karau predicted that if *Striga* damage continues to increase at the present rate, there will be severe famine in the community in the next 15 years. Similarly, Abron farmers firmly believe that the entire community would be forced to migrate out of the area in search of less infested areas unless *Striga* is brought under control in the next 20 years.

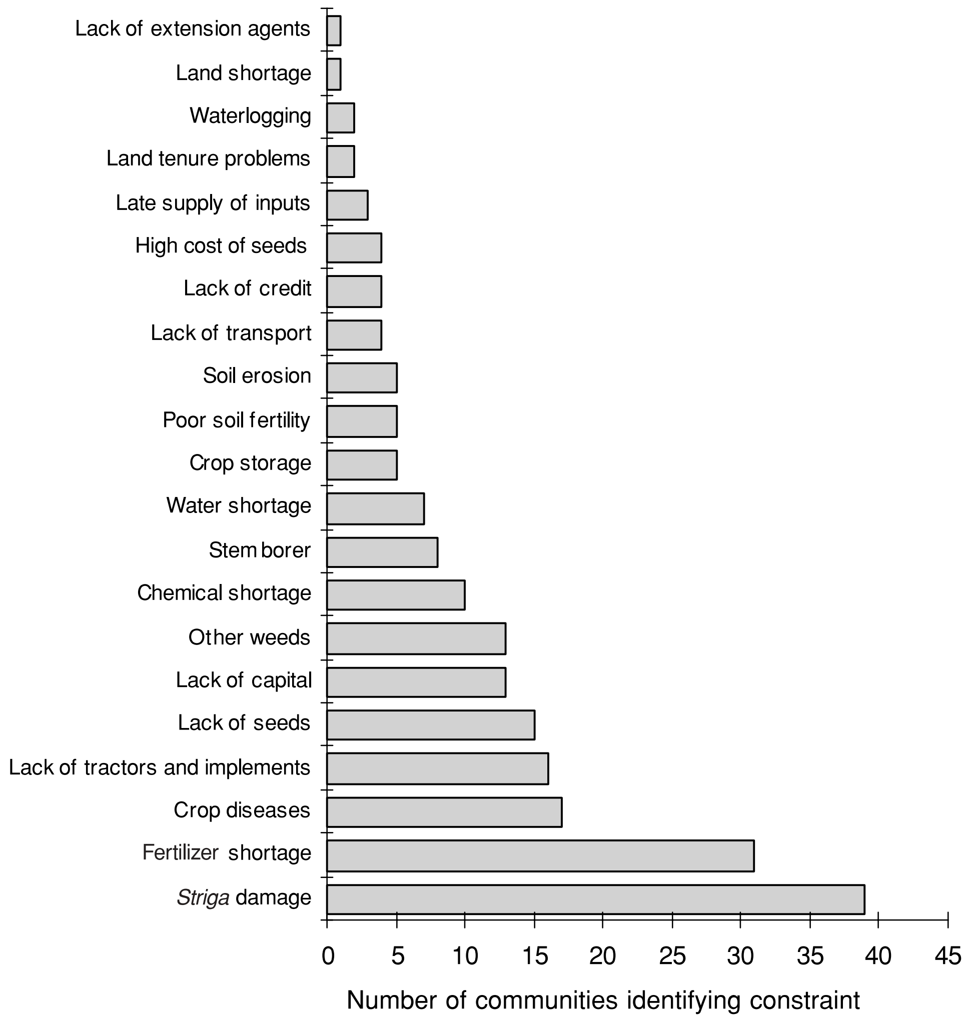

Figure 2. Number of communities identifying crop production constraints.

Farmers' perception of the causes of Striga *damage and factors aggravating it*

Farmers in the three villages attributed *Striga* damage to two types of *Striga*, namely underground *Striga* and aboveground *Striga*. They emphatically stated that underground *Striga* does more damage to crops than aboveground *Striga*. However, farmers in the three villages had different views about the factors that were responsible for the increasing incidence and severity of *Striga* damage. Farmers in Dambo village strongly believed that lack of capital (for purchased inputs including labour, fertilizer and land) is the primary factor that aggravates *Striga* damage. According to them, lack of capital directly or indirectly results in continuous cereal cropping (due to limited land availability), lack of fertilizer, poor soil fertility (due to lack of farmyard manure),

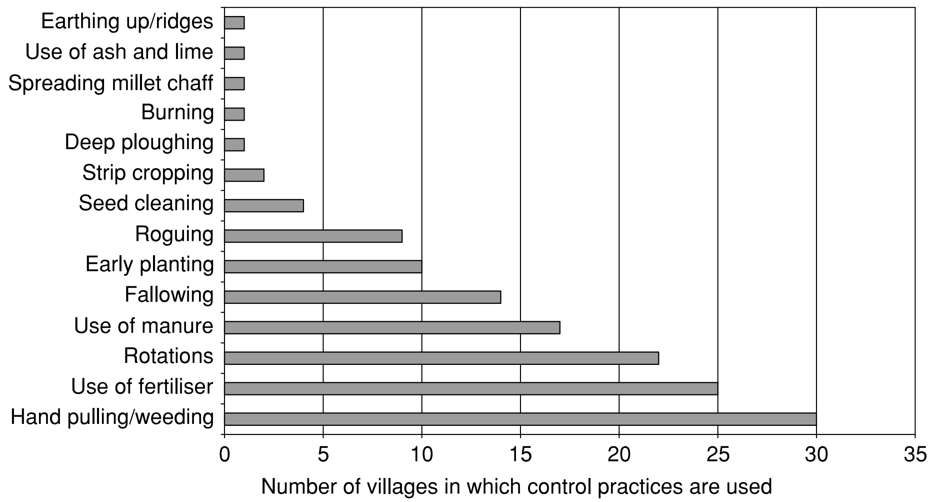

Figure 3. Relative popularity of the main *Striga* coping strategies in sampled villages ($n = 39$).

poor soil type, and shallow tillage of land (due to lack of animal traction) (Figure 3). On the other hand, Abron farmers considered poor soil fertility (due to continuous cropping and soil erosion) and *Striga* dissemination, on hooves and dung of migrating cattle, as the principal factors that exacerbate the *Striga* problem; Karau-Karau farmers attributed intensification of the *Striga* problem to infestation of previously uninfested land (through planting of crop seed contaminated by *Striga* seeds and dispersal by animals), declining soil fertility (due to continuous cropping and lack of fertilizer), poor land preparation (due to lack of time and labour), and application of ash to farm land. In general, these views suggest that farmers would consider testing new *Striga* control options that do not require additional capital while at the same time enhancing soil fertility and preventing dissemination of *Striga* seeds.

Farmers' assessment of their present Striga *control measures*

Given the yield-reducing effects of *Striga* on the most important crops of these communities, it is clear that interventions aimed at reducing *Striga* damage will have a significant, positive impact on the well being of community members. Farmers in all communities have acquired or developed various techniques to combat *Striga* in order to minimise damage done to their crops. Fourteen control techniques were identified, the most widely used being hoe weeding and hand pulling, use of fertilizer, crop rotations, use of manure, fallowing and early planting (Figure 3). More details on the *Striga* control options (broadly classified under three headings: controlling weeds; crop rotations; and improving soil fertility) used by farmers in Abron, Dambo and Karau-Karau are shown in Table 4. Farmers learnt about the relatively newer techniques comparatively recently (in the last 3–8 years). Information about older control measures (such as, hand-pulling, hoe-weeding, land fallowing, application of organic manure, and cereal rotation with crops other than legumes) was usually

Table 4. *Striga* control methods used by farmers in Abron, Dambo and Karau-Karau communities.

Striga control method	When method was acquired	Source of information	Advantages	Disadvantages
Weed removal				
Hoe weeding during general weeding	Since time of forefathers	Parents and elders	Greater plant vigour; makes farm look very clean; high yielding Prevents flowering and seed production by *Striga*	Requires labour to be done properly; Labour intensive requiring a task force for timeliness; costly,
Hand pulling, burying or burning of *Striga*	Since time of forefathers	Parents and elders	Reduces *Striga* seed bank Gives bumper harvest if done early before flowering	*Striga* reemergence after hand pulling Increases seed bank if done late
Herbicide application	7 years ago	Youths	Reduces *Striga* vigour	Costly; reduces soil fertility
Early planting	Since time of forefathers	Parents and elders	Escapes *Striga* attack; vigorous early growth especially if fertiliser is applied Requires less fertiliser High yielding; Early harvest and high income	Early season drought could result in crop failure Matures in the rainy season and no period for drying; Mouldiness of grains; Can be attacked by army worms if there is early season drought; Greater attack by aphid on groundnut and cowpea
Crop rotations				
Sorghum or maize-millet rotation	Since time of forefathers	Parents and elders	Reduces *Striga* incidence	None
Cereal with soybean and/or cowpea	8 years ago (A) 3–4 years ago	Youth (A) Extension (D)	Involves early planting and consequently less *Striga* damage Increases soil fertility; Reduces *Striga* damage	Bird damage (eating seeds and seedlings) results in poor establishment of soybean and reduced effectiveness
Cereal rotation with groundnut, yam, pepper, rice or cowpea	Since time of forefathers	Parents and elders	High yielding; increases soil fertility soil fertility; for yam, land preparation made easier; for pepper weeding next crop is easier	Demands rigid adherence to rotation system
Double cropping of groundnut, and cowpea in one year followed by maize in following year	5 years ago	Experience of some farmers	High yield in double legume cropping; fodder for animals; Increases soil fertility with residual effect for subsequent maize	Loss of groundnut fodder because of lifting during wet period

Table 4. (Continued)

Striga control method	When method was acquired	Source of information	Advantages	Disadvantages
Cereal-yam rotation	7 years ago	Youths	Different land preparation method	Labour intensive
Yam-maize rotation	Since time of forefathers	Parents and elders	*Striga* seeds exposed during making mounds for yams lose viability	Making yam mounds is labour intensive
Rotation of cereal with ginger	Since time of forefathers	Parents and elders	Increases soil fertility; reduces *Striga* damage	Increases weed pressure
Fallowing	Since time of forefathers	Parents and elders	Increases soil fertility	Soil erosion associated with intensive grazing of fallow vegetation by increased number of Fulani cattle
Improving soil fertility				
Compost manure application	Since time of forefathers	Parents and elders	Increases soil fertility; high yielding; reduces *Striga* damage; high soil moisture retention	Heavy application increases damage by soil-borne insects, e.g., white grubs It encourages termites if not spread out in time
Application of urea fertiliser	8 Years ago	Extension agents	Kills *Striga* seed	Expensive; drought occurring soon after application results in heating up and death of plants
Mix urea with potash and apply as top dressing after emergence of *Striga*	5 years ago	Trial and error following discussion with friends	It reduces the rate of *Striga* emergence; high yielding; has residual effect (2–3 yrs); increases sugar content of the stalk for fodder	Results in crop damage if there is rain shortage

obtained from parents and elders. On the other hand, farmers learnt about relatively new techniques (such as, application of urea fertilizer, herbicide application, cereal rotation with soya-bean, and double cropping) from innovative farmers, often younger people or extension agents. For each control option, farmers identified advantages and disadvantages (Table 4). A control method was considered as advantageous if it resulted in: (i) higher crop yield, (ii) reduced *Striga* reproduction and *Striga* emergence, (iii) greater crop vigour, and (iv) increased soil fertility. By contrast, farmers considered as disadvantageous those techniques that resulted in: (i) increased labour requirement, (ii) higher costs, (iii) increased risks of crop damage or yield reduction through drought, rainfall damage, insect pests, and diseases, and (iv) lower quality and quantity of produce.

Farmers consider their individual household circumstances, the resources available to them and the merits and demerits of various control options in choosing the control measures to use on their farms. Thus, the trends in the use of the control techniques varied among the communities. For example, hand pulling, cereal-yam rotation and sorghum-millet rotation were on the increase in Abron village compared with Dambo village where their use was decreasing. The proportion of farmers using the various control options differed among communities. In Abron, the most popular techniques used by farmers were cereal-ginger rotation (100 %), sorghum-millet rotation (95 %), cereal-yam rotation (85 %) and hand pulling (75 %). By contrast, in Dambo hand pulling and sorghum-millet rotation were used by only 20 % and 10 % of the farmers respectively due to labour shortages and opportunities to work in nearby Zaria, while 95 % and 80 % of them practised urea application and early planting, respectively as these were less labour intensive. In Karau-Karau, early planting was also popular, being practised by 95 % of the farmers, all of whom additionally use hoe weeding and cereal rotation with groundnut, cowpea, yam or pepper. In Karau-Karau the application of urea was the least preferred control option, due to seasonal non-availability and high cost. The trends in use of the control techniques as well as the percentage of farmers that use them in each of the three communities are shown in Table 5.

In each of the communities, farmers' criteria used in evaluating *Striga* control measures were identified from the advantages and disadvantages of each. For instance in Karau-Karau, farmers considered the following six criteria as important in assessing acceptability of any control option: (i) labour requirements, (ii) effectiveness (or reduction in *Striga* incidence and severity), (iii) availability of materials (for instance manure, fertilizer or seed), (iv) associated risks (due to adverse biophysical factors, such as, drought, excessive rainfall, pests, and diseases), (v) cash costs for payment of hired labour and inputs, and (vi) increased quality and quantity of crop yield. Using these criteria, farmers ranked the most widely used control options in each of their communities. Eight control methods were evaluated (Table 6).

A legume-cereal rotation was the most acceptable option for *S. hermonthica* control, having been rated first in Abron and Karau-Karau and second in Dambo where early planting was ranked first. Legume-cereal rotation received the maximum possible rating in five of the six criteria considered by Karau-Karau farmers, three of the four

Table 5. Status of *Striga* control options in Abron, Dambo and Karau-Karau communities in April, 2002.

Striga control method	Trend in usage of method in: Abron	Dambo	Karau-Karau	Farmers using method (%) Abron	Dambo	Karau-Karau
Controlling weeds						
Hand pulling	Increasing	Decreasing	Decreasing	75	20	30
Hoe-weeding (for manual weeds)	Increasing	Increasing	Increasing	100	100	100
Herbicide application	Increasing	–	–	25		
Early planting	–	Increasing	Increasing		80	95
Rotations						
Cereal-yam rotation	Increasing	Decreasing	Increasing	85	20	100
Sorghum-millet or maize rotation	Increasing	Decreasing	–	95	10	
Legume-cereal rotation	Increasing	Increasing	Increasing	50	25	100
Cereal-ginger rotation	Increasing	–	–	100		
Double crop of legumes (year 1) followed by single maize crop (year 2)	–	–	Increasing			20
Improving soil fertility						
Fallowing	Decreasing	–	–	50		
Compost and manure application	–	Increasing	Increasing		50	40
Application of urea fertilizer	–	Increasing	Increasing		95	10

− = not practised.

Table 6. Evaluation of *Striga* control options using farmer evaluation criteria.

Striga control method	Village	Farmer evaluation criteria[†] Labour required	Effectiveness in *Striga* reduction	Availability of materials	Associated risk	Cost	Yield increase	Score[‡]	*Rank*[§]
Controlling weeds									
Hoe weeding	Karau	1	2	3	3	1	3	13/18	*3=/8*
Hand pulling	Abron	–	1	–	–	1	1	3/9	*3/3*
and destruction	Karau-	1	2	–	3	2	2	13/18	*3=/8*
of *Striga*	Dambo	1	3	–	–	1	3	8/12	*5/5*
Early planting	Dambo	3	3	–	–	3	3	12/12	*1/5*
Rotations									
Legume-cereal	Karau	3	2	3	1	1	3	13/18	*3=/8*
rotations	Abron	–	3	–	–	3	3	9	*1/3*
	Dambo	3	3	–	–	2	2	10/12	*2/5*
	Karau	3	3	3	3	2	3	17/18	*1/8*
Double crop legume then maize	Karau	2	2	3	3	2	3	15/18	*2/8*
Improving soil fertility									
Manure application	Dambo	2	3	–	–	1	3	9/9	*4/5*
	Karau	2	2	2	2	1	2	10/18	*8/8*
Inorganic fertilizer	Dambo	3	3	–	–	1	3	10/12	*2/5*
application	Karau	3	2	1	2	1	3	12/18	*6/8*
Use of herbicide	Karau	3	3	1	1	1	2	11/18	*7/8*
Fallowing	Abron	–	2	–	–	3	2	7/9	*2/3*

Notes:
[†]3 = best, 2 = moderate, 1= worst, − = criteria not identified.
[‡]out of a possible maximum.
[§]out of the number of control options assessed in that community.

used by Dambo farmers, and in all three criteria of Abron farmers. It is interesting that rotation received the second highest score for financial cost criterion in both Karau-Karau and Dambo. In addition, it was the only option that obtained the maximum score for effectiveness in Abron and Karau-Karau, the same score having been given to all five options rated by Dambo farmers. It is noted that fertilizer and compost applications were rated second and fourth, respectively by Dambo farmers and sixth and seventh (last), respectively by farmers of Karau-Karau. Abron farmers ranked hand pulling third (out of three options) while Dambo and Karau-Karau farmers scored it fifth (out of five) and third (out of three), respectively. Early planting was rated first in Dambo and practised by 80 % of its farmers while in Karau-Karau it was rated fifth, although it is practised by 95 % of the farmers. The low rating it received in Karau-Karau was associated with its being given the lowest possible score in respect of two criteria, namely associated risks and financial costs.

DISCUSSION

The community workshops and discussion groups conducted in the 42 rural communities in the present study were the first step in participatory testing of components of integrated management of *Striga hermonthica* in cereals (maize, sorghum and pearl millet) in the northern Guinea agro-ecological zone of Nigeria. The participatory approach is especially appropriate when dealing with a basket of technologies rather than single innovations (Norton *et al.*, 1999). The technologies identified by farmers can be evaluated as components of integrated *Striga* management (ISM), requiring involvement of stakeholders (farmers, extension agents, and researchers) in the design, implementation, evaluation and long-term sustainability of the programme (Norton *et al.*, 1999).

Participants at the community workshops identified *Striga* damage as the most important constraint to crop production in two of the three major communities as well as in all of the 39 other villages; being second to lack of capital and low soil fertility in the other major villages. In these rural communities, crop yield losses due to severe *S. hermonthica* infections were up to 70–100 % resulting in cessation of maize and sorghum production on heavily infested land. Similar loss estimates have been reported in maize and sorghum, especially under low soil fertility, in surveys conducted by Lagoke *et al*. (1991) as well as in on-station field experiments on maize (Kim and Adetimiri, 1997; Adetimiri *et al*., 2000; Emechebe *et al*., 2002) and sorghum (Vasudeva Rao *et al*., 1989).

Farmers of the 42 communities attributed these losses to what they considered as two types of *Striga* – underground and aboveground – but they emphatically attributed greater damage to underground than aboveground *Striga*. This perception agrees with the scientific finding that *Striga* spp. cause up to 75 % of damage to their host crop during their subterranean phase (Parker and Riches, 1993). Although participants of the three community workshops differed in detail in respect of the factors that they considered to be responsible for the increasing incidence and severity of *Striga* damage, they were unanimous in identifying poor soil fertility as one of these factors. However, they had different views about the causes of poor soil fertility. In Dambo village poor soil fertility was attributed to lack of farmyard manure and inorganic fertilizer, in Abron to continuous cropping and soil erosion and in Karau-Karau to continuous cropping and lack of fertilizer. These views are partly related to the view that increased intensity of the *Striga* problem in Africa is associated with both environmental and anthropogenic factors (Kroschel, 1999). A drastic change in the farming system from shifting cultivation to more or less continuous monocropping of host plants (with little or no fallow to non-host crops) is mainly responsible for the increase in *Striga* infestation and damage (Berner *et al*., 1996; Kroschel, 1999).

It is interesting that farmers in two of the three main communities considered *Striga* seed dissemination (on hooves and dung of migrating cattle and through planting of crop seed contaminated by *Striga* seeds) as a major factor that has exacerbated the *Striga* problem. This agrees with the findings of Berner *et al*. (1994) that *Striga* seeds are mostly disseminated through contaminated host crop seeds and by cattle. Subsequently, IITA's integrated *Striga* management programme (Berner *et al*., 1995, 1996) recommended that the first step in reducing *Striga* damage is to prevent dispersal of the seeds into uninfested fields by restricting cattle movement from infested to *Striga*-free areas and by planting uncontaminated crop seeds.

The most widely used of the 14 control options identified by farmers included hoe-weeding and hand-pulling, use of inorganic fertilizer, crop rotation, use of manure, fallowing, and early planting. Farmers considered their individual household circumstances, the resources available to them, and their perception of the merits and demerits of the control options in selecting those to use on their own farms. Thus, the most popular techniques used by Abron farmers were cereal-ginger rotation, sorghum-millet rotation, cereal-yam rotation and hand-pulling. By contrast, hand-pulling and sorghum-millet rotation were not popular in Dambo, which being closer to input suppliers, enabling greater urea application and early planting practised by 95 % and 80 % of farmers, respectively. In Karau-Karau, early legume rotation, hoe-weeding, cereal rotation with groundnut, cowpea, yam and pepper were the most popular control options. Overall, legume-cereal rotations were the most popular technique among farmers in all the three major communities. This agrees with recent findings of Schulz *et al*. (2003) for farmers in the neighbouring communities. It is generally accepted that cereal rotation with trap crops (mostly legumes and oilseeds) is perhaps the most important component of sustainable, integrated *S. hermonthica* management in cereals (Berner *et al*., 1996; Ransom, 1999). However, cultivars of the same trap crop species vary considerably in their capacity to induce suicidal germination of the same population of *S. hermonthica* (Berner *et al*., 1995; Dashiell *et al*., 2000; Singh, 2000; di Umba *et al*., 2001; Botanga *et al*., 2003). In addition, *S. hermonthica* is obligately cross-pollinated; consequently, there is a great deal of variation between and within its populations as reported by Koyama (2000). Thus, effective use of trap crops requires that cultivars of a trap crop species be evaluated for their efficacy to stimulate suicidal germination of seeds of populations of *S. hermonthica* in the areas of intended use (Berner *et al*., 1995; 1996).

Use of resistant host crop varieties for *Striga* control was not practised in any of the 42 communities. This is probably related to the non-availability of cereal host crop cultivars that combine high levels of stable resistance to *S. hermonthica* with acceptable agronomic and grain characteristics, wide adaptation and resistance to major pests and diseases (Kroschel, 1999). On the other hand, it was surprising that *S. hermonthica* control by early sowing was rated first in Dambo and second in Karau-Karau. Apparently, in these communities, the perceived advantages of early sowing outweigh the disadvantages (Table 5). This technique requires proper evaluation by researchers, especially as earlier workers had reported that higher *Striga* infections are associated with early sowing compared with late sowing in West African savannas where rains are monomodal and soil temperatures high; delayed planting often results in reduced number of emerged *Striga* (Parker and Riches, 1993). Other techniques popular with farmers in the study area, whose effectiveness should be evaluated by research, include double legume crop followed by cereals, as well as some rotations such as sorghum-millet, cereal-yam, cereal-ginger and cereal-pepper; all these are novel techniques in respect of *S. hermonthica* management in cereals and their effectiveness in reducing the parasite's seed bank through suicidal germination should be investigated.

CONCLUSIONS

Analysis of the information discussed at the three village community workshops and the subsequent 39 village group discussions confirmed that:

- Crop production is an important livelihood source for the communities in the target areas.
- The most important crops from both food security and cash sale perspectives, namely maize and sorghum, are those that are worst affected by *Striga*.
- *Striga* is a priority problem for every community in the area and is likely to become worse unless successfully controlled.
- Farmers have their own novel techniques for controlling *Striga*, which provide opportunity for further research and development, in particular early (rather than delayed) planting, double legume cropping before cereals as well as new rotations such as sorghum-millet, cereal-yam, cereal-ginger and cereal-pepper.
- Farmers have conflicting views on the increasing incidence and severity of *Striga* damage. However, their views suggest that they would consider testing new *Striga* control options that do not require additional capital and which, at the same time, enhance soil fertility and prevent dissemination of *Striga* seeds. This laid the foundation for each community to become involved in subsequent testing and demonstration of alternative *Striga* control methods.
- Differing access to resources within the community means that a number of different options with different resource requirements should be considered.

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