Integrating farmers' knowledge, attitude and practice in the development of sustainable Striga control interventions in southern Mali.

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Abstract

Technologies for Striga control have not been widely adopted because of the mis-match between technologies and farmers' socio- economic conditions. This study uses a participatory rural appraisal technique at the village, household and plot levels to diagnose the extent of the Striga problem in two agro-ecological zones in southern Mali. It has led to the understanding of farmers' attitudes and constraints to Striga control, and opportunities for the development of sustainable technologies suitable for a wide range of farming conditions. Results show that the degree of Striga infestation, levels of farmer knowledge and control practices vary substantially across village territories and fields, and that the severity of the infestation is clearly linked with soil fertility condition and farming practices. It was concluded that in general, the Striga control interventions that would most likely appeal to farmers would be those that will simultaneously improve soil fertility and suppress the development of Striga.

Résumé

Les technologies de contrôle du Striga n'ont pas été suffisamment adoptées à cause de l'inadéquation entre les technologies développées et les conditions socio- économiques des paysans. Cette étude utilise la technique de l'approche participative aux niveau du village, du ménage et des parcelles pour diagnostiquer les problèmes liés au Striga dans deux zones agro-écologiques du Sud Mali. Cette approche a conduit à une meilleure compréhension de l'attitude des paysans, des contraintes liées au contrôle du Striga et de nouvelles opportunités pour le développement de technologies de lutte durables et applicables à une large gamme de conditions culturales. Les résultats montrent, d'une part, que le dégrée d'infestation du Striga, et les connaissances et pratiques paysannes d'autre part, varient énormément entre les terroirs villageois et les champs. Les résultats montrent aussi que la sévérité de l'infestation est fortement liée aussi bien aux conditions de fertilité des sols qu'aux pratiques culturales. Il ressort de l'interaction continue avec les paysans à tous les niveaux, qu'en général, les technologies de contrôle du Striga qui les intéresseraient plus seraient celles qui auraient la double potentialité d'améliorer la fertilité des sols et d'empêcher le développement du Striga.

***Keywords*:**
Participatory approach, farmers' knowledge, Striga control, soil fertility improvement, Mali.
***Mots clés*:**
Approche participative, connaissances paysannes, lutte contre le Striga, amélioration de la fertilité des sols, Mali

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Introduction

Cereal productivity in Africa would increase substantially if Striga (Striga spp.), a parasitic weed which causes significant cereal losses could be controlled on farmers' fields. Roughly estimated, one-third of the cereal cropping area in Africa is infested by Striga, causing annual grain losses of over 4 million tons (Lagoke *et al*., 1991; Sauerborn, 1991). In response to this threat, several methods of Striga control have been developed, yet farmers have not adopted them to any appreciable extent. The reasons include the mis-match between technologies and farmers' socio- economic conditions, particularly the non- availability of economically feasible and effective technologies that are adapted to these conditions (Debrah, 1994). Kachelriess *et al*. (1996) have noted that proposing standardised Striga control interventions in heterogeneous environments of Africa has been inefficient and led to the lack of adoption. Defoer *et al*. (pers. comm. 1996) have shown that through a participatory action research approach, involving farmers, scientists and extension personnel at all stages, Striga control interventions can be better targeted to respond to the highly diversified environment.

The objective of this study was to use farmer participatory diagnosis at the village, household and plot levels to better understand the Striga problem faced by farmers, the consequences of their current practices, and to identify Striga control interventions that have the most chance of being adopted. Information from the study would be useful input in the development of sustainable Striga control interventions that are adapted to different local conditions and farming systems.

Materials and methods

Figure 1.

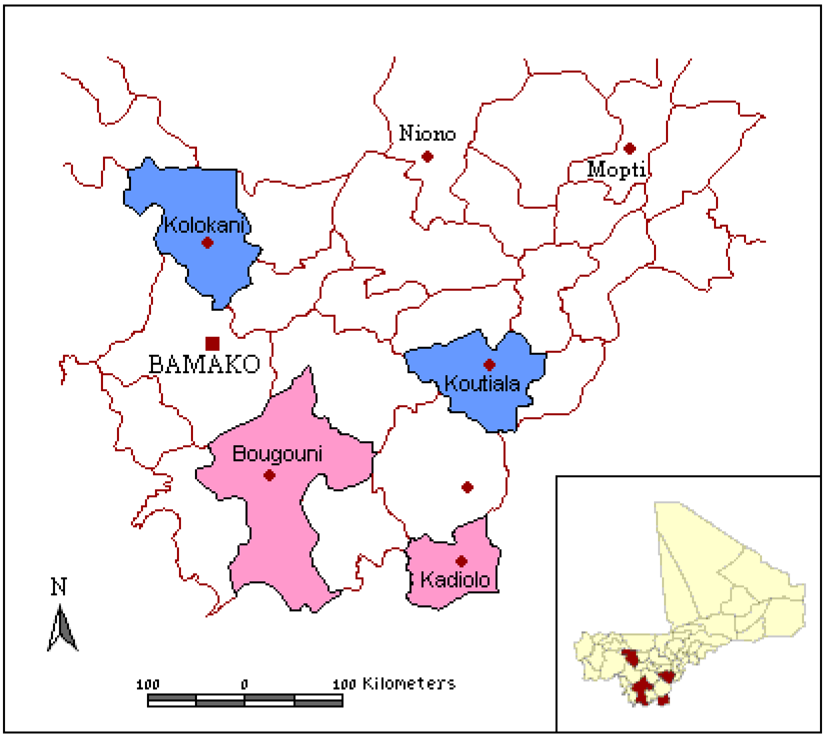

Figure 1. Map of Mali showing study zones. The Kolokani and Koutiala zones (vertical hatched area - blue) represent the South-Sudan or semi-arid zone while the Bougouni and Kadiolo zones (horizontal hatched area - red) represent the North-Guinea or humid zone.
Figure 1. Carte du Mali montrant les zones d'étude. L'espace hachuré verticalement représente les regions de Kolokani et de Koutiala (zone sud-soudanienne ou semi-aride; celui hachuré horizontalement représente les regions de Bougouni et de Kadiolo (zone nord-guinéenne ou sub-humide).

The research was conducted jointly by the farming systems research team of the Agricultural Research Institute of Mali (IER) and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). The study area covered a total of 11 villages selected at random from two distinct agro-ecological zones in southern Mali. Six of the selected villages were from the Kolokani and Koutiala administrative districts, representing the South Sudanian agro-ecological zone (vertical hatched area - blue, Figure 1), and five villages from the Bougouni and Kadiolo administrative districts, representing the North Guinean agro-ecological zone (horizontal hatched area - red, Figure 1). Table 1 describes the basic characteristics of the two zones.

Table 1. Selected characteristics of South Sudanian and North Guinean agro-ecologies in southern Mali (1995/96)
Tableau 1. Quelques caractéristiques des zones agro-écologiques Sud-Soudanienne et Nord-Guinéenne du Mali-Sud (1995/96)

Characteristic		South Sudanian (Semi-arid)	North Guinean (Sub-humid)
☐ Annual rainfall	(mm)	800-1000	1000-1300
☐ Population density	(persons km^{-2})	13-49	11-22
☐ Population growth	(% per year)	3.5	0.8
☐ Arable land	(% of total land area)	55	76
☐ Cultivable land	(% of arable land)	69	14
☐ Available cultivable land per farm worker	(ha)	1.5	1.8
☐ Land area in cotton	(% of land in crops)	30-46	20-25
☐ Mechanized farms	(% of all farms)	98	79
☐ Organic fertilizer	(kg ha^{-1})	1646	463
☐ Inorganic fertilizer NPK, 15-15-15	(kg ha^{-1})	31-96	15-20
☐ Urea	(kg ha^{-1})	24-87	23-27

A Participatory Rural Appraisal (PRA), based on the approach of Bengaly *et al.* (1996) was used. It comprises five related steps involving farmers and a multidisciplinary team composed of scientists and extension workers (Table 2). The main objective was to obtain information on farmers' perceptions of the Striga problem and to identify constraints and possible opportunities for developing sustainable control methods adaptable to local conditions. The PRA was conducted in four villages which are representative of the general characteristics of all villages selected. The villages of N'Goukan and Wenia represented the South Sudanian zone, and the North Guinean zone was represented by Ouatily and Banco. The studies at the village scale level involved a total of 140 farmers (35 per village), and involved discussions and joint appraisals with different ages and gender of the sample farmers. The surveys were conducted during the rainy season of the 1995/96 cropping season, between August and September.

Table 2. Steps in the Striga-related Participatory Rural Appraisal.
Tableau 2. Les Etapes de l'Enquête Rurale Participative sur le Striga

Description	Objective	Information required/provided	Source of information
Step 1: Construction of the village territory map	Obtain farmers' broad perception of their village territory in terms of village boundary and land use history	Land use patterns and physical characteristics, demarcation and distribution of Striga, constraints and potentials for Striga control	Farmer groups consisting of a mix of gender and age
Step 2: Construction of the village territory transect	Obtain farmers' assessment of Striga infestation along a transect through the territory	Relationship between soil types along the transect and Striga infestation, determination of the different Striga species along the transect	Farmer groups together with researchers
Step 3: Diversity analysis and household classification	Obtain farmers' perceptions of different farm and farmer types as they relate to Striga management	Classification of households into different socio-economic classes and related to Striga management. Selection of 'test' households.	Farmer groups together with researchers
Step 4: Whole farm (plot) mapping	Analyse individual household's management practices by 'test' households related to Striga.	Individual plot maps of 'test' households of all classes. Plot-level details: crops, cultural practice, level of Striga infestation, and control methods. Suggestions for testing/adaptation of technologies.	Individual household interviews at the household or field level.
Step 5: Feedback to farmers	Present findings to participating farmers for feedback and fine-tuning	Village, transect and farm maps presented and discussed. Setting priorities for action and test programmes.	Village meetings with farmers

On the basis of the PRA results, a complementary survey was carried out at the household and plot levels to better understand the Striga problem at a more detailed scale level. This particular survey included all the 11 villages and a total of 180 farmers participated. To quantify the Striga infestation, a severity scale of 0-5 was used: 0 = 0; 1 = 1; 2 = 2 to 10; 3 = 11 to 30; 4 = 31 to 60; and 5 = over 61 Striga plants m^{-2}. For the evaluation of the various Striga control methods used by farmers, the rankings assigned by farmers were converted into decimal scores using the formula:

$$SC_{dec} = 10 - (RAN-1)/n*10$$

where SC_{dec} is the decimal score, RAN is order or rank the farmers gave to each control method/strategy and n is the number of control measured ranked. The higher the decimal score, the more important the strategy. For the economic estimation of the consequences of the strategies of fallowing and crop substitution as Striga control strategies, the following crop prices were used: maize 45 FCFA kg^{-1}; pearl millet 60 FCFA kg^{-1}; sorghum 55 FCFA kg^{-1}; groundnut 200 FCFA kg^{-1} and cotton 150 FCFA kg^{-1}.

Results and discussion

Practically all the farmers in the sample were aware of Striga and the damage it causes, and some could even distinguish among the different species and their hosts. The major source of their knowledge of Striga was informal (personal observations; from relatives, parents and other farmers), and only 10% of the farmers claimed their knowledge came from formal sources (research, extension and media). Farmers perceived that, of all the factors favouring Striga development and infestation, the most important ones are related to the soil base (Table 3). Those in the South Sudanian zone perceived low soil fertility as the most important factor while those in the North Guinean zone perceived the duration of cultivation, where the older plots are subjected to continuous mono-cropping, hence susceptible to rapid decline in fertility, as the most important factor. The observations made by farmers of the close relationship between Striga infestation, low soil moisture availability, and poor soil fertility are consistent with previous reports (Boukar *et al.*, 1996; Parker, 1991; Basinski, 1955). Similarly, consistent with studies of Parker & Riches (1993), farmers in the two zones cited water, wind, and animal movement as the most important vectors of Striga dissemination (Table 3). Crop seeds, shown in northern Nigeria to be an important agent of dissemination (Berner *et al.*, 1994) were not perceived by farmers in both the North Guinean and Southern Sudanian zones of Mali to be important agents of Striga dissemination.

Table 3. Farmers' perception (% of citation) of the factors favouring Striga development and of vectors of dissemination in southern Mali (1995/96)

Tableau 3. Perceptions paysannes (% de réponses) des facteurs favorisant le développement du Striga et des vecteurs de sa propagation au Mali-Sud (1995/96)

	All zones	S. Sudanian	N. Guinean
Factors favouring development			
Duration of land cultivation	68	61	75
Low soil fertility	62	72	52
Soil type (gravel and sandy)	41	16	66
Inadequate use of organic fertilizer	35	37	33
Continuous mono-cropping	25	7	43
Drought	15	28	2
Vectors of dissemination			
By water	38	24	52
By wind	24	25	23
By animal movement	10	3	17
Through farm implements	3	4	2
By contaminated crop seed	1	1	0
Some combination of above	24	43	6

The village territory maps and transects made by farmer groups showed a great variability in the level of Striga infestations between villages and between territory units within villages consistent with other studies (Bengaly *et al*., 1996; Defoer *et al*. (pers. comm. 1996). Infestation is generally a function of the land use system, soil type and cropping pattern. It is much higher in the more humid North Guinean zone than in the semi-arid, South Sudanian zone where cotton production dominates (Table 4). Cotton, cultivated in bi- or triennial rotations with cereals generally receives relatively high doses of mineral and organic fertilizer. This cropping pattern apparently slows down Striga damage to cereals in the cotton producing areas.

Table 4. Crop and plot-wise estimation of Striga infestation levels and severity ratings in southern Mali (1995/96)
Tableau 4. Estimation par culture et par parcelle des niveaux d'infestation et des taux de sévérité du Striga au Mali-Sud (1995/96)

Crop	No. of plots	Average plot distance from village (km)	Estimated crop area (ha) (CA)	Estimated crop area infested (ha) (CAI)	Infestation rate[1] (%) (IR)	Severity rating[2]
All zones						
Groundnut	47	2.6	117	1.9	1.6	0
Cotton	91	2.9	88	2.3	2.6	0
Fonio	11	1.2	13	6.2	47.6	1
Maize	51	2.8	75	56.5	75.3	2
Maize/Pearl millet	24	2.8	30	21.7	72.3	2
Maize/Sorghum	7	1.3	5	4.5	90.0	3
Pearl millet	58	2.6	92	56.4	61.3	3
Sorghum	90	2.0	239	170	71.2	1
Other crops[3]	38	1.9	15	7.5	50.0	2
Total or average	417	2.2	674	327	48.5	2
South Sudanian Zone						
Groundnut	11	2.3	10	1.4	14.0	1
Cotton	14	2.5	31	0	0.0	0
Fonio	0	0.0	0	0	0.0	0
Maize	15	2.9	15	7.5	50.0	2
Maize/Pearl millet	5	3.3	4	1.7	42.5	2
Maize/Sorghum	1	0.9	0.5	0.5	100.0	3
Pearl millet	15	2.0	28	11.4	40.7	3
Sorghum	18	2.1	35	25	71.4	1
Other crops[3]	6	2.1	26	0.5	1.9	2
Total or average	85	2.0	127	48	37.8	2
North Guinean Zone						
Groundnut	36	2.9	107	0.5	0.5	0
Cotton	77	3.2	57	2.3	4.0	0
Fonio	11	2.5	13	6.2	47.6	2
Maize	36	2.8	60	49	81.6	2
Maize/Pearl millet	19	2.4	26	20	76.9	1
Maize/Sorghum	6	1.7	4	4	100	2
Pearl millet	43	3.3	64	45	70.3	2
Sorghum	72	2.0	204	145	71.1	1
Other crops[3]	32	1.7	12	7	58.3	3
Total or average	332	2.5	547	279	51.0	2

1) IR = CIA*100/CA
2) 0 = 0; 1 = 1; 2 = 2 - 10; 3 = 11 - 30; 4 = 31 - 60 and 5 > 61 Striga plants m^{-2}.
3) Includes crops and crop associations other than those listed above.

Similarly, the village transect maps showed that Striga is distributed along the toposequence, with heavier infestations of the different species associated with the sandy and gravely soils of the upper segments of the gradient (which are generally also less fertile). The farmers in the South Sudanian zone have noted a general declining trend in Striga infestation over the last thirty years which they attributed to the increasing trend in cotton-cereal rotation, better cultural practices, and increasing use of fertilizer. On the contrary, farmers in the North Guinean zone have noted a general increasing trend in Striga infestation over the same period. The increase was attributed to increasing pressure on land resulting from population growth, reduced fallows and erosion problems. Roughly estimated, 49% of the total cropped area in the two zones was infested by Striga species with an average severity rating of 2 (Table 4).

The farmers interviewed cited several strategies and methods that they employ to combat Striga on their fields (Table 5). Fertilization (mineral or organic) was ranked by the farmers to be the most important (and possibly the most effective) method in use, with some important differences between the two zones. In the South Sudanian zone, mineral fertilization is the most important method for Striga control as farmers have ready access and the necessary liquidity to purchase fertilizer from cotton income. In the North Guinean zone, where land is relatively abundant, there is more use of fallowing, rotation and cultural control as opposed to organic fertilization. Because of the relative abundance of land, they still are able to produce enough food to meet the family's needs by cultivating less infested lands. In land-acute areas of the South Sudanian zone, this strategy is costly in terms of production loss as farmers have limited opportunity for cultivating new land. An analysis of the fallow strategy showed that for each year that the land was left uncropped, the strategy caused maize, millet and sorghum production losses of 1941, 150 and 1348 kg per farmer, respectively (Table 6). In economic terms these losses are substantial, especially for maize. Fallowing therefore causes large losses in crop production, especially when opportunities for cultivating new land are limited. This implies that alternatives to traditional fallowing are needed particularly in areas of the study zone where land availability is a constraint. One such alternative is the introduction of an agroforestry technology of 'improved fallows' which improves soil fertility within a period of 2 to 3 years while providing several other benefits to the farmer.

Table 5. Farmers ranking of Striga control methods in Southern Mali (1995/96)

Tableau 5. Classement par les paysans des méthodes de contrôle du Striga au Mali-Sud (1995/96)

Control method/Strategy	All zones	S. Sudanian	N. Guinean
Mineral fertilizer (incl. urea)	2.7	5.5	2.1
Organic fertilizer	2.6	3.9	1.0
Crop rotation/substitution	2.1	2.3	2.1
Use of tolerant/resistant varieties	2.1	3.1	1.6
Fallowing/abandonment	1.7	0.8	2.2
Cultural practices	1.6	1.3	1.7

Table 6. Estimates of indirect crop losses arising from a strategy of fallowing or abandoning heavily infested Striga plots in the North Guinean zone of Mali.

Tableau 6. Estimation des pertes indirectes de récoltes résultant d'une stratégie de mise en jachère ou d'abandon de parcelles fortement infestées par le Striga en zone Nord-Guinéenne du Mali (1995/96.

Crop preceding fallow or abandon	Estimated total area in fallow or abandon (ha)	Average period of fallow or abandon (yr)	Average yield loss per year of fallow or abandon (kg ha^{-1})	Total production loss per year of fallow or abandon (kg)	Total production loss per year of fallow or abandon (kg $farmer^{-1}$)	Gross value of production loss per year of fallow or abandon (FCFA $farmer^{-1}$)
Maize	14.5	5.8	2 008	29 116	1941	87 345
Sorghum	20.0	6.7	1 011	20 220	1348	74 140
Pearl millet	4.5	4.3	500	2 260	150	9 000

A recent study conducted in Kenya has shown that not only did a two-year fallow of *Sesbania seban* reduce the number of Striga seeds in the soil by 34% and improved the fertility of the soil by fixing nitrogen and adding leaf litter to the soil but has also increased maize yield (Anonymous, 1996). The net economic profit of crop substitution as a strategy of Striga control in land-scarce areas seems to be highest for cotton substituting for sorghum (Table 7). In general, farmers benefited from crop substitution when they substituted low-value crops previously grown on heavily infested fields with high-value crops. On the contrary, farmers who were forced by circumstances to substitute high-value crops on heavily infested plots with crops of low value lost both in production and in monetary terms. It was estimated that substituting groundnut with sorghum or maize with pearl millet or maize with sorghum etc., resulted in losses in production estimated at between and 285 and 550 kg ha^{-1} or in monetary terms between 12 250 and 98 565 FCFA ha^{-1} (Table 7).

Table 7. Estimates of the net effects of a strategy of crop substitution to control Striga in the North-Guinean zone of Mali.

Tableau 7. Estimation des effets nets d'une stratégie de substitution culturale pour lutter contre le Striga en zone Nord-Guinéenne du Mali (1995/96).

Substituted crop	Substituting crop	Yield of crop prior to substitution (kg ha^{-1})	Yield of substituting crop (kg ha $^{-1}$)	Yield gain (or loss) due to substitution (kg ha $^{-1}$)	Estimated gross value of substituted crop (FCFA ha^{-1})	Estimated gross value of substituting crop (FCFA ha^{-1})	Estimated effect (gross value of crop substitution, FCFA ha^{-1})
Groundnut	Sorghum	613	437	-176	122 600	24 035	-98 565
Sorghum	Pearl millet	970	685	-285	53 350	41 100	-12 250
Maize	Sorghum	912	520	-392	41 040	28 600	-12 440
Maize	Pearl millet	900	350	-550	40 500	21 000	-19 500
Sorghum	Cotton	656	1351	695	36 080	202 650	166 570
Pearl millet	Sorghum	534	869	335	32 040	47 795	15 755
Maize	Groundnut	700	587	-113	31 500	117 400	85 900
Pearl millet	Groundnut	347	545	198	20 820	109 000	88 180
Pearl millet	Maize	325	800	475	19 500	36 000	16 500

Conclusions

The combination of participatory diagnosis at the village level, and complementary surveys at the household and plot levels enabled a fuller understanding of farmers' perceptions of the Striga problem. The village level analysis was useful in visualizing, through the village territory and transect maps, the distribution of Striga over the village territory as well as relationships between infestation and land use, soil types and other characteristics. From the household- level surveys important information on farmers' understanding of the Striga life cycle (e.g., seed production, accumulation and dissemination mechanisms) were obtained. At the plot- level, it was possible to quantify the degree of Striga infestation by crop, as well as the consequences (physical and monetary) of traditional farmer strategies of abandonment, fallowing or crop substitution in heavily infested Striga fields. The findings from the different scale levels of study are useful for developing sustainable Striga control methods that fit the diversity of field conditions in the distinct zones of study. From the foregoing, and in view of the fact that farmers perceive the Striga problem as essentially a soill fertility problem, it becomes necessary to emphasize soil fertility- enhancing strategies in developing or promoting sustainable Striga control methods as these have the best chance of being adopted.

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