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Assessment of Farmers' Anthropological Responses to *Striga hermonthica* Infestation Across Five Regions of Niger

Salamatou Saïdou Sabo[1*], Abdoulaye Ali Koura[2], Moussa Soulé[3], Fanna Maina[2], Riyazaddin Mohammed[4], Harouna Issa Amadou[1], Bakasso Yacoubou[1]

[1]Faculty of Sciences and Techniques (FAST), Abdou Moumouni University of Niamey, Niger
[2]Institut National de la Recherche Agronomique du Niger (INRAN), Niamey, Niger
[3]Faculty of Sciences and Techniques (FAST), Dan Dicko Dankoulodo University of Maradi, Niger
[4]International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Niamey BP12404, Niger

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***Corresponding author:** Salamatou Saïdou Sabo
Faculty of Sciences and Techniques (FAST), Abdou Moumouni University of Niamey, Niger

Abstract **Original Research Article**

The root-parasitic plant Striga is the most economically significant weed in rain-fed agriculture in sub-Saharan Africa, infesting pearl millet, sorghum, and other cereal crops. Infestation by the root-parasitic weed Striga is one of the major biotic constraints to the production of key agricultural crops in the regions. Therefore, the objective of this study was to analyze anthropigical activities related to Striga hermonthica. In Niger five regions, examining their implications for infestation control. A significant number of farmers 25 to 40 per village, depending on availability were surveyed without gender-based selection criteria across Niger five regions, Dosso, Maradi, Tahoua, Tillabéry, and Zinder. Chi-square tests were used to assess associations among various categorical variables, while Principal Component Analysis (PCA) was employed to explore correlations and reduce data dimensionality. In this investigation, 93% of respondents reported that their fields are infested by Striga. Nine local methods were identified as Striga control methods, with statistically significant differences in their perceived effectiveness. Further analysis of faming practices identified several key factors contributing to Striga proliferation: insufficient organic matter and mineral fertilizer inputs, inadequate manual weeding of Striga plants (often late or incomplete), and a strong reliance on traditional local seeds to the detriment of resistant improved varieties. The findings therefore, highlight the urgent need for an integrated approach that closely associates researchers, farmers, and policymakers to develop and implement sustainable Striga control strategies. The implementation of these concerted solutions could not only significantly reduce Striga infestation but also sustainably improve agriculture productivity and strengthen the resilience of production systems against multiple environmental stresses.

Keywords: Anthropological practices; control methods; infestation levels; local knowledge; root-parasitic weeds.

1. INTRODUCTION

Introduction by the root-parasitic weeds *Striga* (family Orobanchaceae) is one the major biotic constraints to the production of the agricultural crops in sub-Saharan Africa (SSA) (Chemisquy *et al.,* 2010; Gressel *et al.,* 2004; Rispail *et al.,* 2007). The majority of the maize producers are small-scale farmers, who practice mixed cropping under low-input rainfed systems with an average yield that is low relative to regional and word averages. The low yields are partly due to abiotic and biotic stresses. One of the major constraints to maize production in western Kenya is the parasitic weed, Striga *hermonthica* (Mulaa *et al.,* 2025). The root-parasitic plants *Striga hermonthica* (Del.) Benth and *Striga asiatica* (L.) Kuntze is the most economically significant weeds in rain-fed agriculture in sub-Saharan Africa, infesting pearl millet, sorghum, and other cereal crops (Parker, 2009; Rispail *et al.,* 2007). Several *Striga* control strategies have been examined over the past decades, such as cultural practices, biological control by parasitic fungi and bacteria, and the use of chemicals to manage *Striga* in cereal. *Striga* life cycle with that of its host operates simultaneously and requires mechanisms that harmonize the life cycle of both the host and the parasitic plant. Its life cycle usually involves; germination, host attachment haustoria formation, penetration and establishment of vascular connections, accretion of nutrients, flowering, and production of seeds (David *et al.,* 2022).

Geographically, *Striga* species are widely distributed across tropical and semi-arid regions of Africa, the Middle East, Asia, and Australia (Teka, 2014) and have been reported in over 40 countries worldwide, with the most severe infestations occurring in sub-Saharan Africa and India (Ejeta, 2007; De Groote *et al.,* 2008; Parker, 2012). It is estimated that over 50 million hectares of arable land in sub-Saharan Africa are infested by *Striga* spp., causing massive yield losses ranging from 40% to total crop faiture (Ejeta, 2007; Gressel *et al.,* 2004; Parker, 2012; Rodenburg *et al.,* 2005; Westwood *et al.,* 2012). Thus, *Striga* is considered one of the greatest biotic constraint to food production in Africa, negatively impacting the livelihoods of 300 million people, particularly subsistence farmers, and exacerbating food insecurity and poverty (Pennisi, 2010).

Despite its devastating impact on food security *Striga hermonthica* paradoxically has diverse uses among local populations, revealing a complex interaction between humans and this harmful plant (Traoré *et al.,* 2001).

In Niger, various anthropological practices have emerged to manage and even use this parasitic plant. A recent study involving 340 individuals found that 76% of respondents use *Striga* in different ways, including as fodder (35.10%), soil fertilizer (24.08%), and in traditional human medicine (22.12%) to treat 31 different diseases (Saidou *et al.,* 2024).

This dual nature of *Striga hermonthica* both an agricultural scourge and a utilitarian resource raises fundamental question: How do anthropological practices infestation dynamics?, what are the socio-economic and environmental impacts of these traditional uses? to what extent could a utilisation-based approach contribute to integrated management of this species ?

The objective of this study was then to analyse anthropological activities related to *Striga hermonthica* in Niger five regions, examining their implications for infestation control. By integrating ethnobotanical, agronomic, and socio-cultural data, this research aims to propose sustainable strategies that combine agricultural impact reduction with the preservation of local knowledge. Such an approach could mitigate food crises while strengthening the resilience of rural communities against this formidable parasite.

2. MATERIALS AND METHODS

2.1 Ethnobotanical Surveys

The field survey was conducted primary during the months of October and November. In Niger's five regions, two villages were selected based on road accessibility for vehicles during the rainy season.

In each village, before beginning the survey, introductory presentations were made, followed by explanations of the study's objectives. A significant number of famers 25 to 40 per village, depending on availability were surveyed without gender-based selection criteria. Respondents were chosen at random.

Each participant was administered an individual quiz questionnaire in the local language (Hausa or Zarma), with occasional assistance form an interpreter to facilitate communication. The questionnaire covered respondent profiles (gender, age, and education level, etc.), endogenous uses of *Striga*, and *Striga* control methods. Responses were recorded in survey forms. In total, 325 farmers were surveyed across Niger regions (Fig. 1).

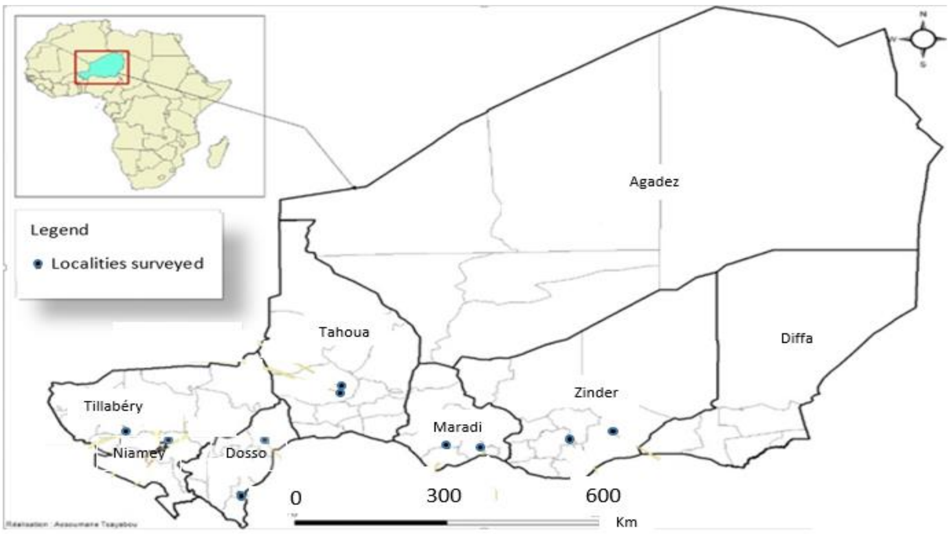

Fig. 1. Localization map of the surveyed areas

2.2 Statistical Analyses

The collected data were entered using Excel 2010. This software was also used to create histograms for preliminary visualisation of distributions. For deeper analysis, we used RStudio 4.2.3. Chi-square tests were performed to assess associations between different variables. Principal Component Analysis (PCA) Was then conducted to explore correlations between these variables and reduce their dimensionality. Finally, a Hierarchical Ascendant Classification (HAC) using Ward's method was applied to group surveys based on their similarities.

The citation frequency (CF) of modality was calculated using the formula:

$$CF = \frac{\text{Citation frequency}}{\text{Total number of citations}} X100$$

3. RESULTS

3.1 Identification of Respondents

Table 1 reveals a predominantly male population, with 68.61% men compared to 31.38% women. The age distribution shows a predominance of adults, with the 31-45 and 46-85 age groups each representing 37.23% of the sample.

The analysis of education levels highlights limited schooling, with 33.23% illiterate and only 8.62% secondary education. In terms of profession, agriculture dominates overwhelmingly, with 57.84% of respondents.

Table 1: Socio-demographic characteristics of respondents

Category	Option	Frequency	Percentage (%)
Gender			
	Female	102	31.38
	Male	223	68.61
Age Group			
	15-30 years	83	25.53
	31-45 years	121	37.23
	46-85 years	121	37.23
Education Level			
	Illiterate	108	33.23
	Quranic school only	116	35.69
	Quranic and public school	20	6.15
	Primary level	53	16.30
	Secondary level	28	8.61
Occupation			
	Farmer	188	57.84
	Other	71	21.84
	Trader/Merchant	63	19.38
	Civil servant	3	0.92

3.2 Field Infestation Rate

93% of respondents reported that their fields are infested by Striga (Fig. 2). Data analysis reveals a concerning predominance of Striga infestations, with 48.61% of fields showing a high infestation level, while 6.46% of plots exhibit minimal Striga presence, and a very small 0.61% are completely free of infestation (Fig. 3).

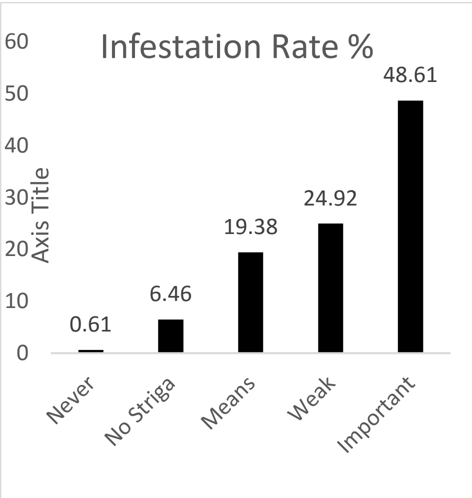

Fig. 2: Proportion of field infestation rates among respondents

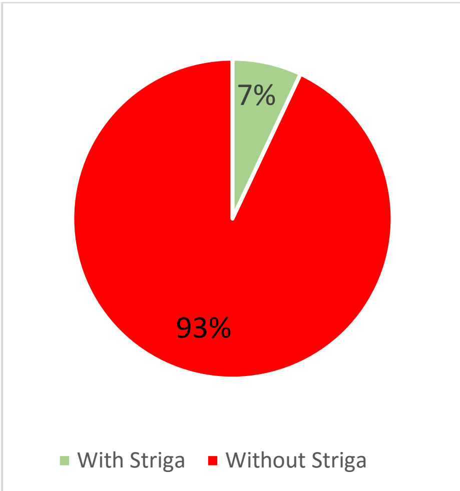

Fig. 3: Proportion of field infestation levels among respondents

3.3 Striga Control Methods

Nine local methods were identified (Fig. 4). The control methods most frequently cited by respondents are mixed cropping (89.2%). The least cited methods are the use of Néré powder (0.61%) and crop rotation (15.38%).

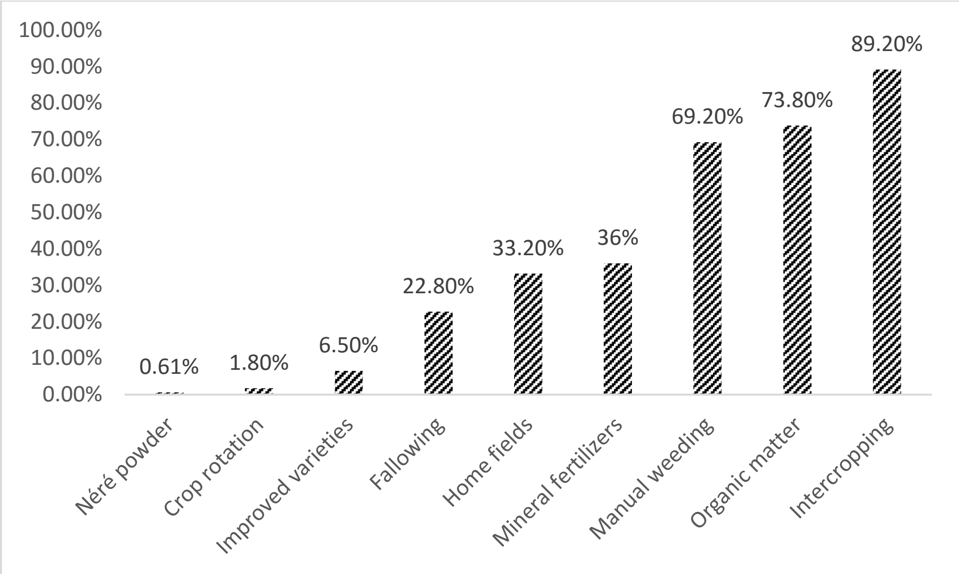

Fig. 4: Proportions of *Striga* control methods

3.4 Differential Effectiveness of Striga Control Methods: Analysis of Infestation Levels Based on the Number of Techniques Employed

Data analysis reveals several significant trends concerning the relationship between the number of Striga control methods used and the observed infestation levels in the fields (Table 2). The results show that using a single control method is associated with the highest rate of significant infestation (62.5%), while adopting two methods.

Reduces this rate to 41.2%. However, this trend does not follow a linear progression, as the use of three, four, and five methods again shows an increase in the rate of significant infestation to 48.6%, 48.7%, 50%, and 50% respectively.

Interestingly, the use of five methods presents the best balance with 50% significant infestation and 35.7% low infestation. Fields with no control methods show intermediate results (50% significant infestation, 30% low).

The complete absence of *Striga* remains rare in all cases (maximum 2.7% for two methods), confirming the parasite persistence. Average infestations vary between 8.3% and 22%, with no clear correlation to the number of methods used.

Table 2: Distribution of *Striga* infestation levels according to the number of control methods applied by farmers

Number of control methods per farmer	*Striga* infestation levels in respondents' fields (%)				
	Low	Severe	Never	Moderate	No *Striga*
1 method	25.00	62.5	-	8.3	4.2
2 methods	27.30	41.8	1.8	16.4	12.7
3 methods	24.80	48.6	-	22	4.6
4 methods	22.10	48.7	0.9	21.2	7.1
5 methods	35.70	50	-	14.3	-
No methods	30.00	50	-	20	-

3.5 Identifying the Best *Striga* Control Strategies

Data analysis reveals significant differences in the effectiveness of various *Striga* control methods (Table 3). Crop association alone (CA) shows 33% low infestation but 42% significant infestation, with only 8% of CA with manual weeding (MW) shows reduced effectiveness with 57% significant infestation.

The most effective methods consistently incorporate Néré powder (NP), achieving 100% success (CA+MW+F+NP and its variations). Conversely, certain practices like fertilization alone (F) or combined with fallowing (Fa) show complete ineffectiveness with 100% significant infestation.

Intermediate methods present variable results. For instance, CA+F+CF yields 32% low and significant infestation, with 23% of fields free of *Striga*. The addition of improved varieties (IV) significantly improves results, as seen in CA+Fa+IV+F, which reduces significant infestation to 18% and allows for 41% of fields to be free of *Striga*. Simple approaches like manual weeding alone (MW) prove inconclusive (89% significant infestation), as does the absence of any method (50% significant infestation).

Table 3: Distribution of *Striga* infestation levels according to control methods employed by farmers (%)

Control Method	Low	Significant	Never	Moderate	No *Striga*
CA	33	42	-	17	8
CA + MW	26	57	-	17	-
CA + F	29	19	5	19	29
CA + Fa	-	100	-	-	-
CA + MW + F	24	53	-	24	-
CA + MW + F + NP	-	-	100	-	-
CA + MW + F + CF	14	63	-	22	-
CA + MW + F + NP + CF	100	-	-	-	-
CA + MW + Fa + F	35	48	-	16	-
CA + MW + Fa + F + CF	31	54	-	15	-
CA + MW + IV + CF	75	25	-	-	-
CA + F + CF	32	32	-	14	23
CA + Fa + MW	-	75	-	25	-
CA + Fa + F + CF	29	57	-	-	14
CA + Fa + IV + F	12	18	6	24	41
CA + CR + CF	33	33	-	33	-
MW	11	89	-	-	-
MW + CF	-	100	-	-	-
MW + F	40	40	-	20	-
MW + F + CR + CF	33	-	67	-	-
No method	30	50	-	20	-
CF	50	50	-	-	-
F	-	100	-	-	-
F + CF	33	33	-	-	33
F + Fa	-	100	-	-	-

CA = Crop Association; MW = Manual Weeding; F = Fertilization; CF = Case Fields; CR = Crop Rotation; IV = Improved Varieties; NP = Néré Powder; Fa = Fallowing

3.6 Principal Component Analysis

This dataset contains 325 observations and 5 variables, with 1 qualitative variable being illustrative. The graph analysis reveals no singular observations.

The PCA results show that the first two principal components collectively explain 59.3% of the total data variability (33.4 and 25.9%, respectively). This means that 59.3% of the information contained in the scatter plot can be represented in a two-dimensional plane defined by these first two axes. The analysis of correlations between the initial variables and the principal components (Table 4) allows for their interpretation:

- Principal Component 1: This component is strongly correlated with the number of control methods and the utilization of *Striga*. This axis can therefore be described as the axis of parasite characteristics and control strategies.
- Principal Component 2: This component is primarily linked to survey yields. This axis represents the dimension of yields.

Table 4: Correlations between variables and each of the first four principal components

Variables	Dim 1	Dim 2
Striga infestation rate	0.33	0.56
Number of *Striga* control methods	0.79	-0.10
Number of *Striga* uses	-0.78	0.19
Yield	0.05	0.82

An analysis of the signs of correlations of each variable with each of the principal components allows us to formulate the following observations.

- On Axis 1, respondents who implement multiple *Striga* control methods use the parasite very little in their daily lives.
- On Axis 2, surveys with field heavily infested with *Striga* show high yields at harvest.

3.6.1. Description of Dimensions

Fig. 5 illustrates the distribution of respondents in the plane defined by principal components 1 and 2, respectively.

Dimension 1 contrasts the respondents located to the right of the origin (negative coordinates). These individual use *Striga* intensively for other purposes (medicinal, folder, etc.) while implementing few specific control methods against this parasite. For example, individual 105, 83 and 102 characterizes this profile. In contrast, individuals located to the left of the origin (positive, coordinates) practice several *Striga* control methods and use this parasite relatively little for other purposes. Individuals 295 and 303 are good examples of this type of profile.

Dimension 2 appears to link the level of *Striga* infestation with agricultural yields. It contrasts individual with positive coordinates on this axis (at the top of the graph) who generally show high infestation levels and also high yields at harvest, for example, individuals 12, 51 and so on. In contrast, individuals with negative coordinates on this axis (at the bottom of the graph) are characterized by low infestation levels and also low yields, for instance, individuals 257, 58 and so on.

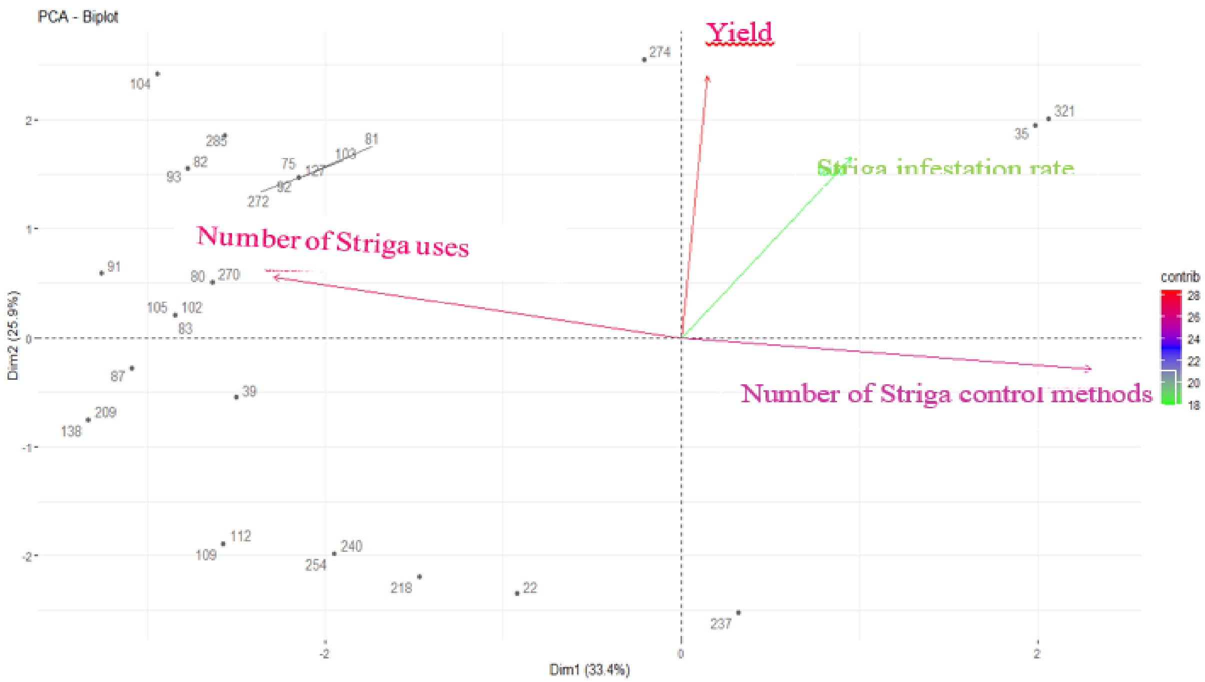

Fig 5: Projection of Individuals and Variables in the Axis System Formed by PC1 and PC2

3.7 Hierarchical Ascendant Classification of Individuals

An hierarchical ascendant classification was performed to group respondents from the five regions of Niger (Dosso, Maradi, Tahaoua, Tillabéry, and Zinder) into sufficiently homogeneous groups. The dendrogram obtained from this classification (Fig 6) indicate three groups of individuals. Group 1 consists of 141 individuals, Group 2 of 115 individuals, while Group 3 comprises only 69 individuals. Each group contains respondents from all five regions of Niger (Dosso, Maradi, Tahoua, Tillabéry, and Zinder). This means that respondents from the same site can be found in different groups (Table 5).

Group 1 is made up of surveys with nearly equal proportion from each region, with the exception of the Tillabéry region. This group is represented by respondents who use the parasite very little for their daily needs, and they practice several *Striga* control methods during the cropping season. At the end of the season, they record significant infestation rates and substantial yields.

Group 2 is primarily composed of respondents from the Tahoua and Tillabéry regions. They practice several *Striga* control methods and also utilize the parasite. These respondents record low *Striga* infestation rates in their fields and also show low yields.

Group 3 is mainly represented by surveys from the Maradi and Tillabéry regions. This group mostly consists of respondents who use *Striga* extensively for their daily needs and practice few control methods against the parasite. Fortunately, they show average yields.

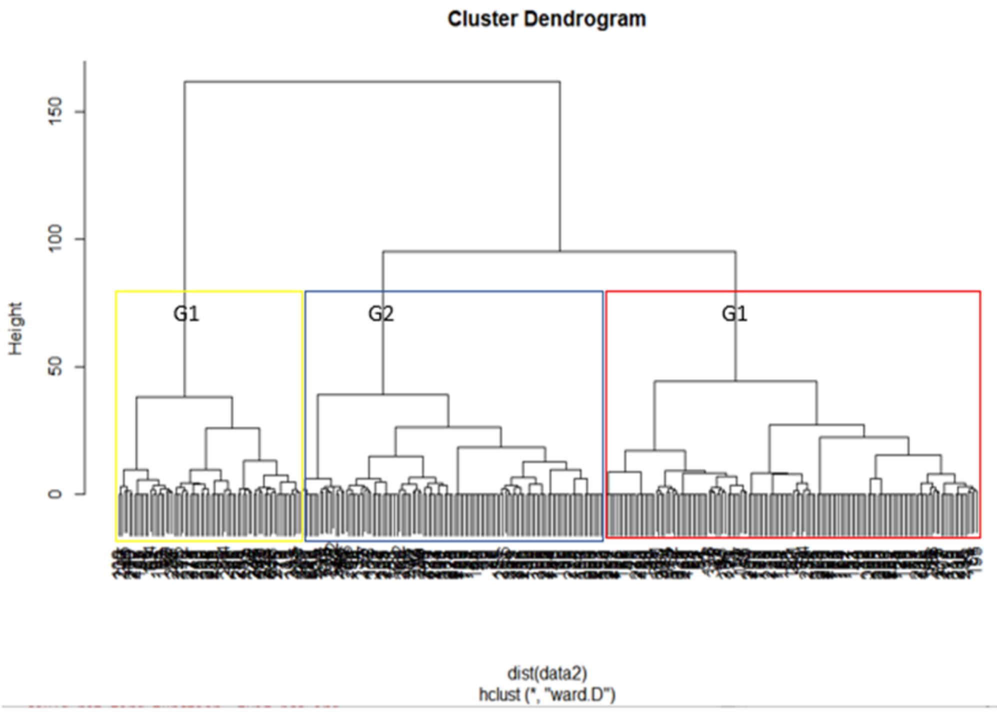

Fig. 7: Dendrogram of the 325 Respondents

Table 5: Number of producers per group

Regions	G1	G2	G3	Total
Dosso	32	22	11	65
Maradi	31	12	22	65
Tahoua	30	32	3	65
Tillabéri	14	31	20	65
Zinder	34	18	13	65
Total	141	115	69	325

3.8 Group Characteristics

The results of the analysis of variance comparing the three groups are presented in table 6. Each variable indicates significant differences between groups (p- value < 0.05), with the exception of the yield variable. However, the highest coefficients of determination were obtained for the variables *Striga* utilization and *Striga* infestation rate in surveyed fields.

Table 6: Characteristics of Each Group

	Striga Infestation Rate	Striga Utilization	Yield	Number of Control Methods
Group 1				
Mean	3.89	1.21	1.67	3.19
sd	0.33	0.54	0.64	0.99
Group 2				
Mean	2.05	1.23	1.58	3.07
sd	0.94	0.52	0.53	0.86
Group 3				
Mean	2.90	4.00	1.64	2.22

4. DISCUSSION

Data collected from 325 surveyed individuals reveal a clear gender disparity among millet farmers in the studied regions. Indeed, men represent 68.61% of farmers compared to only 31.38%women. This disparity is primarily explained by social norms and the traditional division of labor in rural communities. Traditionally, men handle cereal crops like millet, which are considered primary production, while women focus more on market gardening or processing activities.

This study revealed a high level of infestation across all surveyed farmers' fields in the five regions of Niger. These findings corroborate those of Amadou *et* *al.,* (2021), who also observed a high prevalence of this parasite in five rural communes of the country.

The survey identifies nine local methods for *Striga* control: Néré powder, crop rotation, improved varieties, fallowing, champ case (a traditional farming practice), mineral fertilization, manual weeding, organic matter, and mixed cropping. This range of methods is comparable to that identify by Amadou *et al.,* (2021). Nevertheless, variations exist, notably the use of natron and ash reported by the same authors, but absent in our study.

These differences could be explained by the methodological and geographical specificities of the two studies, with the previous one focusing on the central part of the Dosso region and the eastern band of the Tillabery region.

Manual weeding of S. hermonthica plants is one of the these most cited control methods by surveyed respondents due to its low cost. Nevertheless, it requires significant labor and must be performed as soon as young parasite plants emerge to limit seed production, as highlighted by Ogbon (1984).

Although organic matter is widely used by farmers, the quantities spread per hectare remain below the recommended rates (8 to 20 t/ha) estabilized by research (Guéro and lamso, 2006). This underutilization is explained by several factors: insufficient production of organic substrates (manure, compost, waste) to fertilize all plots, as well as logistical constraints related to transporting these materials to distant fields. Consequently, only farmers with large livestock holdings can ensure a regular supply of manure to their crops (Guéro and lamso, 2006).

The survey reveals that mineral fertilizers are often associated with organic matter inputs. This practice, common across all studied areas, is due to soil degradation and the need to improve yields. However, the quantities of both mineral and organic fertilizers used remain insufficient compared to recommendations (60 to 100 kg/ha). Furthermore, paradoxically, does that are too low can favour *Striga* development by strengthening the host plant's resistance (Dembélé *et al.,* 2005).

The use of improved seeds was quickly perceived by sahelian countries as a very important factor in increasing the productivity of agricultural production systems. Indeed, *Striga*-resistant varieties prevent a large number of *Striga* plants from emerging and provide good yields (Dembélé *et al.,* 2005). However, their adoption by farmers remains limited. Several factors explain this situation: difficult access to seeds, high cost, and agronomic or taste characteristics sometimes deemed, unsatisfactory by producers. Additionally, the vulnerability, of certain short-cycle varieties to insect attacks in the event of early drought poses an additional risk, reinforcing farmer's reductance.

The observation of a 100% significant infestation in plots treated with fertilization alone (F) or combined with fallowing (Fa) indicates a complete ineffectiveness of these isolated practice. This strongly suggests that, on one hand, the fertilization is not only very low but potentially unsuitable for the level of soil degradation or the specific needs of the crop, or even that it indirectly promotes the infesting agent. On the other hand, the fallowing period is also very insufficient, poorly managed, or ineffective in breaking the life- cycle of harmful organism.

These results underscore the importance of adopting an inegrated and adaptive approach to effectively control *Striga*. Indeed, the synergistic combination of different control methods proves more effective than partial or isolated approach. The great diversity of cropping systems and the genetic variability of the parasite render any single method insufficient, this justifying the development of integrated control programs associating several complementary control measures (Badu-Apraku, 2010).

In some cases, farmers who use only one Striga control method manage to maintain very low or even non-existent infestations. This may be because their fields were initially slightly infested, or because they properly applied the chosen method. Similar results were observed by Daoud *et al.,* (2018) in Chad: the application of organic fertilizers, particularly bat guano and high doses of compost or cow dung, significantly reduced or even completely eliminated the emergence of Striga hermonthica in some plots. Thus, for a control strategy to be truly effective, it is essential that farmers strictly follow the technical application guidelines.

Group 2 presents a unique situation where the application of multiple *Striga* control methods and the partial utilization of the parasitic plant lead to low infestation, yet paradoxically, to reported poor yields. Several combined factors explain this apparent contradictions. On one hand, the methods employed, while reducing parasitic pressure, might not be enough to compensate for other agronomic limitations such as poor soil fertility, water stress, or the presence of other pests. On the other hand, the use of *Striga* as a resource (fodder or fertilizer) could create an ecological balance where the plant remains present at tolerable levels without being eradicated.

However, an important bias must be considered: many farmers, hoping for potential future aid, may have voluntarily understated their actual yields during the survey. This distortion in reported data, combined sometimes with difficult soil and climatic conditions and the use of low-yielding varieties, explains the discrepancy between the relative control of the parasite and the reported agricultural performance.

5. CONCLUSION

This study, conducted in five regions of Niger, reveals an alarming situation with widespread *Striga* hermonthica infestation in fields. A depth analysis of farming practices identifies several key factors promoting the proliferation of this formidable parasite: insufficient organic matter and mineral fertilizer inputs, inadequate manual weeding of *Striga* plants (often late or incomplete), and a strong reliance on traditional local seeds to the detriment of resistant improved varieties. These agricultural practices, combined with difficult soil and climatic conditions and the misuse of *Striga* (as fodder and soil fertilizer), have created an environment conductive to the rapid expansion of *Striga*, gravely threatening regional food security.

Facing this complex challenge, our research emphasizes the urgent need to adopt an integrated approach that closely associates researchers, farmers, and policymakers. Such synergy would enable the development of control strategies combining proven traditional methods and scientific innovations, while considering local socio-economic realities.

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