Producers' perceptions and endogenous strategies for the control of *Striga hermonthica* and impacts of cultural practices on millet (*Pennisetum glaucum* (L.) R. Br.) northern of Côte d'Ivoire

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1 SUMMARY

***Striga hermonthica* is a major constraint to cereal production northern of Côte d'Ivoire. The aim of this study was to analyse millet growers' knowledge of this parasite and to identify their endogenous control strategies a survey was carried out through group discussions and an individual questionnaire administered to 144 growers in four departments northern of Côte d'Ivoire. In this study, the presence of *Striga hermonthica* in millet fields was confirmed by 95.45% of the growers surveyed. Two morphotypes of the species were identified. Several factors responsible for its appearance in September were cited, including the type of gravelly soil, the drop in rainfall, the absence of fallow land and the decline in soil fertility. Analysis of the data provided on cultivation practices revealed that they are poorly carried out, which Favors the appearance of *Striga hermonthica* in the plots. Farmers' methods of combating the pest include early sowing, spreading *Parkia biglobosa* powder, organo-mineral fertilization, uprooting Striga plants, using false hosts and crop rotation. The parasite is also used in traditional human medicine and dyeing. The study revealed a good knowledge of the parasite by farmers and could enable the development of control strategies using existing practices in the farming environment in order to reduce *Striga hermonthica* parasitism to a non-harmful threshold.**

2 INTRODUCTION

Striga is an epirrhizal parasitic phanerogam of the Scrophulariaceae family well known in tropical Africa for its damage to host crops (Boussim, 2002). It has become a veritable scourge in several regions of the African continent (Olivier, 1995). Species of the Striga genus are parasitic epirrhizal plants that are unable to complete their life cycle in the absence of a herbaceous angiosperm (Raynal-Roques, 1993).Twenty(20) to 40 million hectares of land are infested by Striga species (Ranson and Odhiambo, 1995), and annual grain yield losses from host crops are estimated at 10.7 million tonnes (Gressel *et al.*, 2004). This is a major constraint to achieving food security. Striga grows preferentially in poor, degraded soils with a sandy surface horizon, a clay content (2 to 5%) and a very low organic matter content (below

0.7%), such as degraded ferruginous soils (Usaid, 2009). A number of factors favor infestation, including low rainfall (between 500 and 1000 mm), the use of agricultural land for many years and the frequent use of susceptible crops in rotations (Usaid, 2009). Of all Striga species, *Striga hermonthica* (Del.) Benth. is the most economically important parasitic weed worldwide and is endemic to the African savannah and Sahel (Parker and Riches, 1993). It is the most feared weed, parasitizing many cereal crops (Hassan *et al.*, 2010) and causing major crop losses of up to 100% of grain yield (Atera *et al.*, 2012). The financial loss caused by *Striga hermonthica* is estimated at seven billion US dollars annually, and the infestation affects the lives of over 100 million people in Africa (Badu-apraku *et al.,* 2011). In Côte d'Ivoire, nine Striga species have been recorded, including three perennials and six annuals (Mohamed *et al.*, 2001). Of these nine species, *Striga hermonthica* is the major constraint to cereal production northern of Côte d'Ivoire (Akanvou *et al.*, 2006). In view of the high cost of the control methods (physical, chemical and mechanical) developed against *Striga hermonthica*, these have been abandoned in favor of other inexpensive control techniques within the reach of growers. These include the use of manure, the association of host plants with Striga trap plants, manual uprooting and crop rotation to control Striga (Traoré and Yonli, 2001). Several studies have shown that there is a repertoire of traditional knowledge of control methods against Striga spp. Indeed, Naoura *et al.* (2021) and Boussim *et al.* (2011) have identified local control methods, believed to be curative, to control *Striga hermonthica* parasitism in Burkina Faso. Managing this pest therefore requires the development of strategies using existing crop management practices that are acceptable to growers. In Côte d'Ivoire, to the best of our knowledge, no such studies have been carried out. It is therefore necessary to gather the traditional knowledge of cereal growers on *Striga hermonthica*, which could help control this parasitic plant. It is within this framework that this study was initiated, with the aim of taking stock of the traditional knowledge of cereal growers on the *Striga hermonthica* species, and of their cultivation practices and traditional control methods against this parasite in cereal-based cropping systems, in particular millet.

3 MATERIALS AND METHODS

3.1 Presentation of the study area: The survey was carried out in the Tchologo, Poro and Bagoué regions northern of Côte d'Ivoire, the main cereal-producing area (figure 1). A total of fifteen (15) localities were surveyed, including six (06) in Ouangolodougou department (Mambiadougou, Nambingué, Diawala, Tiaplé, Tiewolovogo and Koronani), one (01) in Ferkessédougou department (Sambakaha), four (04) in Korhogo department (Norgortanakaha, Kouolo, Kolekaha and Guéfiankaha) and four (04) in Tengréla department (Dougba, Bolona, Zelesso and Debeté). These localities were selected on the basis of accessibility and the presence of cereal producers, with the help of ANADER (National Agency for Rural Support and Development) agents working in the study areas. The questionnaires were submitted to one hundred and forty-four (144) producers, forming twenty-two (22) groups of respondents distributed heterogeneously throughout the localities (Table 1).

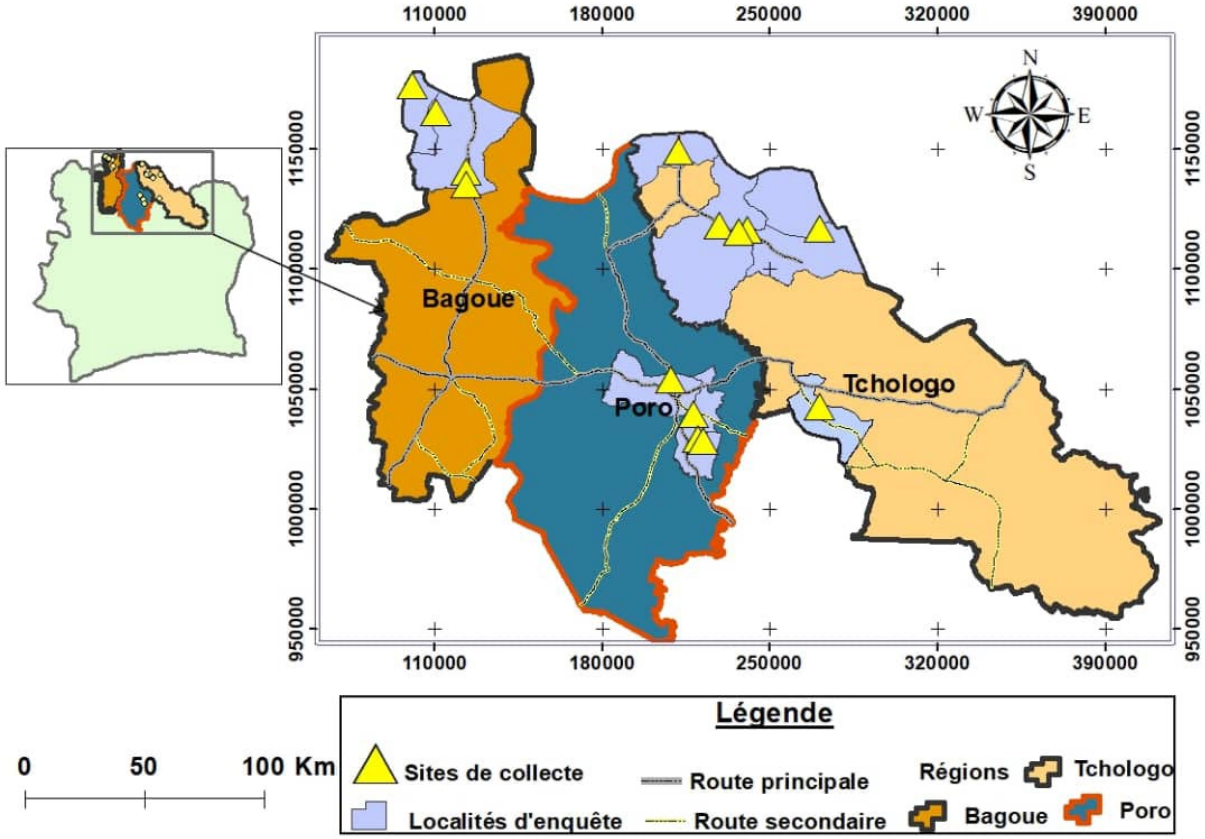

Figure 1 : Survey locations for *Striga hermonthica*

3.2 Data collection: A questionnaire was administered to each group of respondents to gather key information concerning cereal growers' endogenous knowledge of *Striga hermonthica*. This information covered morphological diversity, the times and periods of its appearance in the fields, the factors responsible for its appearance in the fields, the cultivated plant species it attacks, the damage it causes to the latter, the uses made of *Striga hermonthica* and the local control methods practised. A formal survey using semi-structured questionnaires involved individual interviews with the millet growers in each group. This made it possible to gather information on their cropping practices (percentage of people growing millet, types of varieties grown, seed acquisition method, sowing method, type of crop and field, fertilization, animal roaming in the fields and crop rotation).

Table 1 : Identification of producers and survey locations

Regions	Departements	Sub-Prefectures	Localities	Number of respondent groups	Number of people
Tchologo	Ferkessédougou	Koumbala	Sambakaha	1	5
	Ouangolodougou	Kaouara	Manbiadougou	2	5
					5
		Diawala	Diawala	2	5
					5
			Tiaplé	1	5
			Tiewolovogo	1	5
		Toumoukro	Koronani	1	30
		Ouangolodougou	Nambingué	5	3
					5
					3
					5
					5
Poro	Korhogo	Karakoro	Norgortanakaha	1	2
		Napié	Kouolo	1	3
			Kolekaha	1	35
			Guéfiankaha	1	5
Bagoué	Tengréla	Tengréla	Dougba	1	2
			Debeté	2	3
					3
			Zelesso	1	3
			Bolona	1	2
TOTAL	4	8	15	22	144

3.3 Data processing and statistical analysis: Survey data were entered into an Excel spreadsheet and analyzed using XLSTAT 2016 software.

4 RESULTS

4.1 Growers' endogenous knowledge of *Striga hermonthica*

4.1.1 Morphological diversity of *Striga hermonthica:* A morphological difference between *Striga hermonthica* plants was indicated by some of the growers surveyed. The differences they noted in *Striga hermonthica* plants concerned flower color, stem color and capsule size (Figures 2 and 3). Three flower colors were cited by growers : white (18.18%), light-pink (13.64%) and violet-pink (90.91%). Two stem colors were indicated by growers. Green stems were cited by 77.27% of respondents, while purple stems were cited by 59.09% of growers. Regarding capsules, only 4.55% of respondents explained that there was a difference in the size of capsules produced by *Striga hermonthica*. The remaining 95.45% of growers stated that there was no difference between the capsules containing *Striga hermonthica* seeds.

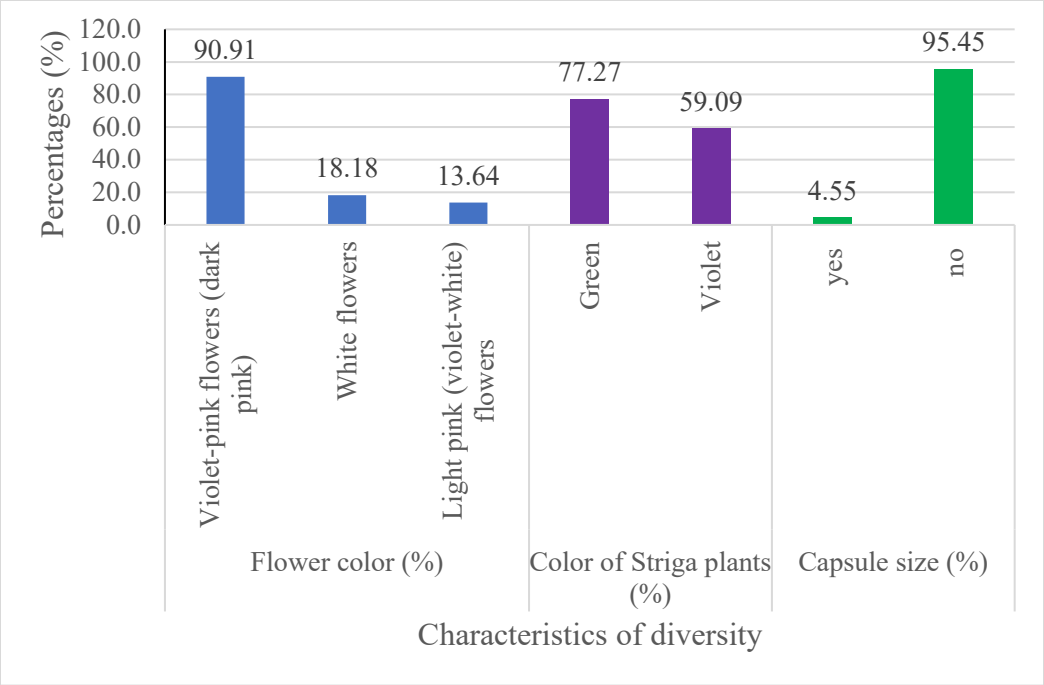

Figure 2: Frequency of diversity between *Striga hermonthica* plants

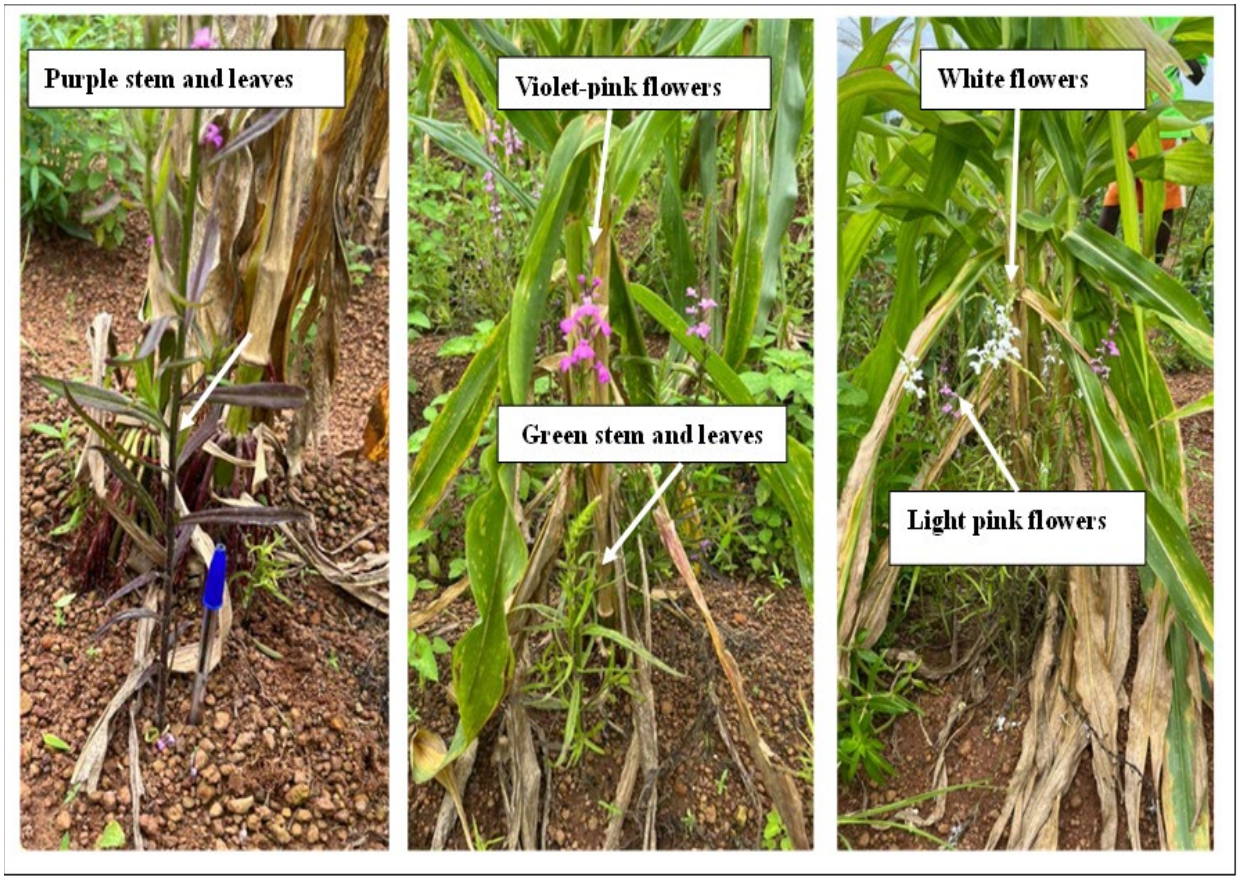

Figure 3: Stem and flower colors of *Striga hermonthica*

4.1.2 Timing and periods of appearance of *Striga hermonthica* in the fields: The vast majority of growers surveyed (69%) said that *Striga hermonthica* appeared in their fields around two months after sowing, and 19% said it appeared in their fields one month after sowing. Only 3% of growers said that it appeared in their plots three months after sowing. Those with no knowledge of the time of appearance of *Striga hermonthica* were 9%. Information on *Striga hermonthica* appearance periods was also noted. Most growers (71%) stated that *Striga hermonthica* plants could be seen in the plots in September. Among the growers surveyed, 19% mentioned the presence of *Striga hermonthica* in the fields during August. A minority of respondents (5%) indicated that *Striga hermonthica* plants were observed in the plots depending on the sowing date or after crop emergence (figure 4).

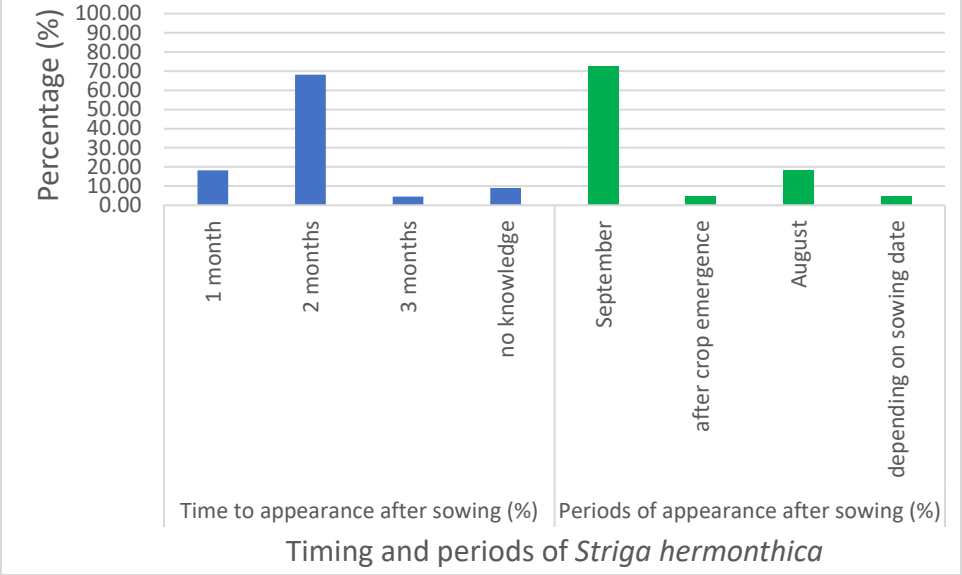

Figure 4 : Times and periods of appearance of *Striga hermonthica* in fields

4.1.3 Factors responsible for the appearance of *Striga hermonthica* in fields: Several factors were cited by growers as responsible for the appearance of *Striga hermonthica* in the fields (Figure 5). These factors were, in order of importance, soil poverty cited by 64% of growers surveyed, lack of fallow (23%), reduced rainfall (9%) and soil type (4%).

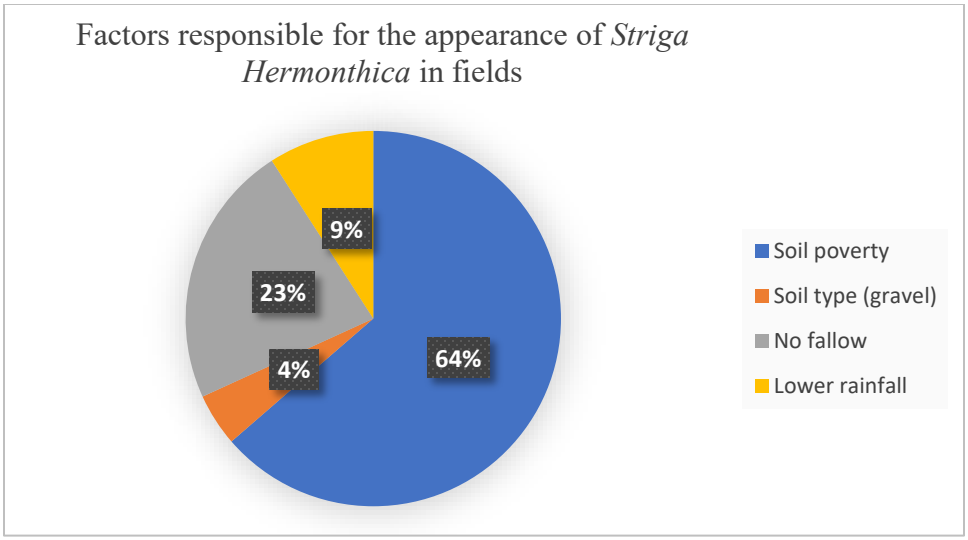

Figure 5 : Factors responsible for the appearance of *Striga hermonthica* in fields

4.1.4 Plant species infested by *Striga hermonthica:* Figure 6 shows all the plant species infested by *Striga hermonthica* cited by the growers surveyed. The species cited by growers as most infested by *Striga hermonthica* were corn (95%), followed by millet (81%) and rice (79%). In addition to these species, other species such as sorghum, fonio, groundnuts and beans (Niebe) were also cited by 34%, 28% and 30% of growers surveyed respectively.

4.1.5 Damage caused by *Striga hermonthica* : According to 95% of growers, *Striga hermonthica* parasitism on cereals causes stunted plants. Yield losses caused by *Striga hermonthica* on these host cereals were mentioned by 81% of growers. Leaf desiccation was cited by 79% of growers surveyed, and 35% described leaf yellowing. Plant death before the end of the crop cycle was mentioned by 29% of respondents (figure 7).

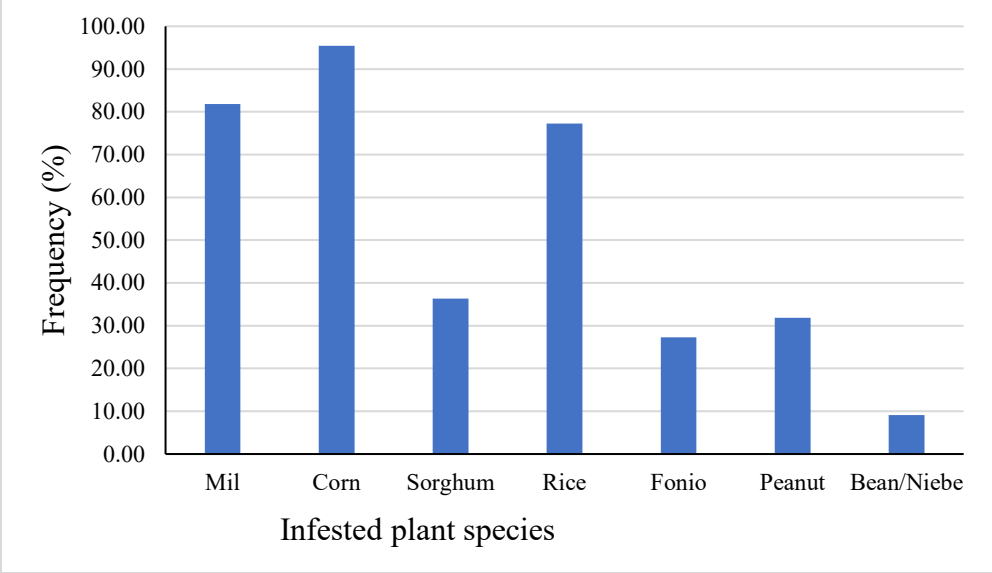

Figure 6 : Frequency of plant species infested by *Striga hermonthica*

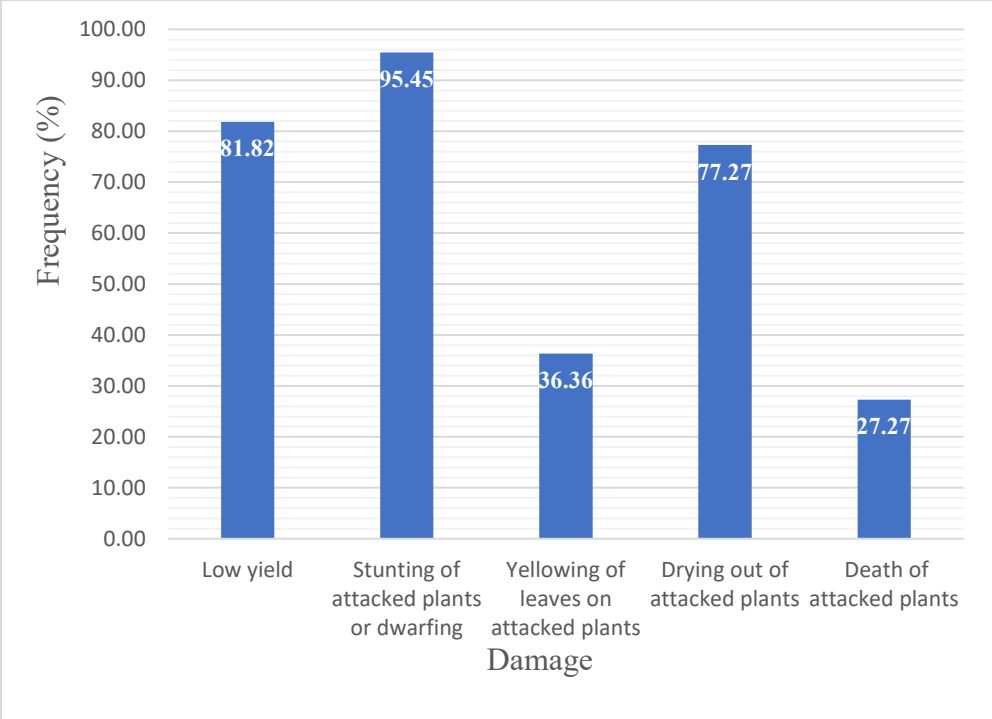

Figure 7 : Frequency of damage caused by *Striga hermonthica* on cereals

4.1.6 Different types of use of *Striga hermonthica* by growers: Two types of *Striga hermonthica* use were cited by growers: therapeutic or medicinal use, and dyeing systems. Indeed, growers reported that *Striga hermonthica* was used to treat women's stomach aches and blood pressure. They also claimed that it was used to treat unknown ailments. According to the growers, *Striga hermonthica* plants are used to make ink for writing Koranic charts, and also to dye young girls' feet (figure 8).

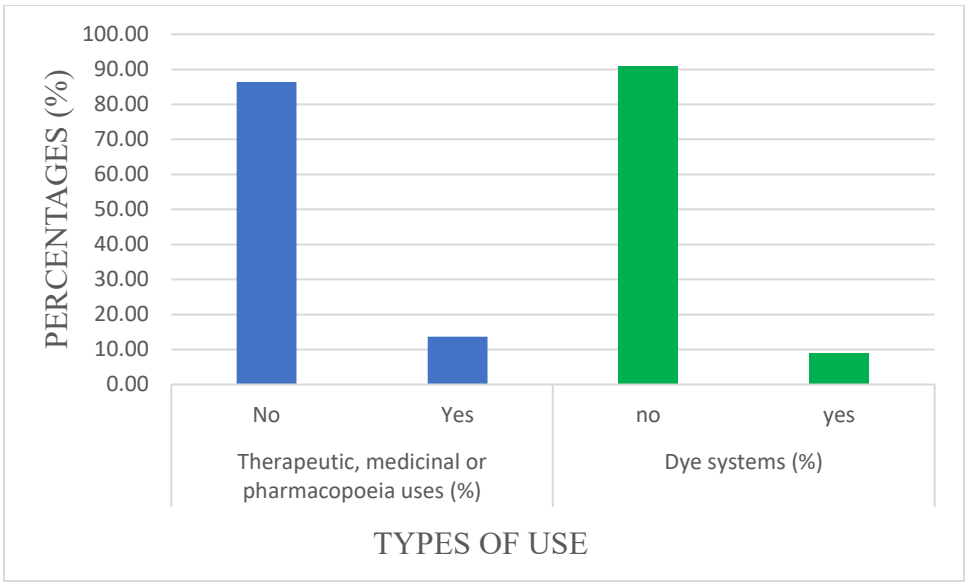

Figure 8 : Types of use of *Striga hermonthica* by growers

4.1.7 Traditional methods used by growers to control *Striga hermonthica*: Table 2 presents some of the local control methods used by growers against *Striga hermonthica*. These different methods are classified into two types: preventive and curative. Preventive methods are those most commonly used by growers: early sowing (13.6%), fertilization (13.6%) and crop rotation (13.6%). Fallowing (9.1%) is also a preventive method, but is less widely used. The curative methods cited by growers are the least used by them, and are the manual uprooting of a few millet plants to allow good growth of the remaining plants (4.5%), manual uprooting of *Striga hermonthica* plants (4.5%), crop association with false hosts (cotton or groundnuts) (4, 5%), spreading wet ash in holes next to *Striga hermonthica* plants (4.5%), spreading nere powder when *Striga hermonthica* first appears (4.5%), spreading tchapalo residues on ridges and using potassium sulphate and manure during ploughing (4.5%).

Table 2 : Traditional methods used by growers to control *Striga hermonthica*

Control Methods or strategies	Type of control method (curative/preventive)	Frequency (%)
Pulling up a few millet plants	Curative	4,5 %
Pulling out Striga plants	Curative	4,5 %
Crop association with false hosts (cotton or peanuts)	Curative	4,5 %
Spreaning wet ash in holes next to Striga plants	Curative	4,5 %
Spreaning nere powder when Striga first appears	Curative	4,5 %
Spreaning tchapalo residues on ridges	Curative	4,5 %
Fertilisation	**Preventive**	**13, 6 %**
Fallowing	Preventive	9,1 %
Crop rotation	**Preventive**	**13,6 %**
Early sowing	**Preventive**	**13,6 %**
Use of potassium sulphate and manure during ploughing	Curative	4,5 %

4.2 Characterization of cropping practices in millet-based cropping systems

4.2.1 Millet cultivation and type of variety grown: Surveys carried out among farmers in the study area revealed that 67% of farmers surveyed grow millet, compared with 33% who do not (Figure 9 A). Among those who grow millet, 64% use late millet varieties and 36% use early millet varieties (Figure 9 B).

4.2.2 Type of crop, fertilization and fallow practice: The information gathered during the surveys showed that monoculture is practised by 85.71% of respondents, compared with 14.26% who practise intercropping. 53.85% of respondents reported using mineral or organic fertilizers, compared with 46.15% who did not. The absence of fallow in farmers' plots was reported by 92.86% (table 3).

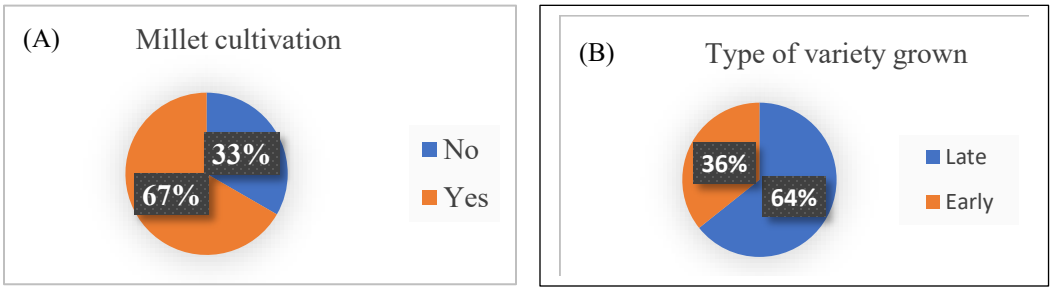

Figure 9: Number of farmers growing millet and types of varieties grown

Table 3 : Sowing methods, crop type and fallowing

Type of crop		Fertilization		Fallow land	
Association (%)	Monoculture (%)	Yes (%)	No (%)	Yes (%)	No (%)
14.26	85.71	53.85 %	46.15	92.6	7.14

4.2.3 Animals roaming the fields : Most of the producers (76.92%) surveyed own grazing animals (oxen 70% and sheep 30%), which they allow to roam the fields at certain times of the day and night after the cropping season, compared with 23.08% of the producers surveyed who do not own grazing animals (table 4).

4.2.4 Crop rotation practised by growers: In the localities surveyed, the most common type of rotation is millet-arachid (38%). In addition, corn-millet (13%), cotton-millet (13%) and cotton-corn-millet (12%) rotations are practiced. However, 25% of growers surveyed do not practice crop rotations (figure 10).

Table 4 : Animals roaming in the fields

Animals running at large		Type of animal	
No (%)	Yes (%)	Beef (%)	Sheep (%)
23.08	76.92	70	30

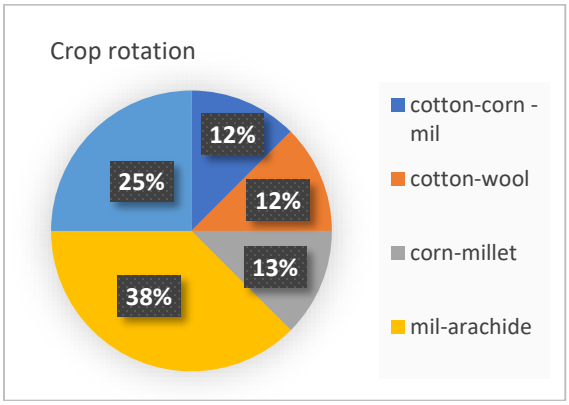

Figure 10 : Crop rotations used by growers

5 DISCUSSION

The survey of cereal growers in the north of the country, the main cereal-growing area with a high infestation of *Striga hermonthica*, showed that there is morphological diversity in the color of flowers and stems, as highlighted by growers. The colors of *Striga hermonthica* flowers cited were violet-pink, white and light-pink. In addition, two colors were indicated by the latter for the stems, namely green and violet. According to Anonymous (2007), in *Striga hermonthica*, a wide variation in plant type, corolla shape, size and color is observed. However, light pink is the usual color, although plants with white flowers have occasionally been found. In Côte d'Ivoire, white-flowered types of *Striga hermonthica* and Striga aspera have been recorded by Kouakou *et al.* (2015). Concerning the timing of the appearance of *Striga hermonthica* in the fields, most growers said that it appeared in the fields two months after the crop was planted, in September. These results confirm the findings of Dembélé *et al.* (1994), who showed that a strong emergence of the parasite occurs in September. Several factors were cited by growers as being responsible for the appearance of this species in the fields. These include gravelly soil type, reduced rainfall, lack of fallow and soil poverty. The increased intensity of the Striga problem in

Africa is associated with both environmental and anthropogenic factors (Kroschel, 1999). Striga grows preferentially in poor, structurally degraded soils with a sandy surface horizon, high clay content (2-5%) and very low organic matter (less than 0.7%), such as degraded ferruginous soils (Usaid, 2009). Observations by Traore and Yonli (2001) in eastern Burkina Faso revealed that sandy and gravelly soils at the top of slopes, and light soils poor in clay and nutrients, are the most infested by *Striga hermonthica*. Akanvou *et al.* (2006) and Béninga (2014) have also shown that reduced fallow and pressure on agricultural land favor the spread of this species. In addition, low rainfall (between 500 and 1000 mm), the use of farmland for many years and the frequent use of susceptible crops (millet, sorghum, corn) in rotations also favor infestation (Usaid, 2009). Indeed, it was shown in this study that growers were not following good cropping practices. The types of crop rotation used by growers are not in line with those recommended for the control of *Striga hermonthica*. Indeed, research recommends the rotation of cereal crops (sorghum, corn and millet) with false host crops (Dembélé *et al.*, 1994). What's more, almost a quarter of the farmers surveyed did not practise crop rotation. This result corroborates that of Siené *et al.* (2024), who showed that 64.20% of millet farmers surveyed did not practice crop rotation. Monoculture, which is responsible for soil impoverishment, is more widely practised than intercropping in farmers' fields. What's more, the majority of farmers interviewed do not leave their plots fallow. As for fertilization, it is only practiced by 53.85% of growers. And when it is carried out, the doses used remain insufficient (Siené *et al.*, 2024). A significant number of the farmers surveyed own grazing animals (oxen and sheep), which they allow to roam the plots at certain times of the day and night after the cropping season. The work of Emechebe *et al.* (2004) has shown that the spread of Striga seeds on the hooves and droppings of migrating cattle are major factors in the increase of the Striga problem. Add to this the fact that most of the growers surveyed (64%) cultivate late varieties. Indeed, the earlier a variety is, the less susceptible it is to *Striga hermonthica* (Naitormbaide *et al.*, 2015). This characteristic of earliness guarantees cereals a head start on weeds (Marceau *et al.*, 2012). Non-compliance with good cultivation practices could be explained by the low literacy rate among growers. Indeed, education is a determining factor in agricultural productivity, as it enables farmers to easily decode information on agricultural technologies and apply them (Toessi, 2024). The species cited by growers as most infested by *Striga hermonthica* were corn, millet and rice. In addition to these species, sorghum, fonio, groundnuts and beans (cowpea) were also cited. The results of our work are like those carried out by Boussim *et al.* (2011), who revealed that *Striga hermonthica* was the weed most feared by Burkinabe farmers, as it constitutes an unprecedented scourge for sorghum, millet and corn crops, the main food cereals. They have also shown that it sporadically parasitizes rice, fonio (*Digitaria exilis* (Kippist) Stapf) and attacks leguminous crops (sesame, groundnuts) in other parts of West Africa (Parker and Riches, 1993). Similarly, Amadou *et al.* (2021) have shown that, in addition to millet, *Striga hermonthica* also parasitizes sorghum, rice, corn and sugarcane in sub-Saharan Africa. In the Sudanian agricultural zone of Chad, sorghum, corn and millet are cited by most farmers as the species most vulnerable to Striga spp. Rice and groundnuts have also been cited as species infested by Striga spp. (Nouara *et al.*, 2021). The metabolic disorders caused by *Striga hermonthica* are numerous and damaging, resulting in visible symptoms on cereal crops and often very high yield losses. Plant stunting (95%) was the most cited symptom, followed by plant desiccation (79%), leaf yellowing (35%) and mortality of infested plants (29%). Similar results were noted in the work of Amadou *et al.* (2021), who demonstrated that the most severe symptoms responsible for reduced millet yields were yellowing and stunting of plants, leading to poor ear development. Faced with the increasing invasiveness of these parasitic plants in farmers' plots, growers use a variety of traditional control methods. These different methods are classified into two types:

preventive and curative. Preventive methods are those most commonly used by growers. These include early sowing, organic and mineral fertilization and crop rotation. Similar work in eastern Burkina Faso has also identified a number of local recipes for controlling Striga, including early sowing, ridging, the use of Striga ash, *Acacia gourmaensis* Bark powder and black goat fat (Traore and Yonli, 2001). The work of Boussim *et al.* (2011) identified seven curative control methods: manual weeding and uprooting, application of organic fertilizer to fields, use of cowpea pods, spreading of shea kernel residues, crop rotation and fallowing. Emechebe *et al.* (2004) identified 15 local Striga control strategies in Nigeria, the most common of which were grubbing, manual weeding and fertilizing fields with organic manure. Although *Striga hermonthica* is a noxious parasitic plant, its systematic eradication appears to be difficult, since despite its harmful effects, it is sought after by people in the study area for a variety of uses. *Striga hermonthica* plays an important role in traditional medicine, treating a variety of ailments such as women's stomach aches and high blood pressure. It is also used as a tincture. *Striga hermonthica* plants are used to make ink for writing Koranic tablets, and also to dye young girls' feet. In Niger, *Striga hermonthica* plays an important socio-economic and cultural role, and is used for fodder, dyeing, human consumption, insecticides, erosion control, fuel, mystical practices and medicinal preparations to treat various pathologies such as hypertension, measles, epilepsy, chronic wounds and diabetes (Saidou *et al.,* 2024). Of all the Striga species recorded in Burkina Faso, only *Striga hermonthica* is used in dyeing and therapeutic treatments. Indeed, the *Striga hermonthica* plant is an important component in the traditional treatment of malaria, cholera, whooping cough, diabetes, smoking, alcoholism and gout. In Senegal, the beautiful violet-pink flowers of the parasitic plant are exploited by florists, who sell them packaged in transparent plastic bags in the same way as roses (Boussim *et al.*, 2011).

6 CONCLUSION

The populations northern of Côte d'Ivoire possess endogenous knowledge of *Striga hermonthica.* Indeed, morphological diversity among *Striga hermonthica* plants has been reported by farmers. The parasitic weed has different stem colors (green and violet) and flowers (light pink, white and violet-pink). *Striga hermonthica* plants can be seen in fields two months after the cereal crop has been planted, generally in September. Several factors are responsible for this appearance in farmers' plots. Among them, the most cited are the type of gravelly soil, rainfall variations, the absence of fallow land and declining soil fertility. The failure of growers to follow good cultural practices, leading to the spread of the parasite, was also noted. This parasitic plant causes extensive damage to cereal crops, up to and including complete crop failure in the event of severe infestation. The species most affected are millet, maize and rice in heavily infested areas. Faced with this situation, growers use several local methods to control *Striga hermonthica.* Among these, the most commonly used are early sowing, organic and mineral fertilization and crop rotation. Although *Striga hermonthica* is a noxious plant, it is used by some people to treat women's stomach aches and blood pressure. It is also used to make ink for Koranic paintings and to dye the feet of young girls. The results of this study could enable the development of control strategies using existing crop management practices in the farming environment, in order to reduce *Striga hermonthica* parasitism on cereals to a no-harmful level.

7 ACKNOWLEDGEMENTS

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