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Research Article

Assessment of Traditional Methods of Controlling *Striga* on Cultivated Crops in Sudanian Agricultural Zone of Chad

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Abstract

The phytoparasite, *Striga spp*., is a major biotic constraint to cereals production in sub-Saharan Africa. This study was carried out at station of Bébédjia of Chadian Institute of Agronomic Research for the Development in Sudanian agricultural zone of Chad, on traditional methods of controlling *Striga spp*. This study helped to find out several methods of controlling *Striga* among which the most important is the agronomic method including organic and or mineral fertilization, associated crops, crop rotation and the use of false hosts and trap crops. Some farmers cultivated resistant varieties and early maturing varieties to control pest attack and some others used shea flour and herbicide treatment to reduce the effect of *Striga* on the farm. Most of these methods were applied by farmers from generation to generation, without a thorough study to understand their mechanism. Thus, the listed methods will be analysed by research in station to find out scientific explanations for each applied method. Then experiments will be carried out to evaluate the effectiveness of some methods previously identified by extension rural services in farmers' area after improvement.

Keywords: Striga Spp.; traditional methods controlling pest; phytoparasite; Chad

Introduction

The phytoparasite *Striga spp*. has become a real scourge in several regions of the African continent (Olivier, 1995). Of the 35 species recorded in Africa, three are found everywhere and are the most important; these are *Striga asiatica*, *Striga gesnerioides* and *Striga hermontica*.

Striga hermonthica is undoubtedly the one that causes the most damage to its guests (cereals essentially). It mainly attacks sorghum (*Sorghum bicolor* (L.) Moench) and millet (*Pennisetum typhoides* Burm), but also parasitizes maize (*Zea mays* L.), fonio (*Digitaria exilis* Stapf), sugar cane (*Saccharum officinarum* L.) and rained rice (*Oryza sativa* L) (Raynal-Roques, 1991). However, study in Sudan showed that, some species of *Striga* can also parasitize species of the Fabaceae family such as groundnuts, cowpea and soybeans, causing significant loss of yield.

De Groote *et al.* (2008) reported that more than six million hectares of agricultural area in West, East and Southern Africa are severely affected by *Striga*. According to Abusin *et al.* (2017), *Striga hermonthica*, infests millions of hectares of cultivated fields of cereal crops in sub-Saharan

Africa. In sorghum, losses can reach up to 70% (Doggett, 1988). Gressel *et al.* (2004) and Rodenburg *et al*. (2005) described that the parasite causes huge losses ranging of 40-90%, depending on crop variety, climatic conditions and seed infestation level of the soil and up to 75% of its overall damage to the hosts occurred during its subterranean stage of development. This parasitic plant can cause very significant yield losses, up to 30% on the cowpea (Aggarwal and Ouedraogo 1989). In the case of a severe infestation, a total loss of the crop can even be observed (Singh and Emechebe 1990). Such a situation can lead to the abandonment of severely infested fields (Lane and Bailey, 1992). Farms heavily infested by *Striga* are abandoned causing temporary migrations of farming communities (Obilana *et al*., 1992).

Striga preferentially grows in poor soils with a degraded structure with a sandy surface horizon, a clay rate (2 to 5%) and a very low organic matter rate (less than 0.7%), such as degraded ferruginous soils (USAID, 2009). Several factors favor the infestation including low rainfall (between 500 and 1000 mm), field exploited many years and sensitive crops (millet, sorghum, maize) using very frequently in the rotation. This parasite prefers high sunstroke and is more abundant in low-density sown plots (USAID, 2009).

Improving soil fertility helps improve the management of Striga. Soil fertilization using inorganic fertilizers as sources of soil nitrogen inputs has also been demonstrated to alleviate the impact of *Striga* on cereal hosts by reducing the amount of *Striga* germination stimulant secreted by the host (Mandumbu *et al*., 2018). Soil fertility plays an important role in the growing cycle of *Striga*. Three components, organic fertilizers, in situ production of organic fertilizer and the contribution of false hosts of this parasite play a decisive role in soil fertility for the control of *Striga*.

Biological control of parasitic plants is used in an integrated pest management context that includes physical and chemical methods (Ouedraogo *et al.,* 2018). According to Hamissou *et al.* (2020), farmers in Niger have endogenous knowledge in the fight against this formidable parasitic plant, among which the use of sesame (*Sesamum undicum* L.) as a trap plant is common in rural areas.

Otherwise, the technique of combining a cereal and a legume in the same field that will cover the line spacing makes it possible to greatly reduce the pressure of the parasite on the cereal. The legume varieties to be used must be resistant to parasitic plants of this crop such as *Striga* (USAID, 2009). Breeding for Striga resistance in cereals could provide a long term solution to the Striga problem especially to the resource-poor farmers (Mrema *et al.*, 2017).

Other methods include crop rotation and the use of false hosts and trap crops existed. Soil moisture greatly influences the development of the parasite. For this reason, sorghum or rained rice crops grown in the low-seas are less attacked, as are plots under continuous irrigation such as sugar cane (USAID, 2009). Tillage can have different effects depending on its nature and depth. Deep ploughing or breaking allows the seeds of Striga to be buried in such a way that they can no longer germinate. This technique is not recommended in the Sahel because it significantly increases the risk of soil degradation by erosion.

In Chad, the damage caused by *Striga* spp., is frequently revealed by producers. This parasite causes a lot of damage but very little study has been done to know the farmer's knowledge in fighting against it. Therefore, the principal objective of this current study was to make directory of traditional knowledge of methods of control against *Striga* spp.

It is with the aim of making a directory of traditional knowledge of methods of control against *Striga* that this study was initiated. It could make possible to know the species that are susceptible to the attack of the *Striga*, to make an inventory of the techniques and processes used by the producers to overcome this parasitic species and to identify the best ones for a possible application after evaluation by research.

Materials and Methods

Description of the Study Sites

The study was conducted in seven departments in southern Chad including Gueni in Logone Oriental Region; Nya and Pendé in Logone Oriental Region; Mandoul Oriental in Mandoul Region; Mayo Boneye in Mayo Kebbi Est Region; Barh-kho in Moyen Chari Region and Tandjilé Ouest in Tandjilé region (Table 1).

Table 1: Identified locations of the study

Regions	Departments	Total Number
Logone Occidental	Gueni	1
Logone Oriental	La Nya	2
	Pendé	
Mandoul	Mandoul Oriental	1
Mayo Kebbi Est	Mayo Boneye	1
Moyen Chari	Barh-Kho	1
Tandjilé	Tandjilé Ouest	1

Survey Methodology

Three to ten villages were selected randomly due to the support of advisors of the National Agency for Rural Development (Agence National de Développement Agricole: ANADER). The villages were previously identified as areas where the Striga was widely spread. Two to five farmers were identified by the agricultural advisor who accompanied the mission in the field and each of the farmers was interviewed individually by unrolling the survey sheet. Their answers were recorded by following the chronology of the questions on the card. Discussions were conducted in the producer's language to allow him to better understand the questionnaires in order to obtain important information from him.

Data Collection and Analysis

The related data to the surveyed sites and the identities of surveyed persons were collected in a survey sheet. Information on the general knowledge of the respondents on Striga and traditional methods of control was recorded on the Excel table. The mean values, the central values and graphs were performed by using Excel.

Results and Discussions

Overview and Identification of The Survey

Villages and Respondents Samples

The study was carried out in 38 villages in the project intervention area (Table 2). It was in the department of Tandjilé that a huge number of villages (11 villages) was involved in the study. On the other hand, in Khou-Est and Barh-Kho, only three villages were surveyed. The investigation involved 88 farmers, including 14 farmers in the departments of Tandjilé Ouest and Mayo Boneye and only 10 farmers in Barh-Kho. Of all those surveyed, only 6 farmers were female and the largest proportion were male (72).

Personal Information of Respondents Sample

The age of the surveyed farmers varied between 25 and 78 years with an average of 47.7 years which corresponded to 47 years and 8 months (Table 3). The oldest farmers (78 years old) were in the department of Mandoul Oriental and the youngest (25 years old) was in the department of Khou Est. The average age was highest in the department of Barh-Koh with 52.2 years followed by the Mandoul Oriental with 51.54 years. The population surveyed in the Nya was the youngest with an average age of 41.54 years and a gap between 33 and 57 years.

Table 1: villages and respondents' samples by department

Region	Departments	Villages	Farmers		
			Male	Female	Total
Moyen Chari	Barh-Koh	3	10	0	10
Mandoul	Mandoul Oriental	7	13	0	13
Logone Oriental	Khou Est	3	10	1	11
	La Nya	6	12	1	13
Logone Occidental	Gueni	4	10	3	13
Tandjilé	Tandjilé Ouest	11	14	0	14
Mayo Kebbi Est	Mayo Boneye	4	13	1	14
Total		38	72	6	88

Table 3: minimum, maximum and average age of farmers surveyed

Region	Departments	Age (years)		
		Average	Minimum	Maximum
Moyen Chari	Barh-Koh	52.2	40	65
Mandoul	Mandoul Oriental	51.54	33	78
Logone Oriental	Khou Est	42.82	25	70
	La Nya	41.54	33	57
Logone Occidental	Gueni	50.75	28	65
Tandjilé	Tandjilé Ouest	50.36	38	61
Mayo Kebbi Est	Mayo Boneye	45	30	61
Total		47.7	25	78

The surveyed farmers belonged to ethnic groups that varied according to the departments (Table 4). In the Barh-kho and Mandoul Oriental departments, the *Sara* dialects were the most spoken languages and represent respectively 70 and 54% of the surveyed farmers. In the Nya and Gueni departments 100% of the surveyed people belonged to the *Ngambaye* ethnic group. In the Tandjilé Ouest and Mayo Boneye departments, the surveyed farmer belonged to five different ethnic groups.

The survey showed that 11.5% of farmers was not literate compared to 83.8% which provided with formal education in school and only 4.6% literate, which means that these farmers were not in school but who can read and write in both French and the local language (Table 5). Of the 83.8% of people which provided with formal education in school, 44.8% studied up to secondary school and 33.3% studied up to primary school. In Barh-kho department, the number of non-literate farmer was highest (30%t), followed by Mandoul Oriental (23.1%t), Mayo Boneye (21.4%). In the Nya, Gueni and Tandjilé Ouest departments there were no non-literate among the farmers surveyed and only 0%, 16.7% and 7.1% of literate farmers respectively for the departments of La Nya, Gueni and Tandjilé Ouest. It was only in the department of Nya that all the farmers surveyed are enrolled in school with 53.8% at the primary school and 46.1% at the secondary school.

Farmers' knowledge of Striga

General Information on Striga and the Species Under Attack

Species attacked by the Striga

Table 6 listed the species attacked by Striga spp., in the departments touched by this current study. Sorghum, maize and pearl millet are cited by most surveyed farmers as the most vulnerable species to Striga spp. In all departments peanuts appeared as a species attacked by the Striga. On the other hand, for rice alone in Mandoul Oriental that it has not been mentioned as a species sensitive to Striga.

The voandzou appeared to be sensitive to Striga in Barh-Kho, Mandoul Oriental and Khou Est. According to Ramaiah (1983), the pea is used as a "false host" of Striga, which means that it stimulates the germination of Striga but does not allow its development. This is at odds with farmers in Barh-kho, Mandoul and Khou Est, who have cited this species as susceptible to Striga. During this survey, producers tended to assign soil poverty to the presence of Striga in this soil.

Table 4: ethnic group of surveyed farmers regarding department

Department	Ethnic group
Barh-Koh	*70% Sara; 20% Saramadjingaye ; 10% Goulaye*
Mandoul Oriental	*54% Sara, 46% Saramadjigaye*
Khou Est	*54% Mongoh; 27% Mbaï; 18% Beti*
LA Nya	*100% Ngambaye*
Gueni	*100% Ngambaye*
Tandjilé Ouest	*57% Lélé ; 21% Zimé ; 7% Marba ; 7% Klang ; 7% Nantcheré*
Mayo Boneye	*36% Massa ; 29% Mouroum ; 21% Foulbé ; 7% Toupouri ; 7% Day*

Table 5: percentage of farmers provided with formal education in school

Department	No literate	Primary school	Secondary school	University	literate
Barh-Koh	30	30	40	0	0
Mandoul Oriental	23.1	38.5	23.1	15.4	0
Khou Est	9.1	54.5	27.3	9.1	0
La Nya	0	53.8	46.1	0	0
Gueni	0	16.7	66.7	0	16.7
Tandjilé Ouest	0	42.9	50	0	7.1
Mayo Boneye	21.4	0	57.1	14.3	7.1
Total	11.5	33.3	44.8	5.7	4.6

Table 2: Species attacked by Striga in study sites

Department	Species sensitive to Striga (%)						
	Maize	Sorghum	Pearl millet	Rice	Peanut	Ground pea	Cowpea
Barh-Koh	100	90	60	10	40	10	0
Mandoul Oriental	77	100	92	0	46	8	8
Khou Est	82	100	82	18	64	18	0
La Nya	92	100	92	46	23	0	0
Gueni	100	100	84	8	69	0	0
Tandjilé Ouest	71	86	100	21	7	0	8
Mayo Boneye	93	100	100	7	57	0	21

For all the surveyed farmers, sorghum was known as the species susceptible to the attack of Striga with a proportion of 85 out of 88 surveyed farmers (Fig. 1). Pearl millet and maize were also reported by the surveyed farmers as species attacked by Striga with a proportion of 78 farmers out of 88 surveyed. Groundnuts were recognized by 38 of the 88 surveyed farmers as sensitive to Striga and rice is also recognized as a species sensitive to Striga with a proportion of 14 farmers out of 88 surveyed.

During the survey, some farmers cited species such as cotton (*Gossypium hirsutum*), sesame (*Sesamum indicum*) and cowpea (*Vigna ingiculata*) as susceptible to Striga attack. After several discussions with the farmers, they have acknowledged that they had rarely seen Striga grow under these species, but linked the poverty of the soil with the presence of the Striga.

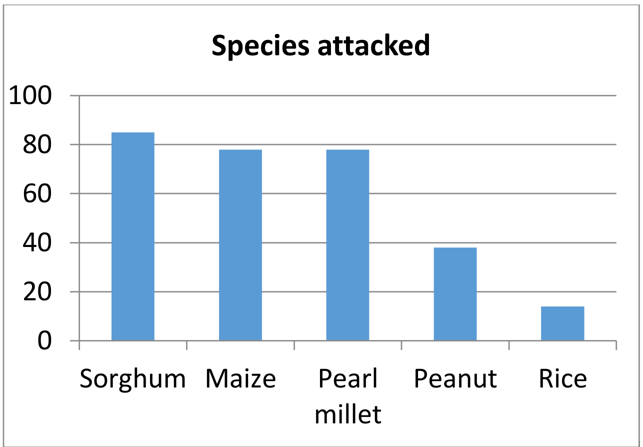

Fig. 1: species attacked by Striga in study sites

The most attacked species by the Striga

On the list of most attacked species by *Striga* were found sorghum, maize and pearl millet with varying proportions depending on the department (Table 7). For the department of Barh-Kho, maize was the most attacked species (80%), followed by sorghum (20%). In Mandoul Oriental department, sorghum is the most attacked species (62%) followed by pearl millet (23%) and maize (15%). In Khou Est department sorghum was the most attacked species (64%) followed by millet (36%). In the Nya Department, pearl millet is the most attacked species (46%), followed by sorghum (38%) and maize (15%). In the department of Gueni, maize is the most attacked species (62%) followed by sorghum (38%). In Tandjilé Ouest department, sorghum and pearl millet were the most attacked species with a proportion of 50% each. Finally, in Mayo Boneye department, sorghum is the most attacked species (86%), followed by millet (14%).

Table 3: Species most attacked by Striga in study sites

Department studied	First species most attacked by Striga (%)		
	Maize	Sorghum	Pearl millet
Barh-Koh	80	20	0
Mandoul Oriental	15	62	23
Khou Est	0	64	36
La Nya	15	38	46
Gueni	62	38	0
Tandjilé Ouest	0	50	50
Mayo Boneye	0	86	14

The result of the survey on the most attacked species shows that sorghum is the most sensitive crop to Striga with a proportion of 46%. It was followed by pearl millet and corn with a proportion of 21 and 20% respectively. Several studies in Africa revealed a significant impact of *Striga hermonthica* on cereal production (Ouedraogo *et al.*, 2018; USAID, 2009).

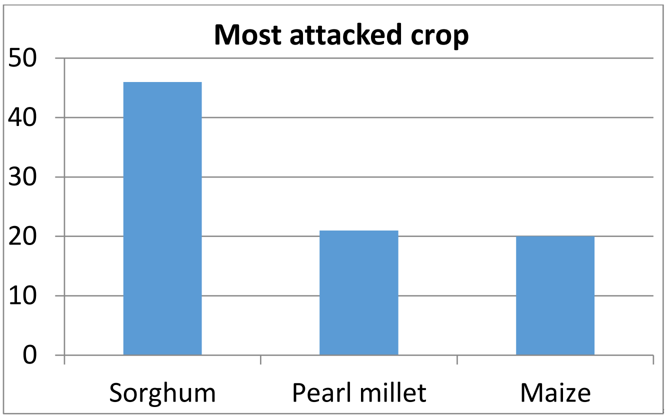

Fig. 2: the most attacked crops by Striga in the study sites

Traditional methods of Striga control

The most commonly used Striga control methods by farmers in the study area are listed in Table 8. The most used are the use of organic and mineral fertilizer to amend soils. Striga preferentially develops in poor soils with a degraded structure with a sandy surface horizon, a clay rate (2 to 5%) and a very low organic matter rate (less than 0.7%), such as degraded ferruginous soils (USAID, 2009). Among the soil improvement techniques in terms of organic fertilizer input identified by producers are the parking of animals and the burial of crop residual.

Fallow land and crop associations are the methods widely used by the surveyed farmers. According to Hamissou *et al*., (2020) the cultivation of sesame varieties (HC110 and ICN130) in combination with millet, significantly decrease the number of *Striga hermonthica* plants emerged.

Crop rotation is placed among the most widely used techniques, including the use of sesame, cotton and okra. These species are used to reduce the germination of Striga in a field. According to Andrews (1947) are called "false hosts", all plants that cause germination without allowing the development of the parasite. The most commonly used fake hosts of *Striga hermonthica* in West Africa are: soybeans, groundnuts, cotton, ground peas and cowpeas (Ramaiah, 1983). In the United States, there is an alternative to germinate Striga seeds in the absence of the host using synthesized chemicals (USAID, 2009). As substances, there is ethylene gas, which injected into the soil at a dose of 16 kg ha^{-1} has been shown to be very effective on Striga seeds and ethephon which releases ethylene after hydrolysis.

The use of Striga-resistant varieties allows farmers in some study areas to reduce the effect of Striga in grain production. According to USAID (2009), varietal resistance has emerged as the main method of controlling Striga. The use of resistant varieties is a particularly attractive solution, inexpensive, labor-intensive and technically demanding. Some farmers recommended early sowing and good field maintenance by close weeding to control *Striga*.

The technique of uprooting young Striga plants at flowering to burn is quite mentioned by producers. According to them, that operation made it possible to reduce, on the one hand, the impact of Striga on current production and, on the other hand, to reduce the effect of Striga on cultivation in the following year.

Table 4: methods most used by farmers in all departments

Most used methods
Using manure or compost to amend soil
Contribution of mineral fertilizer
Uncultivated land for two or three years
Rotation of sorghum and maize with sesame or cotton or okra
Crops association
Early sowing
Early and close weeding
Uprooting of young Striga seedlings at flowering and burning
Use resistant sorghum varieties (village Maïmbororo ; Nelemta ; Neloumta ; Doumkiro…)
Put the crop residues in the ground
Placing animal in the field for an extended period of time

Among the rare methods used by producers is the spreading of kitchen ash; spreading of beverage residue in the fields; digging the termite mound and spreading in the field; mixing natron with NPK and spreading into the soil or mixing natron with seeds before sowing. All these techniques are interested in the improvement of the soil by a contribution of organic fertilizer.

There is the method of burning okra stem and mixing with seeds that allow some farmers to control Striga. However, the mechanism that explains the use of okra ash mixed with seeds was not elucidated.

The use of shea flour to combat Striga in the Gueni Department deserves attention to help understand the control mechanism. Indeed, according to the farmers surveyed, during the emergence of Striga, it is necessary to spread the shea flour on the ground which makes it possible to stop the growth and development of Striga on the ground.

According to some farmers from Nya Department the use of early maturing varieties made it possible to control the Striga. According to these farmers, although the early maturing varieties are not resistant to Striga, their use allowed to escape the effect of Striga which takes longer before manifesting. According to Olivier *et al.* (1992), all early and medium maturing lines were therefore found to be sensitive, both in pots and in the field.

The use of herbicide was further cited by Mayo Boneye and La Nya farmer. Indeed, according to the surveyed farmers, the total herbicide destroys all crops including Striga, which significantly reduces Striga populations to the next generation. According to USAID (2009), the use of pre-emergence herbicides on the soil would form a barrier delaying the emergence of Striga seeds. In general, chemical treatments carried out in post-emergence do not have an immediate effect on the yield of the crop in place because they only avoid the production of new seeds of the parasite and the increase in the stock of pest seed in the soil (USAID, 2009).

Table 5: Least methods used and encountered in some departments

Methods least used	Site of practice
Spreading kitchen ash	Gueni
Burn okra stems and mix with seeds	Barh-Koh
Dig the termite mound and spread over the entire field	La Nya
Spread the beverage residues in the field	Gueni
Spread shea flour at the emergence of Striga	Gueni
Drying Striga and mixing Striga powder with seeds before sowing	Gueni
Planting of forest species	Gueni
Mix the natron with NPK and spread in the ground	Gueni; La Nya
Mix natron with seeds before sowing	Mayo Boneye
Use of early maturity varieties	La Nya
Herbicide use	Mayo Boneye; La Nya

Conclusion

This study made it possible to realize multiple traditional techniques used by producers to control Striga that are doing enough havoc in farmer environments. Most of farmers use mineral and organic fertilizers to improve the soil to control Striga. Sorghum varieties resistant to Striga are sometimes used by farmers to control *Striga hermonthica* and some early maturing varieties are used to escape the parasite effect. In order to better explain scientifically the different techniques used by farmers, this current study suggest the assessment of these various traditional techniques of controlling Striga at the research station for further improvement for the dissemination of the ones that will reveal effective.

Authors' Contribution

All authors contributed equally in all stages of the present work.

Conflict of Interest

The authors declare that there is no conflict of interest with present publication

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