FARMER KNOWLEDGE AND PRACTICES FOR CONTROLING STRIGA HERMONTHICA (DEL.) BENTH IN CEREAL CROPPING AREAS IN NORTHEASTERN BENIN

NADEGE A. AKPO[1]*, LEONARD AFOUDA[1], CYRILLE KANLINDOGBE[1] AND VALERIEN A. ZINSOU[1]

[1]Laboratory of Phytotechny, Plants Breeding and Protection, Faculty of Agronomy, University of Parakou, BP:123 Benin, Republic of Bénin

*Corresponding Author : Tél : (+229) 66206032, e-mail: nadgeakpo@yahoo.com

ABSTRACT

Striga is a major parasite in cereal cropping in Africa notably in Benin. This study evaluated infestation of cereal crops (*maize, sorghum*) by *Striga hermonthica* and farming control practices used in northeastern Benin. Thus, 108 randomly selected farmers with their cereal fields and distributed in the municipalities of Malanville (12), Banikoara (40), Kandi (17), Bembereké (14) and N'dali (25) at the rate of one farmer/field/village, were surveyed during September-October 2018. Farmer perceptions, plant density and farmer practices for controlling Striga were collected and submitted to univariate and factor analyses. The respondent farmers are all aware of Striga and 100% of surveyed fields were infested by this parasitic plant. Purplish-pink-flowered variant of *Striga hermonthica* was more widespread and heavily infested cereal crops (sorghum and maize) in Bembèrèké (934,000 plants/ha), Kandi (815,625 plants/ha) and N'dali (706,000 plants/ha). Weeding practices (46.85%) and crop rotation (31.53%) were the predominant control methods used by farmers which unfortunately don't effectively control the parasite under damage threshold. The transition to an integrated pest management combining biological methods with other control practices, enabling from crop sowing to break holoparasite phase of Striga is necessary for its effective control for boosting cereal production.

Keywords: Farmer perception, cereal infestation, parasitic plant, integrated management, Benin.

RESUME

Striga est un parasite majeur dans la production céréalière en Afrique notamment au Bénin. Cette étude a évalué les niveaux d'infestation du Striga hermonthica *en culture céréalière et les pratiques paysannes de lutte utilisées dans le nord-Est du Bénin. Ainsi, 108 agriculteurs avec leurs champs céréaliers aléatoirement répartis dans les communes de Malanville (12), Banikoara (40), Kandi (17), Bembereké (14) et N'dali (25) à raison d'un agriculteur/champ/village ont été enquetés de septembre-octobre 2018. Les perceptions, la densité de plants et les pratiques paysannes de contrôle du Striga ont été collectées et soumises aux analyses univariées et factorielles. Les agriculteurs enquêtés ont tous connaissance du Striga et 100 % des champs prospectés étaient infestés par ce parasite. La variante à fleurs rose violacée de* Striga hermonthica *a été predominante et a fortement infesté les champs de sorgho et maïs à Bembèrèké (934 000 plantes/ha), Kandi (815 625 plantes/ha) et N'Dali (706 000 plantes/ha). Le sarclage (46,85%) et la rotation culturale (31,53 %) ont été les principales méthodes paysannes utilisées qui malheureusement, n'assurent pas un contrôle efficace du parasite. La transition vers une gestion intégrée (méthode biologique et autres), permettra un contrôle éfficace necessaire à l'amélioration de la production céréalière.*

Mots clés : *Perception paysane, infestation céréalière, plante parasite, gestion intégrée, Bénin.*

Soumis : 06/08/2023 Accepté : 11/12/2023 Online : 30/12/2023

INTRODUCTION

Maize (*Zea mays* L.) and sorghum (*Sorghum bicolor* (L.) Moench) are the most important food resources in sub-Saharan Africa where they are mainly used for human consumption as well as industrial raw material in the production of beverages, animal feed and sweeteners (Dossou-Aminon *et al.,* 2015; Mbuvi *et al.,* 2017). In Benin, these two cereals are mainly grown in the center and north of the country (Missihoun *et al.,* 2012). Sorghum is the third most important cereal after maize and rice with a production of around 133,093 tons in 2021 (DSA, 2022). Most of the production is consumed locally, which shows the strategic role of these crops in household food security(Kayode *et al.*, 2005; Dossou-Aminon *et al.*, 2015). The permanent demand for these two crops is reflected in the upward trend in the areas devoted to them in Africa over the past fifty years (Macauley & Ramadjita, 2015). Unfortunately, the productivity of these crops has not kept pace with demand due to various abiotic and biotic constraints including *Striga hermonthica* infestation. The latter constitutes the major and persistent biotic threat to cereal production mainly in the hottest and driest marginal regions of sub-Saharan Africa, the Middle East and much of Asia (Scholes & Press, 2008; Parker, 2012; Dawud, 2017). *Striga hermonthica* also called "witch weed" attacks the roots of many cereal crops (Sorghum, Maize, Pearl millet, Sugar cane) thus causing remarkable stunting of the host plant and considerable reduction in yields (Nzioki *et al.,* 2016; Mbuvi *et al.,* 2017). Countries where Striga infestation is incipient (for only 25 years) experience heavy infestations of the parasite especially under conditions of drought and low soil fertility. Yield losses can reach 100%, affecting approximately 300 million people in sub-Saharan Africa. Up to 50 million hectares of crops showed varied degrees of pest infestation in these regions with yield losses estimated at over seven (07) billion dollars (Haussmann *et al.*, 2000; Ejeta & Gressel, 2007).

In Benin, *Striga hermonthica* is the species listed in cereal crops such as sorghum, maize, pearl millet and fonio in the northern part of the country (Borgou, Atacora) and causing losses of yield ranging from 60% to 100% in case of severe infestation coupled with a rainfall deficit (Gbehounou *et al.,* 1991; Yehouenou, 1992; Toukourou *et al.,* 2007).The complexity of the biology of this parasitic plant, the decline in soil fertility, the non-practice of good farming method coupled to the phenomenon of transhumance between border regions and countries are factors showing the spread of the parasite to other regions of the country (Joel, 2000; Djenontin *et al.,* 2003; Yonli *et al.*, 2005; Lesse *et al.,* 2015). Indeed, two aspects of the parasite's life cycle make it difficult to control. This is its high fecundity, each flower peduncle of Striga can yield over 50,000 seeds which remain viable in the soil for up to 14 years. Then, its remarkable ability to intimately link its life cycle to its host (Yoder & Scholes, 2010). Striga seeds only germinate in response to chemical compounds (Strigolatone) emitted either by its host or in some cases a non-host (Bouwmeester *et al.,* 2007). After germination of the seeds, the primary roots attach themselves to the root of the host plant through a haustorium from which the parasitic plant draws all the nutrients it needs before it emerges from the soil. 80-90% of the damage is therefore already caused before the emergence of Striga (Gbèhounou, 1997; Scholes & Press, 2008).This makes the parasite the main biotic factor perpetuating agricultural losses linked to cereal production (Yonli *et al.,* 2010).

To control Striga, smallholder farmers in sub-Saharan Africa have developed different control methods aimed at reducing the density of plant seeds in the soil. These methods consist of reducing the quantity of cereal seeds contaminated by Striga, weeding emerged plants by hand, practicing crop rotation, using trap crops which cause the parasite to germinate suicidally. These methods which had also been developed and studied by some authors such as Parker & Riches. (1993) ; Hess & Haussmann (1999) and Elzein (2003) who have been widely promoted for many years but the crop losses and range of Striga are still significant which underlines the need for sustainable management of Striga (Cotter *et al.*, 2012). Integrated control combining the different methods already practiced and new biological control techniques would be the potentially cost-effective technics to prevent the spread of the parasitic plant and reduce its impact in infected areas (Te Beest *et al.*, 1992; Charudattan, 2001).

This study aims at evaluating the infestation of cereal crops (sorghum, maize, pearl millet) by Striga hermonthica and evaluating the effects of farmer's practices for controlling the density of this parasitic plant in the departments of Borgou and Alibori in northern Benin.

MATERIAL AND METHODS

STUDY AREAS

Prospecting and survey took place during September-October 2018 in the municipalities of N'dali, Bembéréké in the department of Borgou; and those of Kandi, Banikoara and Malanville in Alibori department (Figure 1). A total of 108 villages distributed in 15 districts were prospected in these municipalities (Figure 1). The prospecting period corresponded to full growth period of cereal crops in the fields as well as the emergence of Striga plants. In these areas, food crops occupy a prominent place in agriculture dominated by cereals mainly maize and sorghum. The surveyed villages belong to the North-East (11°19' North latitude and 2°55' East longitude) and North-South (10°13' North latitude and 2°40 East longitude) agro-ecological zones (Saré, 2000). Either Alibori or Borgou departments, September was the wettest month with an average rainfall of 522.91 mm and 500 mm respectively (ATDA, 2018). The soils are of the tropical ferruginous type with a sandy-clay texture (Amonmide *et al.*, 2019; Saliga & Alinsato, 2021).

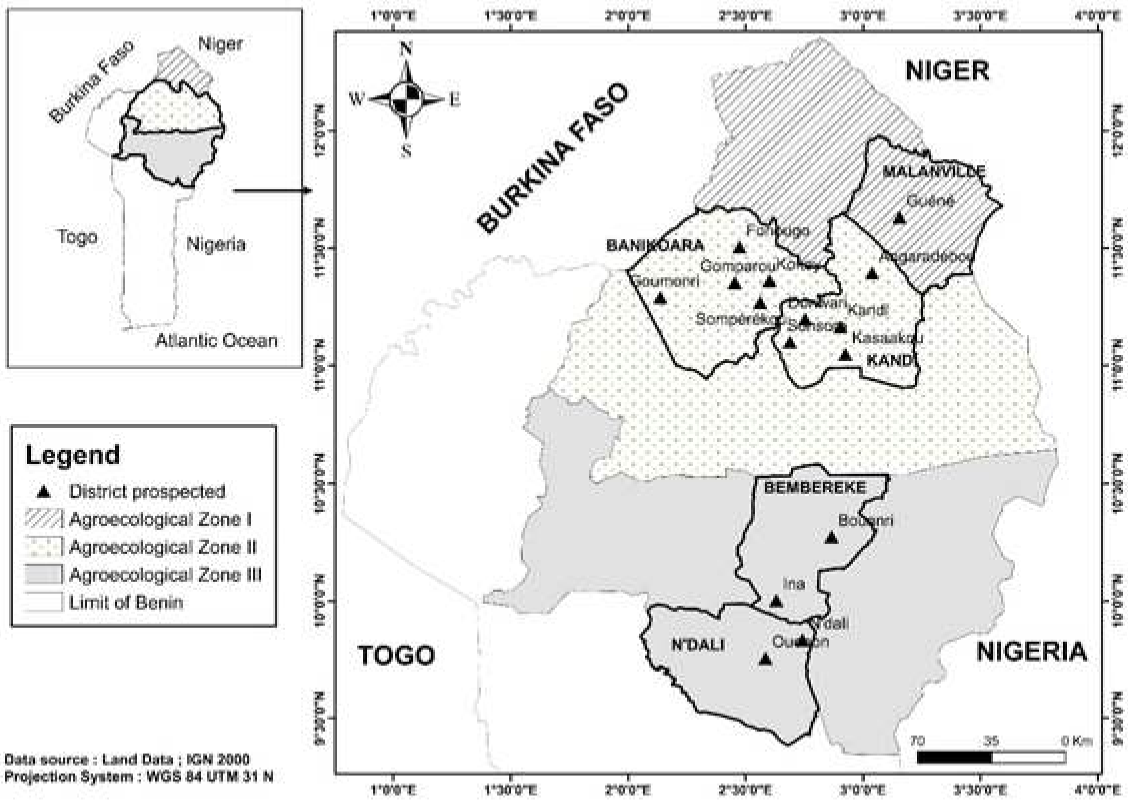

Figure 1. Map of Benin showing the study areas (carte du Bénin montrant les zones d'études).

District prospected : commune prospectée ; Agroecological zone : zone agro-écologique ; Limit of Benin : Limite du Bénin ; Atlantique ocean : océan Atlantique

Survey for collecting farmer knowledge and perceptions on Striga infestation

108 randomly selected farmers distributed in the municipalities of Malanville (12), Banikoara (40), Kandi (17), Bembereké (14) and N'dali (25) at the rate of one farmer/village, were surveyed during September-October 2018 for collecting their perceptions on Striga. Illustrations through photos and samples of Striga plants allowing farmers to appreciate their knowledge of the parasite were used. species are brought back to

laboratory in herbarium form for identification on the basis of available documentation

The farmers interviewed were between 35 and 50 years old, and were all cereal growers in each surveyed municipality. For assessing farmers perceptions on Striga infestation, they were initially submitted to structured interviews (Yes/ No) on their awareness of this parasitic plant. If so, on a grading scale of 1 to 5, It was collected the score they would attribute to the degree of infestation of their fields by the parasitic plant focusing on their knowledge. Moreover, the questionnaires related to the farmer cropping practices developed in each municipality for controlling Striga are collected.

Field prospection and collection of degree infestation of *Striga hermonthica.*

The sampling of villages and fields in each of surveyed municipality was randomly carried out, excluding fallow land and non-cropping areas where Striga was not encountered. At least one village was sampled per district in the municipality producing cereal crops. As for density estimate, this measure was determined by counting the number of Striga plants per unit area (1 m²) and then reported to the hectare (ha) as described by Daget (1999). Thus, the number of Striga was counted on five (05) portions of 1 m² delimited at each plot level, which enabled to have a representative average of the number of Striga per plot. The scale from 1 to 9 defined by Akanvou *et al.* (2009) was used to qualify the infestation degree of each Striga species as follow: 1 = very low infestation (1 to 10 Striga plants/m²), 3 = low infestation (10 to 30 Striga plants/m²), 5 = medium infestation (30 to 50 Striga plants/m²), 7 = high infestation (50 to 100 Striga plants/m²), 9 = very high infestation (more than 100 Striga plants/m²).

DATA ANALYSIS

Collected data have entered using spreadsheet Excel 2016[redacted] statistics on [redacted] infestation, farmer methods), the model of analysis of variance has been performed on Striga density depending on municipality and validated after checking the normality and homogeneity of residuals. After significant effect of municipality, the test of Student Newman and Keul (SNK) was completed for discriminating the densities mean.

To evaluate the effect of the variation of average density of *Striga hermonthica* following the municipality and the control methods, generalized linear models (glm) were generated. Due to overdispersion (Deviance/Degree of freedom > 1), negative binomial fits were used for modeling. The Student Newman and Keul (SNK) mean structuring test was performed to group similar communes in terms of mean Striga density. To highlight and describe the link between the commune and the control methods of S. *hermonthica*, the independence test "X²" of Pearson was carried out, followed by factor analysis of simple correspondences (CFA). All analyzes were performed in R 4.1.2 software (R Core Team, 2022).

RESULTS

FARMER KNOWLEDGE OF STRIGA SPECIES AND THEIR DEGREE OF INFESTATION

The surveys showed the presence of *Striga hermonthica*, one species of Striga in cereal cropping areas studied. There are two variants of this species (Figure 2) which one with a purplish-pink flower found mainly in *sorghum*, pearl millet and maize crops; and the other with a white flower found only on two (02) sorghum plants in Lolo's village of Angaradébou (Kandi municipality). All surveyed farmers (100%) have knowledge of Striga. Indeed, to distinguish Striga from other parasitic plants, farmers according to their socio-cultural group designate Striga by a specific name like "Sakara" which means "to make sterile" in Batonou group and "Mali" in [redacted] "to prevent cultural [redacted]

A b

Figure 2. Plant of *S. hermonthica* (Del) Benth (a): variant with purplish pink flower; (b): variant with white flower (Plant de *S. hermonthica* (Del) Benth (a) : variant à fleur rose; (b): variant à fleur blanche).

On a scale ranging from 1 to 5 defined to assess the infestation level of their crops, 77.78% of these farmers gave the maximum score of 5 (Figure 3).

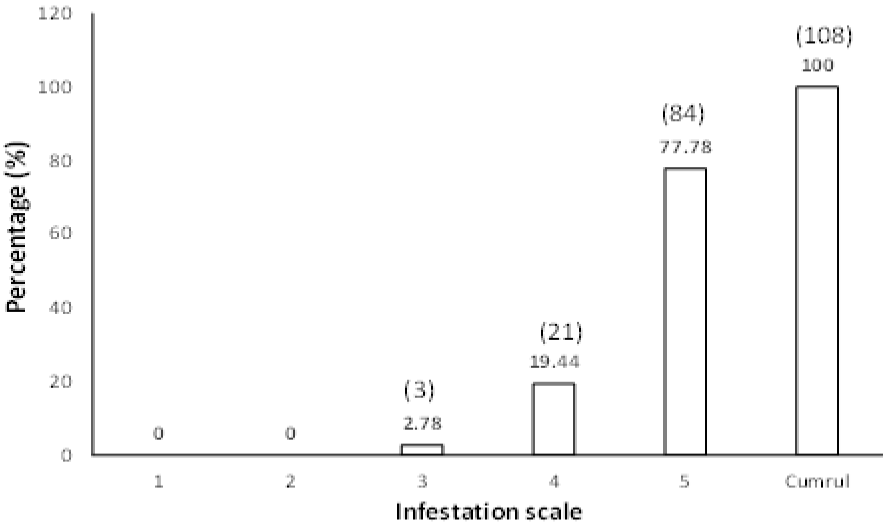

Figure 3. Estimate of degree of Striga infestation on fields by farmers (estimation du degré d'infestation du Striga par les producteurs des zones d'étude).

The integer value in parenthesis stand for the respondent numbers.

DENSITY AND DEGREE OF INFESTATION OF *STRIGA HERMONTHICA* IN SURVEYED MUNICIPALITIES

The analysis of variance revealed a highly significant difference between the mean densities of *Striga hermonthica* depending on the municipalities (P <0.001) (Figure 3). So, the municipality of Bembèrèké (934,000 plants/ha), Kandi (815,625 plants /ha) and N'Dali (706,000 plants /ha) presented the densities of Striga the highest Likewise, infestation at Striga is described as high (500,000-1,000,000 vines/ha) to very high in these municipalities (more than 1,000,000 vines/ha) (Figure 4).

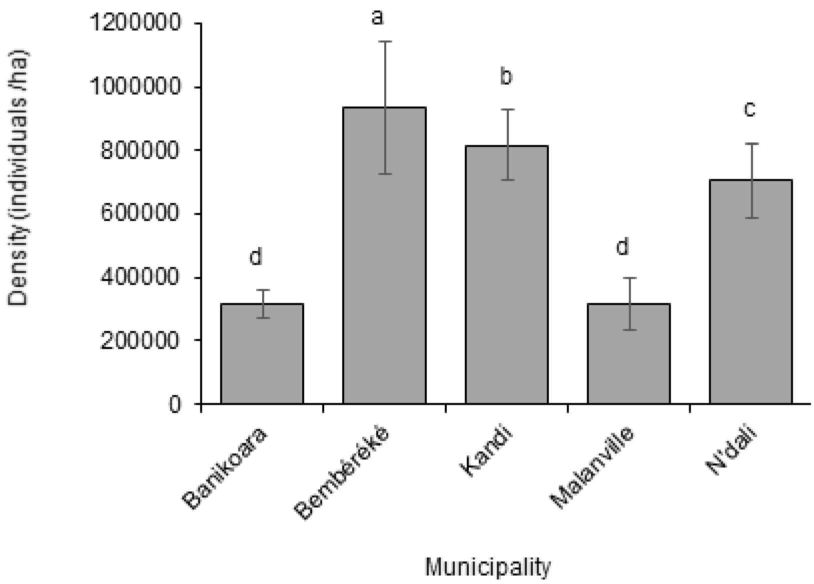

Figure 4. Density of *Striga hermonthica* in the municipalities (Densité de *striga hermonthica* dans les communes).

Density: densité; Municipality: commune; individuals: individus.

FARMER PRACTICES FOR CONTROLLING *STRIGA HERMONTHICA*

The control methods of Striga infestation most used by farmers in the study areas are weeding (46.85%) and crop rotation (31.53%). The chemical pesticides (10.81%), the intercropping (9.91%) and the fallow practice (0.9%) are the least methods used to control Striga (Figure 5).

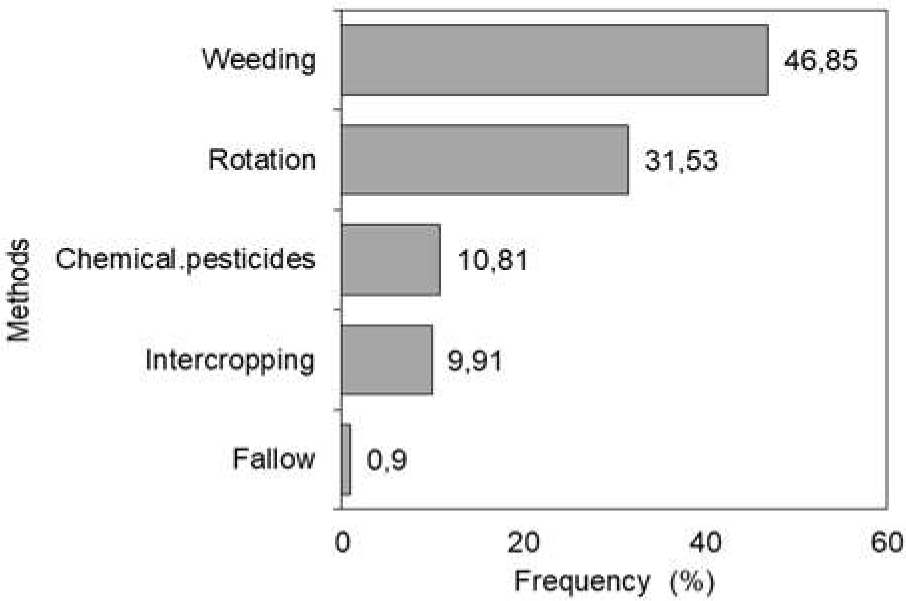

Figure 5. Importance of farmer methods for controlling Striga infestation in cereal cropping.

(importance des methodes utilisées par les producteurs pour lutter contre striga hermonthica en cultures céréalières).

Methods: methods; Frequency (%): Fréquence (%); Weeding: sarclage; Rotation: rotation; Chemical pesticides: produits chimiques; Intercropping: associations culturales; Fallow: Jacher.

REPARTITION OF CONTROL METHODS PRACTISED BY INVESTITAGED MUNICIPALITIES AGAINST S. *HERMONTHICA*

The independence tests 'X^2' of Pearson indicated a significant association between common and control methods for *S. hermonthica* ($X^2 = 55.08$, $P < 0.001$). Similarly, the factor analyzes of the correspondences showed the first three factor axes (Figure 6 A & B) captured 99.60% of the initial information, thus guaranteeing an accurate description by these axes. Thus, on the positive side of the first axis, "the intercropping method and the municipalities of Malanville and N'dali" have a good contribution and quality of representation while "crop rotation method and the municipality of Banikoara have been on the negative side. This reflects that the farmers of Malanville and N'dali have mainly preferred intercropping method for control the invasion of *S. hermontica,* unlike those of Banikoara who practiced more crop rotation (figure 6 A). On the positive side of the second axis, chemical method was the most practiced by Kandi farmers. As for Bembèrèkè farmers, no control method is specific to them (Figure 6 A). Finally, on the positive side of the third axis, N'dali farmers no longer leave the plots fallow to reduce the effect of *S. hermontica* (Figure 6B) unlike those of Banikoara who practice more crop rotation for this purpose (figure 6 A).

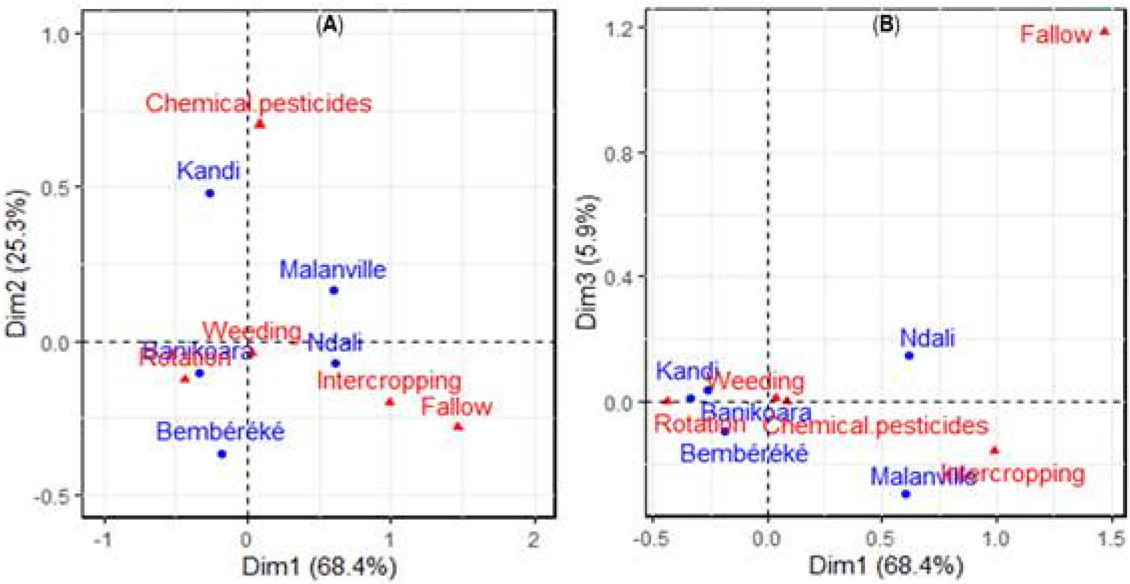

Figure 6. Projection of the municipalities surveyed and methods for controlling *S. hermontica* on the first three factor axes.

Methods: methods; Frequency (%): Fréquence (%); Weeding: sarclage; Rotation: rotation; Chemical pesticides: produits chimiques; Intercropping: association culturales; Fallow: Jacher.

EFFECT OF CONTROL METHODS ON STRIGA DENSITY

The model of generalized linear regression indicated average density of S. hermontica varied statistically ($P<0.05$) depending on whether or not the farmer practiced weeding, fallowing, intercropping, crop rotation and the use of chemical pesticides (Table 1).

Table 1. Results of generalized linear regression assessing the effect of control methods on average density of *Striga hermontica.*

Résultats de la régression linéaire généralisée évaluant l'effet des méthodes de contrôle sur la densité moyenne de Striga hermonthica.

Method	Deviance	Resid.Dev	Pr(>Chi)
Weeding	15.40	1875.60	<0.001***
Fallow	10.14	1865.50	0.001**
Intercropping	120.51	1745.00	<0.001***
Chemical pesticides	121.86	1623.10	<0.001***
Crop rotation	120.24	1502.90	<0.001***

Residual deviation (Resid.Dev) : Ecart résudiel ; Probability (Pr) : probabilité Deviance : Déviance ; Method : Méthode.

Moreover, Figure 7 highlighted that surveyed farmers practicing neither weeding nor fallowing have recorded high Striga density of 89.5 x 104 plants/ha and 60.5 104 plants/ha respectively in their fields. On the other hand, crop associations highlighting cereals/legumes (maize/cowpea) and even cereals/cereals (maize/millet) make it possible to have an average density of Striga (35,103 plants/ha) in the fields.

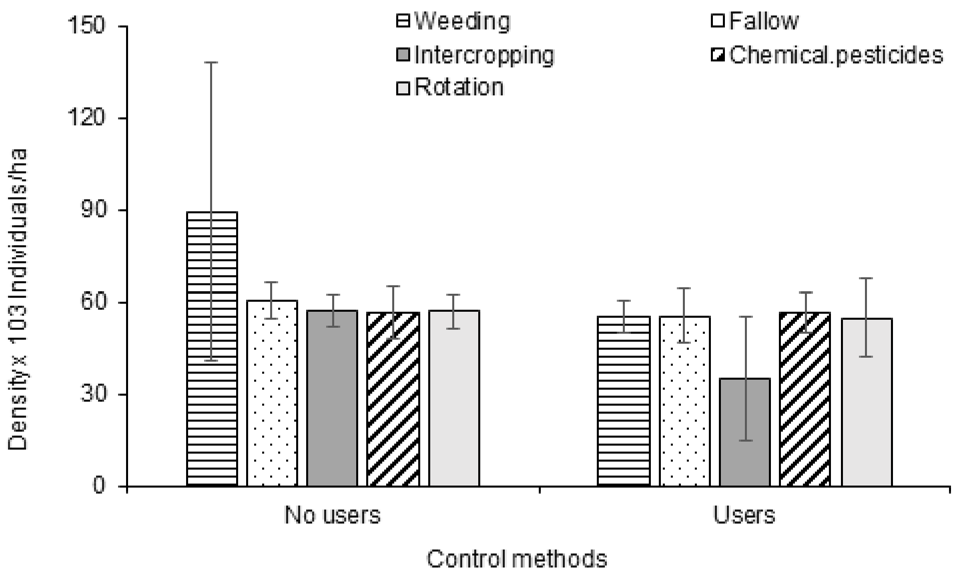

Figure 7. Variation in the average density of *Striga hermonthica* following control methods.

Variation de la densité moyenne de Striga hermonthica suivant les méthodes de lutte.

Control Methods: méthodes de lutte; Frequency (%): Fréquence (%); Density: Densité; individuals: individus; No users: non utilisateurs; Users: Utilisateurs; Weeding: Sarclage; Rotation: Rotation; Chemical Pesticides: Produits Chimiques; Intercropping: Association Culturales; Fallow: Jacher.

DISCUSSION

This study confirmed the existence of two variants of *Striga hermonthica i*n the cereal fields (maize, sorghum and pearl millet) of the study area in northern Benin namely the pink-purple and white-flowered variants of *S. hermonthica.* The presence of white-flowered variant could be the start of its infestation in the area. The same results were reported by Gbehounou *et al.* (1991) indicating the existence of this species on these different crops in the departments of Borgou and Atacora in northern Benin. Similarly, *S. hermonthica* remains the species found in heavy infestation in cereal crops (maize, pearl millet, sorghum) in the main study areas and causing severe damage. The same author argues that in Benin this species causes yield losses ranging from 60 to 100% under severe infestation rate (more than 10 parasites/host) due to the diversion of assimilates and the host intoxication (Gbèhounou, 1996; Gbèhounou & Adango, 2003). However, the analyses of farmer perceptions also revealed *S. hermonthica*, variant with purplish-pink flowers, as the dominant parasites and causing substantial damages to cereal crops (Azonhoumon *et al.,* 2020). This result was congruent to the previous findings of Azonhoumon.(2020) highlighting *S. hermonthica* negatively influenced vegetative development and yield of maize lines in northern Bénin

In Central and West Africa, *S. hermonthica* is often associated with ecosystems prone to desertification because of overgrazing, tree cutting and bush fires which reduce the vegetation cover (Muleba *et al.,* 1997 cité par Dubé & Oliver, 2001). The problem is further aggravated with the increasing pressure on arable land, by single-crop farming (Agalati *et al.*, 2022; Kombienou & Dagbenonbakin, 2022). In several areas of Borgou, mainly the districts of Banikoara, Kandi, N'dali and Bemberekè, there is huge soil degradation following deforestation in the cultivation of crops such as cotton, maize, sorghum, pearl millet and yam (Agalati *et al.,* 2022; Hermann *et al.,* 2015). The impact of chemical inputs (fertilizer, pesticide) in soil degradation should also not be neglected, especially in major cotton production areas such as Banikoara, Kandi (Biaou *et al.,* 2003; Djenontin *et al.,* 2003). In addition, the transhumance phenomenon in Benin, not only has an impact on soil degradation, but also on the spread of Striga seeds into croplands through animal droppings.

De Haan (1992) and Lesse (2016) revealed that during the driest months, herds go on transhumance in search of grass and water to neighboring countries (Niger, Nigeria, Burkina, Togo) where Striga is also a real scourge (Labrada, 2008), then return at the beginning of the rainy season to graze the new grass. Several herds of animals (cattle, sheep, goats) graze on the same pastures during the same year, resulting in their overloading (De Haan, 1992). These grazing areas which have nowadays become cropping areas following the constantly growing food needs of galloping population are therefore increasingly degraded (Lesse, 2009; Sounkéré, 2003).

As for control methods, the weeding mainly practiced by farmers to control Striga is not of great importance. Since even before the emergence of Striga, 80 to 90% of crop damage cereals are already caused (Gbèhounou, 1997; Azonhoumon *et al.*, 2020). Moreover, farmers in the district of Bembèrèkè have no specific control method, which explains the prevalence of Striga infestation in this area. Cereal crops are cultivated after cotton and yam, and therefore receive almost no upkeep. Similarly, cropping rotation included a succession of cereal crops (maize/sorghum - maize/millet). Leguminous plants or false hosts are practically non-existent in this system. It would therefore be almost impossible to break the infernal cycle of this parasitic plant.

Finally, Synthetic pesticides are the third most widely adopted control method in the study areas. In their study evaluating the growth and yield of maize lines under *Striga hermonthica* infestation in northern Benin, Azonhoumon *et al.* (2020) also concluded that these same control methods, taken individually, were not effective in reducing *S. hermonthica* population. Under such circumstances, control approaches allowing from the cereals sowing to prevent the emergence and/or reduce this parasite vigor is highly desirable for the integrated control against Striga.

CONCLUSION

Striga hermonthica (variant with pink-violet flower) in cereal production (maize, sorghum, millet) in northern Benin is real concern for farmers in areas with high infestation (Bembérékè, Kandi, N'dali). The control methods used by farmers in these areas remain ineffective and some contribute to environmental pollution. Several factors, in particular the non-practice or the reduction of the time for setting fallow land, unsuitable crop rotation, loss of soil fertility, etc. are the basis of the infernal cycle of the parasitic plant. The adoption of integrated pest management including biologic methods would be an ideal option for better management of striga parasitism.

ACKNOWLEDGEMENTS

The author thanks the Ministry of Higher Education and Scientific Research for its financial support throughout the project. We are also grateful to M. Yanik AKIN YAÏ for his valuable contribution to this project.

REFERENCES

Agalati B., Boukari K., Ayedegue O. I., Degla P., and Batonwero P. 2022. Effets des rotations culturales sur la performance économique des exploitations cotonnières au Centre et Nord du Bénin, Afrique Science, 20 (5), pp. 1-12.

Akanvou L., Akanvou R., and Toto K. 2009. Effets des variétés de maïs et de légumineuses dans la lutte contre *Striga hermontica* en zone de savane en Côte d\'Ivoire, Agronomie Africaine, 18 (1), pp. 13-21. DOI:10.4314/aga.v18i1.1675.

Amonmide I., Dagbenonbakin G., Agbangba C. E., and Akponikpe P. 2019. Contribution à l'évaluation du niveau de fertilité des sols dans les systèmes de culture à base du coton au Bénin, International Journal of Biological and Chemical Sciences, 13 (3), pp. 1846. DOI:10.4314/ijbcs.v13i3.52.

Agence Territoriale pour le Développement Agricole (ATDA). 2018. les données pluviométriques des zones agricoles Nord-Bénin, Alibori, Borgou

Azonhoumon S. D., Logbo J., Yaoitcha A. S., and Adandonon A. 2020. Evaluation de la croissance et du rendement de quelques lignées de maïs (Zea mays L.) à l'infestation de *Striga hermonthica* (Del.) Benth dans le Nord du Bénin, Revue Africaine d'Environnement et d'Agriculture, 3 (3), pp. 106-113.

Biaou C., Alonso S., Truchot D., Abiola F. A., and Petit C. 2003. Contamination des cultures vivrieres adjacentes et du sol lors d'une pulverisation d'insecticides sur des champs de coton: cas du triazophos et de l'endosulfan dans le Borgou (Benin)., Revue de Médecine Vétérinaire, 154 (5), pp. 339-344.

Bouwmeester H. J., Roux C., Lopez-Raez J. A., and Bécard G. 2007. Rhizosphere communication of plants, parasitic plants and AM fungi, Trends in Plant Science, 12 (5), pp. 224-230. DOI:10.1016/j.tplants.2007.03.009.

Charudattan R. 2001. Biological Control of Weeds by Means of Plant Pathogens: Significance for Integrated Weed Management in Modern Agro-Ecology, BioControl, 46 (2), pp. 229-260. DOI:10.1023/A:1011477531101.

Cotter M., de la Pena-Lavander R., and Sauerborn J. 2012. Understanding the present distribution of the parasitic weed *Striga hermonthica* and predicting its potential future geographic distribution in the light of climate change, Julius-Kühn-Archiv, (434), pp. 630.

Daget P. 1999. Evaluer la densité des ligneux par la méthode des dénombrements?? Une difficulté, Revue d'élevage et de médecine vétérinaire des pays tropicaux, 52 (3-4), pp. 270-271. DOI:10.19182/remvt.9675.

Dawud M. A. 2017. Striga resistance in cereal crops: Recent progress and future prospects. A Review, Global Journal of Science Frontier Research, 17 (3), pp. 39-50.

De Haan L. 1992. Changes in livelihood strategies in Northern Benin and their environment effects, The Courier. Africa-Caribbean-Pacific-European Union, 133, pp. 88-90.

Djenontin J. A., Wennink B., Dagbenongbakin G., and Ouinkoun G. 2003. Pratiques de gestion de fertilité dans les exploitations agricoles du Nord-Bénin, in: Savanes africaines: des espaces en mutation, des acteurs face à de nouveaux défis. Actes du colloque, Garoua, Cameroun. Cirad-Prasac, pp. 9-p.

Dossou-Aminon I., Loko L. Y., Adjatin A., Ewédjè E.-E. B. K., Dansi A., Rakshit S., and al. 2015. Genetic Divergence in Northern Benin Sorghum (Sorghum bicolor L. Moench) Landraces as Revealed by Agromorphological Traits and Selection of Candidate Genotypes, The Scientific World Journal, 2015, pp. 1-10. DOI:10.1155/2015/916476.

Direction de la Statistique Agricole (DSA) 2022. les chiffres définitifs de la campagne agricole 2021-2022 (Bilan et prévision). pp. 1-28. Cotonou: Ministère de l'Agriculture de l'élevage et de la pêche.

Dubé M. P., and Olivier A. 2001. Le *Striga gesnerioides* et son hôte, le niébé: interaction et méthodes de lutte, Canadian Journal of Botany, 79 (10), pp. 1225-1240.

Ejeta G., and Gressel J. 2007. Integrating new technologies for Striga control: towards ending the witch-hunt. USA: World Scientific.

Elzein A. E. M. 2003. development of a granular mycoherbicidal formulation of Fusarium oxysporum" Foxy 2" for the biological control of *Striga hermonthica* (Del.) Benth., Tropical Agriculture 12, pp. 172.

Gbèhounou. 1997. La condamnation de Kao la sorcière, numéro spécial striga 97, pp. 26.

Gbèhounou G. 1996. Survie des graines de Striga hermonthica en milieu réel au Bénin: Implications pour le choix des méthodes de lutte, Bulletin de la Recherche Agronomique Numéro [Preprint].

Gbèhounou G., and Adango E. 2003. Trap crops of Striga hermonthica: in vitro identification and effectiveness in situ, Crop Protection, 22 (2), pp. 395-404. DOI:10.1016/S0261-2194(02)00196-5.

Gbehounou G., Egbers W. S., Verkleij J. a. C., and Pieterse A. H. 1991. A survey on Striga infestation in Borgou and Atacora provinces in Benin, in: CIMMYT,.

Haussmann B. I. G., Hess D. E., Welz H.-G., and Geiger H. H. 2000. Improved methodologies for breeding striga-resistant sorghums, Field Crops Research, 66 (3), pp. 195-211. DOI:10.1016/S0378-4290(00)00076-9.

Hermann M. B., Moumouni I., and Mere S. B. J. T. O. 2015. Contribution à l'amélioration des pratiques paysannes de production durable de coton (Gossypium hirsutum) au Bénin: cas de la commune de Banikoara, International Journal of Biological and Chemical Sciences, 9 (5), pp. 2401-2413.

Hess D. E., and Haussmann B. I. G. 1999. Status quo of Striga control: Prevention, mechanical and biological control methods and host plant resistance, Advances in Parasitic Weed Control at On-Farm Level, 1, pp. 75-87 :DOI: 10.1007/978-94-010-0005-5_10.

Joel D. M. 2000. The long-term approach to parasitic weeds control: manipulation of specific developmental mechanisms of the parasite, Crop Protection, 19 (8-10), pp. 753-758. DOI:10.1016/S0261-2194(00)00100-9.

Kayode A. P., Adegbidi A., Hounhouigan J. D., Linnemann A. R., and Robert Nout M. J. 2005. Quality of Farmers' Varieties of Sorghum and Derived Foods as Perceived by Consumers in Benin, Ecology of Food and Nutrition, 44 (4), pp. 271-294. DOI:10.1080/03670240500187302.

Kombienou P. D., and Dagbenonbakin G. D. 2022. Pratiques agricoles et techniques de conservation des eaux et des sols de Boukombé au Bénin, J. Anim. Plant Sci, 52, pp. 9343-9361.

Labrada R. 2008. Progress on farmers training on parasitic weed management, Food Agriculture Organisation United Nations, 156.

Lesse P. 2009. Transhumance et changement climatique: Productivité et capacité de charge des pâturages naturels des terroirs riverains de la réserve de biosphère transfrontalier du W (Bénin), (Thèse d'Ingénieur agronome.). Faculté des science Agronomique, Université d'Abomey-Calavi, Bénin.

Lesse P., Houinato M. R. B., Djenontin J., Dossa H., Yabi B., Toko I., Tente B., and Sinsin B. 2016. Transhumance en République du Bénin?: états des lieux et contraintes, International Journal of Biological and Chemical Sciences, 9 (5), pp. 2668. DOI:10.4314/ijbcs.v9i5.37.

Lesse P., Houinato M. R., Djenontin J., Dossa H., Yabi B., Toko I., Tente B., and Sinsin B. 2015. Transhumance en République du Bénin: états des lieux et contraintes, International Journal of Biological and Chemical Sciences, 9 (5), pp. 2668-2681.

Macauley H., and Ramadjita T. 2015. Cereal crops: Rice, maize, millet, sorghum, wheat.

Mbuvi D. A., Masiga C. W., Kuria E., Masanga J., Wamalwa M., Mohamed A., and al. 2017. Novel Sources of Witchweed (Striga) Resistance from Wild Sorghum Accessions, Frontiers in Plant Science, 8. DOI:10.3389/fpls.2017.00116.

Missihoun A., Agbangla C., Adoukonou-Sagbadja H., Ahanhanzo C., and Vodouhe R. 2012. Gestion traditionnelle et statut des ressources génétiques du sorgho (Sorghum bicolor L. Moench) au Nord-Ouest du Bénin, International Journal of Biological and Chemical Sciences, 6 (3), pp. 1003-1018. DOI:10.4314/ijbcs.v6i3.8.

Muleba N., Ouedraogo J. T., and Tignegre J. B. 1997. Cowpea yield losses attributed to striga infestations, The Journal of Agricultural Science, 129 (1), pp. 43-48. DOI:10.1017/S0021859697004450.

Nzioki H. S., Oyosi F., Morris C. E., Kaya E., Pilgeram A. L., Baker C. S., and Sands D. C. 2016. Striga Biocontrol on a Toothpick: A Readily Deployable and Inexpensive Method for Smallholder Farmers, Frontiers in Plant Science, 7.

Parker C. 2012. Parasitic Weeds: A World Challenge, Weed Science, 60 (2), pp. 269-276. DOI:10.1614/WS-D-11-00068.1.

Parker C., and Riches C. R. 1993. Parasitic weeds of the world: biology and control. Wallingford: CAB International.

Saliga F., and Alinsato A. 2021. Analyse de la sécurité alimentaire des ménages agricoles dans le département du Borgou en République du Bénin, Repères et Perspectives Economiques, Vol. 5 (1), pp.153-170. DOI:10.34874/IMIST.PRSM/RPE/25756.

Saré C. G. 2000. Rapport préliminaire du sous secteur des cultures vivrières (Bilan diagnostic No. PROJET PNUD / FAO SPPD

BEN / 99 / 004). pp. 1-69. Cotonou: Ministère du développement rural.

Scholes J. D., and Press M. C. 2008. Striga infestation of cereal crops - an unsolved problem in resource limited agriculture, Current Opinion in Plant Biology, 11 (2), pp. 180-186. DOI:10.1016/j.pbi.2008.02.004.

Sounkéré K. 2003. Analyse des formes d'utilisation de l'espace dans les terroirs agropastoraux de la périphérie du parc national du W: cas de la commune de Karimama (Thèse d'Ingénieur agronome). Faculté des sciences Agronomiques, Université d'Abomey-calavi, Bénin.

Te Beest D. O., Yang X. B., and Cisar C. R. 1992. The Status of Biological Control of Weeds with Fungal Pathogens, Annual Review of Phytopathology, 30 (1), pp. 637-657. DOI:10.1146/annurev.py.30.090192.003225.

Toukourou A. M., Adegbola Y. P., Yallou G. C., and Gbehounou G. 2007. Amélioration du rendement et de la rentabilité de la culture de maïs sur des terres infestées par *Striga hermonthica* au nord du Bénin, Demand-Driven Technologies for Sustainable Maize Production in West and Central Africa, pp. 291.

Yehouenou A. 1992. La distribution du Striga au nord Bénin. Proceedings du 4e Séminaire National du Groupe des Chercheurs sur les cultures vivrières, 59-67. Pobè 26-28.

Yoder J. I., and Scholes J. D. 2010. Host plant resistance to parasitic weeds; recent progress and bottlenecks, Current Opinion in Plant Biology, 13 (4), pp. 478-484. DOI:10.1016/j.pbi.2010.04.011.

Yonli D., Hess D. E., Abbasher A. A., Sérémé P., and Sankara P. 2005. Biological Control Of Witch Weed In Fields Of Burkina Faso Using Isolates Of *Fusarium oxysporum*, African Crop Science Journal, 13 (1), pp. 41-47. DOI:10.4314/acsj.v13i1.27721.

Yonli D., Traoré H., Hess D. E., Abbasher A. A., and Boussim I. J. 2010. Effect of Growth Medium and Method of Application of *Fusarium oxysporum* on Infestation of Sorghum by *Striga hermonthica* in Burkina Faso, Biocontrol Science and Technology, 14 (4), pp. 417-421. DOI:10.1080/0958315042000198456.