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Nuisibility of *Leucas aspera* (Willd.) Link (Lamiaceae) in Pearl Millet Culture [*Pennisetum glaucum* (L.) R. Br. (Poaceae)] in Eastern South East Niger

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A B S T R A C T

Weed competition is a major obstacle to millet cultivation [*Pennisetum glaucum* (L.) R. Br. (Poaceae)]. The present study was conducted in the south-east of Niger to determine the density of *Leucas aspera* (Willd.) Link (Lamiaceae) likely to influence millet production, in order to help farmers define technical itineraries for controlling this species. The experimental set-up is a randomized complete block design with four replications and 24 elementary plots. Five types of density (1, 2, 3, 7 and 10 plants) of *Leucas aspera* around the millet plot were tested. Data collected were mean height, number of plants and plot weight of millet. A one-factor analysis of variance (ANOVA) and Duncan's test at the 5% threshold were used to compare mean heights and yields with the control. Results showed that tolerant density can be estimated at 2 plants/m² of *Leucas aspera*. Above this critical value, early competition occurs between weed and millet plants from the third week onwards. The lower the density of *Leucas aspera*, the higher the yield. The average reduction in millet yield from *Leucas aspera* was 81.95%, with a minimum of 96.55% for the treatment of one *Leucas aspera* plant and a maximum of 99.66% for the treatment of 10 *Leucas aspera* plants. These results could help improve weed management in millet cultivation.

Introduction

Pearl millet [*Pennisetum glaucum* (L.) R. Br. (Poaceae)] has today become the seventh crop (Shivhare and Lata, 2016; Kadri *et al.,* 2019; Dan *et al.,* 2020). It is a major subsistence food crop in the Sahelian region of West Africa, where it constitutes the staple diet of several million people (Goudiaby *et al.,* 2018). Niger is the second largest producer in Africa after Nigeria (Hamadou *et al.,* 2017). The last twenty years have seen

a rapid expansion of millet cultivation in most African countries (FAOSTAT, 2022). In Niger, since 1961, production and, above all, cultivated areas have been steadily increasing (Kadri *et al.,* 2019).

However, many crop pests such as birds, insects and fungi affect millet fields at all stages of development, from seedling to formedears. These pests do not constitute real impediments to production. Data obtained during the work of Cramer (1967); Akobundu (1986) and Akobundu and Agyakwa (1989) showed that weeds are the main concern for farmers. Weed flora includes several species that infest the same plot at the same time (Sattin *et al.,* 1997). In Niger, the major weeds of annual crops include annual broad leaf dicotyledons, annual grasses and Cyperaceae (Carson, 1988 cited by Soumaila, 2024).

Leucas aspera, an annual dicotyledonous weed, is the subject of this study. This weed aggressively invades several crops, notably millet. According to local growers, *Leucas aspera* infestations can lead to crop losses or abandonment of farm land. It is difficult to control, and to date there are no effective control techniques available.

Farmers still resort to manual control, which is very costly. In Africa, and particularly in Niger, studies showing its impact on millet production are almost non-existent. Against this background, we set out to assess the impact of *Leucas aspera* on millet growth and yield [*Pennisetum glaucum* (L.) R. Br. (Poaceae)]. This work was carried out in the Department of Illéla.

Materials and Methods

Location of Experimental site

Illéla, is located in the South-East of Niger between14° 27'43" North latitude and 5°14'38" East longitude (Ministère de l'Agriculture et de l'Elevage, 2019) (Fig.1.). This locality was chosen because of the strong presence of *Leucas aspera* but also because of the current development of millet cultivation.

Leucas aspera (Willd.) Link (Lamiaceae)

Leucas aspera is an annual, branched herb, erect to a height of 15-60 cm with an acute, stout, hispid, quadrangular stem and branches (Prajapati *et al.,* 2010). The leaves (8 cm long and 1.25 cm wide) are sub-sessile or briefly petiolate (2. 5-6 mm long). They may be linear or linearly lanceolate, obtuse, pubescent, with a whole or crenatemargin. Flowers are white, sessile, small, in dense terminal or axillary whorls. Bracts are 6 mm long, linear, acute, bristly, ciliated with long, thin hairs. Fruits are 2.5 mm long, oblong, brown, smooth nuts with angular insides and rounded outsides.

Millet [*Pennisetum glaucum* (L.) R. Br. (Poaceae)]

The local “Guèreguera” variety of millet, an early variety (98 days), was used. It is an upright plant. The root system is fasciculated, with a single main seminal root followed by numerous adventitious roots (Kadri *et al.,* 2019). The number of productive tillers varies from 1 to 7 (Anonyme, 2004 cited by Kadri *et al.,* (2019). Stem height averages 2.98 cm. Leaves are alternate and parallel-veined at the nodes.

Their number varies from 8 to 16. They bear 8 to 16 nodes and 7 to 15 internodes. The leaf blade can measure up to 12 cm wide and 1 m long. The inflorescence is a stiff, compact apical panicle of cylindrical and conical forms (Kadri *et al.,* 2019). Its diameter averages 4 cm but can reach up to 69 cm in length, and it can weigh an average of 0.98 Kg. Fruits are caryopses wrapped in glumes and glumellae. Seeds are obovate to globose (IBPGR & ICRISAT, 1993). Their color varies from ash-gray to gray-brown and yellow-brown.

Technical and Computer Equipment

Data entry, processing and analysis were carried out using IT tools. Microsoft Word version 2007 (for word processing), Microsoft Excel version 2007 (for data entry, processing and part of the analyses) and R version 4.4.1 (for analyses of variance and Duncan's tests).

Choice of Experimental plots

The choice of experimental plot was guided by the presence of large numbers of *Leucas aspera* plants on the site.

Experimental Design

The experimental set-upis a Fisher block (Fig.2.). It is a complete randomized block. It comprises four replicates

(Fig.2a.). Each block comprises an untreated control and five treatments (Table 1). The elementary plot covers an area of 4 m² (2 m x 2 m) and is composed of two croplines, one meter apart. Each cultivation line is located 50 cm from the boundary of the elementary plot, and consists of four planting patches 40 cm apart (Fig.2b.). Each plot is sown with five millet grains. The distance between plots within a block is 1 m, and 2 m between blocks. On each elementary plot, there are therefore 40 millet plants. The number of *Leucas aspera* plants per elementary plot varied from 8 to 80 (Table 1).

Conducting the Trial

The trial was set up in July 2023 and June 2024. Plots were ploughed manually. After sowing, all weeds other than *Leucas aspera* were systematically weeded manually just after emergence. For the latter, we take care to leave only the number of individuals in competition with each other, depending on the treatment.

All these precautions are taken to optimize evaluation of the effect on the vegetative and production characteristics of millet. The control plots were kept clean until harvest.

Data Collection

Data collection focused on the response of millet to variations in *Leucas aspera* density. The parameters observed are those related to the development of millet plants, notably height growth and yield. Measurements were taken weekly for the first parameter.

Data Analysis

The results of the observations were subjected to analysis of variance and comparison of means (Duncan test with 95% confidence interval) for classification into homogeneous groups.

Results and Discussion

Effect of *Leucas aspera* plant density on millet plant height growth

After the first week, the results show that there is no significant difference between the average height of millet plants in the control and those in the different treatments, with p = 0.01 (Table 2). The young millet plants are almost the same height, at 7.25 cm.

At the fourth week, a highly significant difference was observed between the mean heights of millet plants in the control and those in competition with *Leucas aspera* (Table 3). The performance of the millet plants is characterized by five classes of average heights. This analysis revealed that the five classes are: a, b, c, cd and d. Class a is illustrated by TM control millet plants measuring 67 cm in height. Class b is made up of millet plants from treatments T1 and T2, with average heights of 23.25 cm and 17.87 cm respectively.

Class c represents millet plants from treatment T3. The corresponding average height is 15.75 cm. Classes cd and d group together the average heights of millet plants from treatments T7 (32 cm) and T10 (29.75 cm). The best growth was obtained on plots kept clean. At week 14, there was still a highly significant difference between the average heights of millet plants in the control and those in competition with *L. aspera* (Table 4). Analysis of millet plant heights at week 14 revealed five classes of average plant heights: a, b, bc, cd and d.

Class a includes the heights of millet plants from the TM control, averaging 282 cm. The average height of the millet plants in this class is the greatest of the heights of the millet plants measured at week 14. Class b is characterized by the average height of millet plants from treatment T1, with an average height of 143.37 cm. Class bc comprises the average heights of millet plants in treatments T2 and T3, reaching 123 cm and 115 cm respectively. Class cd is made up of millet plants from treatment T7, with an average height of 95.5 cm. Class d comprises millet plants from treatment T10, with an average height of 79 cm. The average height of the millet plants was 7.27 cm in the first week and 30.94 cm in the fourth week. This corresponds to 139.73 cm in the fourteenth week. In addition, the heights of millet plants in the TM control had the highest value in each week's ranking. Millet plant heights for the T1 treatment ranked second overall. Analysis of variance of millet plant heights shows no significant difference between the four blocks of experimental plots. As in the fourth week, the best growth was obtained on plots kept clean. *Leucas aspera* therefore slows millet plant

Effect of *Leucas aspera* plant density on millet yield

The results of the analysis of variance and Duncan's test at the 5% threshold on millet grain yield showed a highly significant difference with p = 0.01. In fact, two groups

of average yield were observed: groups a and b (Table 5). Group a shows the average yield of millet plants from the TM control. The grain weight obtained was 2375 kg/ha (Table VI).

Group b comprises the average millet yields of treatments T1 (81.87 kg/ha), T2 (54.75 kg/ha), T3 (31 kg/ha), T7 (21 kg/ha) and T10 (7.88 kg/ha). The difference in average millet yield between the control and the treatments is 1946.42 kg/ha. The difference in average millet yield between the control and T1 treatment is 2293.25 kg/ha, and between the control and T10 treatment is 2367.12 kg/ha. Yield was higher in the control plots without weeds. Yield decreased with increasing density of *Leucas aspera*.

Change in number of millet plants as a function of *Leucas aspera* density

Table 7 presents the results of the analysis of variance and Duncan's test at the 5% threshold carried out on the number of millet plants as a function of *Leucas aspera* density.

The analysis shows that the treatment effect is significant, with p-value = 0.0001. The number of millet plants in the TM control plots (49.50 plants/m²) was the highest. Plots T1 (38.50 plants/m²) and T2 (37.50 plants/m²) had approximately the same number of millet plants at harvest. Plots T10 (31 plants/m²) had the lowest number of millet plants at harvest.

The effect of *Leucas aspera* density on the height growth of maize plants is only noticeable after the third week. At this date, significant differences appear between the average height of millet plants in the non-weeded control plots and those of millet plants in the other plots.

These differences become increasingly significant as we approach the end of the crop cycle (harvest). During the first three weeks of cultivation, millet can tolerate competition from *Leucas aspera*. This is more noticeable above 2 *Leucas aspera* plants/m².

The tolerable critical threshold is therefore 3 weeks for a density of 2 to 4 plants/m2. In their studies, Rojas *et al.,* (1993) in Costa Rica and Bridgemohan *et al.,* (1992) in Trinidad showed that the critical interference period was between 45 and 60 days for densities of 66 to 74 plants/m² and 0 to 63 days for 55 plants of *Rottboellia cochinchinensis* after sowing. The difference observed could be due to the millet variety, the nature of the weed, climatic and ecological conditions, and the conduct of the experiment.

All in all, this work shows that *Leucas aspera* is harmful to millet. This observation is similar to that made by Burnside and Wicks (1969) in the United States and Olaya and Cardenas (1969) in Colombia, on sorghum plantations.

In sugarcane plantations in northern Côte d'Ivoire, Boraud and Kouassi (2005) defined threshold densities of a single *Amaranthussp.* plant per 2.5 m of row. These results show the variability of the nuisance threshold density depending on the crop and weed present.

Infestation by *Leucas aspera* plants leads to yellowing and eventual death of millet plants at densities greater than 2 plants/m² of *Leucas aspera*. Yield reductions in treatments T1 and T10 were 96.55% and 99.66% respectively. Rojas *et al.,* (1993) in Costa Rica and Bridgemohan *et al.,* (1992) in Trinidad obtained yield reductions of 46-54% and 50% respectively.

Our results on losses to millet production caused by *Leucas aspera* plants are also in line with those of numerous authors, notably Boraud and Aman (1998); Alex *et al.,* (2000) and Strahan *et al.,* (2000), who have also worked in agroecosystems weeded by weeds.

This study has enabled us to observe and understand the behaviour of *Leucas aspera* on the cultivation of the local millet variety “Guèreguera”. The effect of *Leucas aspera* pressure on millet plants can be seen in plant growth and development, as well as in production. The tolerable density can be estimated at less than 2 *Leucas aspera* plants/m². Beyond this critical value, we note that the interference of *Leucas aspera* plants on millet starts from the third week.

Leucas aspera plants slow down and often even stop the growth of millet plants. Even in low densities, *Leucas aspera* is harmful to millet crops. The infesting power of *Leucas aspera* is particularly note worthy in terms of millet yield losses. The average reduction in millet yield by *Leucas aspera* was 81.95%, with a minimum of 96.55% for treatment T1 and a maximum of 99.66% for treatment T10. For the purposes of this study, the local variety “Guèreguera”, which has a crop cycle of 98 days, was found to be sensitive to the damaging effect of *Leucas aspera*.

Table.1 Definition of treatment characteristics

Codes	Number of *Leucas aspera* plants around a pearl millet pocket	Density of *Leucas aspera* (number/m²)
TM	0	0
T1	1	8
T2	2	16
T3	3	24
T7	7	56
T10	10	80

Table.2 Comparison of average height of pearl millet plants at 7 days after sowing (DAS)

Treatments	TM	T1	T2	T3	T7	T10	Average	S .D	T. E
Average Height (cm)	7.35a	7.15a	7.14a	7.13a	7.36a	7.36a	7.25	1.75	N.S

a : average followed by the same letter in a given column, are not significantly different according to the Duncan test at 5 %; S.D. standard deviation; T.E. treatment effect ; N.s. not significant difference at probability 0.001.

Table.3 Comparison of average height of pearl millet plants at 28 days after sowing (DAS)

Treatments	TM	T1	T2	T3	T7	T10	Average	S .D	T. E
Average Height (cm)	67.00a	23.25b	17.87b	15.75c	32.00cd	27.00d	30.94	13.21	***

a.b.c : average followed by the same letter in a given column, are not significantly different according to the Duncan test at 5 %; S.D. standard deviation; T.E. treatment effect ; *** : highly significant difference at probability 0.001.

Table.4 Comparison of average height of pearl millet plants at 98 days after sowing (DAS)

Treatments	TM	T1	T2	T3	T7	T10	Average	S .D	T. E
Average Height (cm)	282a	143.37b	123.00bc	115.50bc	95.50cd	79.00d	139.73	53.01	***

a.b.c.cd.d : average followed by the same letter in a given column, are not significantly different according to the Duncan test at 5 %; S.D. standard deviation; T.E. treatment effect ; *** : highly significant difference at probability 0.001.

Table.5 Comparison of average weights of pearl millet with respect to treatments

Treatments	TM	T1	T2	T3	T7	T10	Average	S .D	T. E
Average Weight (Kg/ha)	0.95a	0.0327b	0.0219b	0.0124b	0.0084b	0.0031b	0.17	0.25	***

a.b.bc.c.d : average followed by the same letter in a given column, are not significantly different according to the Duncan test at 5 %; S.D. standard deviation; T.E. treatment effect ; *** : highly significant difference at probability 0.001.

Table.6 Change in the average weight of pearl millet with different treatments in Kg/ha

Treatments	TM	T1	T2	T3	T7	T10	Average	S .D	T. E
Average Weight (Kg/ha)	2375	81.87	54.75	31	21	7.88	428.58	648.80	***

a.b.bc.c.d : average followed by the same letter in a given column, are not significantly different according to the Duncan test at 5 %; S.D. standard deviation; T.E. treatment effect ; *** : highly significant difference at probability 0.001.

Table.7 Comparison of average numbers of millet plants in 98 DAS

Treatments	TM	T1	T2	T3	T7	T10	Average	S .D	T. E
Number of Millet plants	49.50a	25.00b	11.50C	4.75d	2.25de	0.50e	15.58	14.44	***

a.b.bc.cd.d : average followed by the same letter in a given column, are not significantly different according to the Duncan test at 5 %; S.D. standard deviation; T.E. treatment effect ; *** : highly significant difference at probability 0.001.

Figure.1 Location of the study in the Department of Illéla (MAG/EL, 2019)

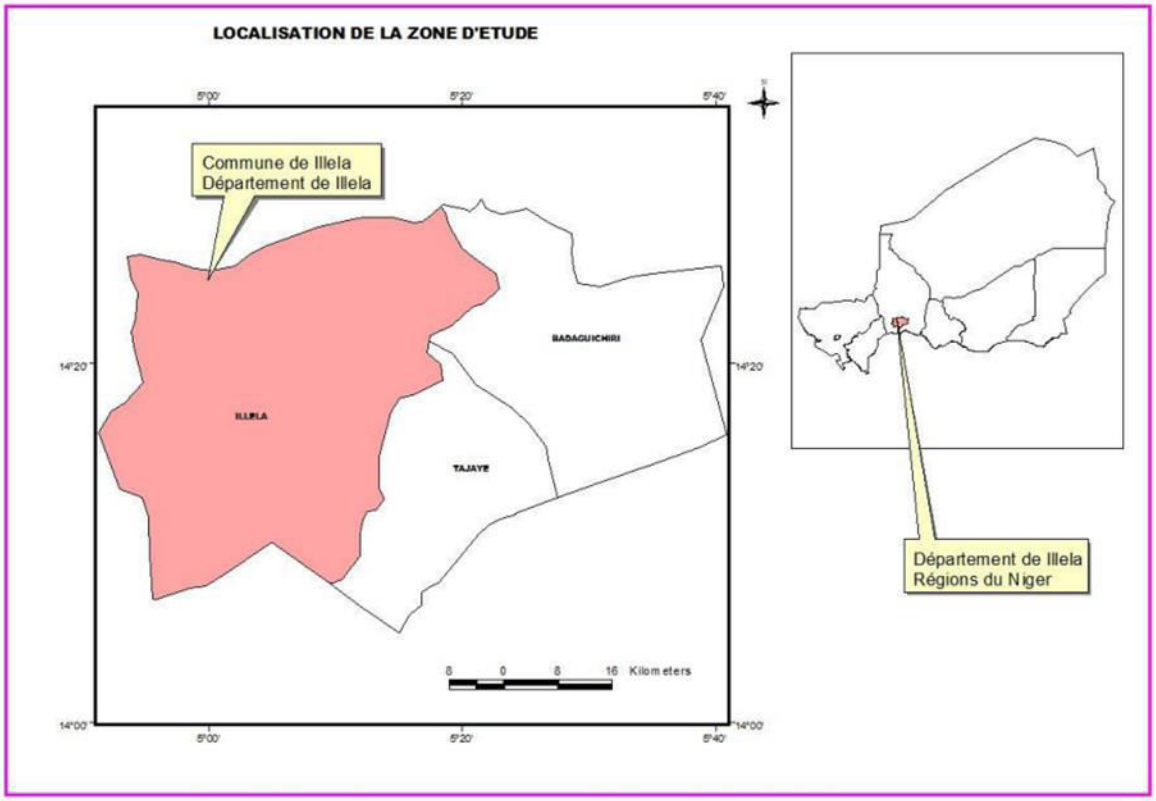
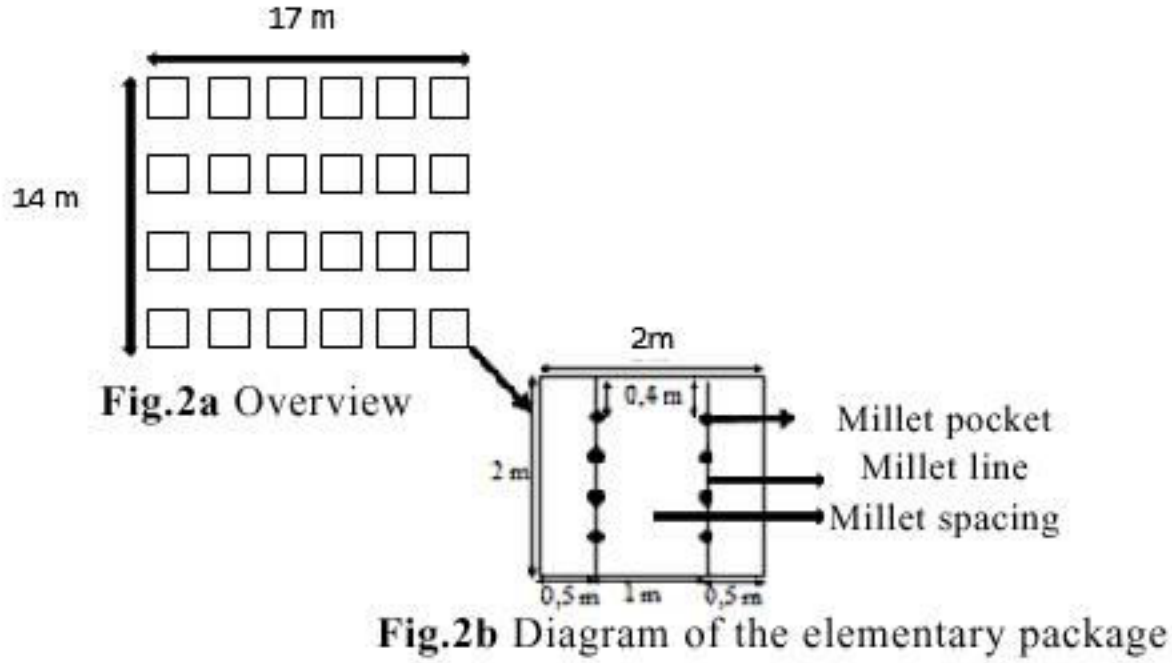


Figure.2 Experimental device set up



Recommendations

In view of this result, we would like to reinforce the management of *Leucas aspera* by using a technical itinerary for effective control of this weed. Management of *Leucas aspera* involves firstly avoiding contamination of young plots and then eliminating populations in fields that have already been grassed.

This involves studying certain points not covered in this work. For example, we need to (i) study the biology and ecology of *Leucas aspera* plants, (ii) evaluate the germination potential of *Leucas aspera* seedlings in field soils; (iii) compare the effect of *Leucas aspera* on other more selective varieties.

Author Contributions

Mahamane Adamou: Investigation, formal analysis, writing—original draft. Toudou Daouda Abdoul Karim: Validation, methodology, writing—reviewing. AdaMOU Ibrahim Maman Laowali:—Formal analysis, writing—review and editing. Abdourazak Alio Moussa: Investigation, writing—reviewing. Adamou Aboubacar Kolafane: Resources, investigation writing—reviewing. Douma Soumana: Validation, formal analysis, writing—reviewing. Inoussa Maman Maarouhi: Conceptualization, methodology, data curation, supervision, writing—reviewing the final version of the manuscript. Mahamane Ali: Investigation, formal analysis, writing—original draft. Bakasso Yacoubou: Validation, methodology, writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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