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Influence of *Cassia mimosoides* L. (Fabaceae) Density on Millet Yield [*Pennisetum glaucum* (L.) R. Br. (Poaceae)] in Eastern South East Niger

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Abstract

Large scale cereal farming faces many problems in the West African Sahel. One of the constraints to large-scale cereal production is competition from weeds. The problem of controlling weeds in millet fields is an obstacle to increasing the area sown. In addition to that, there is a scarcity of studies that looked at the impacts of ruderal weed such as legume ruderal weed on the yield of cereal like pearl millet which is of staple food in Niger. The present study, carried out in the Department of Illéla, located in the east-southeast of Niger, aims to determine the density of *Cassia mimosoides* that can influence millet production. Our experimental design was a randomized Fisher block with four replications. Each block comprises a control and five treatments. Our study focused on measuring certain production parameters, namely millet plant height and yield of millet plants. The tolerant density can be estimated at four *Cassia mimosoides* plants per square meter. A one factor analysis of variance (ANOVA) was used to compare the production obtained according to the type of treatment at $P \leq 0.05$. Beyond this critical value, the weed starts to interfere with the millet from the fifth week onwards (period of interference). The results showed the sensitivity of seedlings under the influence of *Cassia mimosoides* plants. The best yields were obtained in the control plots (2375 Kg/ha). Millet grain yield decreased with increasing *Cassia mimosoides* density. Plots with low *Cassia mimosoides* densities produced more millet (plots with 2 plants/m^2 of *Cassia mimosoides*: T1 = 1500 Kg/ha at $P \leq 0.05$) than those with high densities (plots with 20 plants/m^2 of *Cassia mimosoides*: T10 = 168.75 Kg/ha at $P \leq 0.05$). The difference in the average yield of pearl millet between the control and the treatment T1 is 875 kg/ha and that of the control and treatment T10 is 2206.25 kg/ha. The results showed that the cycle of reproduction of the local variety "Guèreguera" is 98 days (from July 12, 2023 to October 25, 2023). These findings of this study complete the efforts of developing weed control techniques in pearl millet fields densely populated with *Cassia mimosoides*.

Keywords

Influence, *Cassia mimosoides*, Yield, Millet, Niger

1. Introduction

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is the main cereal crop in the Sahel. This is because it is adapted to the difficult conditions of arid and semi-arid zones Soumaila [1]. Pearl millet provides the food base for some 200 million inhabitants of tropical arid and semi-arid zones Goudiaby *et al.* [2]. In Niger, millet constitutes the staple food of the mainly rural population and livestock Soumaila [1]. Moreover, pearl millet is grown on more than 65% of the sown area and accounts for 75% of the country's total cereal production Institute for Development Research [3]. Pearl millet is grown in all production zones in Soumaila [1].

Production is estimated at 2.147.000 tonnes for 6.140,000 hectares in 2021 FAO STAT [4]. Despite its recognized importance, millet cultivation is faced with climatic variations, pests and diseases, high input costs and a lack of expertise in cultivation techniques.

Among these difficulties, weediness is a major one. The presence of weeds exerts strong pressure on crop development Pageau *et al.* [5]. Weeds' competition with crops for water, light, nutrients and space could have a direct negative effect on yield Ipou Ipou [6].

In Niger, *Cassia mimosoides* is one of the major weeds of annual crops. This weed aggressively invades several crops, notably millet. It is difficult to control, and to date there are no effective control techniques available. To achieve food self-sufficiency for growing populations, it is essential to focus on the factors of good cereal production, including production techniques (Ipou Ipou [6], Mahamane [7]).

It is with this in mind that the present study was conducted in the Department of Illéla, located in the south-east of Niger. Despite the increase in cultivated areas, millet production is low due to the regular and accelerated decline in yields, one of the causes of which is believed to be weed pressure. Average estimates of cereal crop loss due to weeds are between 90% and 100% in some years (Chikoye *et al.* *[8]*; Mahamane [9]).

In the current context, where weed control is made difficult by the often costly and ineffective management of weeds, how can we achieve good weed control in millet crops in order to improve yields? This study, whose general objective is to evaluate the density of *Cassia mimosoides* plants that could influence the agronomic characteristics of the millet crop, aims to respond to this concern. The aim is to compare the influence of *Cassia mimosoides* plants on the height growth of millet plants and their impact on millet yield.

2. Study Methods

2.1. Study Area

This study was carried out in the Department of Illéla, one of the departments of the Tahoua region located in the east-southeast of Niger (**Figure 1**). The department covers an area of 6933 km^2 or 0.54% of the national territory of Dillo [10]. The population of the Illéla Department is estimated at 366704 (Institut National de Statistique du Niger [11]). It is an agro-pastoral zone with rainfall ranging from 300 to 600 mm Dillo [10]. The vegetative growth period varies between 75 and 100 days. Soils planted with millet are essentially dune soils, poor in organic matter, phosphorus and nitrogen. They are leached, very poorly structured and do not facilitate good water retention for crops (Médecins Du Monde [12]). Intercropping of pearl millet with cowpea constitutes the dominant farming system in the study area. Fallow land is tending to disappear. Farmers use almost no agricultural inputs Dillo [10].

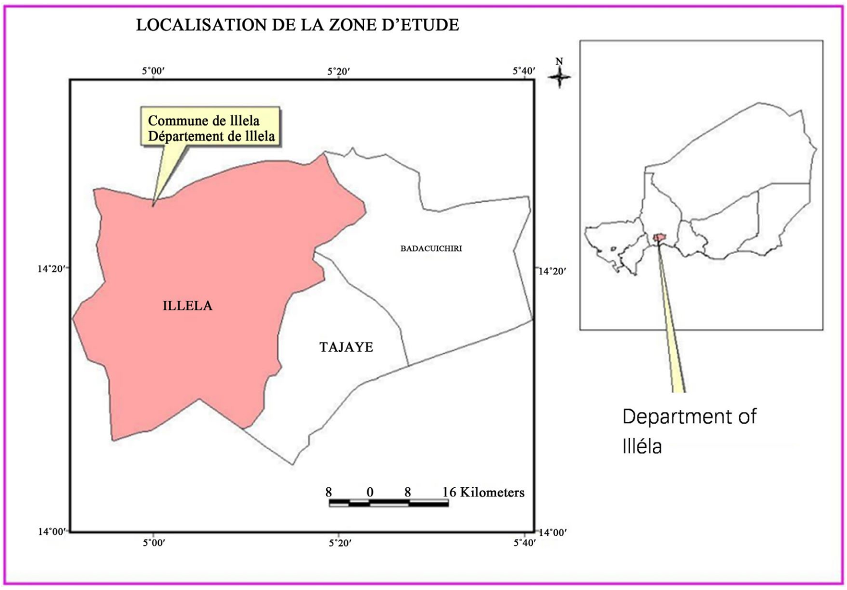

Figure 1. Map of study area (MAG/EL [13]).

2.2. Sampling Design and Choice of Study Site

The study site was chosen at the suggestion of the village farmers. They felt that the site was easy to explore thanks to the existence of a good road network.

2.3. Determination of *Cassia mimosoides*—Millet Competition

Several methods can be used to characterize competition between weeds and crops. These include the additive method, the series of alternative options, the systematic treatment method and others. The additive method is the most widely used in weed interference experiments. It involves maintaining a constant crop density and varying the weed density (Cousens [14]; Radosevich [15]; Olivier and Buchanan [16]). In this study, the treatment consisted of varying the density of *Cassia mimosoides* (0, 8 ... and 80) per plot. No fertilizer was applied to any of the plots. None of the plots were fertilized, in keeping with the growing conditions of pearl millet growers in the study area (few growers apply fertilizer here).

2.4. Experimental Design

The experimental design was a randomized Fisher block with four (4) replications (**Figure 2**).

Each block contains one (1) control and five (5) treatments (**Figure 2(a)**). The usable surface area is 238 m². The elementary plot covers an area of 4 m² (2 m × 2 m) and is composed of two (2) crop lines, one meter (1 m) apart. Each cultivation line is located 50 cm from the boundary of the elementary plot and comprises four (4) bunches 40 cm apart (**Figure 2(b)**). Each plot contains five (5) millet plants. The distance between plots within the same block is one meter (1 m), and two meters (2 m) between blocks. On each elementary plot, there are forty millet plants. The number of *Cassia mimosoides* plants varies from 8 to 80 (**Table 1**).

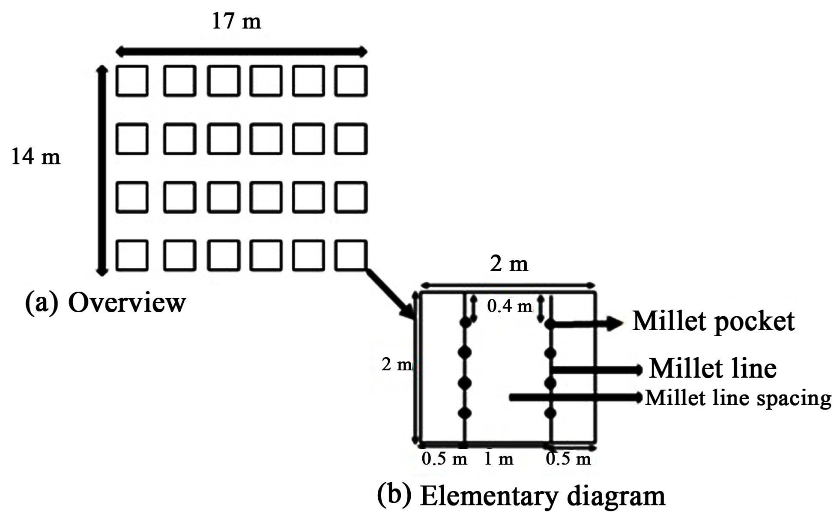

Figure 2. Experimental design.

Table 1. Number of plants of *Cassia mimosoides* within the basic parcels.

Treatments	TM	T1	T2	T3	T7	T10
Number of *Cassia mimosoides* plants	0	8	16	24	56	80
Densitities (plants/m²)	0	2	4	6	14	20

TM: Control parcel; Numbers 1; 2; 3; 7 and 10 assigned to *Cassia mimosoides* and representing, respectively, the numbers of plants of *Cassia mimosoides* around a pocket of pearl millet.

2.5. Test Conduct

Plowing of the elementary plots was carried out manually three (3) weeks after sowing. During the plowing of the treatment plots, we eliminated all weeds other than *Cassia mimosoides* sown around the millet holes. On the other hand, for the control plots we only retained the millet plants. Weeding is renewed every two (2) weeks until harvest.

Pearl millet and *Cassia mimosoides* seeds were sown on the same day (July 12, 2023 at 7:48 am) on the experimental plots. Millet ears were harvested on October 25, 2023 at 8:14 am.

2.6. Data Collection

The height growth and development of millet plants was monitored from sowing to harvesting of the millet ears. Parameters such as the height of millet plants, the number of branches of *Cassia mimosoides* and the grain yield of millet were taken into account. Thus, from the different densities of *Cassia mimosoides* plants, the average height of millet plants and the average plot dry weight were determined.

Pearl millet is generally more tolerant of variability, climate change and water stress. The study focused on the local millet variety "Guèreguéra". This variety is mainly cultivated by local populations. It is the staple food of the local population. This local variety of pearl millet is a subsistence crop. "Guèreguera" is cultivated by all farmers (there is no farmer without a field of millet in this locality).

Moreover, the study focused on *Cassia mimosoides* for the following reasons:

- it is cited by the local population as one of the major weeds of this terroir,
- it is one of the most harmful weeds in pearl millet cultivation,
- it often causes fields to be abandoned.

2.7. Statistical Analysis

Average millet plant height, number of branchings of *Cassia mimosoides* branches and average millet kernel weight were compared for each treatment studied as a function of the density of *Cassia mimosoides* plants around the millet patches. Results were analyzed using R software version 4.4.1.

A one-factor analysis of variance (ANOVA1) was used to compare the production obtained according to the type of treatment. To carry out the ANOVA, variances were first checked for normality and equality. When a significant difference was observed between treatments and the control, or between treatments, the ANOVA was completed by multiple comparisons using Duncan's test. This test allows us to rank the average heights or number of branches of *Cassia mimosoides* branches or the average weights as a function of *Cassia mimosoides* densities. The smallest significant difference between these parameters was set at $P \leq 0.05$.

3. Results

3.1. Effect of *Cassia mimosoides* on Height Growth of Millet Plants

Analysis of variance (ANOVA) and Duncan's test (5% threshold) of the average height of millet plants at the first week showed that there was no significant difference between the control and the different treatments, with p = 0.01. In fact, all the young millet plants (emergence stage) are almost the same height, with an average of 7.28 cm (Table 2).

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	7.30a	7.27a	7.27a	7.25a	7.22a	7.28	2.00	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.

On the other hand, analysis of millet plant heights at week 4 shows a highly significant difference between the control and the treatments. Millet plant performance is characterized by three classes of average millet plant height. This analysis revealed that the three classes are: **a, b** and **c**. Class **a** is characterized by millet plants from the TM control measuring 67 cm in height. Class **b** includes millet plants from treatment T1, with an average height of 54.12 cm. Finally, class **c** contains millet plants from treatments T2, T3, T7 and T10. The corresponding mean heights are 38 cm, 32 cm and 27 cm (Table 3).

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	54.12b	38.00c	32.00c	29.00c	27.00c	41.19	13.72	***

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.

An analysis of millet plant heights at week 14 revealed five groups of average plant heights: **a, b, c, 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 heights of millet plants from treatment T1, with an average height of 173 cm. Class **c** comprises the heights of millet plants from treatment T2, averaging 96 cm.

Class **cd** is made up of millet plants from treatments T3 and T7, averaging 87cm and 82cm respectively. Class **d** comprises millet plants from treatment T10. The average height of millet plants is 66 cm. The average height of the millet plants was 7.28 cm in the first week and 41.18 cm in the fourth week. This corresponds to 131 cm in week 14. In addition, the millet plant heights of the TM control had the highest value in each week's ranking. T1 treatment millet plant heights were second highest overall. The heights of millet plants from treatments T2, T3, T7 and T10 form the same category (**c**) at week 4. This category is subdivided into three classes (**c, cd** and **d**) at week 14. Analysis of variance of millet plant heights shows no significant difference between the four blocks of experimental plots (Table 4).

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	173b	96c	87cd	82cd	66d	131.00	66.33	***

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.

3.2. Trend in Branch Density of *Cassia mimosoides* Branches

Table 5 shows the results of the analysis of variance and Duncan's test at the 5% threshold for the mean number of branches produced by *Cassia mimosoides* branches . The analysis shows that the treatment effect is highly significant, with p = 0.01. Branch production of *Cassia mimosoides* plants in plots T2, T3, T7 and T10 showed a decrease compared with branch production of *Cassia mimosoides* plants in plot T1. We distinguish four homogeneous categories of branch multiplication in *Cassia mimosoides*: categories **a**, **b**, **c** and **d**. Category **a** includes the average number of branches on *Cassia mimosoides* plants in plot T1, which is 143.50 branches/m^2. Category **b** refers to the average number of branches on *Cassia mimosoides* plants in treatment T2, corresponding to 110.25 branches/m^2. Class **c refers** to the average number of branches on *Cassia mimosoides* plants in treatments T3 and T7, corresponding to 72.50 branches/m^2 and 60.75 branches/m^2 respectively. Finally, class **d** represents the average number of branches on *Cassia mimosoides* plants in treatment T10, with 31.25 branches/m^2. The number of branches produced decreases from T1 to T10 (Table 5).

Table 5. Comparison numbers of branches of plants of *C. mimosoides*.

Treatments	T1	T2	T3	T7	T10	Average	S .D	T. E
Number of branches of *Cassia mimosoides*	143a	110.25b	72.50c	60.75c	31.25d	83.65	15.74	***

a.b.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.

3.3. Effect of *Cassia mimosoides* Density on Millet Yield

The analysis of variance (ANOVA) and Duncan test performed on the weight of harvested maize showed a highly significant difference (p = 0.001). This analysis revealed that the five groups yield were: a, b, bc, c and d (Table 6). Group **d** includes the performance of pearl millet plants from the treatments of high density of *Cassia mimosoides* per experimental plot (T10). This group shows the average value in the lowest (168.75 kg/ha) corn. Yield of group «c» is represented by density T 7 with an average weight of 1000 kg/ha.

Yields of groups **b** and **bc** contain treatments with weak densities of *Cassia mimosoides* which are, respectively, T1 with an average weight of 1500 kg/ha, T2 with 1225 kg/ha and T3 with 1125 kg/ha. Statistical analysis revealed no significant differences between the yields of the group "bc", that is to say, the T2 treatment with an average weight of pearl millet of 1225 kg/ha and T3 with an average of 1125 kg/ha. Indeed, the average yield in dry pearl millet-grain per hectare is higher in the control representing the group "a" with 2375 kg/ha.

The average weight of the grains of pearl millet of 5 treatments is 1003.75 Kg/ha. The difference in the average yield of pearl millet between the control and the treatment is 1371.25 kg/ha. The difference in the average yield of pearl millet between the control and the treatment T1 is 875 kg/ha and that of the control and treatment T10 is 2206.25 kg/ha. **Table 7** summarizes the results with respect to the performance.

Table 6. 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	0.6b	0.49bc	0.45bc	0.4c	0.06d	0.49	0.20	***

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. 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	1500	1225	1125	1000	168.75	1232.29	501.04	***

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.

3.4. Change in Number of Millet Plants as a Function of *Cassia mimosoides* Density

Table 8 presents the results of the analysis of variance and Duncan's test at the 5% threshold, on the number of millet plants as a function of the weeding period. The analysis shows that the treatment effect is significant, with *p-value* = 0.023. The number of millet plants in the TM control plots (49.50 plants/m^2) was the highest. Plots T1 (38.50 plants/m^2) and T2 (37.50 plants/m^2) had approximately the same number of millet plants at harvest. Plots T10 (31 plants/m^2) had the lowest number of millet plants at harvest (**Table 8**).

Table 8. 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	38.50b	37.50b	36.25bc	34.25cd	31.00d	37.87	4.12	***

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.

4. Discussion

The study of the effect of *Cassia mimosoides* on the height growth of millet plants revealed that there was no significant difference between the control and the treatments in the first week. The effect of *Cassia mimosoides* densities was therefore not sufficient to hinder the height growth of millet plants, but was tolerable. These results are in line with those achieved by Mahamane [7], who showed that maize plants, despite the influence of *Rottboellia cochinchinensis* densities, measured the same height in the first week of cultivation.

However, from the fifth week onwards, significant differences appeared between the heights of millet plants in the control and treatment treatments. These differences remained significant until harvest. This shows that the local Guèreguéra variety used can tolerate the effect of *Cassia mimosoides* plant density during the first five weeks of cultivation, at a density of around four (4) plants/m^2 (treatment T2). Beyond this threshold density, millet plants become vulnerable to competition from *Cassia mimosoides* plants. This explains why weed density has a significant influence on crop damage. Furthermore, in the work of Mahamane [7], the threshold density is 4 plants/m^2 of *Rottboellia cochinchinensis*. This means that the nuisance density varies according to the crop and weed present.

A study of the evolution of millet plant heights over time indicates that low-density *Cassia mimosoides* plants establish competition for a short period and have little effect on millet height growth and yield. However, the slowdown in height growth and reduction in yield increases when *Cassia mimosoides* plants with a large number of branch branches are allowed to compete for longer.

These results are similar to those of Mahamane [7] and Kouakou [17], who showed that the effect of weed density depends strongly on the length of time spent in the fields. This reveals that the depressive effect of *Cassia mimosoides* also affects the speed of height growth of millet plants.

The infestation of *Cassia mimosoides* on the local Guèreguéra variety had a greater impact on yield, with the weight of the control far exceeding that of the treatments. In fact, the greater the density of *Cassia mimosoides*, the lower the yield. *Cassia mimosoides* infestation leads to yellowing and death of millet plants at densities greater than four (4) plants/m^2.

This is in line with the study of Mahamane [7] conducted on the observations on *Rottboellia cochinchinensis* infestation in maize crops in central-eastern Côte d'Ivoire and those of Dugje *et al.* [18] in cowpea production in West Africa. Losses to millet production caused by *Cassia mimosoides* plants were 36.84% for treatment T1 and 92.89% for treatment T10. This is in line with observations by Mahamane [7] showing 44.41 % for the treatment of one (1) plant of *Rottboellia cochinchinensis* per millet bunch and 89.28 % for the treatment of ten (10) plants of *Rottboellia cochinchinensis* per millet bunch in plots infested by this weed.

The low millet yield obtained in our study is also due to the month-long interruption of rainfall and to attacks by animal pests (worms, insects and birds) and fungi.

5. Conclusions

This study has enabled us to observe and understand the behaviour of *Cassia mimosoides* in the cultivation of the local variety (Guèreguéra) of millet.

However, competition from *Cassia mimosoides* plants on millet plants is tolerant for the first four weeks, with a nuisance threshold of 4 plants/m^2. Beyond this critical value, *Cassia mimosoides* causes millet plants to slow down or even stop growing. Even in low densities, *Cassia mimosoides* are undesirable for millet crops.

Our results therefore confirm that weeds are one of the main constraints affecting agricultural food production worldwide, and particularly in developing countries.

The infesting power of *Cassia mimosoides* is especially edifying in terms of millet yield losses, where we obtained an average of 48.11% production loss compared with the clean control. The cycle of reproduction of the local variety «Guèreguera» is 98 days (from July 12, 2023 to October 25, 2023).

For the purposes of this study, we note that the local variety (Guèreguéra) used is sensitive to the competitive effect exerted by *Cassia mimosoides*. This weed has the power to invade, enabling it to conquer space and establish itself as a repressive weed in millet crops.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Soumaila, S.I. (2024) Amélioration de la tolerance au stress hydrique du mil [*Pennisetum glaucum* (L.) R. Br] au Niger: Effet de l'application foliaire du bore. Thèse de doctorat unique, Université Abdou Moumouni de Niamey, Niger.

[2] Goudiaby, M.F., Sarr, I. and Sembène, M. (2018) Source of Resistance in Pearl Millet Varieties against Stemborers and the Ear Head Miner. *Journal of Entomology and Zoology Studies*, **6**, 1702-1708.

[3] Institute for Development Research (2009) Le mil, Aliment du futur au Sahel. Fiche N°325, Juillet 2009, p. 2. https://www.inter-reseaux.org/ressource/le-mil-aliment-du-futur-au-sahel/#:~:text=Le%20mil%20est%20la%20base,et%20aux%20habitudes%20alimentaires%20traditionnelles

[4] FAO STAT (2022) Données de l'alimentation et de l'agriculture.

[5] Pageau, D., Lajeunesse, J. and Lafond, J. (2006) Influence de la densité de semis sur la productivité du pois sec cultivé sous un climat frais. *Canadian Journal of Plant Science*, **87**, 41-48. https://doi.org/10.4141/P06-057

[6] Ipou Ipou, J. (2005) Biologie et écologie de *Euphorbia heterophylla* L. (Euphorbiaceae) en culture cotonnière, Au nord de la Côte d'Ivoire. Ph.D Thesis, Cocody University.

[7] Mahamane, A. (2013) Influence de la densité de *Rottboellia cochinchinensis* (Loureiro) W. Clayton (Poaceae) sur le rendement de *Zea mays* L. (Poaceae) dans le Département de M'Bahiakro (Centre-Est de la Côte d'Ivoire). DEA Thesis from Cocody University, 51.

[8] Chikoye, D., Manyong, V.M. and Ekeleme, F. (2000) Characteristics of Speargrass (*Imperta cylindrica*) Dominated Fields in West Africa: Crops, Soil Properties, Famer Perceptions and Management Strategies. *Crop Protection*, **19**, 481-487. https://doi.org/10.1016/S0261-2194(00)00044-2

[9] Mahamane, A. (2018) Gestion des mauvaises majeures en cultures vivrières et evaluation de l'efficacité biologique de quelques methods de désherbage en culture de maïs (*Zea mays* L. Poaceae) dans la Région du Iffou (Centre-Est de la Côte d'Ivoire). Ph.D Thesis, Cocody University, 180.

[10] Dillo, S. (2020) A la découverte d'Illéla (Tarihi). Edition L'Harmattan, 322.

[11] Institut National de Statistique du Niger (2011) Recensement general de la population. 23. https://www.stat-niger.org/?page_id=500

[12] Du Monde, M. (2014) Evaluation de la couverture et de l'accessibilite du programme de nutrition de medecins du monde (MDM) dans le district sanitaire d'illela département d'illela, Région de Tahoua, Niger, 56. https://www.coverage-monitoring.org/wp-content/uploads/2015/03/Rapport-SQUEAC-MDM_Niger_Illela-2014.pdf

[13] MAG/EL (2019) Rapport d'Etude d'impact Environnemental et Social du Sous-Projet Intégré Communal pour une Agriculture Intelligente face au Climat (SPIC-AIC) d'Illéla. 101. https://documents1.worldbank.org/curated/fr/154071562822631154/pdf/Rapport-d-Etude-d-Impact-Environnemental-et-Social-pour-Ill%C3%A9la.pdf

[14] Cousens, R. (1991) Aspects of the Design and Interpretation of Competition (Interference) Experiments. *Weed Technology*, **5**, 664-673. https://doi.org/10.1017/S0890037X00027524

[15] Radosevich, S. (1987) Methods to Study Interactions among Crops and Weed. *Weed Technology*, **1**, 190-198. https://doi.org/10.1017/S0890037X00029523

[16] Oliver, R. and Buchanan, G. (1986) Weed Compétition and Economic Threshold. In: Camper, N.D., Ed., *Research Methods in Weed Science*, Southern Weed Science Society, 71-97.

[17] Kouakou, N.J. (2017) Importance relative des mauvaises herbes de la culture du maïs; impact de *Rottboellia cochinchinensis* (Loureiro) W. Clayton (Poaceae) sur la production du maïs (*Zea mays* L.) à M'Bahiakro au Centre-Est de la Côte d'Ivoire. Ph.D Thesis, Cocody University, 167.

[18] Dugje, I., *et al.* (2009) IITA, Ibadan, Nigeria. https://www.feedipedia.org/node/21139