International Journal of
Agriculture
(IJA)

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International Journal of Agriculture

ISSN 2520-4629X (Online)
Vol.8, Issue 2, No. 5. PP. 80 - 92, 2023

www.iprjb.org

Effects of Zai on Cowpea Productivity (*Vigna unguiculata* (L.) Walp.) in a Peasant Environment Agrosystem in Digargo in Diffa's Urban District

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Article History

Received 10th September 2023
Received in Revised Form 22nd September 2023
Accepted 6th October 2023

How to cite in APA format:
Rabo, Y., Abba , G., & Mahamane, A. (2023). Effects of Zai on Cowpea Productivity (Vigna unguiculata (L.) Walp.) in a Peasant Environment Agrosystem in Digargo in Diffa's Urban District. *International Journal of Agriculture*, *8*(2), 80–92. https://doi.org/10.47604/ija.2136

Abstract

Purpose: Cowpea (Vigna unguiculata (L.) Walp.) is one of the most widely cultivated food crops in Niger, but Niger's agriculture remains dependent on agro-climatic and edaphic conditions. The main objective of this study is to evaluate the combined effect of zai and the number of plants per crop on cowpea growth and yield parameters.

Methodology: Two (2) factors were studied: the zaï's factor (A) and the number of plants per crop factor (B). The experimental design used is a total randomization device with three (3) repetitions.

Findings: The results showed that the A2B2 treatment is characterized by the variables, good yield of pods, seeds, biomass and dry matter. A2B2 treatment had the best grain yield compared to A2B1. The average grain yield ranges from 173.3±68.1 to 1250±720 (kg/ha). However, there is no significant difference between the different treatments on the parameter of biomass.

Unique Contribution to Theory, Practice and Policy*:* In this study, the best performance is obtained with two (2) plants per crop without zai techniques.

Keywords: *Cowpea, Zai, Number of Plants, Effect and Digargo*

INTRODUCTION

In Niger, like all Sahelian countries, the desertification process is characterized by severe degradation of land and vegetation, mainly due to climatic variations and human activities (CNEDD, 2009). Agriculture is the most important sector of Niger's economy, but in recent decades, it has been exposed to climatic risks, particularly those that are due to natural resources (soil, water, vegetation) and related to degradation. As a result, agricultural lands are becoming poorer and pastoral lands increasingly degraded. Tillage becomes more difficult as a result of structural degradation.

The sustainable management of the environment and the development of the different landscape units have been based on techniques called CES-water and soil conservation and DRS-soil defense and restoration. The realization of the works of the CES / DRS will allow a better control of the flows of water both at the level of the rivers and at the level of run off. Watershed rehabilitation work will not only significantly reduce erosion phenomena, but also allow a gradual recovery and revegetation of degraded land and a decrease in the silting of courses and ponds (Sabine and Dieter, 2012). Agriculture and food security are largely dependent on surface water and sediments, collected and transported by watershed slopes. SEC/SRD measures are an effective way to better manage water and reduce soil degradation, vegetation and biodiversity by increasing and stabilizing agricultural, forestry and forage yields (Sabine and Dieter, 2012). However, there is a growing decline in the productive capacity of the earth's resource (OCHA, 2014). Under these conditions, a number of technical, economic and social adaptation strategies have been developed (Mortimore and Adams, 2001). Among the strategies adopted are the works of CES/DRS including the zai technique. Thus, numerous research studies contribute to show the effects of these CES/DRS techniques (Ibrahim and Nomao, 2004; Ganaba, 2005; Abdoulaye and Ibro, 2006; Da, 2008; Dabré et al., 2017; Nyamekye et al., 2018; Coulibaly et al., 2022).

In addition, the benefits of zai relate mainly to the capture of runoff water, the preservation of seeds and organic manure, the concentration of fertility and available water at the beginning of the rainy season (early planting) and at the end of the season (Roose et al., 1995). The zai technique improves the yields of certain crops including millet, cowpea and sorghum, as several authors point out (Roose et al., 1995; Mare, 2009; Bayen et al., 2012). In order to find solutions that can be adopted by producers (Sawadogo, 2001), we have chosen to study the response of the zai technique to cowpea. It is a particular form of growing crops by concentrating on runoff and organic matter in a micro pond (Roose, 2004; Roose et al., 1993; Bayen et al., 2012). This study is part of agroecological soil management This study is part of agroecological soil management. The general objective of this study is therefore to evaluate the effects of zai on the productivity of cowpea (Vigna unguiculata) in an agrosystem in a paysan environment in Digargo in the urban commune of Diffa.

MATERIAL AND METHODS

Study Site

This study was conducted in the region of Diffa, in Niger, and more precisely on the site of Digargo which is a village located about five (5) kilometers in the northwest of Diffa and two (2) kilometers from Awaridi in the district of Diffa. It covers an area of 26 km^2: Its geographical location is 13°21'56" north latitude and 12°34'58" east longitude (Figure 1).

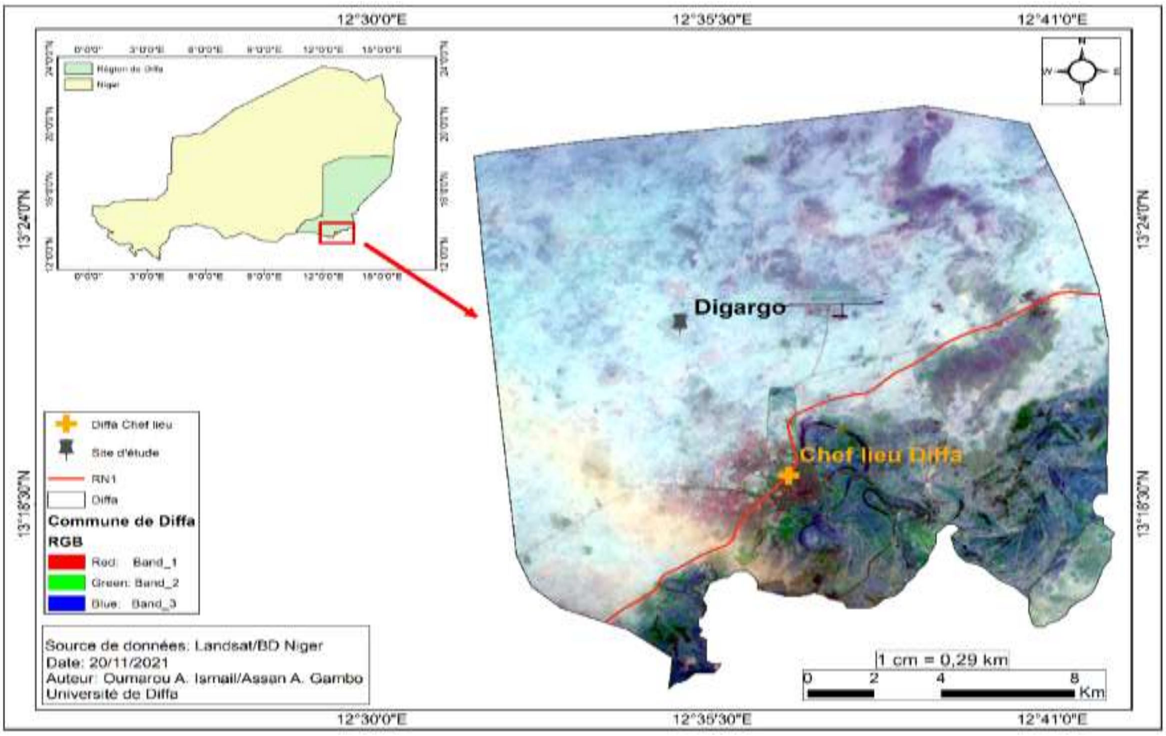

Figure 2: Site Location Map

The Municipality of Diffa is located between isohyets 200 and 300 mm and the very capricious rainfall conditions, the socio-economic activities. Agronomically, there are three (3) agro-climatic zones (Figure 2):

- The southern band favorable to rain fed and irrigated crops (rainfall of 200 to 300mm/year);
- The agro-pastoral zone favorable to dune crops and livestock (rainfall around 200mm / year) and;
- The far north mainly pastoral (rainfall less than 200mm/year).

The Sahelian climate is characterized by a long dry season (October-June) subdivided into two (2) periods: the first (October-February) displays low temperatures with absolute minima of 6 ° to 25 ° C, favorable to off-season crops; the second (March-June) records high temperatures between 33 ° and 46 ° C; and a short rainy season (July-September).

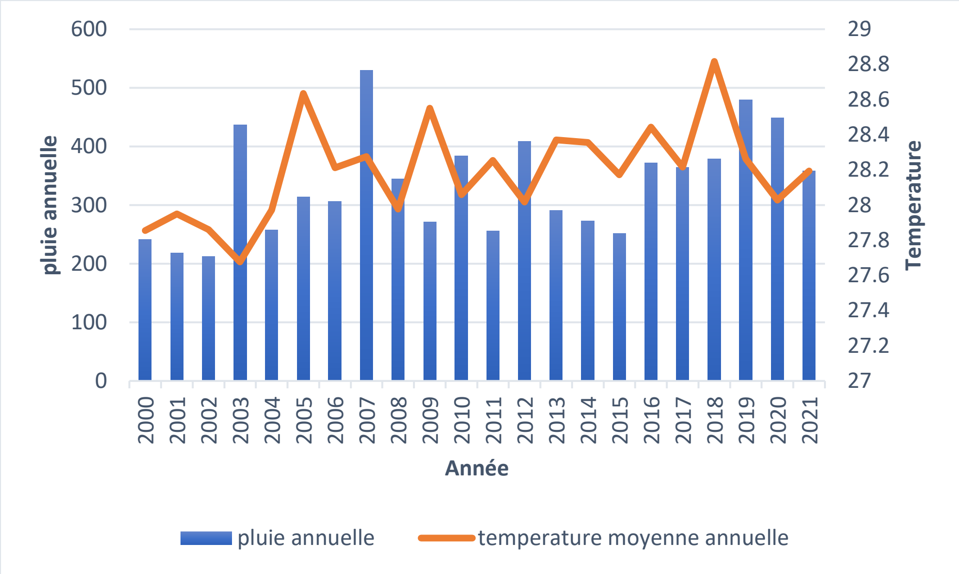

Figure 2: Ombrothermic Curve of the Meteorological Data from the Diffa Weather Station

Experimental Device

As part of this study, two (2) factors are studied: the work factor (A) and the number of plants per crop factor (B).

Thus, factor A consists of two (2) levels:

- Level 1 (A1): cowpea is sown on soil treated with zai;
- Level 2 (A2): cowpea is sown on untreated zai soil (control);

Factor B consists of three (3) levels:

- Level 1 (B1): one (1) plant per crop;
- Level 2 (B2): two (2) plants per crop;
- Level 3 (B3): three (3) plants per crop;

Each level of the first factor was combined with each of the levels of the second factor giving 2*3 = 6 treatments. The experimental design is a total randomization device with four (3) repeats with 3*6=18 experimental units. Each experimental unit had dimensions of 3m*3m. Figure 3 illustrates the plan of the device:

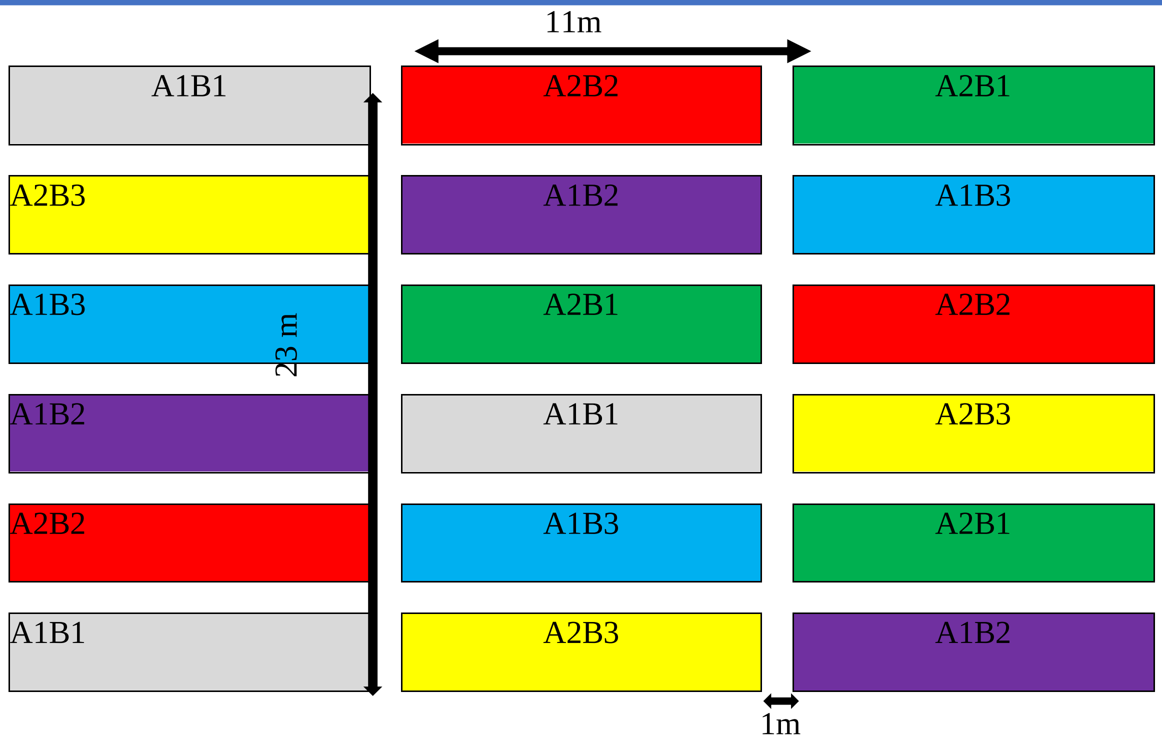

Figure 3: Test Design for Cowpea

Legend:

- A1B1: cowpea is sown on soil treated with zai with one (1) plant per pocket

- A1B2: cowpea is sown on zai-treated soil with two (2) plants per crop;

- A1B3: cowpea is sown on soil treated with zai with three (3) plants per crop;

- A2B1: cowpea is sown on untreated zai soil (control) with one (1) plant per crop;

- A2B2: cowpea is sown on untreated zai soil (control) with two (2) plants per crop;

- A2B3: cowpea is sown on untreated zai soil (control) with three (3) plants per crop.

Crop Monitoring

The device was set up on July 11, 2021 and has benefited from two weedings. The first weeding was carried out 25 days after sowing followed by demarriage at 1, 2 and 3 plants per crop. The duration of crop management was 97 JAS. Weekly harvesting was done by hand for pods four times in a row, the first of which took place on September 25 and the last on October 16, 2021 and biomass using a hoe on October 16, 2021.

Cowpea Parameters

The variety used is TN-85. So, the following parameters were studied:

- The length of the leaves;
- The width of the sheets;
- The length of the pods;
- The diameter of the pods;
- The number of grains per pod;

- The amount of biomass produced;
- The yield in pods;
- The number of pod
- Seed yield;
- The weight of the hundred grains.

Data Collection

Data were collected every three (3) days according to protocol. In order to avoid the border effect, observations were made on the four (4) crops contained in the squares obtained from the competition point of the two (2) diagonals of each experimental unit. Observations were regularly made on the growth parameters of each study. At harvest, the pod and grain yields of each unit were evaluated using a CAMRY electronic scale. The amount of biomass was also assessed.

Data Analysis and Processing

Excel and Minitab 18 software were used for statistical processing. The data were submitted to the Shapiro-Wilks and Levens tests to verify the normality and homogeneity of variances respectively before submitting them to analysis of variance (ANOVA). A Principal Component Analysis (PCA) was performed to find a link between the treatments and the parameters studied.

RESULTS AND DISCUSSION

Results

Effect of Treatments on Cowpea Leaf Length

Analysis of variance shows that there is no statistically significant difference between treatments at the 5% threshold ($p = 0.448$) (Table 1). Average length of cowpea leaves depending on the treatments varies from 6.75±2.016 to 8.208±2.96 cm.

Effect of Treatments on Cowpea Leaf Width

The average width of cowpea leaves according to treatments is given in Table 1. The analysis of this table shows that there is no significant difference between treatments at the 5% threshold ($p = 0.533$). The average width of cowpea leaves ranges from 4.267±1.23 to 5.058±1.68 cm.

Effect of Cowpea Pod Length Treatments

The average pod length as a function of treatment is given in Table 1. It appears from the analysis of this table that there is no significant difference ($p = 0.289$) between treatments at the 5% threshold. The average length of cowpea pods ranges from 11.88±1.169 to 13.02±0.728 cm.

Effect of Treatments on Cowpea Pod Diameter

The average pod width as a function of treatment is given in Table 18. It appears from the analysis of this table that there is no significant difference ($p = 0.302$) between treatments at the 5% threshold. The average width of cowpea pods ranges from 0.700±0.026 to 0.748±098 cm.

Effect of Treatments on Cowpea Pod Yield

The average yield of cowpea pods by treatment is shown in Table 1. Analysis of this table shows that there is a statistically significant difference between treatments at the 5% threshold (p=0.036). Thus, the A2B2 treatment had the best yield in cowpea pods unlike A2B1.

The average pod yield of cowpeas ranges from 223.3±87 to 1557±860 (kg/ha).

Effect of Treatments on Seed Yield

Table 1 shows that there is a statistically significant difference between treatments at the 5% threshold (P = 0.041). Analysis of this table shows that A2B2 treatment had the best grain yield compared to A2B1. The average grain yield ranges from 173.3±68.1 to 1250±720 (kg/ha).

Effect of Treatments on the Weight of a Hundred Grains

Analysis of variance shows that there is no statistically significant difference between treatments at the 5% level (p=0.245) (Table 1). The average weight of the hundred grains varies from 136.67±28 to 170 (kg/ha).

Effect of Treatments on Grain Filling

The average number of grains per pod is shown in Table 1. The analysis of this table shows that there is no significant difference between treatments at the 5% threshold (p=0.762). The average number of grains per pod ranges from 10±1.888 to 10.8±1.08.

Effect of Treatments on Cowpea Biomass

Analysis of variance (Table 1) shows that there is no significant difference (p=0.362) between treatments at the 5% threshold. The average cowpea biomass ranges from 667±280 to 1400±280 kg/ha, with an average yield of 1094.5±266.86 kg/ha.

Effect of Treatments on Pod Count

The average number of pods per m^2 according to treatments is given in Table 1. The table analysis shows that there is a statistically significant difference between treatments at the 5% threshold (p = 0.023). Thus, the A2B2 treatment had the best average number of pods as opposed to the A2B1 treatment.

The average number of pods per m2 ranges from 24.67±15.18 to 128±12.50.

Table 1: Effect of Treatments on Cowpea Growth Parameters and Yield

Treatment	Leaf length(cm)	Leaf width(cm)	Pod length (cm)	Biomass (kg/ha)	Pod diameter (cm)	Pod count/m²	Number of grains per pod	Pod yield (kg/ha)	Grain yield(gk/ha)	Weight of hundred grains
A1B1	6,95±1,48^{a}	4,333±0,93^{a}	12,47±1,46^{a}	1333±350^{a}	0,719±0,040^{a}	89,67±12,5^{ab}	10,5±1,03^{a}	1070±65^{ab}	853,3±57,7^{ab}	170±0^{a}
A1B2	7,267±1,76^{a}	5±1,128^{a}	11,88±1,169^{a}	1167±500^{a}	0,754±0,048^{a}	78,3±54,8^{ab}	10,5±0,94^{a}	867±640^{ab}	687±506^{ab}	163,33±5,7^{a}
A1B3	7,825±1,868^{a}	4,908±1,52^{a}	13,02±0,728^{a}	1000±700^{a}	0,732±0,047^{a}	101±23,5^{ab}	10±1,888^{a}	1230±430^{ab}	963±359^{ab}	156 ;7±20^{a}
A2B1	7,1±1,258^{a}	4,617±1,199^{a}	12,31±1,25^{a}	1000±1,7E-13^{a}	0,716±0,031^{a}	24,67±15,18^{b}	10,8±1,08^{a}	223,3±87^{b}	173,3±68,1^{b}	136,67±28^{a}
A2B2	6,75±2,016^{a}	4,267±1,23^{a}	12,7±0,81^{a}	1400±280^{a}	0,748±0,098^{a}	128±52,50^{a}	10,4±1,17^{a}	1557±860^{a}	1250±720^{a}	153,33±15^{a}
A2B3	8,208±2,96^{a}	5,058±1,68^{a}	12,15±1,19^{a}	667±280^{a}	0,700±0,026^{a}	39±7^{ab}	10,7±0,97^{a}	373,3±66^{ab}	283,3±70,2^{ab}	143,3±15^{a}
P-value	0,448	0,533	0,289	0,362	0,302	0,023	0,762	0,036	0,041	0,245

Averages not sharing any letters are significantly different.

Legend: *A1B1: cowpea is sown on soil treated with zai with one (1) plant per crop ; A1B2: cowpea is sown on zai-treated soil with two (2) plants per crop ; A1B3: cowpea is sown on zai-treated soil with three (3) plants per crop ; A2B1: cowpea is sown on untreated zai soil (control) with one (1) plant per crop ; A2B2: cowpea is sown on untreated zai soil (control) with two (2) plants per crop ; A2B3: cowpea is sown on untreated zai soil (control) with three (3) plants per crop .*

Principal Component Analysis

The two (02) axes concentrate more than 80% of the inertia. That is enough to interpret the data. The analysis of Table 2 shows that on the one hand, the variables Pod yield, Seed yield, Biomass and Dry matter are positively correlated to axis 1 and on the other hand, the variables Leaf length, Leaf diameter and Pod length are negatively correlated to axis 2. On the other hand, Biomass and Number of seeds per pod are positively correlated to axis 2. In addition, the analysis of Figures 4 and 5 shows that the treatment A2B3 and to a measure A2B1 are negatively correlated to axis 1. They are,, therefore, characterized by a low yield of pods, seeds, biomass and dry matter. On the other hand, A2B2 treatment is positively correlated to the same axis. It was, therefore characterized by the variables (a good yield of pods, grains, biomass and dry matter). The A1B3 treatment, on the other hand, is negatively correlated with axis 2. The parameters that characterize it are, therefore, long leaves with large diameter, long pods, low biomass yield and few grains per pod.

International Journal of Agriculture
ISSN 2520-4629X (Online)
Vol.8, Issue 2, No. 5. PP. 80 - 92, 2023
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Table 2: Results of Principal Component Analysis of Cowpea Parameters

Variable	PC1	PC2
Leaf length	-0,246	-0,544
Leaf diameter	-0,246	-0,426
Pod length	0,224	-0,32
Pod diameter	0,294	0,051
Pod yield	0,394	-0,137
Seed yield	0,395	-0,123
Weight of one hundred seeds	0,278	-0,036
Biomass	0,353	0,341
Number of pods	0,392	-0,135
Number of seeds per pod	-0,275	0,497

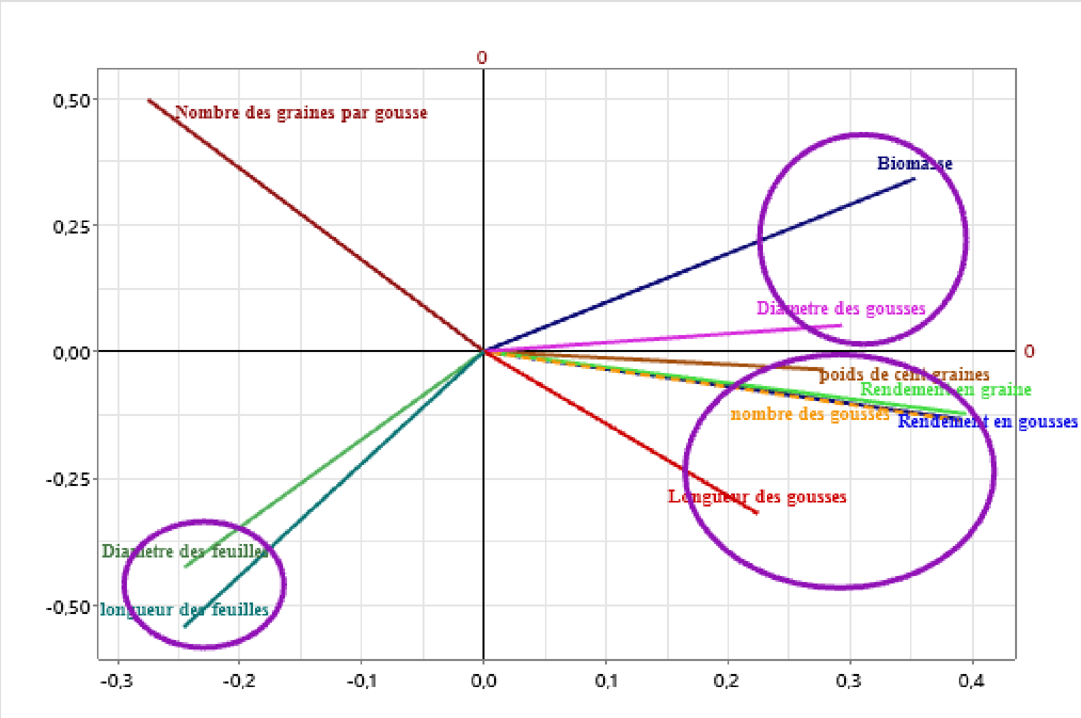

Figure 4: Effect of Cowpea Parameters Subjected to a Principal Component Analysis

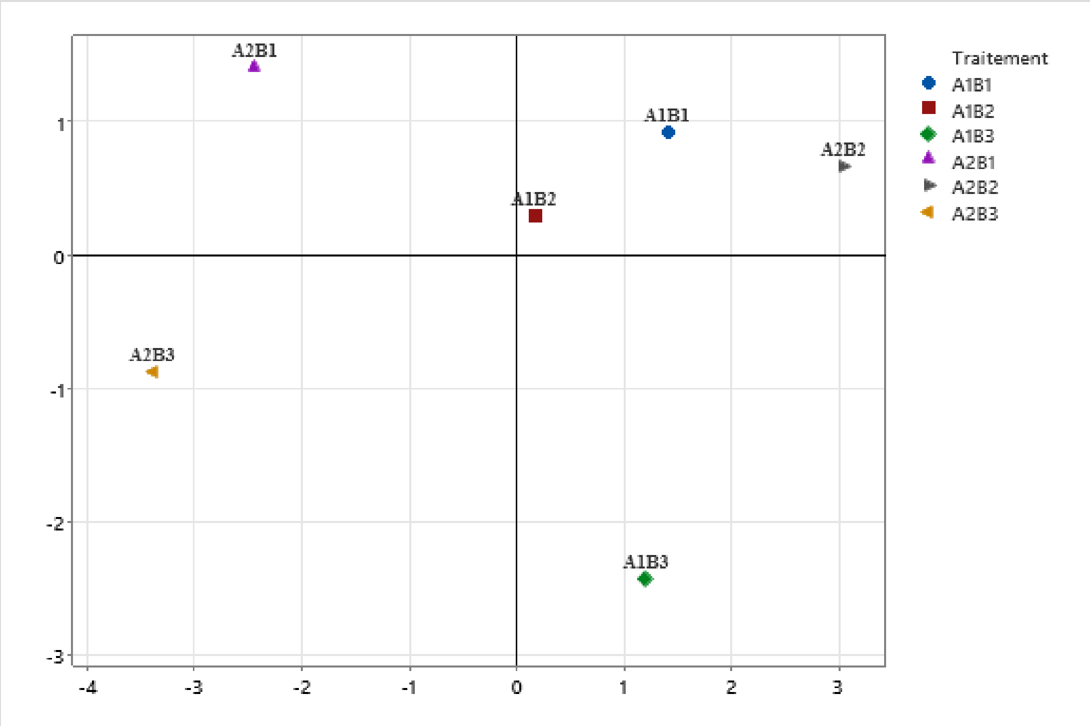

Figure 5: Effect of cowpea treatments subjected to a main component analysis

Discussion

Installed on a plot with loamy-clay soil, cowpea had a vegetative cycle ranging from 72 to 97 JAS. The data collected made it possible to study the different parameters. The data from this study show that the works did not have a significant effect on certain production parameters. The A2B3 treatment is characterized by long (8.208 ± 2.96 cm) and wide (5.058±1.68 cm) leaves. Indeed, the longer and wider the leaves are, the more the biomass increases. It is also the A2B3 treatment that gave the best biomass yield with a biomass yield of 1400±280 kg/ha. These results are higher than those reported by Mare (2009) who obtained a cowpea biomass yield of 0.08 and 1.41 kg/ha. This difference may be related to the KVX 61-1 variety used by this author. For this author, the production of tops has also evolved in the same direction as that of the grains produced. The maximum number of tops produced on the test (2991,66Kglha) is obtained on the plot treated with Zai + Manure + Phosphate while the low rate of tops (40Kg/ha) is recorded on the plot serving as absolute control. The production of air biomass (straw) and grains varies significantly according to applied enrichment (Bayern et al., 2012).

In fact, according to the same author the yield of straw and grains is important in the treatments of zaï with compost, followed by half associates of zaï associating half compost and half herb. They trump that the low yield of straw and grains has been recorded with treatments associating zaï, straw, and sometimes zaï only. In addition, the maximum and minimum yields of cowpea grain are 1250±720 kg/ha and 173.3±68.1 kg/ha, respectively. These results corroborate. Oumarou et al. (2017) who obtained yields of 560 kg/ha, 860 kg/ha and 405 kg/ha respectively for varieties IT97K499-35, IT98K205-8 and the local variety. By studying the impact of cowpea use and various amendments under zai on the characteristics of degraded soils, Mare (2009) obtained the best yield of cowpea grain with the Zaï + Manure + Phosphate treatment (2053Kg/ha); followed by the treatment Zaï + Compost + Phosphate (1793,33Kg/ha). The plots

Absolute Control (10Kg/ha) and Simple Zai (766.66Kg/ha), gave the lowest yields. This corroborates the results of this study. The work of Bayen et al. (2011) on sorghum shows that the highest yields are found in compost-treated zai pockets, which are on average 12 times higher than in zai pockets alone. According to these authors, the grain yield varies between 383.10 ± 32.13 kg/ha in large zai pockets + compost and 5.77 ± 1.90 kg/ha in small zai pockets without amendment. Large pockets increase grain yields especially at the level of zai + compost treatments of which they significantly improve yields by 25% compared to small pockets. According to these authors, the grain yield varies between 383.10 ± 32.13 kg/ha in large zai pockets + compost and 5.77 ± 1.90 kg/ha in small zai pockets without amendment. Large pockets increase grain yields especially at the level of zai + compost treatments of which they significantly improve yields by 25% compared to small pockets. By analyzing the strengths of the CES/DRS Coulibaly et al., (2022), report that producers indicate that they capture rainwater, maintain soil moisture and increase agricultural production. Thus, yield is one of the main elements of appreciation, which can support or motivate the producer to increase or decrease his productive power of a given speculation (Mare, 2009).

Yield is the most prominent parameter for expressing the performance of production techniques (Sangaré, 2002). Ado et al., (2021) showed in Tahoua, Niger, that zai structures, conventional half-moons and multifunctional half-moons are operational in the Tahoua region of Niger and allow the growth and development of sorghum crops on initially routed and uncultivated land. At the same time, variations in the number of pods, the number of seeds per pod and the weight of one hundred (100) seeds can influence cowpea yields between treatments. The results thus obtained make it possible to give a certain scientific importance to these cultivation techniques in the choice of land and what type of works manufactured but which seem to be important as promising strategies for adapting the crop to climate variations and changes. The A2B2 treatment obtained the largest pod diameter with 0.748 ± 0.098cm. However, the zai had an effect on the weight of the hundred grains and the length of the pods. In addition, it should also be noted for all the parameters studied that the little difference obtained between the treatments with structures and that of the controls may be due to crop pests.

Conclusion

The study assessed the effects of structures combined with the number of plants per crop on cowpea production. This study found that the treatments only affected the parameters of pod count, pod yield and grain yield. The A2B2 treatment proved to be more effective, suggesting that with the TN-85 variety, the best yield of grain and biomass can be obtained even without the zai technique.

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