INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print), 2222-5234 (Online)
http://www.innspub.net
Vol. 21, No. 2, p. 189-198, 2022

RESEARCH PAPER OPEN ACCESS

Effect of Compost and Animal Manure on Cowpea (*Vigna unguiculata* (L.) Walp) Productivity in Maradi, Niger Republic, Using Zai Technology

Charipatou Abdou Mainassara[1,2], Aminu Alhassan Fagge[1,2], Ali Malam Labo Mohamed[1,3*], Shehu Usman Yahaya[1], Aisha Muhammad Aliyu[4]

[1]*Department of Agronomy, Bayero University, Kano Nigeria, 70001, Kano, Nigeria*

[2]*Centre for Dryland Agriculture CDA, Bayero University Kano, 70001, Kano, Nigeria*

[3]*International Crops Research Institute for the Semi-Arid Tropics, Niamey, Niger*

[4]*Department of Geography, Kano State College of Education and Preliminary Studies, Kano State*

Key words: Cowpea, manure, compost, zai technique, Niger.

http://dx.doi.org/10.12692/ijb/21.2.189-198 Article published on August 10, 2022

Abstract

Cowpea (*Vigna unguiculata L.* Walp.) is an important leguminous crop largely grown by smallholder farmers in Niger for food security. Field trials were carried out during the 2019 rainy season in Dangali and Dan Bouzou, villages of Mayahi, department of Maradi region, Niger Republic, to determine the effect of organic manure on cowpea productivity using the zai technique. The IT 99 K-573-1-1 cowpea variety was used as plant material. The experimental design consisted of 16 combinations of compost and animal manure, with compost (0t/ha, 3t/ha, 6t/ha, and 9t/ha) and animal manure (0t/ha, 5t/ha, 10t/ha, and 15t/ha) in a randomized complete block design with three replications. The results revealed that the yields obtained were not statistically significant between the treatments, except at Dan Bouzou. Nevertheless, numerically, the greatest value for compost about gain yield (1025kg/ha) was obtained by the combination zai + of compost (3t/ha). For animal manure, 1292kg/ha of grain yield was achieved by the combination zai +animal manure (15t/ha). It should be noted that the yield of 1292 kg/ha of zai + animal manure (15t/ha) was higher than the yield of 1025 kg/ha of zai + compost (3t/ha) which is also higher than the yield of 617 kg/ha of zai only. This technique is effective, but its effectiveness depends on the good distribution of precipitation over time and space during the rainy season.

* **Corresponding Author:** Ali Malam Labo Mohamed ✉ mohamedlabo91@gmail.com

Introduction

Cowpea (*Vigna unguiculata (*L) Walp) is an economically and nutritionally important indigenous African grain legume grown throughout the world's tropical and subtropical regions (Abate *et al.*, 2011). Cowpea was grown on an estimated 11 million ha in Africa in 2017, with most of the production confined to West Africa (10.6 million ha), especially in Niger, Nigeria, Burkina Faso, Mali, and Senegal. More than 7.4 million tons of cowpeas are produced worldwide, with Africa producing nearly 5.2 million tons (https://www.iita.org/cropsnew/cowpea/). According to FAOSTAT (2017), Africa produces more than 87 percent of the world's cowpeas. Brazil increased cowpea cultivation in South America, and the country is now third in global production. After Nigeria, Niger is the second-largest producer of cowpeas in West Africa and the world (FAO, 2018). Cowpea is Niger's second-largest crop after millet, with a total annual production of 2,380,068 tons in 2019. (MAE, 2020). Cowpea accounts for one-quarter of total agricultural output and 80% of cash crops (MAE, 2018). Cowpea production in Niger is affected by biotic and abiotic factors, resulting in lower yields and earnings for smallholder farmers. Efforts to improve cowpea production have been made for decades, including the development and release of improved varieties that are high-yielding and resistant or tolerant to pests and diseases, but yield remains low. Poor soil fertility may take some responsibility for the low productivity in Niger. Soil fertility and plant nutrition must be improved to sustain adequate crop yields, as soil degradation has been identified as a major constraint and root cause of declining crop productivity in many developing countries, including Sub-Saharan Africa (SSA). (Sanchez, 2002). All of the major nutrients can be found in animal manure from poultry, pigs, cattle, goats, and sheep. These manures are excellent for increasing soil fertility and crop yield (JIRCAS, 2010; Issaka *et al.*, 2012). (Tobita *et al.*, 2011). The soils in Niger are extremely degraded, and small-scale farmers earn very little money (FAO, 2017). Farmers do not have the funds to purchase mineral fertilizers to amend their soils because they are expensive and usually available at the end of the crop season. However, the use of inorganic fertilizer has not been beneficial because it has been linked to increased soil acidity and nutrient imbalance (Ayoola *et al.*, 2009), as well as the high cost of procurement for low-income small-scale. Some of the arguments for using organic manures are related to the negative effects of inorganic fertilizer on humans and the environment. Organic manures such as cow dung, poultry manure, and crop residues can be used as alternatives to inorganic fertilizers (Timsina, 2018). Moreover, mineral fertilizers play an important role in the rapid increase of soil fertility and crop yield due to their high nutrient content and ease of availability (Sawada, 2002). Nevertheless, in terms of maintaining soil fertility over time, this type of fertilization may not be the most effective or adequate, because excessive application of mineral fertilizers can lead to low nutrient efficiency and deterioration of the soil and environment (El-Metwally *et al.*, 2008; Liu *et al.*, 2013). Moreover, there have been studies that show that manure is a better fertilizer than mineral fertilizers for increasing crop yields (Jannoura *et al.*, 2014; Cai *et al.*, 2019). However, there has been a lot of interest in using organic fertilizer in cowpea production to reduce plant and soil contamination with different elements and also to reduce the use of mineral fertilizers, which can boost cowpea production in the Niger Republic. Zai pit technology employs the use of holes dug in the soil for crop planting to support soil moisture retention and nutrient/fertilizer maintenance. It is a type of water harvesting technology (Kimaru-Muchai *et al.*, 2020). As a result, the use of zai is viewed as a major strategy for improving soil fertility as well as crop productivity. This has been demonstrated in several cowpea studies conducted in Burkina Faso. Because there has been little research on the zai technique in Niger, the goal of this paper was to determine the influence of organic manure on cowpea productivity using the zai technique.

Materials and methods

Study area and land preparation

The field work was carried out in two locations (Dan Bouzou North-East and Dangali West) of the Mayahi department of the Maradi region located in the south-central agricultural part of Niger. The average rainfall varies between 300 and 600 mm per year and the population is comprised of 100 inhabitants /km² (MA, 2012). The field was ploughed and debris removed. The field was then demarcated using lines and pegs and leveled before sowing.

Treatment and experimental design

One variety of cowpea (IT 99 K-573-1-1) supplied by the International Institute of Tropical Agriculture (IITA, Kano) was used in this experiment. This variety has determined growth habit, medium maturing (70-75 days), with medium 17 seed size and yield potential of 2.6 t/ha then it has some level of resistance to *Fusarium* wilt, *Striga,* and tolerance to drought. The experiment consisted of four levels (0, 3, 6, and 9 tons/ha) of compost and four levels (0, 5, 10, and 15 tons/ha) of animal manure. These were laid out in a randomized complete block design and replicated three times. A total of 48 plots were used, each plot measuring (5m x 3m). The spacing between consecutive blocks was 2m and between consecutive plots was 1m. The distribution of the treatments in the plots of each block was carried out randomly. The fertilizer was applied at the rate of 0kg/plot, 4.5kg/plot, 9kg/plot and 13.5kg/plot for compost and 0kg/plot, 7.5kg/plot, 15kg/plot and 22.5kg/plot for animal manure.

Data collection and statistical analysis

Data were collected on the following parameters: plant height, number of pods per plant, pods weight per plant, number of seeds per plant, 100- seed weight, and grain yield. Data collected from the experimental field were subjected to Analysis of Variance (ANOVA) using Genstat statistical software. Significant treatment means were compared using the Least Significant Difference (LSD) procedure at 5 % probability level.

Results

Climatic conditions for Dangali and Dan Bouzou during the 2019 period of the experiment

The mean average monthly minimum and maximum temperatures and rainfall for Dangali and Dan Bouzou are presented in figures 1 and 2. In Dangali, the average minimum and maximum temperatures were 24.38°C and 34.68°C, respectively. In Dan Bouzou, the average minimum and maximum temperatures were 24.63°C and 35.35°C, respectively.

Table 1. Physical and Chemical Properties of Soil and Compost at the Experimental Fields.

Soil Property	Dangali	Dan Bouzou	Compost
Physical Property (%)			
Sand	53.25	58.85	55.45
Silt	30.34	26.45	22.39
Clay	16.41	14.7	22.15
Texture Class	Sandy Loam	Sandy Loam	
Chemical Property			
PH	5.98	5.88	5.81
O. C. (%)	0.82	0.51	1.33
Nitrogen (%)	0.06	0.05	0.1
Available P (mg/kg)	4.87	4.22	6.76
Cu (mg/kg)	2.03	2.56	3.72
Mn (mg/kg)	23.34	15.45	27.72
Zn (mg/kg)	8.7	7.71	16.4
Fe (mg/kg)	128.23	252.76	173.28
Exchangeable Base ($cmol.kg^{-1}$)			
Ca ++	2.24	1.67	2.08
Mg++	0.73	0.552	1.04
K++	0.14	0.15	0.18
Na++	0.08	0.11	0.06
CEC	3.35	2.69	3.37
E. A	0.15	0.22	0

The total rainfall amounts recorded during the experiment were 547.79 mm in Dangali and 492.97 mm in Dan Bouzou. This rainfall is poorly distributed over time, whose month of August records more rainfall (up to 249.01mm in Dangali and 255.25mm in Dan Bouzou) than the rest of September (51.72mm in Dangali and 46.91 mm in Dan Bouzou) and October (45.05 mm in Dangali and 42.49 mm in Dan Bouzou).

Physical and Chemical Property of Soils and Compost at the Experimental Fields

The results of soil and compost analysis is shown in Table 1. This result indicated that the soils at both locations (Dangali and Dan Bouzou) were sandy loam with a size distribution of 53.25 % sand, 30.34 % silt and 16.41% clay (at Dangali) and 58.85 % sandy, 26.45 % silt and 14.70% clay (at Dan Bouzou). The percentages of organic carbon of the study areas (Dangali and Dan Bouzou) and compost (0.82%, 0.51% and 1.33%) respectively were very low compared to the ranges of rated soil containing organic carbon (Landon, 2014) as : > 20 % as very high, 10–20 % high, 4–10 % medium, 2–4 % low and < 2 % very low. The nitrogen content of the study areas (Dangali and Dan Bouzou)23 and compost (0.06%, 0.05% and 0.1%) respectively was very low compared to the rate percentage total N content in soil (Landon, 2014) as : > 1.0 as very high, 0.5–1.0 high, 0.2–0.5 medium, 0.1–0.2 low and < 0.1 very low. And also, the available P content of the study areas (Dangali and Dan Bouzou) and compost (4.87%, 4.22% and 6.76%) respectively was low compared to the range available P (Buchholz *et al.*, 2004) as: < 3 mgkg^{-1} -very low, < 10 mg kg^{-1} -low, between 10 - 20 mg kg^{-1} -medium, > 20 mg kg^{-1} -high.

Table 2. Effect of compost and animal manure on plant height and number of pod per plant.

Treatments	Plant height		Number of pods plant^{-1}	
Compost	Danbouzou	Dangali	Danbouzou	Dangali
0	15.58	12.42	2.67	2.75
3	14.93	12.28	3.21	3.15
6	15.05	11.79	3.07	3.00
9	14.52	11.97	3.03	2.54
Probability	0.452	0.865	0.349	0.562
SE±	0.462	0.581	1.209	0.324
Manure				
0	14.38	11.71	2.94	2.61
5	14.89	13.05	2.87	2.89
10	14.79	12.23	2.70	2.81
15	16.02	11.48	3.47	3.14
Probability	0.096	0.249	0.091	0.716
SE±	0.462	0.581	0.218	0.324
CXM	0.819	0.865	0.820	0.742

Growth parameters and yield, yield components

Tables 2 illustrated the effect of compost and animal manure under zai on plant height and number of pods per plant. The results indicated no significant difference between treatments and the interaction between compost and animal manure at both locations. For compost at Dan Bouzou the highest numerical value was obtained with zai + compost 0t/ha however, at Danbouzou the highest numerical value was given by zai + compost 0 t/ha. For animal manure at Dan Bouzou the higher numerical value was given by zai + animal manure 5t/ha followed by zai + animal manure 10t/ha while the lowest numerical value was obtained with zai + manure 0t/ha. A non-significant treatment effect was revealed from mean value showed in Table for the number of pods per plant in both locations. Cowpea planted under zai + compost 3 t/ha had the highest number of pods per plant for two locations. However the lowest number of pod per plant was obtained with the zai+ compost 0 t/ha at Danbouzou. At Dangali the lowest number of pods per plant recorded with zai + compost 9 t/ha.

The influence of compost and animal manure under zai on number of pods per plant is presented in Table 6. The results indicated no significant difference between treatments and the interaction between compost and animal manure at both Dan Bouzou and Dangali. For compost at Dan Bouzou and Dangali the combination zai + compost 3t/ha have higher numerical value than others treatments. For animal manure the combination zai +animal manure 15t/ha appeared to have higher numerical value than others treatments. The influence of compost and animal manure under zai on pods weight per plant is presented in Table 3. The results indicated no significant difference between treatments and the interaction between compost and animal manure at both villages Dan Bouzou and Dangali. For compost at Dan Bouzou and Dangali the combination zai + compost 3t/ha had higher numerical value than other treatments. For animal manure at Dan Bouzou the combination zai + animal manure 15t/ha appeared to have higher numerical value than other treatments but at Dangali the combination zai + animal manure 5t/ha had higher numerical value than other treatments.

Table 3. Effect of pods compost and animal manure on pod weight per plant and number of seed per plant.

Treatments	Pods weight per plant		Number of seed per plant	
Compost	Danbouzou	Dangali	Danbouzou	Dangali
0	2.81	2.42	3.81	2.93
3	3.85	3.13	5.02	3.35
6	3.28	2.79	4.37	3.41
9	3.46	2.18	4.32	3.09
Probability	0.085	0.249	0.085	0.503
SE±	0.277	0.345	0.298	0.249
Manure				
0	3.40	2.38	4.30	3.06
5	3.02	2.85	4.17	2.92
10	3.18	2.67	4.79	3.37
15	3.81	2.63	4.27	3.44
Probability	0.225	0.817	0.225	0.404
SE±	0.277	0.345	0.298	0.249
CXM	0.798	0.472	0.798	0.209

The effect of compost and animal manure under zai on number of seeds per plant is presented in Table 3. The results indicated no significant difference between treatments and the interaction between compost and animal manure at both sites. For compost at Dan Bouzou and Dangali the combination zai + compost 3t/ha appeared to have higher numerical value than all treatments. For animal manure at Dan Bouzou zai +animal manure 15t/ha had higher numerical value than other treatments but at Dangali zai + animal manure 5t/ha appeared to have higher numerical value than other treatments. The effect of compost and animal manure under zai on 100-seeds weight is presented in Table 4. The results indicated no significant difference between all treatments and the interaction between compost and animal manure. For compost at Dan Bouzou zai +compost 6/ha had higher numerical value than all treatments but, at Dangali, zai + compost 3t/ha appeared to have higher numerical value. For animal manure at Dan Bouzou the combination zai + animal manure 15t/ha had higher numerical value than other treatments but at Dangali the combination zai + animal manure 10t/ha appeared to have higher numerical value than all treatments.

Analysis of variance showed that there were a significant effect of manure application on grain yield at Dan Bouzou. The highest grain yield was obtained with zai + animal manure 15t/ha followed by zai + animal manure 10 t/ha however, the lowest grain yield was produced by zai + animal manure 0 t/ha (Table 4).

Discussion

The highest numerical values of plant height were recorded for compost with zai + compost 0t/ha at Dan Bouzou and Dangali (15.58cm and 12.42cm) respectively with Dan Bouzou have higher number of plant height than Dangali and for animal manure with zai + animal manure 15t/ha (16.2cm) at Dan Bouzou and zai + animal 5t/ha (13.05cm).

These results are lower than the result of (Sillus *et al.*, 2021) who obtained 32.9cm. For compost at both locations the highest numerical values of number of pods per plant were recorded with zai + compost 3t/ha which Dan Bouzou had higher numerical value than Dangali (3.21±1.209, 3.15±0.324). For animal manure the values were recorded with zai + animal manure 15t/ha at Dan Bouzou and Dangali (3.47±0.218 and 3.14±0.324). These results are lower than the result reported by (Sillus *et al.*, 2021) who obtained 10.65 by adding manure.42.

Table 4. Influence of compost and animal manure on 100-seed weight and grain yield.

Treatments	100-Seed weight		Grain Yield	
Compost	Danbouzou	Dangali	Danbouzou	Dangali
0	18.14	14.95	617	196
3	18.82	15.64	1025	394
6	19.02	14.99	910	360
9	18.07	15.31	680	180
Probability	0.418	0.792	0.240	0.347
SE±	0.485	0.552	157.6	103
Manure				
0	18.48	15.62	614c	294
5	18.38	15.73	638bc	392
10	18.16	14.69	688b	172
15	19.04	14.85	1292a	217
Probability	0.615	0.452	0.013	0.521
SE±	0.485	0.552	157.6	103
CXM	0.065	0.511	0.528	0.808

The highest numerical value of pod weight per plant for compost at both locations were recorded with zai + compost 3t/ha (3.85±0.227, 3.13±0.345) which Dan Bouzou had higher numerical value than Dangali. For animal manure the highest numerical values were recorded with zai + animal manure 15t/ha (3.81±0.227) at Dan Bouzou and 5t/ha (2.85±0.345) at Dangali. This result is lower than the result of (Nkaa *et al*, 2014) who obtained 11.9 ± 2.2 by the application of 60kg/ha of phosphorus. For compost the highest numerical values were recorded at Dan Bouzou with zai + compost 3t/ha (5.02±0.298) and at Dangali with zai + compost 6t/ha (3.41±0.249). For animal manure the highest numerical values were recorded with zaï + animal manure 10t/ha (4.27±0.298) at Dan Bouzou and with 15t/ha (3.44±0.249) at Dangali. These results are lower than the result of (Khandelwal *et al.*, 2012) who obtained 7.83 by application of 75% of recommended dose of fertilizer.

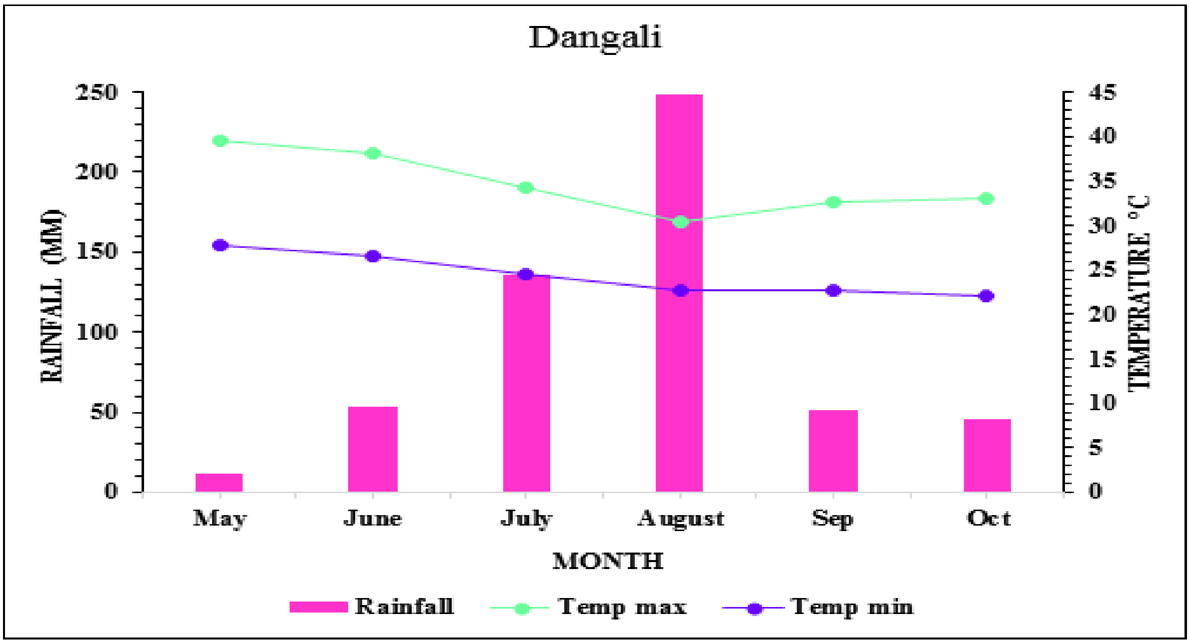

Fig. 1. Weather data for Dangali during 2019rainy season.

The highest numerical value of 100-seed weight for compost were recorded at Dan Bouzou with zaï + compost 6t/ha (19.02±0.485) and at Dangali with zai + compost 3t/ha (15.64±0.552). For animal manure the highest numerical values were recorded with zai + animal manure 15t/ha (19.04±0.485) at Dan Bouzou and at Dangali with zai + animal manure 5t/ha (15.73±0.552). These results are superior than the result of (Sillus *et al.*, 2021) who obtained 12.25± 0.33 by application of manure. For compost at both locations the highest numerical values of grain yield were recorded with zai + compost 3t/ha which Dan Bouzou had higher numerical value than Dangali (1025kg/ha, 394kg/ha) respectively. These results are higher than 360kg/ha and 389kg/ha reported by (Gonda *et al.*, 2016) and 24kg/ha reported by (Der Somé *et al.*, 2004). For animal manure at Dan Bouzou the highest value of grain yield was recorded with zai + animal manure 15t/ha (1292kg/ha) and at Dangali was recorded with zai + animal manure 5t/ha (392kg/ha). Compared to the result of (Der Somé *et al.*, 2004), these results are height. For zai only compost 0kg/ha and animal manure0kg/ha, the highest numerical value is 617kg/ha. This result is height than 0kg/ha reported by (Der Somé *et al.*, 2004). Overall, the yields obtained during this experiment were low, these results were probably due to: First, the poor distribution of rain (Bongo, 2012) explained in his book of research work entitled “Fight against Food Insecurity in Niger: A Solution by Agricultural Micro Insurance " that bad rains spread over time and space cause bad harvests. Thus, during our experiment, this poor distribution of the rain led to a long period of drought which lasted for weeks. This poor distribution of rain also resulted in the non-mineralization of compost and animal manure thus causing the plants to dry out already at the pod formation stage. Secondly, the low phosphorus content in the soil (as seen in the results of the soil analysis showed that the soils of the two villages are very low in phosphorus (4.87 in Dangali and 4.22 in Dan Bouzou) which explains that in part, this factor also has influenced the low yield of two villages by what according to (Dugje *et al.*, 2009), Cowpea like most legumes, needs more phosphorus than nitrogen. It is a critical element in its production. It is also a growth factor because it promotes root development and is also a factor of precocity for fertilization and fruit setting (Vecchia *et al.*, 2001). Its low availability in the soil is a major constraint for growth and symbiotic nitrogen fixation in legumes because 44 the nodules have high phosphorus requirements and their growth is often limited by this element (Jemo *et al.*, 2006).

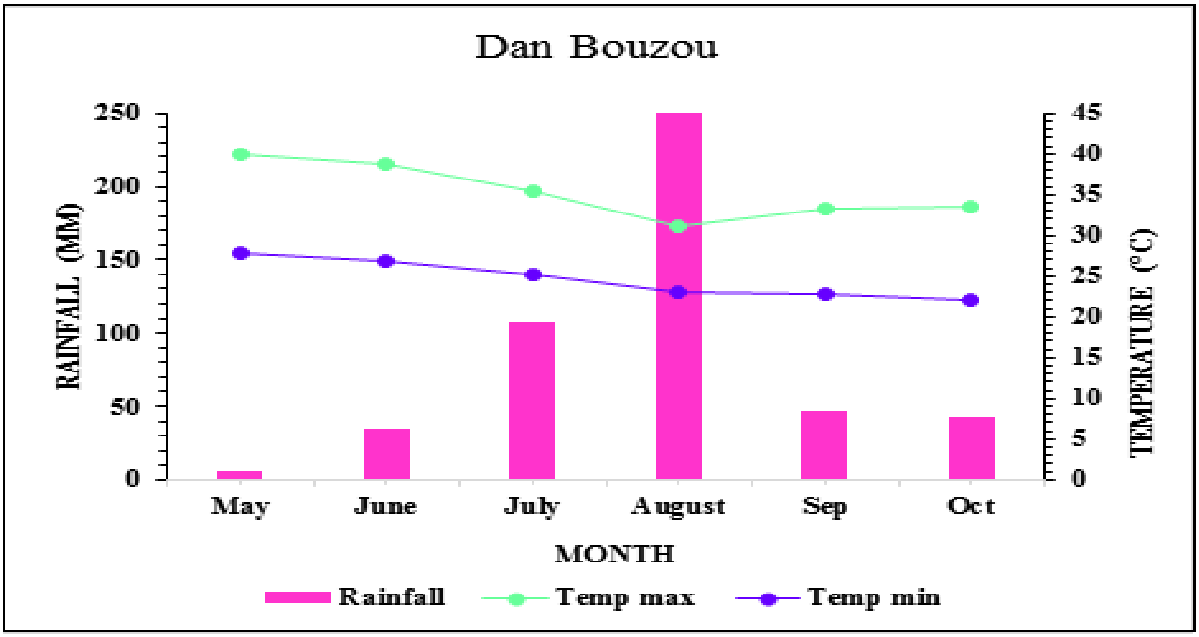

Fig. 2. Weather data for Dan Bouzou during 2019 rainy season.

It is therefore necessary for plants to be able to dispose of it at the start of the growth period (Schöl, 1998). Thirdly, the low nitrogen content in the soil: the results of the soil analysis in Table 1 shows that the soils of two villages are very low in nitrogen (0.06 in Dangali and 0.05 in Dan Bouzou), which explains just like phosphorus this factor has also influence the low yield of two villages by what according to (Vecchia *et al.*, 2001) that Nitrogen constitutes, with carbon, the staple food of the plant.

It is necessary for the development of organic plant compounds: amino acids, nucleic acids, proteins, and chlorophyll. It is the determining factor of yields by its favorable influence on the growth of the vegetative apparatus. Nitrogen is also the main deficiency in most soils (Moreau, 1986). Finally, it should also be noted that this experiment was conducted in rural areas and that in this area the conflict lies between agriculture and pastoralists, hence the complete overnight looting of my Dangali field just after the first harvest and at Dan Bouzou the women harvested before me in the absence of my field guard who went to the exodus to Libya.

Conclusion

In light of all the above, we can say that the result of yield obtained from this study was low and the results were not statistically significant between the treatments and the interaction between compost and animal manure, except between the treatments of animal manure at Dan Bouzou.

However, numerically, the greatest value for compost of the grain yield of 1025kg/ha was achieved by the combination zai +of compost (3t/ha). For animal manure, 1292kg/ha was obtained by the combination zai +animal manure (15t/ha). It should be noted that the yield of 1292 kg/ha of zai + animal manure (15t/ha) was higher than the yield of 1025 kg/ha of zai + compost (3t/ha) which is also higher than the yield 617 kg/ha of zai only.

This technique of zai is effective, but its effectiveness depends on the good distribution of precipitation over time and space during the rainy season. Based on the findings of this study, the following recommendations are made: Repetition of the experiment to determine the optimal dose of compost and animal manure; Addition of doses of phosphorus and nitrogen to the above treatments to improve soil fertility levels and promote good cowpea development, Determination of the influence of its treatments on improving soil fertility by analyzing the soil before sowing and after harvesting.

References

Abate T, Ajeigbe H, Boukero Fatokun C, Kamara A, Ndjeung J, Ntere B. 2011. Grain Legumes of Nigeria. In: Bulletin of Tropical Legumes. A Monthly Publication of the Tropical Legumes II Project n°2.

Bongo AH. 2012. Fight against food insecurity in Niger: Amicro solution agricultural insurance. P 25.

Cai A, Xu M, Wang B, Zhang W, Liang G, Hou E, Luo Y. 2019. Manure acts as a better fertilizer for increasing crop yields than synthetic fertilizer does by improving soil fertility. Soil Tillage Res. 189, 168–175. [CrossRef]

Der Somé, Zombré PN, Zombré G, Harold RM. 2004. Impact of the Zai Technique on Cowpea Production and on the Evolution of Characteristics Chemicals of Very Degraded Soils (Zippéllé) from Burkina Faso. University of Ouagadougou.

Dugje YI, Omoigui OL, Ekelem F, Kamara YA, Ajeigbe H. 2009. Cowpea Production in West Africa: A Farmer's Guide. International Institute of Tropical Agriculture. Ibadan Nigeria. p 20p.

El-Metwally IM, Abdelhamid MT. 2008. Weed control under integrated nutrient management systems in faba bean (Vicia faba) production in Egypt. Planta daninha [online] **26,** 585-594. ISSN 0100-8358.
https://doi.org/10.1590/S0100835820080003000014

FAO. 2018. Fao FAOSTAT statistical database [www document]. URL (2018) Google Scholar.
http://.fao.org/faostat/en/#data/QC

Food and Agriculture Organization of United Nations (FAO). 2017. Targeting farmers in institutional procurement program: A case study of the PAA Africa Programme in Senegal. International Policy Center for Inclusive Growth, Brazil.

Gonda A, Nana EM, Maman N, Francis MT,

Ebnezer YS, Robert CA. 2016. Nutrient release patterns of compost and its implication on crop yield under Sahelian conditions of Niger. Nutrient cycling in agroecosystems **105(2),** 117-128.
https://doi.org/10.1007/s10705-016-9779-9

Issaka RN, Buri MM, Tobita S, Nakamura S, Owusu-Adjei E. 2012. Indigenous fertilizing materials to enhance soil productivity in Ghana. In Soil fertility improvement and integrated nutrient management-A global perspective, Walen JK (ed.) InTech. **5,** 119-134.
ISBN 978-953-307-945

Jannoura R, Joergensen RG, Bruns C. 2014. Organic fertilizer effects on growth, crop yield, and soil microbial biomass indices in the sole and intercropped peas and oats under organic farming conditions. European Journal of Agronomy **52,** 259–270.
http://doi.org10.1016/j.eja.2013.09.001

Jemo M, Abaidor R, Nolte C, Tchienkoua M, Sanginga N, Horst. 2006. Phosphorus benefits from grain-legume crops to subsequent maize grown on acid soils of southern Cameroon. Plant Soil **284,** 385-397.

JIRCAS. 2010. The Study on Improvement on Soil Fertility with Use of Indigenous Resources in Rice Systems of sub-Sahara Africa. Business Report 2009 (February 2010), Tsukuba, Japan.

Khandelwal R, Choudhary SK, Khangarot SS, Jat MK, Singh P. 2012. Effect of inorganic and bio-fertilizers on productivity and nutrients updake in cowpea [*Vigna Unguiculata* (L) Walp] Walp 235-238 p

Kimaru-Muchai SW, Ngetich FK, Baaru M, Mucheru-Muna MW. 2020. Adoption and utilization of zai pits for improved farm productivity in drier upper Eastern Kenya. Journal of Agriculture and Rural Development in the Tropics and Subtropics **121,** 13-22.

https://doi.org/10.17170/kobra-202002281030

Liu X, ZhangY, Han W, Tang A, Shen J Cui J Vitousek P Erisman JW, Goulding KWT Christie P, Fangmeier A, Zhang F. 2013. Enhanced nitrogen deposition over China. Nature **494,** p 459-463. https://doi.org/10.1038/nature11917

MA. 2012. National Catalog of Plant Species and Varieties (CNEV) Niger, Ministry of Agriculture, P 152.

MAE. 2018. Rapport d'évaluation de la campagne agricole d'hivernage 2017 et perspectives alimentaire 2017-2018 Ministère de l'agriculture Niamey Niger.

MAE. 2020. Rapport d'évaluation de la campagne agricole d'hivernage 2019 et perspectives alimentaire Ministère de l'agriculture Niamey Niger.

Moreau R. 1986. Soil Fertility and Fertilization of Tropical Crops. Seminar on French Agronomic Research in the Intertropical Zone, p 58.

Sawada H, Kuykendall LD, Young JM. 2003. Changing concepts in the systematics of bacterial nitrogen-fixing legume symbionts. The Journal of General and Applied Microbiology **49,** 155–179. [CrossRef].

Schöl VL. 1998. Managing soil fertility. Agrodock 2, fourth edititon, Aagromisa, Wageningen The Netherlands. P 88.

Sillus OO, Nancy WM, Set FOO. 2021. Zai Pit Effect on Selected Soil Properties and Cowpea (*Vigna unguiculata*) growth and grain yield in two selected dryland region of Kenya Open Journal of soil science, **11,** 39-57. https://doi.org/10.4236/ojss.2021.111003.

Timsina J. 2018. Can organic sources of nutrients increase crop yields to meet global food demand? Journal of Agronomy **8,** 214-234. https://doi.org/10.3390/agronomy81002148.

Tobita S, Issaka RN, Buri MM, Fukuda M, Nakamura S. 2012. Indigenous organic resources for improving soil fertility in rice systems in Sub-Saharan Africa.

Vecchia DA, Kone B, Bakary D, Moussa L, Tarchiani V. 2001. Agricultural Skills and Pastoral Care of Soils in CILSS Countries. Early Warning and Forecasting Project Agricultural Productions (AP3A). P 173.