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Comparative Effect of Biofertilizer System and Other Fertilizer on the Growth and Yield of Millet (*Pennisetum Glaucum* [L] R. Br.)

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Abstract: *Current soil and agricultural management strategies are mainly dependent on continuous use of inorganic chemical-based fertilizers which are industrially manipulated substances, largely water-soluble and contain high available nutrient concentrations. The experiment was conducted under screen house at Lake Chad Research Institute, in Maiduguri (semiarid region). The experiment consists of six treatments which were namely: T_0 - 2 kg soil; T_1 - 2 kg soil + NPK (60:30:30 recommended rate per hectare); T_2 - 2 kg soil + Azospirillum; T_3 - 1 kg soil + 1 kg Vermicompost ; T_4 - 1 kg soil + 1 kg Vermicompost + Azospirillum;T_5 - 1 kg soil + 1 kg Vermicompost + NPK and T_6 - 2 kg soil + Azospirillum + NPK and were replicated six time to make total of fouirty two experimental unit and was laid out on Completely Randomized Design (CRD), respectively. The result showed that NPK, Azosprillium, Vermicompost, Vermicompost + Azosprillium gave significantly longer roots than the control. Similarly, all the bio- and synthetic- fertilizers gave better plant growth than the control, except Azosprillium + NPK at 6 WAS. Furthermore, results consistently showed that all the bio- and synthetic- fertilizers were significantly better than the control in terms of leaf dry matter weight, panicle weight and grain weight. Furthermore, results showed that NPK gave comparable results with that of Vermicompost + Azosprillium on plant height and leaf dry matter. NPK also gave longer roots and better growth than Azosprillium + NPK and Vermicompost + NPK, while it was more effective on panicle weight and grain weight than the remaining treatments. Based on the obtained results from this study, combination of the two organic-fertilizer, Vermicompost and NPK the synthetic fertilizer, stand out as the best treatments. Thus, Vermicompost + NPK and Vermicompost + Azosprillium are recommended as the best bio- and organic - fertilizers for millet. However, it is suggested that further studies be carried out on different rates and doses of these organic, bio- and synthetic- fertilizers.*

Keywords: *Millet; Biofertilizer; Fertilizer; Azosprillium and Vermicompost*

1.0 INTRODUCTION

Millet (*Pennisetumglaucum* [L.] R.Br.) is an important grain crop ranking as sixth most important world cereal, (Singh *et al*., 2003; Henry and Kettlewell, 1996), as source of nutrition such as calories, proteins, and vitamins for the Nigerian population resident in the Sudan savanna and the Sahel agro-ecological zones. Nigeria, Niger and Mali are thethree major producers of millet in Africa, with Nigeria accounting for about 39% [4,200,000 metric tonnes] of the total Africa millet production (Nkama, *et al.* 1994; Ronney and McDonough, 1987). The most important millet producing countries in the World after India and China is Nigeria (Aminu *et al*, 1998). Biofertilizer is a natural product carrying living microorganisms derived from the root or cultivated soil. Besides their role in atmospheric nitrogen fixation and phosphorous solubilisation, they also help in stimulating the plant growth hormones providing better nutrient uptake and increased tolerance towards drought and moisture stress. Under appropriate conditions a small dose of biofertilizer is sufficient to produce desirable results because each gram of carrier of bio-fertilizers contains at least 10 million viable cells of a specific strain of micro-organism (Anandaraj and Delapierre, 2010), it can enhance plant development and promote the yield of several agricultural important crops in different soils and climatic regions (Okon and Labendera-Gonzalez, 1994). Biofertilizers are eco-friendly and supply the nutrient input of biological origin for plants. They are not only important for the reduction of quality chemical fertilizers but also for providing better yield in sustainable agriculture. Bio-fertilizers have been identified as alternatives to chemical fertilizers to increase soil fertility for crop production in sustainable farming (Amin, 1997). These beneficial effects of *Azospirillum* on plants are attributed mainly to an improvement in root development, an increase in the rate of water and mineral uptake by roots, displacement of fungi and plant pathogenic bacteria and, to a lesser extent, biological nitrogen fixation (Okon and Itzigshohn, 1995). Synthetic fertilizers were chemically formulated by the industries and most important are the 16 essential plant nutrients (such as N, P, K, Ca, Mg and S are called macronutrients, while Fe, Zn, Cu, Mo, Mn, B and Cl are called micronutrients) in required quantities to achieve the maximum yield in crop production is well-established. N, P and K are required in enhancing the natural ability of plants to resist stress from drought and cold, pests and diseases (Tsai *et al.*, 2007). Therefore, the present study will evaluate the effect of Vermi-composts enriched with bio-fertilizers and synthetic fertilizer on growth and yield of millet.

2.0 EXPERIMENTAL SITE DESCRIPTION

The experiment was conducted at the Lake Chad Research Institute in Maiduguri, (11^0 54' N, 13^0 05' E), at an elevation of 300 meters above sea level, in order to compare the effects of vermicompost, biofertilizer and synthetic fertilizer on the growth and yield of millet (*Pennisetum glaucum* L.) under screen house condition.

2.1 Materials and Methods

As stated earlier, the experiment was conducted at the at the Lake Chad Research Institute in Maiduguri. Completely Randomized Design (CRD) was employed for the experiment with six treatments (T_0, T_1, T_2, T_3, T_4, T_5 and T_6) replicated six times to make total of forty two treatment. Similarly, the millet variety, SUPER SOSAT used was obtained from the germplasm store of Lake

Chad Research Institute. The variety was jointly developed by LCRI and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and released in 2003. It is medium maturing (75 - 90 days) and is adapted to Sudan and Sahel agro-ecological zones of Nigeria (LCRI, 2009). The reagents used were Conical flasks, pipette, Petri dishes, universal bottles, test tubes, hydrogen peroxide, filter paper, cotton wool, aluminum foil, glass slides, pH meter, wire loop, incubator, autoclave, electronic weighing balance and microscope, hot air ovens, nitrogen free media, normal saline, distilled water, hydrogen peroxide, immersion oil, Kovac reagent, peptone water, gram staining reagents, test tubes, conical flasks, beakers, pipettes, wire loop and spatula. Likewise, Standard inorganic fertilizer NPK (15:15:15) was used as source, applied at the rate of 60:30:30: with half of the dose of N and all of P and K (0.2 g/pot) applied at planting, while the remaining dose (0.1 g N/pot) was top-dressed as urea to millet at 6 weeks after planting.

Microbiological examination of vermin-compost that is 'Serial dilution pour plate method' was followed (Allen, 1953; Kannan, 1996) to assess the microbial load of vermicomposting for the estimation of microbial populations. Microbes colonies on the plates were counted with the help of colony counter on first day and third days of incubation for bacteria and fungi on number of bacteria per ml was calculated using equation 1 below

$$= \frac{\text{Number of colonies (average of 3 replicates)}}{Amount\ planted \times dilution} \ldots\ldots\ldots\ldots\ldots\ldots \textbf{(1)}$$

Determination of Biochemical Tests

Confirmatory tests on biological parameters such as catalase, coagulase, indole, motility, urease, starch hydrolysis, citrate agar and oxidase were carried out using methods as reported by cheeserough (2006) and Bergey's Manual of Determinative Bacteriology (1994).

Statistical Analysis

All data collected was subjected to analysis of variance (ANOVA) with the help of statistical software, Statistix 8.0. The treatment means was compared using least significant difference (LSD) at 5% level of probability when F value is significant (Gomez and Gomez, 1984).

3.0 RESULTS AND DISCUSSION

3.1 Isolation and Identification of *Azospirillium* species

Result of the biochemical analysis has confirmed the presence of *Azospirillium* spp in the soil, deduced from the fact that microscopic examination of the isolate revealed gram negative rodshaped and a darting movement in different direction across the field of view of the microscope, indicating a motility The organism was also tested for Indole, , coagulase, lactose, hydrogen sulphide, voges proskaeur sucrose and all tests were negative, while oxidase, catalase, citrate, dextrose, acid production and molecular identification which all showed positive reaction, indicating that the isolate was gram negative non lactose fermenting bacteria, *Azosprillium* sp.

3.2 Microbial Load of Vermicompost

Table 1 shows bacteria and fungi coliform forming unit /g in vermivompost sample. Results showed that bacterial load range from 1.2×10^{-5} - 1.5×10^{-3} cfu/g, while the fungal load ranged from 7.9×10^{-6} - 1.7×10^{-3} cfu/g in the 5th, 6th and 7th serial dilutions. This indicates that the bacterial load in the 5th and 7th serial dilutions were relatively higher than fungi. In contrast, result indicated higher fungal load in the 6th serial dilutions than bacteria.

Table 1. Microbial load of vermicompost

S/No.	Bacteria cfu/g	Fungi cfu/g
1. 5th Serial dilution	1.5×10^{-3}	1.7×10^{-3}
2. 6th Serial dilution	1.8×10^{-4}	1.3×10^{-4}
3. 7th Serial dilution	1.2×10^{-5}	7.9×10^{-6}

3.3 Effects of Bio, Organic- and Synthetic- Fertilizers on the Plant Height of Millet

Table 2 shows the result on effects of the six treatment of organic, bio- and synthetic- fertilizers on the plant height of millet at 3, 6 and 9 weeks after sowing. Results consistently indicated significant ($p<0.05$) difference in the effects of the six treatments on plant height at 3, 6 and 9 WAS, which ranged from 21.17 – 29.33 cm, 32.37 – 40.12 cm and 33.67 – 49.83 cm, respectively. At 3 WAS, the treatments were significantly ($p<0.05$) different, to the effect that all treatments (bio, orgasnic and synthetic- fertilizers) gave better plant growth than the control. However, the height of millet crop in which NPK, Azosprillium, Vermicompost, Vermicompost + Azosprillium and Azosprillium + NPK were applied are statistically at par ($p<0.05$), but were significantly taller when compared with vermicompost + NPK. Similarly, at 6 WAS, all the treatments bio, organic and synthetic- fertilizers, except Vermicompost + NPK gave better plant growth than the control. Therefore, plants in the remaining treatments were also significantly ($p<0.05$) taller compared to control. The best effect was obtained with Vermicompost + NPK, with significantly taller plants than all applied treatments. The result also showed better plant growth when Vermicompost + Azosprillium were applied, when compared to Azosprillium +NPK. However, there was no significant difference in the effects of NPK, Azosprillium and Vermicompost on one hand, and Vermicompost + NPK Azosprillium Vermicompost and Azosprillium + NPK on the other hand, on plant growth. At 9 WAS, there was highly significant ($p<0.01$) difference in the effects of treatments on plant height. All the treatments bio,organic and synthetic- fertilizers gave better plant growth than the control. Similarly, plants were also significantly taller in the other bio, organic and synthetic- fertilizers compared to control. However, Vermicompost +NPK stimulated significantly better growth than all treatments, except Vermicompost +Azosprillium which was in turn better compared to Azosprillium + NPK. Plant heights in millet fertilized with NPK, Azosprillium and Vermicompost were statistically at par, as the case also was among Azosprillium+ Vermicompost and Azosprillium + NPK.

Table 2. Effects bio, organic and synthetic- fertilizers on plant height of millet

Treatment	Plant height (cm)		
	3 WAS	6 WAS	9 WAS
NPK	28.57a	37.15bc	44.67bc
Azosprillium	23.83b	33.55d	38.33d
Vermicompost	27.83a	36.23c	43.83c
Vermicompost + Azosprillium	29.00a	39.17ab	47.22ab
Azosprillium + NPK	29.00a	37.82abc	45.33bc
Vermicompost + NPK	29.33a	40.12a	49.83a
Control	21.17c	32.37d	33.67e
Mean	26.96	36.63	43.27
SE±	0.571	0.811	1.108
F-test	31.0	12.2	24.7
P-value	0.0000**	0.0000**	0.0000**
$LSD_{0.05}$	1.6393	2.3289	3.1796
$LSD_{0.01}$	2.1995	3.1247	4.2661
CV (%)	5.19	5.42	6.27

*** = Significant at1% probability level of the F-test*

3.4 Effects of Organic, Bio- and Synthetic Fertilizers on Number of Panicles/Plant

Table 3 shows the effects of treatment (bio, organic and synthetic fertilizers) on number of panicles/plant. Mean number of panicles/plant ranged from 1.00 - 2.17. with control and Vermicompost + NPK. However, results showed that effects of the treatments on number of panicles/plant., did not differ significantly (p<0.05).

Table 3. Effects of organic, bio and synthetic fertilizers on number of panicles/plant

Treatment	No. of panicles/plant
NPK	1.6667abc
Azosprillium	11.3333bc.
Vermicompost	5.000abc
Vermicompost + Azosprillium	1.8333ab
Azosprillium + NPK	1.6667abc
Vermicompost + NPK	2.1667a
Control	1.0000c

Mean	1.5952
SE±	0.26870
F-test	1.90
P-value	0.1076 Ns
$LSD_{0.05}$	Ns
$LSD_{0.01}$	Ns
CV (%)	41.27

Ns = Not significant at 5% probability level of the F-test.

3.5 Effects of Organic, Bio and Synthetic Fertilizers on Leaf Dry Matter Weight

Table 4 shows the effects of organic, bio and synthetic fertilizers on leaf dry matter weight. Results showed highly significant (p<0.01) difference in the effects of treatments on leaf dry matter weight. This ranged from 9.46 – 17.85 g with the lowest and highest from Control and Vermicompost + NPK, respectively. Leaf dry matter weight in all the treatments (bio, organic and synthetic- fertilizers) were significantly higher compared to the control. Among the treatments (bio, organic and synthetic- fertilizers), dry matter obtained from Vermicompost + NPK significantly outweighed those of other treatments, except Azosprillium. There was no significant difference in dry matter weight among NPK and Vermicompost. Similarly, result did not show significant difference in dry matter weight among Azosprillium + NPK, Vermicompost + NPK and Vermicompost +Azosprillium.

Table 4. Effects bio, organic and synthetic fertilizers on leaf dry matter weight

Treatment	Leaf dry matter weight (g)
NPK	14.775b
Azosprillium	12.072c
Vermicompost	14.389bc
Vermicompost + Azosprillium	16.392ab
Azosprillium + NPK	15.227b
Vermicompost + NPK	17.850a
Control	9.457d
Mean	14.309
SE±	0.8637
F-test	10.4
P-value	0.0000**
$LSD_{0.05}$	2.4797
$LSD_{0.01}$	3.3270
CV (%)	14.79

*** = Significant at1% probability level of the F-test.*

3.6 Effects Bio, Organics and Synthetic Fertilizers on Grain Weight

Table 5 shows the effects of bio- and synthetic fertilizers on grain weight. Results indicated significant ($p<0.01$) in the effects of bio, organic and synthetic fertilizers on grain weight, which ranged from 2.3063g – 5.8812 g. The Control gave the lowest grain weight while the highest was obtained with Vermicompost + NPK. The result further expressed that grain weight from Vermicompost + NPK was significantly higher compared to all treatments. Similarly, Vermicompost + Azosprillium gave significantly higher grain weight compared to the remaining treatments. In general, though, all the bio, organic and synthetic- fertilizers gave significantly higher grain weight than the control. Grain weight obtained from Azosprillium and Vermicompost were significantly higher compared to Azosprillium + NPK, Azosprillium and Vermicompost.

However, there was no significant difference in terms of grain weight between Azosprillium and Vermicompost, as the case also was between Azosprillium + NPK and NPK.

Table 4. Effects organic, bio- and synthetic fertilizers on grain weight

Treatment	Grain weight (g)
NPK	3.8753bc
Azosprillium	3.4697c
Vermicompost	3.5317c
Vermicompost + Azosprillium	4.7807b
Azosprillium + NPK	4.2157bc
Vermicompost + NPK	5.8812a
Control	2.3063d
Mean	4.01
SE±	0.5381
F-test	8.73
P-value	0.0000**
$LSD_{0.05}$	1.3214
$LSD_{0.01}$	1s.7730
CV (%)	16.18s

*** = Significant at1% probability level of the F-test.*

3.6 Conclusion and Recommendations

3.7 Conclusion

The present experiment assessed six bio, organic and synthetic- fertilizers, in order to compare their effects on growth and yield parameters in millet. Results of the study clearly revealed differences in effects of treatments on millet root length, plant height, leaf dry matter weight, panicle weight and grain weight. Consequently, the study established that all the bio, organic and synthetic- fertilizers were better than the control, in terms of leaf dry matter weight, panicle weight and grain weight. The study also found that combination of the two bio-fertilizers, Vermicompost + NPK was generally the most effective treatment. Vermicompost + Azosprillium proved more effective on root length than Vermicompost, Azosprillium + NPK and Vermicompost + NPK. It was better than all treatments on plant height at 9 WAS, as well as panicle weight and grain weight. Thus, in terms of growth, regression analysis generally showed that VCM + AZO > NPK > AZO > VCM > VCM + NPK > Control in that order of magnitude. Furthermore, results showed that NPK gave comparable results with that of Vermicompost + Azosprillium on plant height and leaf dry matter. NPK also gave longer roots and better growth than Azosprillium + NPK and Vermicompost + NPK, while it was more effective on panicle weight and grain weight than the remaining treatments.

3.8 Recommendation

All crops require fertilizers for effective growth and yield, and there is recent shift from synthetic- to bio- fertilizers. This informed the present study, in which effects of three organic-fertilizers, Vermicompost and bio-fertilizer Azosprillium, a synthetic-fertilizer, NPK and their combinations were assessed in millet. Although all the six fertilizer treatments and their combinations were generally effective, they showed variable effects on millet growth and yield parameters. Results showed variability in the effects of treatments on the different parameters, thus some of the treatments proved more effective than others. Based on the obtained results from this study, combination of the two organic-fertilizer, Vermicompost and NPK the synthetic-fertilizer, stand out as the best treatments. Thus, Vermicompost + NPK and Vermicompost + Azosprillium are recommended as the best bio- and organic - fertilizers for millet. However, it is suggested that further studies be carried out on different rates and doses of these organic, bio- and synthetic- fertilizers.

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