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Evaluation of Economic Importance of Locally Produced Manure over Inorganic Fertilizer for Maize Production: Vegetative Performance and Cost Implication

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Abstract

Background: Crops of economic importance like Maize are preferred to other crops with capacity of giving the highest yields, having the ability to help alleviate poverty within the African continent. The consistent use of inorganic fertilizers has great adverse effect on soil structure. The quest to seek alternative method of boosting maize production is imminent to avoid further soil degradation. Most plants form symbiotic relationships with mycorrhizae and improve nutrients uptake by host plants. **Objectives:** The aim of this study is to examine the effect of mycorrhizae in local manure production on development of maize, in comparison with inorganic fertilizer application and its cost implication. **Methods:** The experiment involved samples of starter soil from 7 local governments. Organic waste was added to starter soil, each having three replicates. Nine other replicates served as non-inoculated controls and nine served for fertilizer application at 50 g, 100 g and 150 g. One [1] gram of Maize sown in 50 ml pot contains soil at different treatment levels 50 g, 100 g, and 150 g. After two weeks, samples were transplanted in an open field. **Results:** The result showed plots treated with locally produced fertilizer, significantly influenced plant height, culm diameter, number of leaves and leaf broadness in comparison to inorganic fertilizer, which showed 53%, 47% respectively. **Conclusion:** Cost production of a bag of organic fertilizer was one-fourth cheaper compared to an inorganic fertilizer price from an open market.

Keywords

Mycorrhizae, Organic Fertilizer, Inorganic Fertilizer, Maize Production

1. Introduction

Maize is an economic plant, with an impacting capacity to surprise humans. It is a staple food crop grown in diverse environments and consumed by people of varying preference and socio-economic background in Africa. Maize is one of the crops that give the highest yield per man hour of labor spent on it; it provides nutrients in compact form [1]. In terms of taste, many people prefer maize to their local cereals [1]. Importance of maize cannot be over-emphasized in the developing world, including the potential to mitigate the present food insecurity and alleviate poverty. Maize is preferred staple food for over 900 million poor consumers, 120 - 140 million poor farm families and about one third of malnourished children [2]. Due to the fact that maize is highly responsive to production inputs, its food and industrial uses are many and its production potential can hardly be matched by any other cereals. It is therefore definitely a solution to hunger.

Maize is one of the crops that depend substantially on nitrogen for growth and development. It has been established that among all the essential nutrients, nitrogen seems to have the most pronounced effect on plant growth and development [3]. As importance as nitrogen is in plant life, it is low in soils of Nigerian Guinea Savanna. The soils of this zone are characterized with low organic carbon, total nitrogen, available phosphorus, effective Cation Exchange Capacity (CEC) and exchangeable cations as well as clay and silt contents [4]. It has been observed that nitrogen is the most important constraint to increased maize production in the Guinea Savanna of Nigeria [5]. It should be noted the growth and productivity of any plant rest on degree of effectiveness of such a plant to absorb and mobilize the nutrients that are available in the soil for plant growth and dry matter accumulation [6]. Hence, application of nitrogenous fertilizer becomes inevitable to guarantee increased maize production for maximum yield. Long term use of inorganic fertilizer causes deleterious effects on soil health and environment [7]. This has led to seeking alternate source of mineral enhancement in soil, shifting attention to locally produced manure.

Arbuscular Mycorrhizae (AM) plays a crucial role in plant nutrient uptake, water relations, ecosystem establishment, plant diversity, and the productivity of plants. Mycorrhizae send out extensive networks of fine thread which facilitate uptake of limiting nutrients to include phosphorous, nitrogen, several micronutrients to the plant [8] and are capable of absorbing inorganic P either from the soluble P pools in the soil or from insoluble forms such as rock phosphates via localized pH alterations or by producing organic acid anions which act as chelating agents [9].

Furthermore, AM fungi can also have a direct effect on the ecosystem, as they improve the soil structure and aggregation and drive the structure of plant communities and productivity [10] [11] [12].

This research is focused to evaluate the effect of locally made manure induced with mycorrhizae on development of maize, to compare with inorganic fertilizer effect and its cost implication.

2. Materials and Methods

2.1. Collection of Starter Soil

Starter soils were collected in Nigeria from Bauchi State within seven local governments in an open field described by Bauchi State Agricultural Development Program (BSADP) all within Bauchi metropolis namely; Dass (M1), Giade (M2), Tafawa Balewa (M3), Darazo (M4), Ganjuwa (M5), Jama'are (M6) and Bauchi (M7).

Twenty-Five gram of soil samples containing mycorrhiza fungi was obtained using a hand shovel and placed in a polythene bag from each local government and transported to the laboratory between the Month of May-August 2018.

2.2. Identification of AM Fungi

Identification to genus level will usually be sufficient to determine whether or not a specimen is mycorrhizal. Identification of AM fungi was carried out in two ways;

2.2.1. Macroscopic Identification

At first level, soil specimens from an open field were collected and accurately described using colours chart of "the Mathew handbook of colour" [13].

2.2.2. Microscopic Identification

Total heterotrophic count was made after incubation at room temperature with some fungi observed with distinctive features while others lacks key of identification from the information and photographs in field guide. Thus, a second level of investigation was often required to accurately identified species of mycorrhizae fungi. This involved examination of microscopic character such as isolation of fungi into pure culture and consulting specialist for identification by wet preparation and observing the hyphae and spores within the sporangia [14].

2.3. Mycorrhiza Multiplication

Twenty grams of soil samples from each local government are poured into a 25 L container, containing 2L of microbial growth enhancer (molasses), aerator placed within the closed 25 L for proper mixing and left for about 4 - 5 days as described by [15].

2.4. Quantification of Mycorrhiza

Two Milliliter of the starter substrate was scooped from the surface of mixed samples for mycorrhiza multiplication and poured into test-tube to. Five Milliliter of of trypan blue was added then filled with distilled water to 25 ml mark. The 25 ml of sample was centrifuged at 1000 rpm for 5 mins [16].

Then decanted samples was viewed and counted using hemocytometer count as described by [17].

Cells per ml = the average count per square × the dilution factor × 104 (count

10 squares)

Total cell number = cells per ml × the original volume of fluid from which cell sample was removed.

2.5. Local Manure Production

Manure production was carried out as described by [15]. 25 kg of chicken dunk was mixed with the 25 L content and mixed with 10 kg of soil. The mixture is left for the period of 2 - 3 weeks in a moist condition to enable mycorrhiza extension.

2.6. Growing of Maize Seeds Using Produces Manure

Two-third (2/3) of Normal soils were introduced to the various pots having 1/3 of organic manure introduced. The seed were sown and nurtured for 2 weeks before transplanted in an open filed using a (2 × 2) meter complete block design [16].

2.7. Application of Fertilizers

Mycorrhizae induced organic fertilizer and inorganic fertilizer was applied early morning hours between 6.00 am - 7.00 am. Mycorrhizae induced organic fertilizer was applied at the initial stage at 50 g, 100 g and 150 g and applied on the field at the 5th week. Inorganic fertilizer was applied twice on the 5th and 8th week at 50 g, 100 g and 150 g.

2.8. Recording of Growth Parameters

Growth characters recorded are; Plant height was measured in centimeter using a meter rule starting from the surface of the soil to the tip of the flag leaf, number of leaves were counted on the plant, Culm diameter was measured in centimeter using a thread placed round the mid portion of the culm, and then placed on a ruler and leaf broadness was measured in centimeter using a meter rule taking the leaf width.

3. Results and Discussion

Generally, across station spore count range from 1.6×10^7 - 3.8×10^7. M6 (Jama'are) had the highest sporulation and the least was observed in M7 (Bauchi). Abundance of spore within soil environment could be as a result of land formation, topography, soil content and level of anthropogenic activities within sampling points as shown in **Table 1**.

The effect of organic and inorganic fertilizer on plant height for 5th - 9th week. At 5th week mycorrhiza induce organic fertilizer M6T2 had the highest at 81.67 cm and inorganic fertilizer F1T3 had the least at 51 cm, 6th week organic fertilizer had the highest growth M6T2 at 105.67 cm and inorganic fertilizer had the least growth F1T3 at 65 cm, 7th week organic fertilizer had the highest growth M4T2 at 147 cm, both organic, inorganic M3T1, F1T3 had the least

Table 1. Spore counts of prepared sample gotten from different local government in Bauchi state.

	Stations						
	M1 (Dass)	M2 (Giade)	M3 (T|Balewa)	M4 (Darazo)	M5 (Ganjuwa)	M6 (Jama'are)	M7 (Bauchi).
Sporulation count (total cells)	1.7×10^7	2.3×10^7	1.5×10^7	2.1×10^7	3.1×10^7	3.8×10^7	1.6×10^7

growth at 93 cm, 97 cm. At 8th week organic fertilizer had the highest plant height at 170 cm and both organic, inorganic treatments M3T1, F1T3 had the least plant height at 96.33 cm and 109.67 cm. 9th week organic fertilizer induced with mycorrhizae M5T2 had the highest plant height and both organic and inorganic had the least 102 cm, 117.67 cm. 5th, 6th and 7th week showed significant difference between replicates and treatments at ($p < 0.05 = 0.047$, 0.156, 0.017; 0.000, 0.011, 0.001) as shown in **Table 2**. It showed no significant difference between replicates at ($p > 0.05 = 0.290$, 0.601), but was significant between treatments at ($p < 0.05 = 0.000$) in 8th and 9th week.

The effect of organic and inorganic fertilizer on number of leaves was observed in **Table 3** for 5th - 9th week. At 5th week mycorrhiza induce organic fertilizer M3T1 had the highest number of leaves at 9.00, both organic and inorganic fertilizer M2T2, F1T3 had the least at 6.00, 6th week organic fertilizer had the highest number of leaves M2T1 at 12 and inorganic fertilizer had the least number F1T3 at 7 cm, at 7th week organic fertilizer had the highest growth M3T2 at 12, organic M7T1, M2T1, M2T3 had the least number of leaves at 8 cm. 5th, 6th and 7th week showed no significant difference between replicates at ($p > 0.05 = 0.739$, 0.405, 0.920) and between treatment showed significant difference at ($p < 0.05 = 0.006$, 0.000,0.081). At 8th and 9th week showed no significant difference at ($p > 0.05 = 0.896$, 0.337). Organic fertilizer induced with mycorrhizae M5T1 had the highest number of leaves 11 and both organic and inorganic had the least 7.

The effect of organic and inorganic fertilizer on number of culm was shown in **Table 4** from 5th - 9th week showed no significant difference between replicates and treatments at ($p < 0.05 = 0.103$, 0.665, 0.261, 0.183; 0.235, 0.743, 0.258, 0.162) of organic fertilizer induced with mycorrhizae and inorganic fertilizer.

Table 5 shows the effect of organic and inorganic fertilizer on Leaf broadness from 5th - 9th week. At 5th, 6th week, showed no significant difference between replicates at ($p > 0.05 = 0.581$, 0.515) and between treatments was significant at ($p < 0.05 = 0.005$, 0.000), but was significant in 7th week between replicates and treatment at ($p < 0.05 = 0.012$, 0.04) and showed no significance in 8th and 9th week at ($p < 0.05 = 0.245$, 0.364) of organic fertilizer induced with mycorrhizae and inorganic fertilizer.

The mycorrhiza induced organic fertilizer showed 53% growth rate compared to inorganic fertilizer application at 47% as clearly observed in **Figure 1**.

Table 2. Average mean of plant height [cm] from 5th - 9th week of observation.

	Weeks				
Treatments	5th	6th	7th	8th	9th
M1T1	71.333abcd	87.000ab	135.667ab	156.333abcd	169.000abcd
M1T2	60.333bcde	88.667ab	126.000ab	131.000abcde	141.333abcde
M1T3	70.067abcde	89.333ab	136.000ab	159.333ab	172.333abc
M2T1	70.333abcde	90.333ab	101.000ab	111.667cde	122.000bcde
M2T2	70.667abcd	91.000ab	132.000ab	146.000abcd	158.333abcd
M2T3	75.133abc	85.000ab	112.000ab	127.333abcde	139.667abcde
M3T1	73.667abc	79.000ab	93.333b	96.333e	102.000e
M3T2	76.733ab	90.000ab	104.333ab	116.667bcde	129.667abcde
M3T3	69.333abcde	97.000ab	116.667ab	134.000abcde	146.667abcde
M4T1	66.500abcde	86.667ab	136.000ab	165.667a	175.000a
M4T2	66.667abcde	87.667ab	147.000a	170.000a	181.667a
M4T3	70.333abcde	81.000ab	116.000ab	141.667abcde	158.000abcd
M5T1	72.500abc	94.333ab	137.000ab	156.333abcd	173.000ab
M5T2	71.000abcd	103.667a	143.333ab	166.333a	181.667a
M5T3	75.000abc	84.333ab	137.667ab	158.667abc	167.667abcd
M6T1	63.333abcde	82.333ab	113.000ab	126.000abcde	139.333abcde
M6T2	81.667a	105.667a	130.000ab	152.333abcd	160.333abcd
M6T3	63.000abcde	78.667ab	126.000ab	151.000abcd	160.000abcd
M7T1	59.333bcde	72.333ab	105.333ab	112.667bcde	120.333cde
M7T2	70.000abcde	92.667ab	107.000ab	116.333bcde	131.667abcde
M7T3	64.000abcde	91.000ab	143.333ab	154.000abcd	161.333abcd
F1T1	57.000cde	70.000ab	103.333ab	109.667de	117.667de
F1T2	53.000de	69.333ab	101.667ab	113.333bcde	121.667bcde
F1T3	51.000e	65.000b	97.333ab	124.333abcde	142.333abcde
ANOVA based on treatments across weeks at $p < 0.05$	0.000	0.011	0.000	0.000	0.000
ANOVA between replicates across weeks at $p < 0.05$	0.047	0.156	0.017	0.292	0.292

Cost of Organic Induced Mycorrhiza Production

Production of the organic fertilizer cost 6000 naira producing 4 bags compared to the surveyed market price of a bag of fertilizer at 8000 naira making the organic induce mycorrhiza one-fourth cheaper than an inorganic fertilizer.

Table 3. Average mean of number of leaves from 5th - 9th week of observation.

	Weeks				
Treatments	5th	6th	7th	8th	9th
M1T1	7.667ab	9.000bcdef	10.333a	10.333a	10.333a
M1T2	8.333ab	10.333abcd	11.000a	7.000a	7.000a
M1T3	7.667ab	10.667abc	11.000a	9.667a	9.667a
M2T1	8.000ab	11.667a	8.000a	8.667a	8.667a
M2T2	6.000b	10.000abcde	9.667a	7.333a	7.333a
M2T3	8.333ab	8.000def	7.667a	8.333a	8.333a
M3T1	9.000a	9.000bcdef	9.000a	8.667a	8.667a
M3T2	7.667ab	7.667ef	11.667a	8.333a	8.333a
M3T3	7.667ab	11.000ab	10.667a	8.000a	8.000a
M4T1	8.333ab	10.333abcd	9.000a	9.667a	9.667a
M4T2	7.000ab	10.667abc	10.000a	9.333a	9.333a
M4T3	7.000ab	9.333abcdef	8.667a	9.000a	9.000a
M5T1	8.333ab	10.667abc	10.000a	11.000a	11.000a
M5T2	6.667 a b	10.667abc	10.000a	9.333a	9.333a
M5T3	6.667 a b	10.000abcde	10.667a	9.000a	9.000a
M6T1	7.000ab	9.667abcdef	8.667a	9.000a	9.000a
M6T2	8.333ab	9.333abcdef	9.333a	9.000a	9.000a
M6T3	7.667ab	8.333cdef	9.000a	8.333a	8.333a
M7T1	7.667ab	8.667bcdef	8.000a	8.333a	8.333a
M7T2	7.333ab	9.000bcdef	8.667a	8.000a	8.000a
M7T3	7.333ab	10.667abc	9.000a	9.667a	9.667a
F1T1	8.000ab	8.333cdef	10.000a	9.000a	9.000a
F1T2	8.000ab	8.000def	10.000a	8.667a	8.667a
F1T3	6.000b	7.333f	10.000a	9.000a	9.000a
ANOVA based on treatments across weeks at $p < 0.05$	0.006	0.000	0.081	0.337	0.337
ANOVA between replicates across weeks at $p < 0.05$	0.739	0.405	0.920	0.896	0.896

Findings of this research showed that organic induced mycorrhiza fertilizer has less cost implication than inorganic fertilizer. Also, mycorrhizae positively affects on plant growth by reducing germination periods and increasing the rate of plant development. Plant and mycorrhizae exudates are known to participate in complex chemical dialogues which play roles in several aspects of plant growth. Plant strigolactones function as signaling compounds during the initiation of

Table 4. Average mean of culm diameter [cm] from 5th - 9th week of observation.

	Weeks				
Treatments	5th	6th	7th	8th	9th
M1T1	2.000a	2.667a	2.667a	2.667a	2.667a
M1T2	1.667a	2.300a	2.300a	2.300a	2.300a
M1T3	1.967a	2.100a	2.467a	2.467a	2.467a
M2T1	1.800a	2.033a	2.100a	2.100a	2.100a
M2T2	1.933a	2.600a	2.800a	2.867a	2.867a
M2T3	2.200a	2.367a	2.533a	2.633a	2.633a
M3T1	1.700a	1.833a	2.000a	2.000a	2.000a
M3T2	2.100a	2.333a	2.633a	2.667a	2.667a
M3T3	1.867a	2.200a	2.467a	2.467a	2.467a
M4T1	2.067a	2.267a	2.400a	2.400a	2.400a
M4T2	2.000a	2.600a	2.633a	2.667a	2.667a
M4T3	1.800a	1.833a	1.833a	1.833a	1.833a
M5T1	1.567a	2.367a	2.433a	2.433a	2.433a
M5T2	1.767a	2.400a	2.667a	2.700a	2.700a
M5T3	1.767a	2.167a	2.500a	2.500a	2.500a
M6T1	1.667a	2.067a	2.167a	2.233a	2.233a
M6T2	2.333a	2.567a	2.800a	2.800a	2.800a
M6T3	1.467a	2.067a	2.767a	2.800a	2.800a
M7T1	1.933a	2.267a	2.633a	2.733a	2.733a
M7T2	1.800a	1.933a	2.033a	2.033a	2.033a
M7T3	2.233a	2.467a	2.867a	2.867a	2.867a
F1T1	1.933a	2.367a	2.567a	2.833a	2.833a
F1T2	1.967a	2.467a	2.500a	2.500a	2.500a
F1T3	2.233a	2.700a	3.267a	3.267a	3.267a
ANOVA based on treatments across weeks at $p < 0.05$	0.235	0.743	0.258	0.162	0.162
ANOVA between replicates across weeks at $p < 0.05$	0.103	0.665	0.261	0.183	0.183

arbuscular mycorrhizae colonization and stimulates fungal metabolism and branching [18]. AM appears linked to increased production of auxins and cytokinins which promote plant growth [18].

Table 5. Average mean of leaf broadness [cm] from 5th - 9th week of observation.

	Weeks				
Treatments	5th	6th	7th	8th	9th
M1T1	5.233ab	8.167a	9.000a	9.000a	9.000a
M1T2	4.667ab	7.600ab	8.367ab	8.500a	8.500a
M1T3	6.433ab	7.000abc	7.267ab	7.667a	7.667a
M2T1	7.067a	7.667ab	7.667ab	8.000a	8.000a
M2T2	6.200ab	7.400ab	7.500ab	7.667a	7.667a
M2T3	6.867a	7.800a	7.867ab	8.333a	8.333a
M3T1	5.667ab	6.000abc	6.733ab	7.067a	7.067a
M3T2	6.333ab	6.667abc	7.000ab	7.700a	7.700a
M3T3	4.100ab	7.000abc	7.467ab	7.833a	7.833a
M4T1	6.033ab	7.000abc	7.000ab	8.333a	7.833a
M4T2	4.633ab	7.167ab	7.700ab	8.067a	8.067a
M4T3	5.000ab	5.233abc	6.500b	7.333a	7.333a
M5T1	5.333ab	7.167ab	8.600ab	8.600a	8.600a
M5T2	5.167ab	6.833abc	8.333ab	9.000a	9.000a
M5T3	5.267ab	6.500abc	8.067ab	8.333a	8.333a
M6T1	5.200ab	7.667ab	7.667ab	7.667a	7.667a
M6T2	6.500 ab	8.333a	8.600ab	8.633a	8.633a
M6T3	5.667ab	6.700abc	7.500ab	8.167a	8.167a
M7T1	5.767ab	6.667abc	7.167ab	8.000a	8.000a
M7T2	5.433ab	5.933abc	7.567ab	7.567a	7.567a
M7T3	6.333ab	8.333a	8.333ab	8.600a	8.600a
F1T1	5.100ab	5.333abc	6.833ab	7.833a	7.833a
F1T2	3.000b	4.333bc	6.233b	8.033a	8.033a
F1T3	3.333b	3.667c	7.667ab	8.967a	8.967a
ANOVA based on treatments across weeks at $p < 0.05$	0.005	0.000	0.004	0.364	0.364
ANOVA between replicates across weeks at $p < 0.05$	0.581	0.515	0.012	0.245	0.245

4. Conclusion

The results showed mycorrhizae induce organic fertilizer effectiveness on accelerated developmental phase of maize, cheap cost of production and little or no

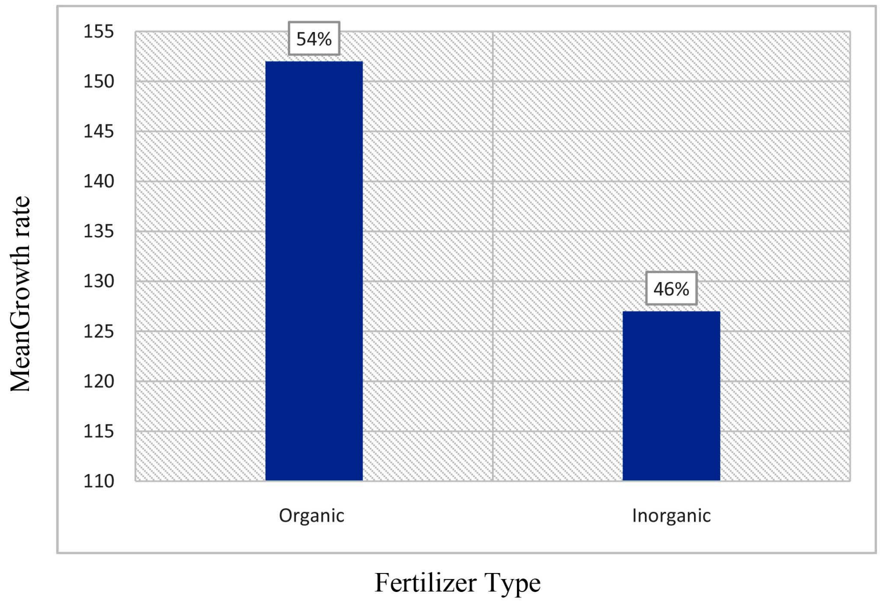

Figure 1. Mean comparison between organic and inorganic effect on growth rate of maize.

damage on soil composition. Additionally, it can be used for colonization and propagation of desired vegetation in a natural environment and significant impact in habitat restoration efforts. Agriculture might also be positively impacted by shorter crop cycles [19].

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Conflicts of Interest

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

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