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Comparative Performances of Different Varieties of Maize under Organic, Inorganic and Combined (Organic and inorganic) Fertilization

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Abstract:

The current world-wide shortage of fertilizer and its anticipated adverse effect on food production has made many countries to explore the manorial value of organic manure to reduce pressure on the demand for mineral fertilizer as complementary use. The trial was carried out at the Teaching and Research farm of The College of Education, Lanlate, Southwest Nigeria as a rain fed pot experiment to determine the performance of different varieties of maize under organic, inorganic and combined fertilization. There were two varieties of maize (Sweet maize and Swan LSRY) and four fertilization (i.e. control, inorganic, organic and organomineral). Each of the maize varieties was tested with the varying fertilization making a total of eight (8) treatments for the experiment. Each treatment was replicated thrice using Randomized Complete Block Design (RCBD). In the experiment, plant height, stem girth and number of leaves were collected at 2,4,6,8 and 10 weeks after planting. The treatments with organic and organomineral fertilizer (inorganic + organic) with each of the maize varieties gave the highest plant height in relative to the use of inorganic fertilizer or control. The variety treated with organic fertilizer gave the highest stem girth at 2WAP with the least recorded at the control. Also, the plant treated with complementary application of organic and inorganic fertilizer gave the highest value from 4 WAP to 10WAP; however the least was also recorded at the control. Though there were no significant different in the number of leaves at 8 and 10WAP for both maize varieties, however the use of organomineral fertilizer for Swan maize gave the highest number of leaves at 4 and 6 WAP.

Keywords:

Maize, Organic, Inorganic, Organomineral, Fertilizer

1. Introduction

In many developing countries, farmers have limited financial resources and can rarely afford to purchase sufficient mineral fertilizer. The use of single super-phosphate (SSP) and other synthetic fertilizers are beyond the reach of peasant farmers due to their cost and scarcity. Crops have become so expensive to grow that nutrient deficiencies should not be allowed to limit the yields. With management practices such as continuous cropping and reduce fallow periods, the soil can hardly support cropping. The need therefore, arises for production practices that will ensure high yield.

Organic fertilizers are materials derived from plant and animals' parts/dropping or residue which are applied to fertilize the soil. (Omar, [25]).

Inorganic fertilizers are essential component of any system in which the aim is to maintain good yield in the absence of organic manure (Ayoola, [11]). However the rate of application and dosage has a greater influence on both crop yield and its environment (Gruhn, [14]). Unlike inorganic fertilizer, organic fertilizers are cheap, easy to come-by, always safe to use, not poisonous or kill crop and environmentally friendly, but must be applied in large quantity to the crop because the nutrient concentration is very low compared with inorganic fertilizer which would definitely result to high transportation cost of manure materials. Maize or corn is rated the third most important cereal crop of the world and the most important cereal crop in Sub-Saharan Africa (FAO, [13]). Organic based fertilizers release their nutrients slowly therefore these nutrients are thereby stored in the soil for a longer time (Abou El-Magd, *et. al.*[5]) while inorganic fertilizers released their nutrients immediately it is applied to the soil provided there is adequate moisture. (Olowokere, *et. al.* [24])

Maize is essentially an important component of the farming systems and the diet of many people in the tropics and can be processed into different products for various end uses both at the traditional level and industrial scale, though a large production of products utilized in developing countries is obtained via traditional processing while industrial processing meets the bulk of the demand in developed countries (Abdulraheem and Charles, [3]; Ogieva, [21]).

Maize is the third most important grain crop in the Savannah zone of Nigeria, following sorghum and rice, respectively. However, its yield is drastically limited by deficiency of N and P in the soils, low cation exchange capacity and soil acidity. Hence, responses of maize to N and P fertilizers have often been recorded in the guinea Savannah zones of Nigeria (Odiete *et al*., [20]).

Maize has the potential to supply large amounts of energy-rich forage for animal diets, and its folder can safely be fed at all stages of growth without any danger of oxalic acid, prussic acid (Abdulraheem, et. al. [4]). In Nigeria, it is mainly used for human consumption (Omar, [25]). Maize is stable food as well as an industrial crop for flour mills, breweries, breakfast cereals and baby food in Nigeria (Saliu and Obasi, [26]). The demand for maize is always higher than what is being produced in the country. For instance in the year 2005, over 4.0 million tons of maize was imported from Lebanon, Italy, Belgium and Indian (NBS, [17]) and about 1.772 billion Naira worth of maize was imported in 2006 (NBS, [18]). One of the greatest challenges confronting Nigeria in her development process is how to raise the level of agricultural productivity to be able to meet the food requirements of her rapidly growing population and how to lay a sound agro-industrial raw material base. In the face of the ever-increasing pressure on the nation's arable land resources arising from competitive demands from the other sectors of the economy, the only way to meet

these challenges would be substantially raise crop yield per unit of land under an intensive cropping system.

Maize is the most highly distributed cereal in the World used for human and animal feeds as well industrial purposes (Abdulraheem and Charles, [2]). Maize does best on a fertilized soil that is adequately supplied with fertilizer. Under continuous cultivation judicious use of the various fertilizers (organic and inorganic) is imperative apart from adoption of the improved technological input of crop production. The inability to meet up the demand for maize could be partly traced to poor nature of our soil. The soil fertility problem in Africa generally has been attributed to land degradation from extensive agriculture, deforestation and overgrazing by livestock (NEPAD, [19]). The cropping system is inevitably, fast becoming a characteristic feature of the country's agriculture, is however heavily dependent on mineral fertilizers which unfortunately are not cost effective. (Omar,[25]). However, Fakorede, [12] asserted that inorganic fertilizer is not efficiently used due to it unavailability at the right time, cost and insufficient quantity.

The use of mineral fertilizer by farmers is limited because of scarcity, high costs and basic disadvantages in apparent inability to substantially redress the physical fragility and chemical deterioration of the soil (Adeniyan and Ojeniyi, [6]). This necessitates research on the use of organic wastes that are cheap, readily available and environmentally friendly that can be used as fertilizers (Ayeni et al., [7]).

Organic fertilizers are materials added to the soil to supply the essential plant growth, development and enhance optimum productivity (Ojeniyi, [22]). Organic manure is many wastes and residues of plant or animal life. The best known organic manure is the waste from mixed arable and livestock farming called farmyard manure. Farmyard manure is partially rotted straw containing urine and feaces. Other rotting plant remains is usually called composts. Undecomposed materials like straw are manure too. Organic wastes from industrial processes, town refuses and sewage sludge are also referred as manures. Common amongst the farm and bi-products at various adaptive trials areas in Nigeria are poultry droppings, cow dung, goat dung, sheep dung, brewery wastes, cocoa pod husks, tea fluff, chromoleana odorata mulch, calapogonium mulch. And ash wastes such as cocoa pod husk ash, wood ash, rice bran ash and sawdust ash. Organic fertilizer materials are cheap and easy to come by. Most of the organic fertilizer materials are wastes or bi-products of other agricultural crops and animal and they could be used to augment the soil nutrient status, the biological and physical conditions of the soil.

Inorganic fertilizers are synthetic, chemical, artificial material added to the soil that supplies one or more required materials for plants. Inorganic fertilizers are one of the major inputs din crop production. They play a vital role in the improvement of soil fertility and enhancement of crop yields. Fertilizer application to crops is a necessary condition for good yield of crops in Nigeria due to inherent low fertility status of the soils. The stability of production depends on replenishing nutrients removed from the soil by crops, maintaining desirable physical condition of the soil, preventing an increase in soil acidity and toxic elements and minimizing or preventing erosion. (Abdulraheem and Charles, [2]). Use of fertilizers is reported to be responsible for over 50% yield increase in crops (Omar, [25]).

Use of inorganic fertilizer is still a must since the land is limited and the demand for higher production is pressing. Investigations have indicated that Nigerian soils are largely deficient in major essential nutrients. Nutrient elements have specific function

in crop growth and development but no single nutrient can produce any meaningful plant growth on its own (Abdulraheem and Charles, [2]). Chemical fertilizers represent known technology of near-immediate application to solve many of the fertility problems. The addition of artificial fertilizers is efficient, due to its nutrient concentration and relative ease of transportation.

In Nigeria, straight fertilizers such as urea, single super-phosphate and muriate of potash (potassium chloride) were the first set of fertilizer sources widely imported or produced for cereal production. Along with this, the bulk of compound fertilizer used in the country were in form of N.P.K. 15-15-15 which is popular with peasant farmers due to lower costs involved in its use on the field and compared with using the straight fertilizers. The compound fertilizer contains N, P and K in ratio 1:1:1 lacks sulphur and its continuous use may cause nutrient imbalance in the soil.

Currently in Nigeria, there is a general shift in emphasis over the sole use of inorganic fertilizers to other source of plant nutrients such as farmyard manure (Omar, [25]); Sawdust (Abdulraheem and Ojeniyi, [1]). This has necessitated the use of inorganic fertilizers in combination with organic fertilizer. This shift in emphasis is attributed to low cost effectiveness, destructive effect on physical and chemical soil properties, inadequate and untimely supply of inorganic fertilizers (Abdulraheem, *et al.*, [4]).

Organomineral fertilizer is a low input technology of improving the nutrient status of tropical soils for sustainable crop production. They combine the attributes of both organic and inorganic fertilizers (Ayeni, [9]). Efficient use of organic fertilizer could alleviate the problem of declining land productivity in most part of the world. Irrespective of the enormous production potential, very little amount of the available manure is being utilized for crop production (Ojeniyi, [22])

The objective of this paper is to assess the performances of two varieties of maize under organic, inorganic and combined (organic + inorganic) fertilization.

2. Materials and Methods

This experiment was carried out at the experimental site of the Teaching and Research Farm of The College of Education, Lanlate. Lanlate lies between latitude 7^0 30'N and Longitude 3^0 52'E in the tropical rainforest belt f Nigeria. There are two rainy seasons; one from April to July (early season) and the other from mid-August to November (late season). Annual average minimum and maximum temperatures are 24.80^0C and 28.10^0C respectively. The mean relative humidity is about 75%. The soil at the site is classified as an alfisol (Oxic tropuldalf) according to (Adeputu, *et. al.*, 1979). There were two varieties of maize (Sweet maize and Swan LSRY) and four fertilization (i.e. control, inorganic, organic and organomineral). Each of the maize varieties was tested with the varying fertilization making a total of eight (8) treatments for the experiment. Each treatment was replicated thrice using Randomized Complete Block Design (RCBD). Each of the 24 plots was 3m by 3m ($9m^2$) in size and seeds were planted at 0.60m X 0.90m. The varieties were sited into two different locations in other to prevent cross pollination. The organic fertilizer was applied two weeks before planting at the rate of 2.5g/stand and inorganic fertilizer was applied two weeks after planting at the rate of (100kg/ha) per plot. Three seeds of maize was planted and thinned to two stands after two weeks of planting. Plant growth and yield parameters taken at 2, 4, 6, 8 and 10 weeks after treatments (WAT) included plant height, stem girth and number of leaves. Data were analysed using

Analysis of Variance (ANOVA) to determine the effects of treatments on the parameters measured. Factorial experiment was use to designed analysis.

3. Results and Discussion

Table 1 shows the pre-planting soil analysis. It was loamy sand with a pH (H_2O) of 6.6, total N 0.09%, available P 5.6 mg/kg, organic C 1.73%, organic matter (OM) 2.62%. The respective values for exchangeable K, Ca, Mg and Na were 0.25,2.6,2.1 and 0.18 cmol/kg. The OM falls within 0.5-4.0% established for soils of southwestern Nigerian (Adepetu and Corey, 1976) but lower than critical level of 3% specified by Akinrinde and Obigbesan (2000). The total N, available P and exchangeable Ca fell below critical level levels of 0.15% N, 10.0mg/kg available P, 2.0 cmol/kg exchangeable Ca and 0.4 cmol/kg established for crop production in southwestern Nigeria by Akinrinde and Obigbesan (2000). Therefore, response to the applied fertilizers is expected.

Table 1. *Initial soil analysis of experimental site at Lanlate.*

Properties	**Values**
pH (H_2O)	6.50
Organic Matter (%)	2.62
Total Nitrogen (N) g/kg	0.09
Available Phosphorous (P) (mg/kg)	5.60
Exchangeable Calcium (cmol/kg)	2.60
Exchangeable Magnesium (Mg) (cmol/kg)	2.10
Exchangeable Sodium (Na) (cmol/kg)	0.18
Exchangeable Potassium (K) (cmol/kg)	0.25
Sand (%)	81.20
Silt (%)	5.60
Clay (%)	13.20
Texture	Loamy sand

The variety treated with the complementary application of organic and inorganic fertilizer gave the highest mean value at 2WAP and 4WAP while the swan variety treated with complementary application gave the highest mean value for plant height from 6WAP to 10WAP. However, the least value was obtained from the control. This is due to the fact that materials which are plant and animal residues are used for organic fertilizers and these materials differ in chemical composition and will affect their release of nutrient and the amount of nutrient left in the soil after the first cropping. FAO [13] highlighted the role of organic matter in sustaining the fertility of soil for good production of vegetables by binding the soil, but best performance is obtained on well drained fertile soil with adequate organic matter content. Organic fertilizers are very active and important component of soil, it is the nitrogen reservoirs, it furnishes large portion of the soil phosphorous and sulphur, it protects soil against erosion, it supplies the cementing substance for desirable aggregate soil formation and it loosen the soil from all available organic fertilizer.

Previous studies also shows that organic based fertilizers release their nutrients slowly therefore these nutrients are thereby stored in the soil for a longer time (Abou El-Magd, *et. al.*[5]) while inorganic fertilizers released their nutrients immediately it is applied to the soil provided there is adequate moisture. (Olowokere, *et. al.* [24])

Table 2. *Performance of the two varieties of maize under Inorganic, Organic and combined (organic and inorganic) fertilization on the plant height at 2, 4, 6 and 10WAP (CM).*

TREATMENT	2 WAP	4 WAP	6 WAP	8WAP	10 WAP
V_1T_0	66.00ab	116.57b	170.60b	233. 10e	253. 57b
V_1T_1	67.13ab	133.47b	190.43bc.	252.00dc	265.93b
V_1T_2	65.48ab	133.90b	194.45bc	260.80bc	266.68b
V_1T_3	71.28a	170.93a	212.90a	268.37bc	280.00b
V_2T_0	65.37ab	124.57b	179.16bd	237.733	255.30b
V_2T_1	63.37b	135.47b	197.30b	277.07ab	292.63ab
V_2T_2	63.10b	128.30b	195.40bc	266.73bc	317.703
V_2T_3	66.73ab	137.93b	214. 03a	293.708	313.00a

Means with the same letter are not significantly different at < 0.05 using DMRT.

The variety treated with organic fertilizer give the highest value at 2 WAP while the least was obtain in the control. Also, the plants treated with complementary application of organic and inorganic fertilizer gives the highest value from 4WAP to 10 WAP, however, the least was also recorded the control. This was due to the fact that while inorganic fertilizers ensure quick availability of nutrients to crops they have limited residual effect of the applied nutrients (Okigbo, 2000) and their reckless use can create nutrient imbalance that limits the uptake of other essential nutrients and cause soil acidity leading to low crop yields. In addition, they are expensive and may not be readily available

Table 3. *Performance of the Two Varieties of Maize Under Inorganic, Organic And Combined (Organic And Inorganic) Fertilization On The Stem girth at 2, 4, 6, 8 and 10 WAP.*

TREATMENT	2 WAP	4 WAP	6 WAP	8WAP	10 WAP
V_1T_0	12.40b	16.47b	18.53d	20.03c	20.31cd
V_1T_1	12.60b	17.73ab	19.77c	21.17b	22.33bc
V_1T_2	12.63b	18.43a	21.67a	22.53ab	22.80ab
V_1T_3	12.73b	18.77a	21.57a	23.07a	23.37a
V_2T_0	13.20a	15.90c	19.90bc	20.93bc	21.57c
V_2T_1	13.07a	16.67bc	20.17b	21.10b	21.77c
V_2T_2	13.30a	15.87c	19.63c	21.43b	21.83c
V_2T_3	13.10a	16.88b	20.07b	21.97b	22.40b

Means with the same letter are not significantly different >0.05 using DMRT.

In the performance of the treatments on the number of leaves, there were no significant differences between the numbers of leaves for the two varieties of maize from 2 WAP to 10WAP respectively (Table 4). It is clear that the prospect of obtaining enough chemical fertilizer to meet the requirement of the teaming farming population in the tropic is remote. The current price of fertilizer calls for its economic utilization to meet specific requirements of crops.

Research have also shown that the use of inorganic fertilizer in combination with organic materials is able to give the desired higher and sustainable crop yields than the sole use of inorganic fertilizer or animal manure. (Lombin et. al; [15]). Adenawoola and Adejoro ([6]) found out that organic matter and soil nutrients increased with application rate of poultry manure and therefore affirmed that poultry manure contains organic matter, N, P, K, Ca and Mg which are released into the soil

upon decomposition of the manure, and that depletion of soil organic matter under intensive cropping can be amended by proper addition of poultry manure into the soil. Ayoola ([10]) stressed that the wide gap existing between the farmers and the researchers might cause inefficient use of farm input such as fertilizers because many farmers would not receive up to date knowledge on the use of such input.

However, due to high quantity of organic fertilizer needed, adequate quantity of an organic and inorganic waste may be obtained, hence the farmers are often apply organic and inorganic fertilizer combined. Complementary use of organic and inorganic fertilizers has been proved to be a sound soil fertility management strategy in many countries of the world (Lombion et al., [15]).

Table 4. *Performance of the two varieties of maize under Inorganic, Organic and Combined (organic and inorganic) fertilization on the number of leaves at 2, 4, 6, 8 and 10WAP (CM).*

TREATMENT	2 WAP	4 WAP	6 WAP	8 WAP	10 WAP
V_1T_0	12.33ab	14.67ab	18.67ab	21.00a	20.66a
V_1T_1	11.00bc	14.00b	18.00ab	21.30a	2I.30a
V_1T_2	11.00bc	15.00ab	19.00ab	20.00a	20.00a
V_1T_3	10.33c	14.00b	17.67b	20.00a	20.00a
V_2T_0	12.33ab	15.33ab	19.33ab	20.67a	20.67a
V_2T_1	13.00a	15.00ab	19.00ab	21.33a	21.33a
V_2T_2	12.67ab	15.00ab	19.00ab	2I.00a	21.00a
V_2T_3	11.12bc	16.00a	20.00a	20.33a	20.33a

Means with the same letter are not significantly different 0.05 using DMRT.

Recently, research attention in tropical countries has shifted to the utilization of agro industrial and organic wastes which can pose environmental hazards if not converted to agricultural and economic uses (Ayeni, [8]). These materials include waste derived from city refuse, animal wastes and other plant residues. Studies carried out in Nigeria and elsewhere confirm poultry manure as effective nutrient sources for increasing yield and nutrient status of crops such as maize, amaranth, sorghum and pepper (Adeniyan and Ojeniyi [6]).

4. Conclusions

In view of the increasing demand for food due to population, high cost and scarcity of inorganic fertilizer due to government deregulation policy, and unavailability of high yielding crop varieties as planting materials; total reliance on inorganic fertilizer or organic materials alone as fertilizer may not be realistic. Though there were no significant different in the number of leaves at 8 and 10WAP for both maize varieties, however the use of organomineral fertilizer for Swan maize gave the highest number of leaves at 4 and 6 WAP. The use of inorganic fertilizer to sustain cropping was found to increase yield only for some few years but on long-term basic, it has not be effective (Ojeniyi, [23]) but it often leads to decline in soil organic matter content, soil acidification and soil physical degradation, leading to increase soil erosion. On the other hand, inorganic fertilizers are beyond the reach of resource-poor farmers because of high cost and uncertain accessibility and organic inputs, which are often proposed as alternative to inorganic fertilizer composition and high labour requirement.

The integral use of organic manure and inorganic fertilizers for the supply of adequate quantities of plant nutrient required to sustain maximum crop productivity and profitability while minimizing environmental impact from nutrient use is highly advocated for farmers.

Complementary use of organic with inorganic fertilizer should be employed so as to sustain soil fertility management strategy for maize production.

It is therefore concluded that there are abundant organic wastes that could be used alone or combined with mineral fertilizers. The presence of organic manures in organomineral fertilizers ensures more residual effect, balanced nutrition and improvement in soil physicochemical properties. The use of the two sources has synergistic effect and reduces expenditure on scarce and expensive mineral fertilizers. It is a sustainable approach to ensuring high soil productivity and crop yield.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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