



Science

**PERFORMANCE OF MAIZE (ZEA MAYS) GROWN ON MILDLY
ACIDIC LOW FERTILE SOIL AS AFFECTED BY SELECTED
ORGANIC-BASED SOIL AMENDMENTS AND SYNTHETIC
FERTILIZER**

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Abstract

Under intensive cropping systems in the tropics, application of chemical fertilizers becomes an apparently indispensable means of replenishing the rapidly depleting soil nutrients. However, the reported side effects of continuous application of synthetic fertilizers on soil and man are now a major concern. Hence, determination of the potentials of some easily exploitable natural or organic-based fertilizer material(s), which can effectively compete with the commonly used synthetic fertilizers like NPK 15-15-15, is a worthwhile scientific approach, not towards improved performance of versatile arable crop like maize, but also for total eradication or alleviation of chemical inputs on tropical soils. A field experiment was conducted at the Teaching and Research Farms, Ladoke Akintola University of Technology (LAUTECH), Ogbomoso, in the year 2017, to comparatively determine the effects of NPK fertilizer and some selected organic-based fertilizer / amendments on growth, yield and nutrient uptakes of maize (*Zea mays*). Six treatments were introduced, T0 (the control which received no fertilizer application), T1 (NPK fertilizer application), T2 (Tithonia compost application), T3 (Organomineral fertilizer application), T4 (Poultry manure application) and T5 (Cow dung application). All fertilizers were applied at recommended rates. The experiment was laid out in Randomized Complete Block Design (RCBD), replicated thrice. Data were collected on growth and yield parameters, and were subjected to analysis of variance. Means were separated using Duncan multiple range test. Application of different fertilizer materials significantly improved maize performance and nutrient uptakes, compared to the control. Organomineral fertilizer application produced the highest values of most of the growth and yield parameters measured. Although, the values obtained were mostly not significantly different from other fertilizer materials tested (except for cow dung, which was

in some cases, significantly lower in values than other fertilizers tested, but significantly higher than the control (which steadily had the least values of all the parameters measured). Such significant increments may be due to the cherished attributes of organomineral fertilizer (some its nutritious fractions may be rapidly released while remaining fractions may be slowly released, over a long period of time). Hence, application of organomineral is therefore recommended. This will considerably reduce chemical loads on the soil in the study area. Meanwhile, in order to be purely organic in maize production, either composted tithonia or poultry manure is recommended for the study area. This will not only prevent total dependence on harmful and highly priced chemical fertilizers, but may promote improved soil nutrition and hygienic crop productivity.

Keywords: Maize; Synthetic Fertilizer; Soil Amendments; Soil Acidity; Low Fertile Soil.

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1. Introduction

Rapid depletion of soil nutrients and continuously low crop productivity persist particularly under tropical soil conditions. These could be easily traced down to the abusive application of chemical fertilizers and lack of appropriate soil management strategies (Babajide, *et al.*, 2008). Besides, some tropical climatic attributes (such as torrential rainfall and high solar radiation) and certain undesirable human activities (such as yearly bush burning, continuous cropping, mono-cropping, overgrazing, mining, bulldozing, open-clean-clear cultivation, ridging-along-the-slope and excessive logging) are equally aggravating the conditions (Babajide and Olla, 2014). Hence, there is a crying need to search for an environment friendly and organic based means, which could be easily adopted and afforded particularly by the resource-poor farmers, for improving soil nutrition and performance of globally cultivated and versatile cereals like maize.

Maize (*Zea mays*), which is also referred to as corn, is an annual monocotyledonous arable crop plant. It belongs to the grass family Poaceae. Maize was believed to be probably originated from the Central America. Mexico was tagged as the centre of origin from where the spreading started northwardly to Canada and southwardly towards Argentina. The Archaeologists in Teotihuacan, discovered the oldest maize at around 7000 years old in a valley near Puebla in Mexico, but it is possible that there were other secondary centres of origin in America (Aguirre *et al.*, 2006; Galinat, 2006). Maize is a cultivated crop throughout the world, germplasm resources are preserved ex-situ in many parts of the world. However, only in the Meso-American region there still exist, ex situ, the original ancient maize that gave rise to improved varieties that are grown in all regions of the world. Most of the maize variation can be found in the Meso-American region and the Northern part of South America. The great diversity of environments and conditions have created the basis for the development of maize varieties well adapted to harsh conditions of soil and climate as well as to biotic stresses. There is a close correlation among community culture, a production system and the type of consumption of maize, with the diversification and variation of maize (FAO, 2000;

Aguirre *et al.*, 2006). Maize is globally ranked third (3rd) in the order of importance amongst all the cereals i.e. after wheat and rice (FAO, 2000). In Africa, particularly in Nigeria, maize is commonly found to be solely cropped (i.e. mono cropping), or under mixed cropping farming system in combination with other arable crops like cowpea, yam, cassava, soybean etc. It is commonly grown in the rainforest and savannah zones of Nigeria, and its popularity does not depend only on its versatility, but also on its adaptability and its reasonable responses to varying edaphic and climatic conditions, as well as soil nutritional variations (Akanbi, 2002; Babajide *et al.*, 2017). Maize is a very important and highly versatile grain crop, which is grossly consumed domestically and industrially all over the World. It grains contains approximately 76 -88 % carbohydrate, 6-15% protein, 4.5-7.0% fat and 1.3% minerals as reported by (Klingman, 1977). It grows on a wide range of climatic and soil conditions. Although a pH range of 6.0 to 7.0 is the most suitable for maize production, it can still perform reasonably at pH values ranging from 5.0. to 8.0, particularly when the soil is a well drained, well aerated loam or silt loam, with adequate organic matter content and essential nutrients (Akanbi *et al.*, 2006). Maize is known to be relatively high in carbohydrate content which makes it to be widely suitable for human consumption, as well as for livestock feeding and raw materials for local industries, particularly in the breweries, edible oil, alcohol and starch producing industries (FAO, 2000). Despite the adaptability and versatility of maize, its production in Africa (particularly Nigeria) is insufficient to cater for the rapidly increasing population (Babajide *et al.*, 2017). However, one of the major limiting factors is soil fertility. Tropical soils are mostly marginal and therefore require supplementary application of fertilizer materials. Meanwhile, adequate and regular maintenance of soil organic matter is one of the most important conditions to be met, in order to stabilize agricultural systems in the humid and sub-humid tropics (Babajide *et al.*, 2012). This could be achieved by ensuring steady additional supply of organic materials to the soils (Akanbi, 2002; Chukwuka and Omotayo, 2009). Maintenance of soil organic matter is therefore relevant and crucial to crop performance. Poor soil management practices which do not encourage maintenance / improvement of the soil organic matter had been reported to adversely influence general soil productivity and nutrition (Babajide *et al.*, 2012). The undesirable levels of most arable crops' yield in Nigeria today are not unconnected to abusive use of mineral or chemical fertilizers and poor soil nutrients and moisture conservation techniques adopted by local farmers which encourage rapid soil depletion and persistent soil nutrients' imbalance on most agricultural lands. In the course of enforcing optimum crop performance out of the marginal tropical soils, farmers opted for incessant and incorrect application of chemical fertilizers, which overtime aggravated soil fertility conditions and imposed more fatal threats to beneficial soil microbes, man and animals alike, as induced by toxic nitrate pollution of surface and underground waters, eutrophication, soil acidity, accelerated erosion etc. (Tejada *et al.*, 2005; Olabode *et al.*, 2007). Such undesirable effects of have recently drew the attention of agricultural researchers back to the use of organic manures as soil amendments and organic agriculture, which totally discourages the use of agrochemicals on agricultural fields. However, several organic materials have been reported as suitable soil amendments for increasing crop production and soil quality. These include green manure, cow dung, poultry droppings, municipal waste, compost, farmyard manure etc. (Makinde and Ayoola, 2010). In addition, apart from supplying nutrients which could be slowly released to meet crop requirements, application of organic and biological materials had been reported to possibly supply growth-regulating substances which improve the physical, chemical and microbiological properties of the soil (Babajide *et al.*, 2012). Since chemical fertilizers had been reported severally to possess residual effects, apart from being highly priced (Babajide, 2014), researching into various techniques of

ensuring regular supply of organic materials to encourage organic maize production is a reasonable research exercise. Therefore, this experiment was designed to compare the effect of applying NPK fertilizer to other fertilizer types.

2. Materials and Methods

2.1. Description of Experimental Site

The experiment was conducted in the year 2017, at the Teaching and Research Farms, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria, to assess maize under the commonly used chemical fertilizer (NPK 15-15-15) and selected organic / organomineral fertilizers in the study area. The experimental site (Ogbomoso) is found in the guinea savanna zone of south western Nigeria, and being located on latitude 8°10'N and 4°10'E in. Naturally, Ogbomoso is characterized by bimodal rainfall distribution. The early rains start in late March /early April and end in late July / early August, followed by a short dry spell in August. Also, between August and November the late rainy season are the late rains spanned. The annual mean rainfall of the study area ranges between 1150 mm and 1250 mm (Babajide and Olla, 2014). The site was earlier being subjected to continuous sole cropping of yam, cowpea and guinea corn on rotational basis for the past nine (9) years.

2.2. Land Clearing and Preparation

Land clearing was manually carried out with hoe and cutlass. Each plot size was 1.5m × 2.0m with inter and intra row spacing of 75cm X 25cm. The space between the plots was 1.0m × 1.0m, while the space between the replicates was 1.5m × 1.5m. Also, the cleared weeds were left to decay on each plot, as useful basal manure application for each plot.

2.3. Soil Sampling and Analyses

Soil sampling was randomly carried out (during land preparation), while soil auger was placed at a soil depth of 0-15 cm, across the farm plots for pre-planting collection of soil samples used for laboratory analyses of the soil physical and chemical properties. Unwanted materials such as debris, steel, stone and other foreign particles were carefully removed, from the collected soil samples. The samples collected were then made into a composite sample, which was air dried, crushed and sieved through 2 mm and 0.5 mm meshes for the determination of particle size, pH (H₂O), total nitrogen (N), organic carbon, and available phosphorous (P), Iron (Fe), copper (Cu), zinc (Zn), the exchangeable cations (Ca, Na, Mg and K). The particle size analysis was carried out according to the Bouyoucos (1951) hydrometer method, using sodium hexametaphosphate as the dispersant. Soil pH was determined in a 1:1 soil: water ratio and 2:1 soil: KCl ratio (IITA, 1982). Available phosphorus was determined using Bray and Kurtz P-1 method (Page *et al.*, 1982). Total nitrogen was determined by the micro Kjeldal method (Bremner and Mulvaney, 1989). The exchangeable K and Na were determined using the EEL flame photometer while Ca and Mg were estimated using Versenate titration method, and the organic carbon was determined using the Walkley and Black method (Nelson and Summers, 1982). The soil textural class was determined from the soil textural triangle.

2.4. Treatments and Experimental Design

The treatments introduced were TO (The control), T1 (application of NPK), T2 (application of tithonia compost, T3 (application of organomineral fertilizer), T4 (application of poultry manure) and T5 (application of cowdung). Two plots per treatment were used, and the trial was laid out in Randomized Complete Block Design (RCBD), replicated thrice.

2.5. Propagation and Agronomic Practices

After being treated accordingly, the viable maize seeds of variety Suwan solo yellow, were sown at three (3) seeds per hole, which were later thinned to one seed per hole, at precisely two weeks of sowing (WAS). This experiment was purely a rain-fed type requiring no artificial watering throughout. Manual weeding was done using hoes. Basal manure application was done by carefully burying the plant residues found on the plots. All the organic based soil amendments / fertilizers were incorporated into the soil at two (2) weeks before sowing, at the recommended rate of 6tons/ha, while NPK fertilizer was applied at three (3) weeks after sowing, at the recommended rate of 400kg/ha (Akanbi, 2002; Babajide *et al.*, 2017).

2.6. Data Collection

Data collection was done on some maize growth and yield parameters. Data collection on growth parameters commenced at ten week after sowing (10 WAS) on: plant height, stem circumference, leaf length and leaf width. Plant height was determined by using measuring tape placed at the above ground base of the plant and allowed to run to the plant's tip), stem girth (by using venier calipers place at the 20cm height of each plant, the value obtained was referred to as the stem diameter, which was later converted to girth or circumference by a fomular: πD (i.e.3.142 multiplied by the original diameter (D) value as obtained from the reading with the venier calipers). Also determined were leaf length and leaf width. The leaf length was by directly placing the measuring tape on the base of selected leaf and run it on the surface of the leaf to the apex, while the leaf width was determined by placing the measuring tape horizontally at exactly 10cm point from the base of each of the selected leaves. However, after the termination of the experiment, the yield parameters measured (using Mp 600H electronic weighing balance), were ear fresh weight, cob dry weights, grain dry weight, above ground and below ground biomass dry weights.

2.7. Plant Sampling and Analysis

Manual harvesting of maize cobs was done when the plants were properly dried at about ninety-five days after sowing. The harvested plant samples were oven dried at 80°C for 72 hours to a constant weight, according to the procedures described by IITA (1982) and Babajide *et al* (2012), followed by the determination of nutrient concentrations and uptakes. Total N was determined by micro-Kjeldahl method. The P was determined using vanadomolybdate colorimetry, and K by flame photometry. The nutrients accumulated in plant parts were then calculated as; Nutrient uptakes = % Nutrient content X sample dry weight (Gungula, 1999).

2.8. Statistical Analysis

All data collected were subjected to analysis of variance (ANOVA). The means were separated using Duncan's Multiple Range Test (DMRT) at 5% probability level (SAS, 2016).

3. Results and Discussion

3.1. Soil Physical and Chemical Characteristics

From the pre-cropping soil physico-chemical analyses results, the soil sample used was sandy-loam in nature. The soil sample was also slightly acidic and grossly low in major nutrient concentrations. These results corroborated the findings of Babajide and Fagbola (2014) and Babajide and Olla, (2014), who reported that the soils in the study area required supplementary application of fertilizers to compensate for the relatively low concentrations of the major essential nutrients (Table 1).

3.2. Influence of NPK and Selected Organic / Organomineral Fertilizer Applications on Growth Parameters of Maize (Zea Mays)

Application of different fertilizer treatments significantly enhanced maize growth parameters, compared to the control (Table 2). Application of organomineral fertilizer produced significantly higher plant height (236.2cm) but the value was not significantly different from those obtained from NPK, tithonia compost and poultry manure, but significantly higher than that of cowdung (181.4cm), while the control had the least value (112.4cm), as indicated in Table 2. Similar trend was observed in stem girth and leaf width of maize. In the case of leaf length, all the fertilizer materials tested significantly enhanced leaf length of maize compared to the control which had the least value (Table 2). These results corroborated the research findings of Akanbi (2002); Babajide *et al* (2012); Babajide and Olla, (2014) and Chukwuka and Omotayo, (2009) which established improved crop growth and development through improved soil nutrition by application of fertilizer materials irrespective of their origins.

3.3. Yield Parameters of Maize (Zea Mays) as Influenced by NPK and Selected Organic / Organomineral Fertilizers

Application of different fertilizer treatments significantly enhanced maize yield parameters (Table 3). The values obtained from fresh ear weight (342.0g per plant) and above ground biomass (301.8g per plant) of maize were significantly higher with application of organomineral fertilizer but the values were not significantly different from those obtained from applications of NPK, composted tithonia and poultry manure, but significantly higher than that obtained from application of cow dung. The control had the least values of fresh ear weight and above ground biomass (Table 3). The dry cob weight, grain dry weight and above ground biomass dry weight values followed similar trend, as the organomineral fertilizer application significantly enhanced their productions (with the values of 27.6g, 198.8g and 301.8g per plant respectively), but there were no statistical dissimilarities in those means to those obtained from other fertilizer treatments investigated, but the values were significantly higher than the mean values of the control, which had the least (Table 3). These results were in agreement with the research findings of Ali *et al.*,

(2006); Akanni and Ojeniyi, (2007), Makinde and Ayoola (2010) and Babajide *et al.* (2012), which indicated positive yield responses of arable crops to different fertilizer applications.

3.4. Nutrient Uptakes of Maize (*Zea Mays*) as Influenced by NPK and Selected Organic / Organomineral Fertilizers

Application of different fertilizer materials significantly enhanced nutrient uptakes of maize, compared to the control (Table 4). The N, P and K uptakes were significantly improved by all fertilizer treatments introduced (Table 4). For the N uptake, organomineral had the highest uptake, although the value obtained (6.1 gkg^{-1}) was not significantly different from those obtained from applications of NPK, composted tithonia and poultry manure (5.9 , 6.0 and 6.0 gkg^{-1} respectively), but was significantly higher than that obtained from application of cow dung (4.2 gkg^{-1}), while the control had the least value (Table 4). For P and K uptakes all fertilizer treatments introduced significantly improved the uptakes of the two nutrient elements, compared to the control, which had the least of the values of P and K uptakes (Table 4). These results were in line with some researchers' reports like Olabode *et al.*, (2007); Babajide *et al.* (2012); Chukwuka *et al.* (2014), who reported improved plant nutrient concentrations through improved soil nutrition by fertilizers of diverse origins.

4. Conclusion and Recommendations

Maize was found to respond well to all fertilizer treatments introduced. Application of organomineral significantly enhanced maize performance in terms of growth, yield and nutrient uptakes compared to the control. Although mean values obtained from cowdung application was occasionally found to be significantly lower than those recorded for other fertilizers, but always significantly higher than the mean values of the control. This is then establishing the fact that application of soil amendments may be a good replacement for and may also favour effective competition with highly priced and harmful chemical fertilizers commonly used for arable crop production in the tropics. Therefore, as emanated from these research findings or results, application of organomineral fertilizer recommended which will considerably reduce chemical loads on such typically marginal soil in the study area. However, in order to be purely organic in maize production in the study area, either composted tithonia or poultry manure is recommended. Hence, incorporation of such soil amendments into arable crop production is a worthwhile technology, which could be easily exploited for organic farming. This will not only prevent total dependence on harmful and highly priced chemical fertilizers, but may also favour organic maize production, for promoting general soil health and human welfare. Also, use of either organomineral or any of the recommended organic fertilizer is desirable for promoting environment friendliness and discouraging or alleviating total dependence on chemical inputs for arable crop production, under tropical soil conditions.

Table 1: Results of the Physico-chemical Analyses of the Soil Sample used

Soil Properties	Values
pH (H ₂ O)	6.14
Total N (gkg^{-1})	0.32
Organic carbon (gkg^{-1})	3.38
Available P (mgkg^{-1})	2.32

Exchangeable K (cmolkg ⁻¹)	0.22
Fe (mg kg-1)	1.30
Cu (mg kg-1)	2.40
Zn (mg kg-1)	2.36
Exchangeable Na (cmol kg-1)	0.30
Exchangeable Ca (Cmol kg-1)	0.16
Exchangeable Mg (Cmol kg-1)	2.62
Sand (%)	86.36
Silt (%)	9.01
Clay (%)	4.63
Textural class	Sandy loam

Table 2: Growth Parameters of Maize (*Zea mays*) as Influenced by NPK fertilizer and selected organic / organomineral fertilizers

Treatments	Plant height (cm)	Stem girth (cm)	Leaf length (cm)	Leaf width (cm)
T0 (Control)	112.4c	5.7c	58.8b	5.3c
T1 (NPK)	224.8a	12.4a	92.2a	11.6a
T2 (Tithonia compost)	230.0a	12.2a	98.6a	11.8a
T3 (Organomineral)	236.2a	12.9a	96.8a	11.9a
T4 (Poultry manure)	228.6a	12.2a	94.8a	11.6a
T5 (Cowdung)	181.4b	10.8b	96.6a	7.7b

Mean followed by same letters are not significantly different at 5% probability level, using Duncan's Multiple Range Test (DMRT).

Table 3: Effects of NPK and selected organic / organomineral fertilizers on Yield parameters of Maize (*Zea mays*)

Treatments	Ear Fresh Weight (g plant ⁻¹)	Cob Dry Weight (g plant ⁻¹)	Grain Dry Weight (g plant ⁻¹)	Below-ground Biomass (Dry) weight (g plant ⁻¹)	Above-ground Biomass (Dry) weight (g plant ⁻¹)
T0 (Control)	126.0c	11.7b	101.8b	28.3b	92.6c
T1 (NPK)	324.4a	25.4a	188.2a	42.6a	292.2a
T2 (Tithonia compost)	330.6a	26.2a	192.6a	44.8a	284.7a
T3 (Organomineral)	342.4a	27.6a	198.8a	46.9a	301.8a
T4 (Poultry manure)	328.8a	24.2a	191.8a	44.6a	294.3a
T5 (Cowdung)	282.4b	24.8a	181.6a	39.7a	232.4b

Mean followed by same letters are not significantly different at 5% probability level, using Duncan's Multiple Range Test (DMRT).

Table 4: Nutrient uptakes of maize (*Zea mays*) as influenced by by NPK and selected organic / organomineral fertilizers

Treatments	Nutrient Uptakes (gkg ⁻¹)		
	N	P	K
T0 (Control)	2.0c	0.3b	0.4b
T1 (NPK)	5.9a	0.7a	1.1a
T2 (Tithonia compost)	6.0a	0.7a	1.2a
T3 (Organomineral)	6.1a	0.8a	1.3a
T4 (Poultry manure)	6.0a	0.7a	1.2a
T5 (Cowdung)	4.8b	0.7a	1.0a

Mean followed by same letters are not significantly different at 5% probability level, using Duncan's Multiple Range Test (DMRT)

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