



Response of Hybrid Maize, (*Zea mays* L.) to Organic and Inorganic Fertilizers in Soils of South-West and North-Central Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author ABO designed the study, wrote the protocol, and wrote the first draft of the manuscript. Author FEF managed the literature searches, analyses of the study performed the spectroscopy analysis and author ABO managed the experimental process and identified the species of plant. Both authors read and approved the final manuscript.

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ABSTRACT

Studies were carried out to evaluate the effect of organic and inorganic fertilizers on the growth and yield performance of maize (*Zea mays* L.) at the experimental site of Plant science Department, Faculty of science, Ekiti State University, Ado-Ekiti (7°40' N, 5°15' E) and the Teaching and Research Farm of Landmark University, Omu-Aran Kwara state (8°25' N, 4°40' E) in 2012 and 2014 cropping seasons respectively. The treatments were NPK 20-10-10 (200 kg ha⁻¹) at two weeks after planting (2WAP), Foliar NPK (2.5 l ha⁻¹) at two weeks after planting (2WAP), NPK at 2WAP+foliar NPK at 6WAP, Poultry manure (8 ton ha⁻¹) at planting + foliar NPK at 6WAP, Poultry manure at planting, and the control. Poultry manure at planting + foliar NPK at 6WAP produced the highest maize performance in terms of height, stem girth, leaf area, kernel yield and weight per 100 kernels. This performance was not significantly different from those obtained in the NPK (200 kg ha⁻¹) at 2WAP + foliar at 6WAP. The findings from this work further corroborate the usefulness of

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poultry manure in organic crop production. The improved performance of maize observed in the poultry manure or NPK that received additional foliar NPK application in this work shows the relevance of supplementary foliar fertilizer in addition to poultry manure or NPK on maize performance. The comparable yield obtained in poultry manure with NPK fertilizer also suggested that maize can be organically fertilized to produce high yield in these locations without Chemical fertilizer which could be harmful to our soils and human.

Keywords: Poultry manure; NPK; foliar NPK; maize yield.

1. INTRODUCTION

In Nigeria, maize is an important crop grown both commercially and at subsistent level for food, fodder and industrial purpose. Maize is also used for the production of indigenous and commercial food products that are relished for their unique and distinctive flavours [1,2]. The area planted of maize in West and Central Africa alone increases from 3.2 million in 1961 to 8.9 million hectares in 2001. This phenomenal expansion of the land area devoted to maize resulted in increased production from 2.4 metric tons in 1961 to 10.6 million metric tons per hectare in 2001[3].

In maize production, nitrogen is a major yield determining factor and its availability in sufficient amount or quantity throughout the growing season is essential for optimum maize growth [3]. Nitrogen which is a major component of poultry manure is associated with high photosynthetic activities, vigorous vegetative growth and dark green colouration of the leaves [4].

Phosphorus is one of the most important nutrient elements that limit agricultural production in most regions of the world [5,3]. Phosphorus deficient plants, therefore, are stunted with a limited root system and thin stems. The plant may produce only one small ear containing fewer, smaller kernels than usual leading to severe grain yield reduction [6].

Organic fertilizer supplies the essential macro and micro nutrient elements to plants, as well as improves soil physico-chemical conditions for better maize growth and yield [7,8].

Poultry manure had been reported to contain essential nutrient elements that are associated with increased photosynthetic efficiency which promotes more vigorous growth, improved meristematic and physiological activities in the plants, as well as improve the soil properties, thereby resulting in the synthesis of increased photo-assimilates that enhanced maize yielding ability [9]. However, the nutrient content of

manure varies, and the reason is that the fertilizer value of manure is greatly affected by diet, amount of bedding, storage and application method [10].

Application of foliar fertilizer is an effective way of correcting soil nutrient deficiencies, when soil applied fertilizers are not readily available or when plants are unable to absorb them directly from the soil [11,12]. Folia applied fertilizers provides a quicker response and are more effective for some nutrients than soil applied fertilizers [13].

Despite the increase in land areas under maize production, yield is still low. This is due to the increasing human population which has led to intensive cultivation and nutrient mining without adequately replenishing soil nutrients which brings about some of the major causes of low maize yield, resulting to declining soil fertility and insufficient use of fertilizers leading to severe nutrient depletion of soils [14,15].

Organic and inorganic fertilizers have been comparatively evaluated in maize production [9,4], but the present work aims at investigating the effect of soil and foliar applied organic and inorganic fertilizers on the growth and yield performance of maize (*Zea mays* L.).

2. MATERIALS AND METHODS

Field experiments were carried out at the experimental site of Plant Science Department, Faculty of Science, Ekiti State University, Ado Ekiti (7°40' N, 5°15' E) and the Teaching and Research Farm of Landmark University, Omuara Kwara state (8°25' N, 4°40' E) in 2012 and 2014 cropping seasons respectively. Ado Ekiti and Omu-Aran are respectively located in located in the South-western and North-central Nigeria. Both locations have a bimodal rainfall pattern with an annual mean of 1,400 mm and 1232 mm respectively.

The experimental sites were cleared, ploughed and ridged before planting in April and May of

2012 and 2014 respectively. Each plot consisted of four ridges of 6m with 0.75 m between ridges and planting was done at 0.25 m apart on the ridges to make 53,000 plants per hectare. The experimental design was a randomized complete block and each treatment replicated four times.

The land at Ado Ekiti had been previously planted with water melon while the Omu-Aran land was planted with pepper. Soil samples were collected at random from different locations on the experimental plots to the depth of 15cm. Routine soil analysis was carried out to determine the physical and chemical properties. The soil at the experimental site in Ado Ekiti and Omu-Aran were analysed to be a sandy clay loam with organic matter content- 4.28 and 4.63, 0.48 and 0.45%N, 5.95 and 6.01 mgkg⁻¹ P; 0.08 and 0.07 Cmol K; and a pH of 6.65 and 6.71 respectively. There were six treatments with each replicated four times: These were NPK fertilizer 20-10-10 (at 200 kgha⁻¹ two weeks after planting (2WAP), Poultry manure at 8tha⁻¹ two weeks before planting (2WAP) [16], foliar fertilizer at 2.5Lha⁻¹ two weeks after planting (2WAP), NPK fertilizer 200 kgha⁻¹ at 2 WAP plus foliar 2.5 Lha⁻¹ at 6WAP, Poultry manure at planting plus folia at 6WAP and the sixth was the control experiment. Hybrid Maize (Oba Super 1 white), NPK fertilizer and folia fertilizer were obtained from Fountain Agricultural Management Agency (FAMA) in Ado Ekiti while the poultry manure was collected from the poultry farm of Ekiti State University and Teaching and research farm of Landmark University. The compositions of the foliar fertilizer in weight per volume are: NPK 20-20-20; Mg, Fe, Mn, Cu, Zn, B, Co and Mo at 1.5, 0.15, 0.075, 0.075, 0.075, 0.0315, 0.0012 and 0.0012% respectively.

Data were collected on the following growth and yield components: Plant height, stem girth, number of leaves per plant, leaf area, cob length, cob weight, number of kernels per cob, weight per 100 kernel, and grain yield.

Collected data were statistically analysed and means compared using the Duncan's multiple range Tests.

3. RESULTS

The effects of organic and inorganic fertilizer on maize plant height and stem girth are presented in Table 1. The tallest maize plants (168.7 and 170.1 cm) were produced in 2012 and 2014 respectively from the poultry manure with supplementary foliar NPK fertilizer application. These were not significantly different from the NPK plus supplementary NPK foliar fertilizer. The shortest plants were produced in the control plots. NPK at 2WAP and foliar fertilizer at 2 WAP produced similar maize height. Poultry manure at planting gave taller plants than NPK at 2 WAP. The highest plant girth was produced in the poultry manure + foliar fertilizer applied plots but not significantly different from those of poultry manure without foliar NPK and soil applied NPK with or without foliar fertilizer application. Foliar NPK applied plots had smaller stem girth but higher than those of the control with the smallest girth.

The numbers of green leaves recorded in the organic and inorganic fertilizer applied plots were not significantly different. The control produced the lowest number of green leaves per plant (Table 2). The effects of organic and inorganic fertilizers on leaf area of maize plant Showed that Poultry manure + foliar treatment had the widest leaf area while the was observed in the control. There were no significant differences between the leaf area observed in the Poultry manure + foliar and NPK + foliar. Poultry manure at planting without supplementary foliar NPK fertilizer gave similar leaf area with poultry manure + foliar in 2014 but lower in 2013. Foliar NPK at 2WAP had a lower leaf area compared to soil applied NPK fertilizer at 2WAP.

Table 1. Effects of organic and inorganic fertilizer on maize plant height

Treatments	Plant height (cm)		Stem girth (mm)	
	2012	2014	2012	2014
Control	88.7d	91.6d	6.3c	6.9c
NPK at 2WAP	141.3c	144.6c	9.9a	9.7a
Foliar NPK at 2WAP	130.6d	140.5c	8.0b	8.6b
NPK at 2WAP + Foliar NPK at 6WAP	161.5ab	168.5ab	9.4a	9.9a
Poultry manure at 2WBP	158.3b	165.8b	9.6a	10.3a
Poultry manure + Foliar NPK at 6WAP	168.7a	170.1a	9.8a	10.4a

Means followed by the same alphabet(s) within columns are not significantly different (p= 0.05)

The effects of organic and inorganic fertilizer on the cob length and cob yield of maize are presented in Table 3. The longest cobs were recorded in the NPK + foliar treatment and the poultry manure + foliar applied plots while the shortest were recorded in the control plots. Poultry manure applied plots gave similar cob length with NPK applied plots but higher than the foliar applied plots. Cob yields observed in poultry manure + foliar, poultry manure and NPK + foliar were not significantly different but highest. The cob weight observed in NPK at 2 WAP was higher than those observed in foliar NPK at 2WAP. The least was recorded in the control plots.

Number of grains per cob and 100 kernel weight are presented in Table 4. The number of kernels per cob was highest in plots treated with poultry manure + foliar fertilizer but not significantly different from those of NPK + foliar and poultry manure before planting. NPK at 2 WAP and

Foliar NPK at 2 WAP gave similar number of kernels per cob while the control had the lowest. Poultry manure + foliar had the highest 100 kernel weight while the least was recorded in the control experiment. There were no significant differences in the 100 kernel weight of NPK at 2 WAP, NPK + foliar, poultry manure and poultry manure + foliar treatments. There was no significant difference between the 100 kernel weight of foliar NPK at 2 WAP and NPK at 2 WAP the control had the lowest weight per 100 kernels.

The result of the effects of organic and inorganic fertilizer on the grain yield of maize is presented in Table 5. Poultry manure + foliar at WAP had the highest grain yield which was similar to those of NPK at 2WAP + foliar at 6WAP, while the least grain yield was observed in the control. NPK at 2 WAP had higher grain yield than folia NPK at 2 WAP.

Table 2. Effects of organic and inorganic fertilizer on the number of leaves and leaf area

Treatments	Number of leaves		Leaf area (m ²)	
	2012	2014	2012	2014
Control	8.1b	9.0b	252.9d	368.4d
NPK at 2WAP	10.2a	10.6a	726.0b	753.6b
Foliar NPK at 2WAP	10.3a	10.5a	684.4c	695.8c
NPK at 2WAP + Foliar NPK at 6WAP	11.9a	10.8a	763.5a	781.5a
Poultry manure at 2WBP	10.2a	10.0a	725.4b	777.1a
Poultry manure + Foliar NPK at 6WAP	10.8a	10.5a	775.3a	780.0a

Means followed by the same alphabet(s) within columns are not significantly different (p= 0.05)

Table 3. Effects of organic and inorganic fertilizer on cob length and cob weight

Treatments	Cob length (cm)		Cob yield (tha ⁻¹)	
	2012	2014	2012	2014
Control	9.5c	10.8c	2.5d	2.9d
NPK at 2WAP	13.2b	15.6b	4.4b	4.9b
Foliar NPK at 2WAP	12.9b	14.9d	3.8c	4.1c
NPK at 2WAP + Foliar NPK at 6WAP	15.5a	16.4a	5.2a	5.5a
Poultry manure at 2WBP	14.9a	15.9b	4.9a	5.1a
Poultry manure + Foliar NPK at 6WAP	15.9a	16.3a	5.2a	5.6a

Means followed by the same alphabet(s) within columns are not significantly different (p= 0.05)

Table 4. Effects of organic and inorganic fertilizer on number of grains per cob and weight per 100 kernels

Treatments	Number of kernels per cob		100 kernel weight (g)	
	2012	2014	2012	2014
Control	324c	365c	14.2c	18.5c
NPK at 2WAP	470b	466b	24.5ab	23.3ab
Foliar NPK at 2WAP	465b	459b	22.1b	21.1b
NPK at 2WAP + Foliar NPK at 6WAP	498a	493a	25.4a	25.4a
Poultry manure at 2WBP	496a	488a	26.3a	25.9a
Poultry manure + Foliar at NPK 6WAP	502a	495a	22.7a	25.3a

Means followed by the same alphabet(s) within columns are not significantly different (p= 0.05)

4. DISCUSSION

The result of this study shows that supplementary application of foliar NPK to either poultry manure or soil applied NPK fertilizer increased maize performance in terms of plant height, stem girth leaf area and yield in both locations. The reason for this may be attributed to the high nitrogen concentration provided by the poultry manure, soil applied NPK plus supplementary foliar NPK fertilizer. Similar report has showed that poultry manure contain high nitrogen content which led to increase maize performance [3]. Adequate supply of Nitrogen is associated with vigorous vegetative growth resulting from high photosynthetic activities [17,4]. The use of both foliar and soil applied NPK have been found to increase grain yield in maize [18]. The higher growth values (height, leaf area, cob length, number of kernels per cob and cob length) observed in this study could have attributed to the final highest yield produced in the poultry manure + foliar NPK and NPK + foliar NPK. Higher leaf area might have provided larger area for photosynthesis and subsequent higher translocation of organic solute which resulted to higher yield in maize.

Table 5. Effects of organic and inorganic fertilizer on grain yield

Treatments	Grain yield (tha ⁻¹)	
	2012	2014
Control	2.92d	2.65d
NPK at 2WAP	3.98b	4.15b
Foliar NPK at 2WAP	3.45c	3.06c
NPK at 2WAP + Foliar	4.65a	4.85ab
NPK at 6WAP		
Poultry manure at 2WBP	4.01b	4.50b
Poultry manure + Foliar at NPK 6WAP	4.77a	5.01a

Means followed by the same alphabet(s) within columns are not significantly different (p= 0.05)

The higher performance observed in the poultry manure applied plots may be attributed to the improve soil tilt, aeration, water holding capacity and stimulation of microorganisms in the soil which makes plant nutrient readily available. Also the contributory effect of foliar applied fertilizer in this work may be due to the fact that the foliar applied fertilizer provides a quicker response and release of some nutrients than soil applied fertilizers [13].

The higher yield and yield attributing factors of maize observed in poultry manure + foliar NPK

fertilizer may further be attributed to the fact that poultry manure + foliar NPK supplied the maize plant with adequate quantity of nitrogen is a major yield determining factor in maize production and its availability in sufficient amount or quantity throughout the growing season is essential for optimum maize yield and growth [3]. Also, poultry manure and foliar NPK fertilizer provides the soil with sufficient phosphorus, the deficiency of which produces plants that may produce only one small ear containing fewer, smaller kernels than usual and in which grain yield is often severely reduced [6].

The result of this study clearly showed that the combined application of organic and inorganic fertilizer significantly improves the growth and yield of maize when supplementary foliar NPK was applied. The improved performance of maize as observed in the poultry manure applied plots agrees with earlier studies where the application of organic fertilizer significantly improves the growth and yield of maize [9,19]. An integrated use of both organic and inorganic fertilizers to ensure the adequate supply of plant nutrients and sustain maximum crop yield and profitability has been advocated [20]. Higher levels of poultry manure at the rates of 9.9 tonne per hectare had been reported to improve the growth and yield of *Citrulus lanatus*, in Nigeria [19]. The significant yield and growth increase observed in the poultry manure over the inorganic fertilizer (P=0.05) is in agreement with earlier work where this was attributed to high essential nutrient elements released by poultry manure associated with high photosynthetic activities which promote root and vegetative growth of plants [21,22].

5. CONCLUSION

The findings from this work further corroborate the usefulness of poultry manure in organic crop production. The improved performance of maize observed in the poultry manure or NPK that received additional foliar NPK application in this work shows the relevance of supplementary foliar fertilizer in addition to poultry manure or NPK on maize performance. The comparable yield obtained in poultry manure with NPK fertilizer also suggested that maize can be organically fertilized to produce high yield in these locations without Chemical fertilizer which could be harmful to our soils and human. It is also apparent that a supplementary application of foliar fertilizer to maize after the initial poultry manure application at the rates applied in this

work is capable of further increasing the growth and yield of maize in the study area. Poultry manure application will also serve as substitute to the chemical fertilizer which is too costly and uneasy to procure by farmers. Quality food production which is health friendly will also be produced. The soil acidity usually caused by continuous use of chemical fertilizer is also reduced when organic fertilizer is used. The additive yield effect of foliar fertilizer here also points to its relevance in maize performance when combined with poultry manure.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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