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Comparing Poultry Manure to Inorganic Fertilizer and Their Combination on the Growth and Yield Performance of Omankwa Maize Variety

C. Afriyie-Debrah[1*], E. Obeng Yeboah[1] and P. Francisco Ribeiro[1]

[1]CSIR-Crops Research Institute, Kumasi-Ashanti, Ghana.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: Major effect of soil fertility decline is the observed reduced food production in most African countries, including Ghana. In order to sustain soil and crop productivity, it is necessary to explore alternative soil fertility replenishment strategies, which are effective and affordable to farmers, especially the smallholder farmer.
Study Design: A RCBD in three replications with each block with dimension 4 m × 3 m using spacing of 0.75 m and 0.4 m inter and intra and inter-row.
Place and Duration of Study: The research work was conducted at the CSIR-Crops Research Institute, Kumasi between April 2016 - December 2016 using Omankwa a released maize variety from CSIR-Crops Research Institute, Kumasi, Ghana.
Methodology: There were six treatments per rep and each rep was randomized. Treatments were as follows; control (no fertilizer or poultry manure); T_1 (100% Poultry manure two weeks after planting of maize), T_2 (100% (N.P.K) two weeks after planting of maize), T_3 (25% Poultry manure and 75% NPK fertilizer), T_4 (50% Poultry manure and 50% NPK fertilizer) and T_5 (75% Poultry manure and 25% NPK fertilizer).

**Corresponding author: E-mail: cafriyiedebrah@ymail.com;*

Results: Results from the study showed that Omankwa performed better under treatment T_1 better than other treatments T_4 and T_5 even though T_4 and T_5 perform better in other parameters measure for the experiment but did not results in grain yield for Omankwa.
Conclusion: The use of poultry manure still remains to be the best source as alternative to soil nutrient used for often better yield of crop production but for lack or availability of poultry manure, the poultry manure con be supplemented with NPK a synthetic fertilizer to obtain optimum grain yield in maize production.

Keywords: Omankwa maize variety; poultry manure; NPK; soil fertility and productivity.

1. INTRODUCTION

On smallholder farms, soil fertility decline has been recognized as one of the major biophysical constraints affecting agriculture, particularly nitrogen (N) and phosphorus (P) deficiencies [1]. However, soil fertility has seldom been considered a critical issue by the development community who, until very recently have focused primarily constraints, such as soil erosion, drought and the need for improved crop germplasm, especially in Africa [2,3,4].

Most food crops in Ghana are produced by subsistent farmers, who over the years, practiced slash and burn and shifting cultivation to sustain yield even though at a low level. However, increasing human population has led to intensive cultivation without adequately replenishing soil nutrients. The result has been the decline in crop yields and depletion of the resource base. The soils become fragile, quickly lose organic matter and nutrients when exposed to harsh environmental conditions or intensive cultivation.

Generally, Ghanaian soils are of low inherent fertility and therefore require external inputs to improve fertility. The use of mineral fertilizers is the most effective and convenient way to improve soil fertility [5]. However, fertilizer use in Ghana has dropped to < 5 kg NPK ha^{-1} [6], due mainly to the high cost of mineral fertilizers [7,8]. Consequently, there is presently a serious negative balance in nutrient budgets of soils in the country posing a major constraint to sustainable soil management for increased crop growth and yield [9]. Ironically, there is a large amount of organic waste that can be turned into fertilizers for crop production at low cost. Everywhere in the world people settle first in areas with high potential fertile soils, adequate rainfall and mild temperatures. As populations grow, soil nutrient capital is gradually depleted when farmers are unable to sufficiently compensate losses by returning nutrients to the soil via crop residues, manures and mineral fertilizers.

Increasing pressures on agriculture result in much higher nutrient outflows and the subsequent breakdown of many traditional soil fertility maintenance strategies. These traditional fertility maintenance strategies such as fallowing, intercropping cereals with legume crops and manure producing mixed crop livestock farming have not been replaced by an effective fertilizer supply [10]. Several decades of nutrient depletion have transformed originally fertile lands that yielded about 2 to 4 t ha^{-1} of cereal grains into infertile ones where cereal crops yield less than 1 t ha^{-1} [11]. The bulk of the food in Africa is produced on smallholder farms [12,13]. One of the major problems affecting food production in Africa is the rapid depletion of nutrients in smallholder farms [14]. This is because the smallholder farmer is poorly resourced and unable to invest in soil fertility inputs, particularly mineral fertilizers. This is not surprising since about half of Africa's population is classified as "absolute poor" subsisting on per capita incomes of less than 1 US$ per day [14]. The situation is critical especially when the poor farmer has to bear the full cost of production owing to the removal of subsidies on mineral fertilizers.

Therefore, the use of inorganic fertilizers results in high cost of maize production, destruction of the soil and aquatic life when leached into water bodies. Salt accumulation which develops as a result of repeated application of inorganic fertilizers forces the plants to expend more energy to draw water from the soil and can cause them to appear wilted or dried out. The general objective of this study is to compare poultry droppings, N. P. K inorganic fertilizers (15-15-15) and their combination on growth and yield of corn (Omankwa)

2. MATERIALS AND METHODS

2.1 Location of the Study Area

The research work was conducted at Crops Research Institute Fumesua, Kumasi-Ashanti Region. Fumesua is a Metropolitan Assembly in Kumasi. It is situated on the Accra and Kumasi high way, under Ejisu -Juaben district in the Ashanti region. It is located between latitude 6.8 North and longitude 1.8 west of the equator. The area is a dense forest belt and experiences two types of rain fall pattern which are the major rain and the minor rain pattern, the dry season from November to January [15].

2.2 Experimental Design and Management

Before planting, soil samples from the experimental site were collected at 0-15 cm and 15-30 cm as recommended for depth of maize for analysis of organic carbon, total nitrogen using standard methods, extractable P, Ca, Mg, K, Na where P and Mg^{2+} were determined colourimetrically in a spectrophotometer and Ca^{2+} and K^{+} were determined using flame photometer. Results of the soil analysis is as showed in Table 1. The field was ploughed and left as such for one-week. Total land area of 16 m × 12 m was used with each plot size measuring 4 m × 3 m using spacing of 0.75 m and 0.4 m inter and intra and inter-row respectively in a RCBD in three replications. The blocks were further divided into six treatments per plot with 1 m alley between them. The treatments were; T_0 – Control, T_1 – 100% Poultry manure two weeks after planting of maize, T_2 - 100% (N.P.K) two weeks after planting of maize, T_3 – 25% Poultry manure and 75% NPK fertilizer, T_4 – 50% Poultry manure and 50% NPK fertilizer and T_5 – 75% Poultry manure and 25% NPK fertilizer constituted from recommended rate of 4 ton/ha (poultry manure) and 250 kg/ha as showed in Table 2.

2.3 Data Collection

Data for growth was collected after two weeks of planting and continued after every two weeks based on the following parameters.

- measuring the stem girth
- leave length,
- Number of leaves per plant
- Plant height
- Ear height

Table 1. Compositional soil analysis of the three-study areas

Parameters	Fumesua		Landon (1991) interpretation	
	0-15 cm	15-30 cm	High	Low
pH	3.64	3.47	>6.5	<5.8
Total Nitrogen (%)	0.11	0.07	>0.5	<0.2
Organic Carbon (%)	3.03	2.47	>10.0	<4.0
Organic Matter (%)	5.22	4.26	>10.0	<2.0
Ca (cmol/Kg)	42.4	30.8	>10.0	<4.0
Mg (cmol/Kg)	2.6	4.6	>4.0	<0.5
K (cmol/Kg)	0.36	0.28	>0.6	<0.2
Na (cmol/Kg)	0.94	0.8	>1.0	<1.0
Al (cmol/Kg)	0.5	0.67		
H (cmol/Kg)	0.33	0.33		
P (mg/Kg)	53.47	32.28	>50.0	<15.0
SAND (%)	80	84		
CLAY (%)	10	10		
SILT (%)	10	6		
Textural Class	Sandy Loam	Loamy fine sand		

Table 2. Treatment description

No	Description of treatment	Abbreviation
1	Control (no Fertilizer)	T_0
2	100% Poultry manure two weeks after planting of maize	T_1
3	100% (N.P.K) two weeks after planting of maize,	T_2
4	25% Poultry manure and 75% NPK fertilizer	T_3
5	50% Poultry manure and 50% NPK fertilizer	T_4
6	75% Poultry manure and 25% NPK fertilizer	T_5

Data on yield will be analyzed after harvesting based on

- Cob girth/width
- Number of cob/plants
- Grains weight
- Grain moisture
- Field weight

2.4 Data Analysis

Data of maize yield and growth parameters were analyzed using GenStat to run analysis of variance (ANOVA) and result will be presented in Tables and at LSD of (p=0.05).

3. RESULTS AND DISCUSSION

The analysis of variance for grain yield and yield related traits for Omankwa under various soil amendments at Fumesua are given in Table 3 and Table 4. Analysis of variance showed significant differences for leaf length (cm), Stem girth (cm), grain yield (ton/ha), field weight (kg) and the number of leaves at 4WAP at the experimental site. The significance difference among the treatments indicates the positive responses of the various treatments used for grain yield which could be exploited for improvement of the respective treatments. Results from the experiment showed that leaf lengths were significantly difference even though T_1 recorded the highest leaf length (84.1 cm) and the treatment T_0 recorded the least length (73.3 cm) as showed in Table 4.

Stem girth of Omankwa were significantly different. T_5 recorded the highest stem girth (7.12 cm) and lowest T_0 (5.55 cm). In this study the increase in available nitrogen levels influenced positively the stem girth and ear length of maize plants. These findings were also reported by Okumura et al. [16] and Santos et al. [17]. The ear height of Omankwa under treatment T_4 recorded the highest (61.5 cm) and the lowest T_0 (50.12 cm). Ear height recorded no significant difference among the treatments used for the experiment. Treatment T_5 recorded the highest height (136.34 cm) among the treatments and T_0 the lowest plant height (115.82 cm) as showed in Table 4. No significant difference was recorded among various plant heights under different treatments as showed in Table 4.

Treatment T_4 recorded the highest field weight of 1.6 kg and the lowest field weight of 0.85 kg at T_0 treatment showing no significant difference among the treatments used for the experiment. Increase in grain weight and yield was promoted by adequate nitrogen supply, because nitrogen absorbed by plants is in response by fixation of carbon skeletons to amino acids synthesis [18], which results in several proteins that have specific functions in plant metabolism. On the average the chlorophyll content index of T1 recorded the highest value compared with T0 which recorded less showing significant difference among treatments. T4 treatment recorded the highest girth compared with T0 treatment showing no significant different among the treatments used for the experiment. In addition, increase in chlorophyll content index and stem girth are needed during grain filling period these carbon compounds previously fixed are broken down, transported and stored in form of proteins and amino acids [16]. Gul et al., [19] reported that maize grain yield was linearly influenced by nitrogen level applied. Bashir et al. [20], Okumura et al. [16], Deparis et al. (2007), Cruz et al., [21] and Bastos et al. [22] showed also linear behaviour linked to yield in maize induced by increase in nitrogen level as showed in Tables 3 and 4.

No significant difference was recorded when the number of cobs per plant were taken during the experiment. All treatments used for the experiment the same number of cobs per plant. T2 treatment had 50% tasselling latest and the earliest been T4 showing no significant different among the treatments used for the experiment. Treatments T1, T4 and T5 had its silk appearing earlier than T2 showing significant difference among the treatments as showed in Tables 3 and 4.

There was no significant difference when the number of leaves were determined at 2 WAP but slight difference in number of leaves were observed when they were counted after 4WAP with the least recorded for T0 with no significant difference with the minimum count of 8 and maximum 11. No significant difference was recorded when taken after 6WAP but T4 recorded the highest of 13 leaves and T0 recording the lowest as showed in Tables 3 and 4. Biomass (leaf and stem dry weight) and yield components (ear weight, ear length, ear diameter and 100 seed weight) were also significant increased with the application of poultry manure which resulted in an overall increase in grain yield per hectare.

Table 3. Analysis of variance of yield and yield related performance of Omankwa maize variety

Sources of variation	DF	Length of leaf	Stem girth	Ear height	Plant height	CCI	Grain yield	Field Wt.	Cob girth	DAS	DAT	No of leaves 2WAP	No of leaves 4WAP	No of leaves 6WAP
Rep	3	29.69	0.17	45.08	132.72	35.08	19.27	0.15	0.09	6.11	11.60*	0.28	1.82**	2.38*
Treatment	5	76.34*	1.50*	84.92	246.94	51.42	22.42*	0.26*	0.18*	4.57	1.44	0.30	1.54**	0.88
Error	15	19.15	0.35	39.12	117.61	84.63	7.57	0.07	0.05	3.74	2.20	0.41	0.32	0.48
Total	23													
Descriptive data														
Min		66.10	4.80	46.36	104.64	5.20	1.39	0.60	3.07	53.00	51.00	4.00	8.00	10.00
Max		89.20	8.20	68.18	147.82	39.5	13.18	1.90	4.33	61.00	58.00	7.00	11.00	14.00
Mean		80.14	6.50	56.50	128.21	16.06	6.33	1.20	3.77	56.67	52.96	5.25	9.79	12.12
Std Dev		5.74	0.76	7.06	12.15	8.42	3.51	0.35	0.29	2.06	1.81	0.61	0.88	0.90
CV (%)		5.46	9.06	11.07	8.46	57.29	43.44	22.02	5.95	3.41	2.80	12.21	5.77	5.68

- *P<0.05 significant difference*

Table 4. Means of various yield and yield related performance of Omankwa maize variety

Treatment	N	Length Leaf (cm)	Stem Girth(cm)	Ear Height (cm)	Plant Height (cm)	CCI	Grain yield (t/ha)	Field Wt.	Cob Girth (cm)	DAS	DAT	No of leaves 2WAP	No of leaves 4WAP	No of Leaves 6WAP
T_0	4	73.7b	5.55b	50.12	115.82	10.75	2.72a	0.85b	3.46b	57.25	53.25	5.25	9b	11.5
T_1	4	84.1a	6.85ab	58.86	131.55	16.1	6.41b	1.27ab	3.88ab	56.25	52.75	5.25	9.75ab	12.25
T_2	4	76.28ab	6.05ab	52.16	126.16	21.82	5.07b	1.03ab	3.62ab	58.5	53.75	5	9.5ab	11.75
T_3	4	79.67ab	6.45ab	55.91	123.82	14.57	5.99b	1.2ab	3.81ab	56.5	52.75	5	9.5ab	12
T_4	4	83.65ab	7a	61.5	135.59	16.82	8.88c	1.6a	4.08a	55.5	52	5.25	10.75a	12.75
T_5	4	83.42ab	7.12a	60.46	136.34	16.27	8.93c	1.27ab	3.76ab	56	53.25	5.75	10.25ab	12.5

Means with the same letter is not significantly different (p=0.05)
CCI = chlorophyll Content Index; DAS = Days at Silking; DAT = Days at Tasseling; WAP = Week after planting

4. CONCLUSION

Based on the findings of this study, it can be concluded that maize growth parameters (stem girth and ear length) increase with increase in N level. Maize yield characters, namely grain weight and field weight increased significantly with increase in nitrogen levels. Maize grain yield was increased by N rates evaluated. It was possible to visualize relationships amongst maize growth characters, yield parameters and maize grain yield. The use of poultry manure still remains the best source of soil nutrient used to often better yield of crop production but if the total or required amount are not applied because of the availability, some amount of synthesis fertilizer can be used to supplement the organic fertilizer obtain optimum grain yield in maize production.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Appendix 1. Rainfall figures from Ejura, Wenchi and Fumesua (2016)

Location	Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
FUMESUA	2016	2.8	0	90.1	85.7	149.3	90.9	134.9	496.5	214.31	194	67.6	15.6

Appendix 2. Maximum and minimum temperature from Ejura, Wenchi and Fumesua (2016)

Location	Year	January		February		March		April		May		June		July		August		September		October		November		December	
		Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
Fumesua	2016	32.7	21.1	35.4	23.3	34.4	23.5	32.8	24.1	28.1	23	30.3	22.2	27.9	22	27.4	21.7	30	22.1	30.7	22.3	31.6	22.4	32.5	21.5

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