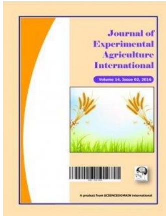

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Varietal Response of Maize (*Zea mays*) to Integrated Nutrient Management of NPK and Chicken Manure Amendments

M. E. Essilfie[1*], H. K. Dapaah[2], K. Darkwa[3], D. Timpabi[1] and D. Boateng[1]

[1]Department of Crop and Soil Sciences Education, Faculty of Agriculture Education, University of Education, Winneba P.O.Box 40, Mampong-Ashanti, Ghana.
[2]University of Energy and Natural Resources, P.O.Box 214, Sunyani, Ghana.
[3] Pan African University, Institute of life and Earth Sciences, University of Ibadan, Ibadan, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author HKD designed the study, performed the statistical analysis and wrote the protocol. Authors MEE and KD managed the analyses of the study and wrote the first draft of the manuscript. Authors DT and DB managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Two field experiments were conducted for two years at the Multipurpose crop nursery, University of Education, Winneba, Mampong-Ashanti from May to August, 2015 and 2016 respectively to evaluate varietal response of maize (Omankwa and Obatanpa) to integrated nutrient management of NPK and Chicken manure [3 t ha^{-1} CM, ½ CM + ½ NPK (32.5:19:19 kg ha^{-1} NPK) and ¾ CM + ¼ NPK]. The experimental design was a 2 x 5 factorial arranged in randomized complete block design with three replicates. The result showed that there was a significant ($p < 0.05$) differences between Obatanpa and Omankwa and fertilizer type in total grain yield in both cropping seasons. Omankwa grown under 65:38:38 kg ha^{-1} NPK and 3 t ha^{-1} CM produced higher grain yield and longer cob length during the 2015 and 2016 cropping seasons respectively. Obatanpa grown on 65:38:38 kg

**Corresponding author: E-mail: maggifremp@yahoo.co.uk;*

ha^{-1} NPK produced thicker cob diameter, higher dry matter accumulation, taller plants at 77 days after planting, and total grain yield in both cropping seasons. Obatanpa grown under 3 t ha^{-1} CM produced the longest cob length and heaviest 100 seed weight during the 2016 cropping season. Obatanpa grown under ¾ CM + ¼ NPK produced thicker cob diameter during the 2016 cropping season. In conclusion (i) Farmers are encouraged to grow Omankwa on 65:38:38 kg ha^{-1} NPK or 3 t ha^{-1} CM for higher grain yield and longer cob length. (ii) Farmers who prefer inorganic fertilizers for increased grain yield, cob length and thicker cob diameter of Obatanpa maize should apply 65:38:38 kg ha^{-1} NPK. (ii) Farmers who practise organic agriculture in transitional agro-ecological zone of Ghana should apply 3 t ha^{-1} CM and ¾ CM + ¼ NPK to enhance maize grain weight, cob length and cob diameter respectively.

Keywords: Obatanpa; Omankwa; mineral fertilizer; cob diameter; grain yield.

1. INTRODUCTION

Maize (*Zea mays* L.) is one of the major cereal crops grown in the humid tropics and sub-Saharan Africa. It is the fourth most consumed cereal during the past two decades, below sorghum, millet and rice [1]. There has been a steady increase in maize production from 7.4 million metric tons in 2009 to 10.3 million metric tons in 2013 [2], although most of the production aims at the domestic market, since a negligible part of the production is formally exported [1]. Maize crop is a key source of food and livelihood for millions of people in many countries of the world. It is produced extensively in Ghana, where it is consumed roasted or boiled. It is also processed and consumed as *banku, apkle*, and porridge. In other countries such as Cote d'Ivoire maize is consumed as a whole grains, couscous, or tôh which is the leg cooked maize flour. Fermentation of the maize grain is also carried out for the alcohol production and it serves as inter alia, for the preparation of beverages (the local beer, beer, whisky, etc.). Some companies produce infant's diets from maize foods. In animal feed, maize is a breeding crop which allows fattening cattle more quickly and thus increases the production of milk from cows [3]. An important part of maize production is intended for the feeding of poultry [4]. Increase in demand of the commodity resulted in expanding production in many areas in Ghana. The soils in the country are generally low in fertility due to continuous crop cultivation as a result of increase in population. The fertility of such soils can be improved to enhance crop yield through external use of organic manure such as chicken manure and inorganic fertilizer [5].

Chicken manure is excellent organic manure, as it contains high nitrogen, phosphorus, potassium and other essential nutrients [6]. It poses high organic matter than inorganic fertilizer, hence have the ability to improve the soil physical, chemical and biological properties, most importantly increasing the organic matter content of the soil thereby providing more sites for cation exchange. These nutrients in chicken manure are released gradually [7,8] unlike inorganic fertilizer that release its nutrients rapidly. In Ghana and other tropical countries, research interest recently shifted to utilization of organic wastes as nutrient source in crop production. This is due to high cost and scarcity of mineral fertilizers. Inorganic fertilizer provides readily available nutrients for plant; their use has not always been successful in the tropics, due to enhancement of soil acidity, easy leaching of nutrients, nutrient imbalanced, low organic matter status, triggers other factors that limit the uptake of the nutrients, and degradation of soil physical properties. Although, organic manures exist in readily available forms; cheap and easy to access, they need to be applied in large amounts to meet the nutrient requirements of crops [9]. Where large hectares are involved, this single fact plays important role in the cost of organic manure application; as it pushes up transportation cost. Owing to the various short comings associated with the use of both sources of fertilizers, nutrient use efficiency have been advocated through the combination of organic and mineral fertilizer [10,11]. It is necessary to integrate chemical fertilizers into the organic sources to reduce the quantity required and enhance nutrient release. In view of this there is the need for subsistence farmers who form the bulk of maize producers know the best type of fertilizer or combination to be use at different rate to increase food to feed the increasing human populations in an economical way. The study therefore seeks to determine the growth and yield response of two maize varieties to integrated nutrient management of NPK and chicken manure.

2. MATERIALS AND METHODS

2.1 Description of Study Area

Two field experiments were conducted at the Multipurpose crop nursery of the University of Education, Winneba, Mampong- Ashanti campus for two consecutive years (2015 and 2016) during the rainy seasons from May to August. The soil type is the savannah ochrosol formed from the Voltaian sandstone of the Afram plains. Texturally, the soil is friable with a thin layer of organic matter and is deep and brown-sandy loam and well-drained. It however has a good water holding capacity. The soil has been classified by FAO / UNESCO legend as Chronic Luvisol and locally as the Bediesi series and the pH of the top soil is 4.0. Prior to the two experiments, a composite soil sample of the experimental site was analyzed for chemical properties. The result is shown in Table 1.

Table 1. Soil chemical properties at the experimental sites for the 2015 and 2016 cropping seasons

Property	Unamended soil	
	2015	2016
pH (1:1)	6.13	5.70
Organic carbon (%)	0.64	0.67
Total Nitrogen (%)	0.05	0.06
Organic matter (%)	1.10	1.16
Exchangeable cations ($cmol_c$ kg^{-1})		
Ca	4.81	4.27
Mg	1.07	0.08
K	0.25	0.07
Na	0.01	0.11
TEB	6.13	5.45
ECEC	6.23	6.00
Base Saturation (%)	98.39	90.83
Available P, mg kg^{-1}	24.32	7.64
Available K, mg kg^{-1}	47.99	11.00

The climatic conditions at the experimental sites for the 2015 and 2016 cropping seasons is presented in Table 2. The wide difference that existed between the chicken manure used for the two experiments is attributed to differences in climatic conditions during litter production and storage after production and the time of use of the chicken manure (Tables 3 and 4).

2.2 Soil and Manure Analyses

The chicken manure used for the study for both cropping seasons was from broiler chicken in deep litter system and four months old (20.0% moisture content) was obtained from the poultry farm of the College of Agriculture Education, University of Education, Winneba, Mampong-Ashanti campus and heaped under shade for 30 days to cure well before use. Sub-samples of the dried manure were taken for nutrient analysis (Tables 3 and 4). The decomposed and dried chicken manure was spot-applied 6 days before planting maize, and inorganic fertilizer, NPK (15:15:15), applied as basal fertilizer 10 days of planting of seeds at appropriate rates as per treatments [12]. Soil samples were taken prior to chicken manure and inorganic fertilizer application from the top 0-20 cm of plots for chemical analyses. Soil samples and manure analyses were carried out at the Soil Research Institute of CSIR laboratory, Kumasi. The characteristics analyzed for included soil pH on 1:1 (soil: distilled water) and 1:2 (soil: 0.01m $CaCl_2$) mixtures and measured on a pH meter (Pracitronic pH meter) manufactured by Veb Pracitron in Dresden, Germany. The soil pH was taken for manure plus soil mixtures and the control plots. Organic matter was determined by the Walkey and Black method [13], and total nitrogen was determined by the micro Kjeldahl method [14]. The available phosphorus was extracted by the Bray method and determined colorimetrically [15]. Exchangeable cations were determined by flame emission photometry [15]. Extraction is carried out by shaking the soil-extract mixture, followed by filtration or centrifugation. Ca and Mg are determined using an atomic absorption or spectrometry (AAS) after the removal of ammonium acetate and organic matter at pH 7.0.

2.3 Experimental Design and Planting

The experimental design used was a 2 x 5 factorial arranged in randomized complete block design (RCBD) with three replicates made up of two maize varieties and four organic manure and inorganic fertilizer rates was assigned to each block. The two maize varieties (Omankwa and Obatanpa) obtained from CSIR- Crop research Institute in Fumesua near Kumasi, Ghana were grown under four fertilizer treatments [(i) 3 t ha^{-1} chicken manure (CM), (ii) Recommended inorganic fertilizer (NPK) (65:38:38 kg ha^{-1} NPK) (iii) ½ CM + ½ NPK (1.5 t ha^{-1} CM + 32.5:19:19 kg ha^{-1} NPK); (iv) ¾ CM + ¼ NPK (2.25 t ha^{-1} CM + 16: 9.5: 9.5 kg ha^{-1} NPK) and (v) No fertilizer (Control)]. Each treatment plot measured 3.2 m x 4.8 m. Three seeds of Omankwa and Obatanpa were planted 0.8 m between rows and at 0.4 m within row plants and

Table 2. Climate data for 2015 and 2016 experimental periods

Month	Total monthly rainfall (mm)		Mean monthly relative humidity (%) (hours GMT)				Mean monthly temperature (°C)			
			06.00	06.00	15.00	15.00	Minimum		Maximum	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
May	118.4	118.6	92	93	58	62	23.4	22.2	32.7	31.6
June	333.4	155.5	92	96	66	68	22.3	21.3	30.2	29.5
July	128.4	108.1	92	96	64	71	22.2	20.9	29.6	27.9
August	2.9	55.1	92	96	66	72	22.0	20.7	28.6	27.6
Total	583.1	437.3								

(Meteorological Department – Mampong Ashanti, 2015, 2016)

Table 3. Nutrient levels of chicken manure used at the experimental site for the 2015 cropping season

Property	pH	Ca%	Mg%	P%	K%	N%
Chicken manure	6.18	3.40	1.92	0.63	0.86	3.54

Table 4. Nutrient levels of chicken manure used at the experimental site for the 2016 cropping season

Property	pH	Ca%	Mg%	P%	K%	N%
Chicken manure	5.97	2.11	0.48	0.70	0.01	0.86

later thinned to 2 plants per hill at a depth of 3-5 cm. Each plot had 4 rows of 96 plants. Chicken manure was spot-applied 6 days before planting maize, and inorganic mineral fertilizer, NPK (15:15:15), applied as basal fertilizer 10 days of planting of seeds at appropriate rates as per treatments and sulphate of ammonia was topdressed at 6 weeks after planting [12].

2.4 Data Collection and Analysis

2.4.1 Vegetative data

Percentage crop establishment was measured on 40 plants from the two central rows at 4 weeks after planting. Number of leaves per plant was counted on six plants from the two central rows, plant height and stem diameter were measured on six plants from the two central rows with meter rule and vernier caliper respectively, while six plants were randomly sampled for the dry matter accumulation. Data were collected at four weeks after planting and at two weeks interval.

2.4.2 Yield and yield components

Number of cobs per plant, total grain yield and yield components including cob diameter, cob length and 100 seed weight were estimated from the two central rows. Data were subjected to ANOVA using GenStat Statistical Package, version 11.1 [16], Least significant difference (LSD) was used to separate means at 5% level of probability. The climatic conditions at the experimental sites were determined during the 2015 and 2016 cropping seasons respectively [17,18].

3. RESULTS

3.1 Vegetative Data

3.1.1 Percentage crop establishment

Table 5 shows percentage crop establishment of maize plants as affected by chicken manure and inorganic fertilizer during the 2015 and 2016 cropping seasons. The percentage crop establishment during the 2015 and 2016 cropping seasons for the two maize varieties (Omankwa and Obatanpa) ranged from (60.0 - 98.1) and (57.6 - 77.8), respectively (Table 5). There was a significant ($p < 0.05$) difference between Obatanpa and Omankwa in percentage crop establishment during the 2015 cropping season (Table 5). Organic and inorganic fertilizer applied singly or in combination did not significantly influence crop establishment across both cropping seasons. Obatanpa and Omankwa grown under ½ CM + ½ NPK produced lower percentage crop establishment in both cropping seasons respectively than same varieties grown on other amended and control plots (Table 5).

Table 5. Percentage crop establishment as influenced by chicken manure and inorganic fertilizer

Fertilizer rates	Percentage crop establishment (%)					
	2015			2016		
	Omankwa	Obatanpa	mean	Omankwa	Obatanpa	mean
3 t ha^{-1} CM	68.60_a	98.10_a	83.35_a	72.90_a	66.00_a	69.45_a
65:38:38 kg ha^{-1} NPK	76.90_a	97.50_a	87.20_a	77.80_a	63.20_a	70.50_a
½ CM + ½ NPK	73.70_a	91.70_a	82.70_a	57.60_a	72.20_a	64.90_a
¾ CM + ¼ NPK	71.10_a	98.10_a	84.60_a	69.40_a	68.10_a	68.75_a
Control	60.00_a	97.50_a	78.75_a	75.70_a	61.10_a	68.40_a
Mean	70.06_a	96.58_b		70.70_a	66.10_a	
LSD (0.05) Var	8.26 *			NS		
LSD (0.05) Fert	NS			NS		
LSD (0.05) Var x Fert	NS			NS		
CV (%)	12.90			16.70		

** = significant at 5% probability level, NS= not significant, Means with the same letters are not significantly different*

3.1.2 Number of leaves per plant

Obatanpa produced higher number of leaves per plant than Omankwa from 49, 63 to 77 days of planting during the 2015 cropping season (Fig. 1). Omankwa and Obatanpa grown under ½ CM + ½ NPK and ¾ CM +1/4 NPK produced the lowest number of leaves per plant after 63 and 77 days of planting than the other amended and control plots during the 2015 cropping season (Fig. 1). Both maize varieties grown on 3 t ha^{-1} CM produced the highest number of leaves per plant at 77 days of planting than the other amended and control plots during the 2016 cropping season (Fig. 1).

3.1.3 Plant height

Obatanpa produced taller plants than Omankwa from 63 to 77 days of planting during the 2015 cropping season (Fig. 2). Omankwa grown on amended plots produced taller plants than those grown on control plot at 35, 49 and 77 days of planting in the same cropping season. The growth rates of Obatanpa grown under amendment and the control during the 2016 cropping season progressively increased with time during the vegetative growth up to 63 days of planting with a peak at the same period after which growth declined. Omankwa and Obatanpa grown under 1/2 CM + 1/2 NPK had the tallest plant height at 49 days of planting during 2015 and 2016 cropping seasons respectively (Fig. 2). Omankwa and Obatanpa grown on control plot produced the shortest plant height from 63 to 77 days of planting during 2015 and 2016 cropping seasons respectively (Fig. 2).

3.1.4 Dry matter accumulation

Omankwa grown on amended plots produced higher dry matter accumulation than the control for the entire 2015 cropping season (Fig. 3). Obatanpa grown under ½ CM + 1/2 NPK produced higher dry matter accumulation from 35 to 49 days of planting at the same cropping period. Omankwa and Obatanpa grown on amended plots produced higher dry matter accumulation than the control from 49 to 77 days of planting during the 2016 cropping season (Fig. 3). Both maize varieties grown on the control plot produced the lowest dry matter accumulation from 49 to 77 days of planting in both cropping seasons. Obatanpa grown under 3 t ha^{-1} CM produced lower dry matter accumulation than the other amended plots from 49 to 77 days of planting in both cropping seasons (Fig. 3).

3.2 Yield and Yield Components

3.2.1 Number of cobs per plot

There was a significant ($p<0.05$) difference between Omankwa grown on amended plots except 3 t ha^{-1} CM and the control in number of cobs per plot during the 2015 cropping season (Table 6). Omankwa under ½ CM + ½ NPK differed ($p<0.05$) significantly from 3 t ha^{-1} CM and the control in number of cobs per plot in the same cropping season. Obatanpa grown under 65:38:38 kg ha^{-1} NPK differed ($p<0.05$) significantly from ¾ CM + ¼ NPK in number of cobs per plot during the 2015 cropping season (Table 6). Omankwa and Obatanpa grown on amended and the control plots did not differ significantly in number of cobs per plant during the 2016 cropping season. There was no significant ($p<0.05$) difference between Omankwa and Obatanpa in number of cobs per plot in both cropping seasons (Table 6).

3.2.2 Cob length

There was a significant ($p<0.05$) difference between Obatanpa and Omankwa in cob length in both 2015 and 2016 cropping seasons (Table 7). Cob length of Omankwa and Obatanpa was significantly influenced by 65:38:38 kg ha^{-1} NPK from other amended and control plots during the 2015 cropping season. There was no significant ($p<0.05$) difference between amended and the control plots in cob length during the 2016 cropping season. Obatanpa grown on amended and control plots had longer cob length than Omankwa in both cropping seasons (Table 7).

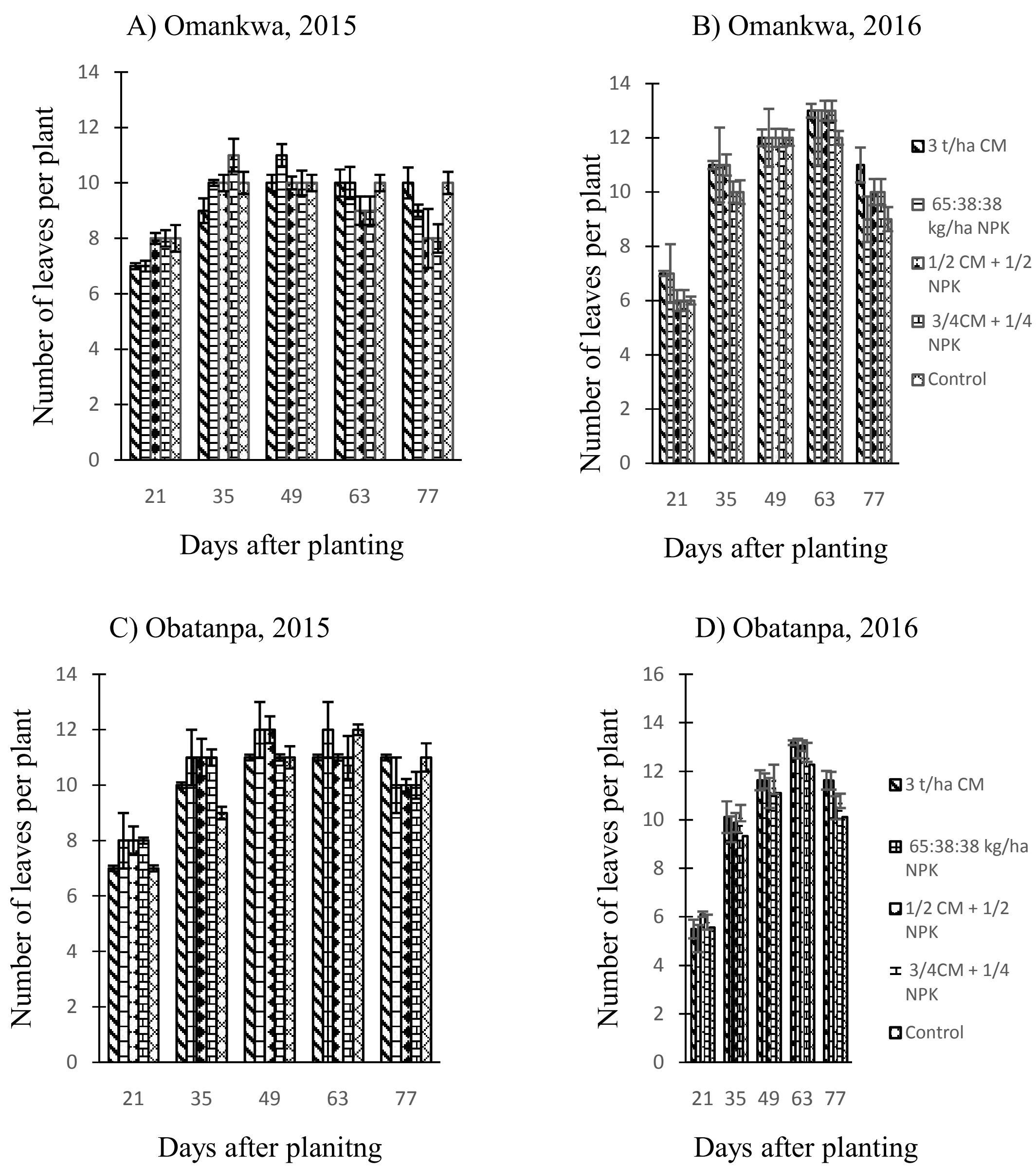

Fig. 1. Effect of chicken manure and inorganic fertilizer on number of leaves per plant of maize from 21 to 77 days of planting, 2015 and 2016

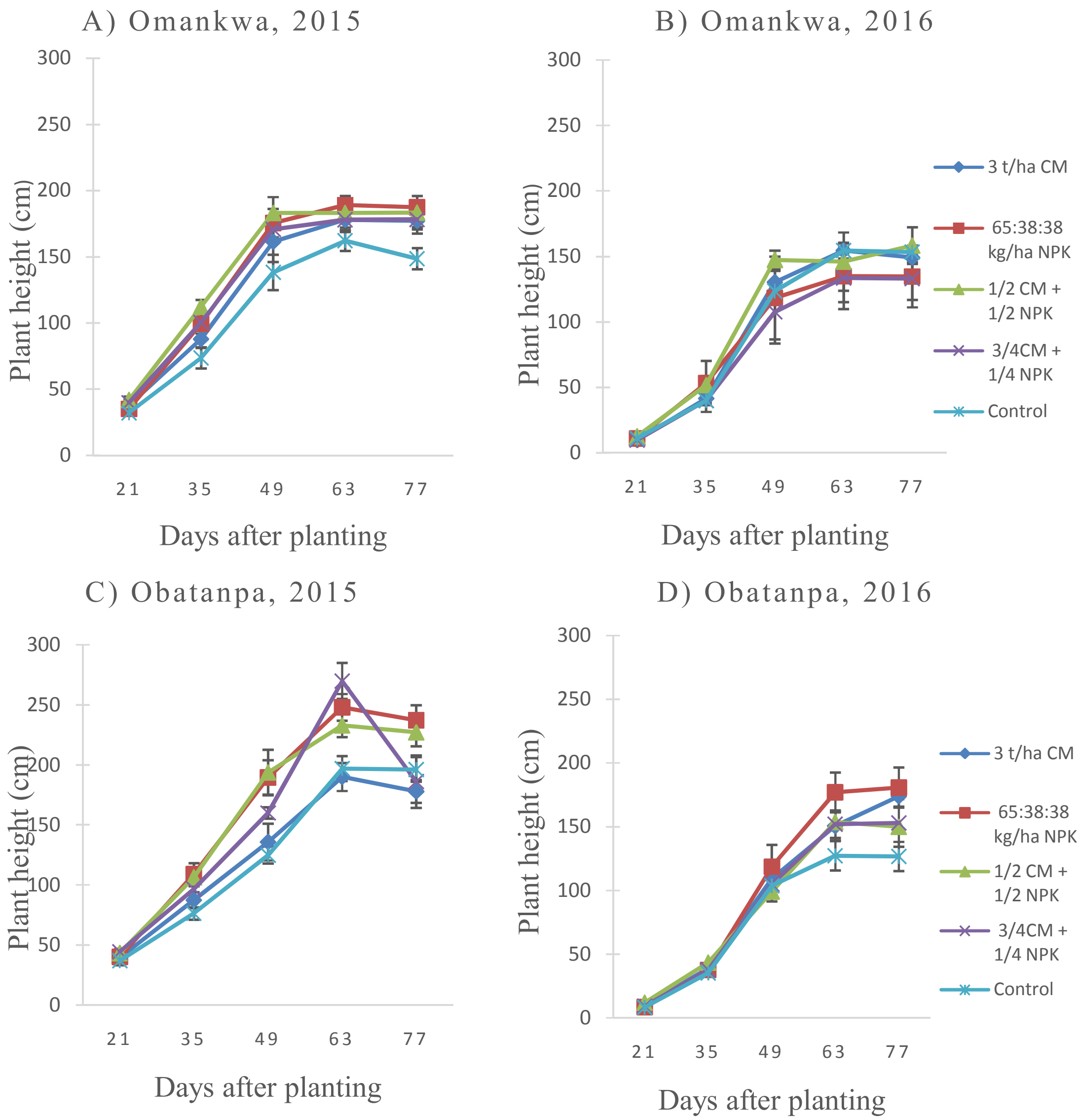

Fig. 2. Effect of chicken manure and inorganic fertilizer on plant height of maize from 21 to 77 days of planting, 2015 and 2016

3.2.3 Cob diameter

There was a significant ($p<0.05$) difference between Omankwa grown under ¾ CM + ¼ NPK from other amended plots except ½ CM + ½ NPK and the control in cob diameter during the 2015 cropping season (Table 8). Obatanpa grown under 65:38:38 kg ha^{-1} NPK differed ($p<0.05$) significantly from 3 t ha^{-1} CM and the control in cob diameter during the same cropping period. Obatanpa differed ($p<0.05$) significantly from Omankwa in cob diameter during the 2016 cropping season (Table 8). Omankwa and Obatanpa grown under control had the least cob diameter during the 2016 cropping season (Table 8). Obatanpa grown under 3 t ha^{-1} CM, 65:38:38 kg ha^{-1} NPK and ¾ CM + ¼ NPK was similar in cob diameter during the 2016 cropping season. Obatanpa grown on amended and control plots produced thicker cob diameter than Omankwa in both cropping seasons (Table 8).

3.2.4 100 seed weight

Omankwa grown on amended plots except ¾ CM + ¼ NPK differed ($p<0.05$) significantly from the control in 100 seed weight during the 2015 cropping season (Table 9). Omankwa and

Obatanpa grown on amended and control plots during the 2016 cropping season produced significantly higher 100 seed weight than during the 2015 cropping season (Table 9). Obatanpa grown on amended plots produced higher 100 seed weight than Omankwa grown on the same treatment in both cropping seasons. Omankwa and Obatanpa grown on control plot produced the least 100 seed weight in both cropping seasons (Table 9).

3.2.5 Total yield

There was a significant ($p<0.05$) difference between Obatanpa and Omankwa in total grain yield in both cropping seasons (Table 10). Omankwa and Obatanpa grown on 65:38:38 kg ha^{-1} NPK produced significantly higher total grain yield than the control in both cropping seasons. Obatanpa grown on amended and control plots produced higher grain yield than Omankwa

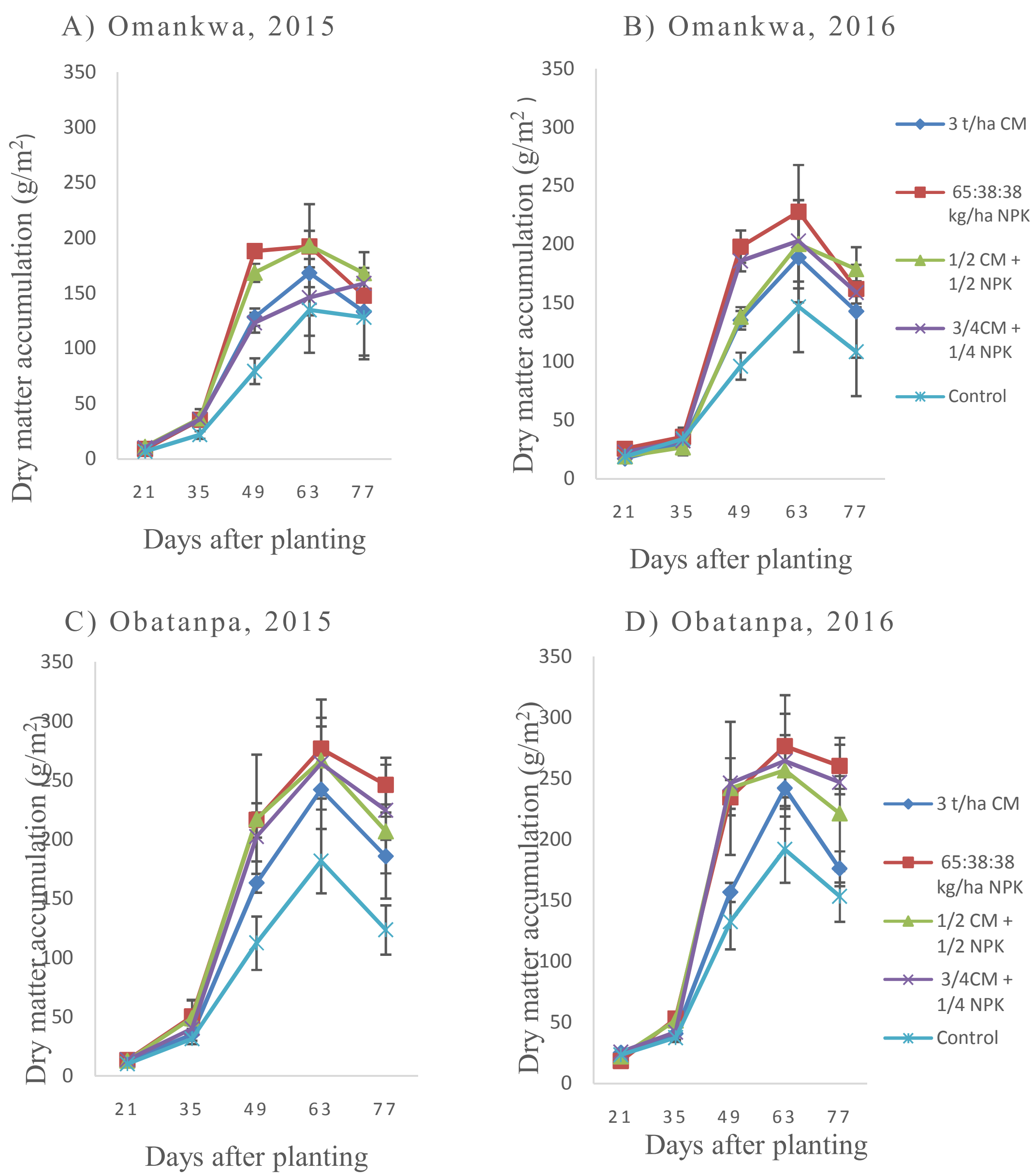

Fig. 3. Effect of chicken manure and inorganic fertilizer on dry matter accumulation of maize from 21 to 77 days of planting, 2015 and 2016

grown on the same plots in both cropping seasons (Table 10). Obatanpa grown under 65:38:38 kg ha^{-1} NPK had higher grain yield of 5668 kg ha^{-1} during the 2015 cropping season and 6938 kg ha^{-1} during the 2016 cropping season (Table 10). Omankwa grown under the same plot had grain yield of 3386 kg ha^{-1} during the 2015 cropping season and 5159 kg ha^{-1} during the 2016 cropping season (Table 10). The yield of Omankwa and Obatanpa grown under organic manure applied alone (3 t ha^{-1} CM) increased by 100% over the control during the 2016 cropping season (Table 10).

4. DISCUSSION

Maize growth and yield were affected by chicken manure and inorganic fertilizer. The higher number of maize plants established in both 2015 and 2016 cropping seasons might be due to the healthy seeds used as planting materials. However, the varietal difference showed the significant ($p < 0.05$) difference in percentage crop establishment during the 2015 cropping season. This might be due to the fact that Obatanpa showed higher germination capability coupled with initial vigorous seedling growth than Omankwa. The lower percentage crop establishment in Obatanpa and Omankwa grown under ½ CM + ½ NPK than same varieties grown on other amended and control plots in both cropping seasons might be that organic manure and inorganic fertilizer applied was not available to the plants and therefore not yet absorbed. The slow rate of mineralization coupled with initial competition for nutrients by the soil microorganisms responsible for mineralization of the chicken manure might have contributed to the low percentage crop establishment. The higher number of leaves per plant of

Table 6. Number of cobs per plot as influenced by chicken manure and inorganic fertilizer

Fertilizer rates	Number of cobs per plot					
	2015			2016		
	Omankwa	Obatanpa	mean	Omankwa	Obatanpa	mean
3 t ha^{-1} CM	17.00_a	36.00_a	26.50_b	37.00_a	33.00_a	35.00_a
65:38:38 kg ha^{-1} NPK	33.00_b	43.00_a	38.00_a	26.00_a	29.00_a	27.50_a
½ CM + ½ NPK	34.00_b	38.00_a	36.00_{ab}	31.00_a	34.30_a	32.65_a
¾ CM + ¼ NPK	29.00_{ab}	32.00_a	30.50_{ab}	32.00_a	36.00_a	34.00_a
No fertilizer (Control)	15.00_a	40.00_a	27.50_{ab}	36.00_a	34.00_a	35.00_a
Mean	25.60_a	37.80_a		32.50_a	33.30_a	
LSD (0.05) Var	NS			NS		
LSD (0.05) Fert	6.76 *			NS		
LSD (0.05) Var x Fert	15.11			NS		
CV (%)	27.70			21.40		

** = significant at 5% probability level, NS= not significant, Means with the same letters are not significantly different*

Table 7. Cob length as influenced by chicken manure and inorganic fertilizer

Fertilizer rates	Cob length (cm)					
	2015			2016		
	Omankwa	Obatanpa	mean	Omankwa	Obatanpa	mean
3 t ha^{-1} CM	13.45_a	14.48_a	13.97_b	23.00_a	27.60_a	25.30_a
65:38:38 kg ha^{-1} NPK	15.49_a	16.06_a	15.78_a	20.70_a	26.00_a	23.35_a
½ CM + ½ NPK	15.09_a	15.69_a	15.39_a	21.10_a	24.50_a	22.80_a
¾ CM + ¼ NPK	13.84_a	15.75_a	14.80_{ab}	22.00_a	26.90_a	24.45_a
No fertilizer (Control)	11.14_a	12.79_a	11.97_c	22.70_a	24.50_a	23.60_a
Mean	13.80_a	14.95_b		21.90_a	25.90_b	
LSD (0.05) Var	1.20 *			1.90 *		
LSD (0.05) Fert	0.76 *			NS		
LSD (0.05) Var x Fert	NS			NS		
CV (%)	6.9			10.20		

** = significant at 5% probability level, NS= not significant, Means with the same letters are not significantly different*

Table 8. Cob diameter as influenced by chicken manure and inorganic fertilizer

Fertilizer rates	Cob diameter (cm)					
	2015			2016		
	Omankwa	Obatanpa	mean	Omankwa	Obatanpa	mean
3 t ha^{-1} CM	4.48_a	4.90a	4.69_b	5.10_a	5.70_a	5.40_a
65:38:38 kg ha^{-1} NPK	4.65_a	5.24a	4.95_{ab}	4.90_a	5.70_a	5.30_a
½ CM + ½ NPK	4.77_a	5.21a	4.99_a	5.20_a	5.40_a	5.30_a
¾ CM + ¼ NPK	4.84_a	5.10a	4.97_{ab}	5.00_a	5.70_a	5.35_a
No fertilizer (Control)	4.53_a	5.04a	4.79_{ab}	4.60_a	5.20_a	4.90_a
Mean	4.65_a	5.10_a		4.90_a	5.50_b	
LSD (0.05) Var	NS			0.20 *		
LSD (0.05) Fert	0.18 *			NS		
LSD (0.05) Var x Fert	NS			NS		
CV (%)	4.80			6.10		

** = significant at 5% probability level, NS= not significant, Means with the same letters are not significantly different*

Table 9. 100 seed weight as influenced by chicken manure and inorganic fertilizer

Fertilizer rates	100 seed weight (g)					
	2015			2016		
	Omankwa	Obatanpa	mean	Omankwa	Obatanpa	mean
3 t ha^{-1} CM	30.77_a	35.13_a	32.95_{ab}	40.70_a	50.00_a	45.35_a
65:38:38 kg ha^{-1} NPK	31.07_a	35.07_a	33.07_{ab}	42.70_a	46.00_{ab}	44.35_a
½ CM + ½ NPK	30.77_a	37.13_a	33.95_a	45.00_a	47.00_{ab}	46.00_a
¾ CM + ¼ NPK	30.27_a	35.03_a	32.65_{ab}	46.00_a	46.30_{ab}	46.15_a
No fertilizer (Control)	27.03_a	32.87_a	29.95_b	38.00_a	37.30_b	37.65_a
Mean	29.98^a	35.05^a		42.50_a	45.30_a	
LSD (0.05) Var	NS			NS		
LSD (0.05) Fert	3.57*			NS		
LSD (0.05) Var x Fert	NS			NS		
CV (%)	14.40			13.90		

** = significant at 5% probability level, NS= not significant, Means with the same letters are not significantly different*

Table 10. Total yield as influenced by chicken manure and inorganic fertilizer

Fertilizer rates	Total yield (kg ha^{-1})					
	2015			2016		
	Omankwa	Obatanpa	mean	Omankwa	Obatanpa	mean
3 t ha^{-1} CM	1243.00_a	2790.00_a	2016.50_c	4993.00_a	6298.00_a	5645.50_a
65:38:38 kg ha^{-1} NPK	3386.00_a	5668.00_a	4527.00_a	5159.00_a	6938.00_a	6048.50_a
½ CM + ½ NPK	3204.00_a	4259.00_a	3731.50_{ab}	4677.00_a	6380.00_a	5528.50_a
¾ CM + ¼ NPK	2795.00_a	3410.00_a	3102.50_{bc}	4988.00_a	5056.00_a	5022.00_a
No fertilizer (Control)	1088.00_a	3266.00_a	2177.00_c	2129.00_a	3163.00_a	2646.00_b
Mean	2343.20_a	3878.60_b		4389.20_a	5567.00_b	
LSD (0.05) Var	840.40 *			461.5 *		
LSD (0.05) Fert	1328.70 *			729.70 *		
LSD (0.05) Var x Fert	NS			NS		
CV (%)	35.20			21.10		

** = significant at 5% probability level, NS= not significant, Means with the same letters are not significantly different*

Obatanpa from 49, 63 to77 days of planting during the 2015 cropping season might be due to suitability and adaptability of Obatanpa in the study area for enhanced growth. The lowest number of leaves per plant of Omankwa and Obatanpa grown under ½ CM + ½ NPK and ¾ CM +1/4 NPK from 63 to 77 days of planting during the 2015 cropping season is an indication of slow release of nutrients from chicken manure. The highest number of leaves per plant in both maize varieties grown on 3 t ha^{-1} CM at 77 days of planting during the 2016 cropping might be attributed to the solubility, absorption and translocation of the absorbable nutrients by the plant for leaf synthesis as a result of chicken manure which decomposed. The significant increase in height of Obatanpa than Omankwa in plant height from 63 to 77 days of planting during the 2015 cropping season might be due to suitability of Obatanpa in the study area that favoured plant growth compared to Omankwa. Omankwa growth in height that was favoured by amendments than the control at 35, 49 and 77 days of planting during the 2015 cropping season is an indication that adequate nutrients, required to support early plant growth can be attained from organic fertilization, by enrichment with inorganic nutrients. The tallest plant height in Omankwa grown under ½ CM + ½ NPK at 49 days of planting in both cropping seasons could be because of the combined effects of the chicken manure improving the physical soil conditions and NPK (15-15-15) also improving the nutrient status of the soil. The progressive increase in plant height of Obatanpa grown under amendment and the control during the 2016 cropping season with time up to 63 days of planting and with a peak at the same period after which growth declined is an indication that the vegetative growth trend follows the normal growth curve of the maize plant. This could be attributed to the remobilization of restored nutrients or sugars in filling the cob or ear. The shorter plant height in control plants at 77 days of planting than amended plots during 2015 and 2016 cropping seasons might be due to effective release of nutrients from inorganic fertilizer and chicken manure to the soil and subsequent plant nutrient. The significantly higher dry matter accumulation of Obatanpa at 21 days of planting and from 49 to 77 days of planting than Omankwa during the 2015 cropping season was favoured by tall plants produced for better usage of sunlight. Omankwa growth in dry matter accumulation that was favoured by application of 65: 38:38 kg ha^{-1} NPK at 49 days of planting in both cropping seasons might be due to effective release of nutrients from inorganic fertilizer. The lowest dry matter accumulation of both maize varieties grown on control plot from 49 to 77 days of planting in both cropping seasons could be due to low soil nutrients. The significant increase in number of cobs per plot with Omankwa grown under ½ CM + ½ NPK than the other amended and control plots during the 2015 cropping season is an indication that adequate nutrients from organic and inorganic fertilization is required to support early cob growth. The greater number of cobs per plot and the longest cob length with Obatanpa grown under 65:38:38 kg ha^{-1} NPK during the 2015 cropping season might be due to effective release of nutrients from the inorganic fertilizer coupled with initial high rainfall experienced during the cropping period. The inorganic fertilizer provides source of necessary macro nutrients in available forms. The available water in the soil enhances plant root growth to extract soil water more efficiently for increased grain yield and elongation of grains. The significant thicker cob diameter with Omankwa and Obatanpa grown under ¾ CM + ¼ NPK and 65:38:38 kg ha^{-1} NPK over the control might be due to the application of high rate of chicken manure and NPK to both maize varieties which have resulted in high inherent nutrients in the manures which promoted broader grain size and heightened meristematic activities that favoured the enlargement of cob. The thicker cob diameter with Obatanpa than Omankwa during the 2016 cropping season is attributed to differences in variety. The lowest cob diameter with Omankwa and Obatanpa grown under control during the 2016 cropping season might be due to low soil nutrients. Addition of chicken manure and inorganic fertilizer made more nutrients available to the maize plants.

The significant increase in 100 seed weight of Omankwa grown on amended plots except ¾ CM + ¼ NPK over the control during the 2015 cropping season could be due to higher rate of nitrogen in chicken manure and inorganic fertilizer that resulted in higher nutrient release for heavier seed weight than the control. The heavier 100 seed weight of Obatanpa grown on amended plots than Omankwa grown on the same treatment in both cropping seasons might be due to differences in variety and its response to soil mineral nutrient. Maize grain yield was significantly increased with fertilization. The significant increase in grain yield of both maize varieties grown on 65:38:38 kg ha^{-1} NPK in both cropping seasons is an indication of early release of mineral nutrient from inorganic fertilizer which was made readily available to plants for their growth and development. The greater grain yield of Obatanpa grown on amended and control plots than Omankwa grown on the same plots in both cropping seasons is attributed to inherent characteristics of the variety and its response to soil nutrient and climatic conditions experienced during the cropping periods.

5. CONCLUSION

Farmers are encouraged to grow Omankwa on 65:38:38 kg ha^{-1} NPK or 3 t ha^{-1} CM for higher grain yield and longer cob length. Farmers who prefer inorganic fertilizers for increased grain yield and thicker cob diameter of Obatanpa should apply 65:38:38 kg ha^{-1} NPK. Farmers who practise organic agriculture in transitional agro-ecological zone of Ghana should apply 3 t ha^{-1} CM and ¾ CM + ¼ NPK to enhance maize grain weight, cob length and cob diameter respectively. Substitution of some portion of chemical fertilizers along with organic manure will maintain and sustain soil health as well as improve economic stability of farmers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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