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Effect of Rate of Blended Fertilizer and Compost Application on Growth of Quality Protein Maize (*Zea mays* L.) at UKE Site Western Ethiopia

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Abstract

Quality protein maize (QPM) is one of the maize varieties being used to sustain food for developing country. BH-545 a QPM variety contains double the amount of protein than conventional maize. The objective of this experiment was to investigate the effect of rate of blended fertilizer and compost application on growth of QPM at Uke research site of Wollega University. The experiment was laid out in Randomized Complete Block Design as factorial combinations of five levels of compost (0, 1, 2, 3 and 4-tons ha^{-1}) and four levels of blended (0, 50,100 and 150 kg ha^{-1}) fertilizers, which were replicated three times. In this experiment, the phenological parameters days to emergence, days of 90% maturity, days of physiological maturity, were affected by blended fertilizer but not affected by compost and their interaction. Increasing application of blended fertilizers significantly decreased emergence day from 7.80 to 6.20 days and increase days to 90% maturity from 121.13 to 122.80, and days to physiological maturity from 132.13 to 133.80 days respectively. Days of flowering and days of silking were affected slightly by compost and blended fertilizer but their interaction was not significantly affected. Combined application of blended and compost fertilizer has shown significant ($p \leq 0.05$) differences for growth parameters *viz*., number of leaves per plant, plant height and leaf area index. The highest mean value is recorded as 14.86, 231.80 cm and 5.81 from the combination of 150kg/ha and 1ton ha^{-1}, 150kg/ha and 4 tons ha^{-1}, 100kg/ha blended and 4 tons ha^{-1} of compost fertilizer respectively. From this study it is possible to conclude that integrated application of compost and blended fertilizers increase the growth of QPM. Combined application of compost and blended fertilizers improves physical and chemical property of soil and effective than using alone.

Keywords

Blended Fertilizer, Compost, Leaf Area Index, QPM

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1. Introduction

Maize (*Zea mays* L.) is an annual plant belonging to the grass family Gramineae or Poaceae [1]. The most likely center of origin of maize is Mexico or Central America with a possible Secondary origin in South America [2]. Maize can be grown on a wide variety of soils, but performs best on well drained, well aerated, deep, warm loams with pH from 6 - 7 and silt loams containing adequate organic matter and well supplied with available nutrients [3].

Maize is an important grain crop of the world which ranks third to wheat and rice in area and its production [4]. United States, China, and Brazil are being the top three maize producing countries in the world. Ethiopia is the third largest producer of maize, following South Africa and Nigeria in Africa [5]. In the 2015/16 production season, 2.11 million

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hectares of land was covered by maize in the country from which 71.51 million qt of output were produced by 9.55 million holders [6]. Quality Protein Maize (QPM) is one of the maize varieties developed by the International maize and wheat improvement Centre (CIMMYT) in the late 1990's. The term Quality Protein Maize refers to maize genotypes whose lysine and tryptophan levels in the endosperm of the kernels are about twice higher than in conventional maize varieties. Quality protein maize is produced in more than 23 developing countries. QPM varieties were produced in an area over 2.5 million ha. In sub-Saharan Africa, 17 countries are growing QPM about 200,000 hectares of land. Most of the QPM varieties developed in Africa had been agronomically characterized and their adaptation to targeted areas was well documented [7, 8].

QPM can help to reduce malnutrition, improve body immunity and overall health in communities that are constrained by economic and environmental factors to access expensive sources of protein such as meat, fish, eggs, milk and legumes [9]. Consuming quality protein maize reduced malnutrition, specifically in communities with poor quality protein intake and lysine deficiency, commonly associated with cereal-based diets [10]. However maize cultivation by Ethiopian farmers face a wide set of problems including low farm productivity, top soil erosion, soil acidity and salinity [11, 12].

Maize production in Ethiopia is constrained by many biotic and abiotic factors. Existing crop management practice is suffered with insufficient supply of improved inputs, lack of suitable farming systems to support relatively intensive food production over a long period of time and incidence of disease, insect, pest and weeds [13, 14]. Organic and inorganic or chemical fertilizer application affects productivity. In Ethiopia, through productivity-enhancing technologies farmers are adopting agronomic practices such as crop rotation, intercropping, fallowing, crop residues incorporation, application of Farmyard manure (FYM) and traditional mixed cropping to restore the fertility of their soils through organic fertilizer [15].

2. Materials and Methods

2.1. Description of the Experimental Site

The experiment was conducted at Uke Research site Guto Gida district East Wollega Zone of Oromia Regional State Western Ethiopia, during 2017 cropping season. Uke research site is located between 8°11'52" and 10°94'44" N latitude and 36°97'51" and 37°11'52" E. longitude about 365 km away from Addis Ababa and 40 km away from Nekemte.

The soil texture of this area is characterized by loamy soil (42.8%), sandy soil (23.09%), clay loamy (16.33%) and clay soil (8.08%). The altitude of the area ranges between 1500 - 1700 masl with gentle slope and the climatic data like maximum and minimum average temperature of the location varies from 16 to 31°C, with fluctuating rainfall condition. The farming system of the local society is a mixed farming system that involves animal husbandry and crop production. Major crops produced in the area includes Maize, Sorghum, Soya bean, Sesame and Groundnut.

2.2. Treatments and Experimental Design

The experimental design was laid out in Randomized Complete Block design with three replications. The gross size of experimental plot was 3 x 4 m (12 m^2) with five rows of maize planted at spacing of 75 cm between rows and 30 cm between plants. Net sampling plot size was 3.00 x 2.25 m in all experimental plots, in which the two outer most rows at both ends were considered as borders. The full dose of blended fertilizer and compost was applied as band application at sowing. Nitrogen fertilizer in the form of urea (46% N) was applied in two doses, *i.e.,* half of the quantity was applied as band application at planting and the remaining half was top-dressed at knee height growth stage of maize.

2.3. Soil Data Collection

Soil sample at a depth of 30 cm was taken from five random spots diagonally across the experimental field before planting. The collected soil samples were composited to one sample. The bulked soil samples were air dried, thoroughly mixed and ground to pass 2 mm sieve size before laboratory analysis. Then the samples were properly labeled, packed and transported to Nekemte Research and soil laboratory center of Oromia Agricultural Research Institute for the analysis of major physical and chemical properties.

2.4. Compost Preparation and Analysis

Compost was prepared three months before maize planting from decomposable materials of clovers, home residues, weeds and grasses, leaves of trees, ashes, cow dung, and top soil which was turned every month. The chemical contents of this compost were analyzed at Nekemte Research and soil laboratory center, of Oromia Agricultural Research Institute. The nutrient contents of compost *viz.,* OC, total N, available P, CEC, exchangeable Ca, exchangeable Mg, exchangeable K, exchangeable Na, nitrate (NO_3^-), ammonium (NH_4^+)and pH value were tested in the laboratory after compost was matured. Organic carbon was analyzed by Walkley and Black method [16] while total N by micro-Kjeldahl method [17], available P by using Olsen method[18] and pH was measured in suspension of 1:2.5 compost to potassium chloride (KCl) solution ratio [19].

2.5. Plant Material

A maize variety (QPM) BH - 545 was used for the experiment. BH - 545 was released through National Maize Research Program to adapt in moist mid altitude agro ecology. This QPM is characterized by pinkish tassel color, yellow seed color, semi flint grain texture and tolerant to major diseases. This QPM has twice higher lysine and tryptophan levels than conventional Maize. This level ranges from 2.7-4.5% in QPM compare to 1.6-2.6% in conventional Maize.

2.6. Phenological Data

Days to emergence: The number of days from sowing to when 50% of the seeds sown emerged.

Days to 50% anthesis: The number of days from sowing to when 50% of the plants in the plot gave tassels.

Day to 50% silking: The number of days from sowing to when 50% of the plants in the plot produced 3cm long silk.

Days to 90% maturity: The number of days from sowing to when 90% of the plant in the plot reached physiological maturity which is indicated by the formation of black layer at the base of ear kernels.

Physiological maturity: The physiological maturity from emergence to when 50% of the plants showed black layer on the tip of the kernel.

2.7. Growth Parameters

Plant height (cm): The height of a plant from the ground to the tip for five randomly selected plants in the plot.

The number of leaf per plant: The average number of leaf per plant for five randomly selected plants per plot was recorded.

The leaf area index was calculated by using the formula:

$$\frac{Number\ of\ leaf\ \times leaf\ length \times leaf\ width}{0.75\ \times\ 0.30} \times 0.75$$

2.8. Data Analysis

The analysis of variance (ANOVA) was carried out for growth and yield parameters following statistical procedures appropriate for the RCBD design using Statistical Analysis System [20] program package version 9.2. Where the F-ratios were found to be significant, treatment means were separated using the least significant difference (LSD) at 5% level of probability.

3. Results and Discussion

3.1. Soil Analysis

Analysis of soil samples before planting was done for the major physical and chemical properties at Nekemte Research and soil laboratory center. The soil of the experimental site has a proportion of 39% sand, 19% Silt, 42% clay and it is classified as clay soil (Table 1). The organic matter content of the soil was 3.0%, which is rated under low, in agreement with the finding of [21]. The pH of the soil is strong acidic before application the crops but during harvesting the pH slightly changed and decreased the acidity of the soil hence higher exchangeable acidity. However, the organic matter content of the soil was found doubled at harvesting. Both calcium and magnesium slightly decreased at harvesting than before application.

Table 1. Selected physicochemical properties of the experimental soils before planting maize.

Parameters	Soil moisture	Sand (%)	Silt (%)	Clay (%)	Texture class	pH1:2.5(W/V)			EC ms/cm	Orga. Carbon %	Orga. matter %
						pH/H_2O	pH/0.01 $CaCl_2$	pH/1M KCl			
Values	6.8	39	19	42	clay	4.69	4.22	3.39	0.092	1.71	3.0

Parameters	Total Nitrogen %	CEC (meq/100 gm soil)	Exch. Acidity (Al^{3+} +H^+ meq/100gm soil)	Available K^+(ppm)	Available P (ppm)	Exchangeable Bases(meq/100gm soil)				
						Ca^{2+}	Mg^{2+}	Na^+	K^+	Base saturation percentage (BSP) (%)
Values	0.15	31.25	1.122	43.741	5.049	7.06	7.2	0.19	1.325	52.766

Table 2 indicates that the chemical properties of compost fertilizer before planting and its content was high in OC (18.2%), Organic matter (31.38%), available P (647.4 ppm), CEC (93.9 cmolc kg^{-1}), exchangeable Ca (48.8 cmolc kg^{-1}), Mg (26.9 cmolc $kg^{-1}$$NH_4^+$ (329.8 ppm) and NO_3^- (301.7ppm). Moreover, total N (0.81%), K (2.8 cmolc kg^{1}) and Na (0.6 cmolc kg^{1}), of the soil were low (Table 2).

Table 2. Chemical content of compost before applying to the soil.

Parameters	Value
Organic carbon	18.2 %
Total nitrogen	0.81 %
Organic mater	31.38%
NH_4^+	329.8 ppm
NO_3^-	301.7 ppm
Available phosphorus	647.4 ppm
Cation exchange capacity	93.9 cmolc kg^{-1}
Exchangeable Ca	48.8 cmolc kg^{-1}
Exchangeable Mg	26.9 cmolc kg^{-1}
Exchangeable K	2.8 cmolc kg^{-1}
Exchangeable Na	0.6 cmolc kg^{-1}

3.2. Effect of Treatments on Phenological Parameters

Analysis of variance (ANOVA) indicated that the different levels of blended fertilizer significantly affected days to emergence, days to flowering and days to silking, days to 90% physiological maturity and days to maturity for quality protein maize (Table 3). Compost application was found significant for the characters days to silking and flowering (Table 4). However, interaction of compost and blended fertilizer was not significant for all phenological parameters (Table 3).

The earlier for days to emergence were 6.20 days for 150kgha^{-1} blended and 7.80 was the late emergence dates for the control. The result showed that fertilizer (N, P, S, B and Zn) gave earlier emergence than the one without blend fertilizer (Table 5). This may be the good interaction of phosphorus with the rest of the chemical fertilizer and the higher dosage N fertilizer which enhanced days to emergence [22]. Early emerged plant develops roots and provides much biological function in plant growth due to chemical fertilizer such as Zn. Compost fertilizer did not affect significantly days to emergence. This result was in agreement with [23]. who concluded that application of farmyard manure did not affect germination.

Application of blended fertilizer at the rate of 150kg/ha resulted in late flowering day (66.80) than the rest treatments. However, the control treatment showed early flowering (64.13) (Table 5). Compost fertilizer application was also found significant; the highest (65.7) and the lowest (65.2) flowering days were recorded from 1ton/ha and 4ton/ha respectively (Table 4). This result indicated that organic and inorganic fertilizer rate have shown significant effect, and as the fertilizer rate increases to the optimum level, day of flowering of crops was delayed and the vegetative growth extended than flowering. The delaying in days to tasseling might be due to the slow release of nutrients from organic sources and N application at appropriate stage which extend the growth cycle of the crop. Addition of nitrogen rate at later stages delayed tasseling of maize and the results were comparable with [24, 25]. During flowering stage Boron has important roles such as, germination of pollen grains and growth of pollen tubes; seed and cell wall formation; protein formation; synthesis of nucleic acids; nutrient transport by plant membranes [26].

Days to 50% silking was significantly ($p<0.05$) affected due to the blended and compost fertilizer rate and the interaction effect was showed non significant effect. The highest days of silking (75.3) was observed from the rate of 4ton/ha compost and the lowest one (74.6) from the control (Table 4). Blended fertilizer of 150 kg/ha took the highest days to silking (75.80) and the lowest one (74.06) was recorded from control (Table 5). From the result obtained the two factors not intractably to affect day to silking. However, as the rate of organic and inorganic fertilizer application rate increases the plants took more days for silking (Table 4). This delay in days to silking might be due to more nitrogen availability for the whole season from organic source because of the slow release of nutrients from organic sources which extend the vegetative growth of the crop and ultimately delay days to silking. The results were in agreement with [27] who stated that availability of N at proper amount and time increased days to silking.

Days to 90% maturity was significantly ($p<0.05$) affected due to the application of blended fertilizer but compost and their interaction fertilizer did not show significant effect on days to 90% maturity (Table 5). The highest value of 90% maturity day (122.80) was observed at (150kgha^{-1}) and the lowest (121.13) was recorded for control. This revealed that only blended fertilizer rate significantly affected and the plot which have high blended fertilizer rate had longest maturity day than the one which have less blended fertilizer rate.

Days to physiological maturity was significantly ($p<0.05$) affected due to blended fertilizer but compost had no effect on days to maturity; this might be due to varietal characteristics (Table 5). Application of blended fertilizer rate had highest days of physiological maturity (133.80) was observed from 150 kgha^{-1} and the lowest (132.13) was recorded from the control (Table 5). The result showed that the less rate of blended fertilizer had early maturity days. When fertilizer rate increases days to physiological maturity was increased. [25] stated that addition of nitrogen at later stage delays physiological maturity of the crop. In addition to these [28, 29] reported that increase in nitrogen extends the vegetative stage which ultimately delays the maturity of crops. This result was disagreeing with [30] who reported that tasseling, silking, and physiological maturity were delayed at lower chemical fertilizer levels and enhanced early development was observed with the application of higher chemical fertilizer levels. The non consistency could have resulted due to opposite action of nitrogen and phosphorus on maturity. [31] stated that application of nitrogen and phosphorus significantly influenced days to 75% maturity; N fertilizer and prolonged days to 75% maturity in teff, where as the reverse trend was seen with applied P.

Table 3. ANOVA table showing mean square of phenology and growth parameters of quality protein maize as affected by the interaction of inorganic fertilizer (NPSBZ) and organic application, grown at Guto Gida district, East Wollega zone, Ethiopia during 2016/17 cropping season.

Parameters	Sources of Variation				
	Blended fertilizer (B)	Compost (C)	BXC	Error	P value for BX C
Days to emergence	7.0**	0.04^{NS}	0.15^{NS}	0.23	0.79
Days to flowering	21.0 **	0.47*	0.10^{NS}	0.14	0.71
Days to 50% silking	8.64**	0.85*	0.21^{NS}	0.25	0.22
Days to 90% maturity	8.31**	0.29^{NS}	0.26^{NS}	0.16	0.13
Days to physiological maturity	8.31**	0.29^{NS}	0.26^{NS}	0.16	0.13
Number of leaf per plant	10.81**	0.30*	0.52*	0.05	<.0001
Plant height	3350.1**	30.23**	437.5**	8.25	<.0001
Leaf area index	22.79**	0.89**	1.68**	0.17	<.0001

BXC= Interaction of blended and compost, NS= not significantly different at probability of 0.05 significance level, *= significantly different at probability of 0.05 significance level, **=highly significant at probability of 0.01 significance level.

Table 4. Days to flowering and silking as affected by different rate of compost application on quality protein maize grown at Guto Gida district, Eastern Wollega zone, Ethiopia during 2016/17 cropping season.

Compost ton/ha	Days to flowering	Days to silking
0	65.6^{ab}	74.6^{d}
1	65.7^{a}	74.7^{bc}
2	65.5^{abc}	75^{ab}
3	65.4^{bc}	75^{ab}
4	65.2^{c}	75.3^{a}
Mean	65.5	74.96
LSD (0.05)	0.31	0.32
CV (%)	2.02	2.02

Means in the same column indicated with the same letter are not significantly different.

Table 5. Phenological stages of quality protein maize as affected by different rate of inorganic fertilizer (NPSBZ) application, grown at Guto Gida district, Eastern Wollega zone, Ethiopia during 2016/17 cropping season.

Blended fertilizer kg/ha	DE	DF	DS	DTM	DTPM
0	7.80^{a}	64.13^{c}	74.06^{d}	121.13^{d}	132.13^{d}
50	7.40^{b}	66.13^{b}	74.66^{c}	121.66^{c}	132.66^{c}
100	7.26^{b}	65.00^{c}	75.33^{b}	122.40^{b}	133.40^{b}
150	6.20^{c}	66.80^{a}	75.80^{a}	122.80^{a}	133.80^{a}
Mean	7.16	65.5	74.96	122.0	133.0
LSD (0.05)	0.36	0.28	0.29	0.30	0.30
CV (%)	2.02	2.02	2.02	2.02	2.02

Means in the same column indicated with the same letter are not significantly different. DE =Days to 50% emergence, DF = Days to 50% flowering, DS = Days to 50% silking, DTM= days to 90% maturity, DTPM= days to physiological maturity.

3.3. Growth Parameters

The ANOVA results showed that there was high significant difference (p<0.01) for plant height due to the application of combined compost, blended fertilizer application and their interaction (Table 6). The tallest (231.80 cm) plant height was recorded from the interaction of (4 tons/ha) compost and (100kg/ha) blended fertilizer and the shortest was (161.06 cm) from the control (without any fertilizer) treatment. This might be due to their synergistic effects of increasing nutrient use efficiencies and special effects of compost which acted as the store house of different plant nutrients, reduce P fixation, improve CEC, aeration, root penetration, water storage capacity of the soil *etc* [32, 33]. The result agrees with [34] who reported that there were high significant differences in maize plant height in plot treated with high fertilizers rate compared with nil application. Similarly, [35] reported that maximum plant height of wheat was obtained at the highest levels of combined application of chemical fertilizer with compost. [36] reported that highest maize plant height was obtained due to integrated organic and inorganic fertilizer applications.

Table 6. Plant height of quality protein maize as affected by the interaction of inorganic fertilizer (NPSBZ) and organic application, grown at Guto Gida district, Eastern Wollega zone, Ethiopia during 2016/17 cropping season.

Factors	Compost tons/ha				
	0	1	2	3	4
Blended kg/ha					
0	161.06	165.00	182.20	180.80	183.60
50	195.60	194.93	188.06	192.60	190.40
100	197.66	202.40	204.06	203.66	231.80
150	217.20	213.73	201.86	198.53	188.40
Mean	194.68				
LSD	4.74				
CV	1.47				

The number of leaves per plant was significantly (p<0.05) affected by the application of combined compost and blended fertilizer. On average the different treatments gave 13.52 leaf numbers per plant (Table 7). The highest leaf number (14.86) was observed from combined 1 ton/ha of compost and 150 kg/ha of blended fertilizer application and the lowest number of leaves per plant (12.26) was found in control (without any fertilizer). The interaction effect of compost and blended fertilizer application was significantly affected this parameter. The higher leaf number per plant on combined application of organic and inorganic fertilizers might be due to ready availability of nutrients during the growth period of the crop. Similarly, an increase in number of leaves per plant on maize due to integrated nutrient application was reported by [37, 38]. Similar data was reported by [39] who reported that leaf number of sorghum was increased due to combined application of organic and blended fertilizer application.

Table 7. Number of leaves per plant of quality protein maize as affected by the interaction of inorganic fertilizer (NPSBZ) and organic application, grown at Guto Gida district, Eastern Wollega zone, Ethiopia during 2016/17 cropping season.

Factors	Compost ton/ha				
	0	1	2	3	4
Blended kg/ha					
0	12.26	12.46	12.80	12.46	12.86
50	12.66	12.53	13.20	13.53	13.60
100	13.33	13.93	14.00	14.00	14.26
150	14.73	14.86	14.66	14.46	13.73
Mean	13.52				
LSD	0.38				
CV	1.72				

Leaf area index (LAI) was significantly ($p<0.05$) affected due to the interaction effect of compost and blended fertilizer levels (Table 8). The highest LAI (5.81) was observed from 100kg/ha of blended fertilizer and 4 ton/ha of compost and the lowest value of LAI (0.71) was recorded from control. When fertilizer rate increases the coverage area of leaf was varying with rate of fertilizer (Table 8). This increase in LAI could be attributed to enhanced production of carbohydrate, which might have resulted in increased leaf expansion. In agreement to this result, [40, 41, 36] reported that combined application of organic with inorganic fertilizer increases in LAI of crops compared to no fertilizer application. The higher LAI could be related to more number of leaves and higher leaf area per plant [37, 38].

Table 8. Leaf area index of quality protein maize as affected by the interaction of inorganic fertilizer (NPSBZ) and organic application, grown at Guto Gida district, Eastern Wollega zone, Ethiopia during 2016/17 cropping season.

Factors	Compost ton/ha				
	0	1	2	3	4
Blended kg/ha					
0	0.71	2.18	2.62	3.00	3.58
50	4.06	4.23	3.89	4.45	4.36
100	4.32	4.91	5.11	5.35	5.81
150	5.54	5.69	4.80	4.73	4.04
Mean	4.17				
LSD	0.58				
CV	9.98				

4. Conclusion

The present study was conducted to investigate the effect of combined application of compost and blended fertilizers on yield and yield components of maize using Quality protein maize (QPM) variety. QPM is one of the maize varieties being used to sustain food for developing country. It contains double the amount of protein than conventional maize. The objective of this experiment was, to investigate the effect of rate of blended fertilizer (NPSBZ) and compost application on growth of QPM at Uke research site of Wollega University. The experiment was laid out in Randomized Complete Block Design as factorial combinations of five levels of compost (0, 1, 2, 3 and 4-tons ha^{-1}) and four levels of blended (0, 50,100 and 150 kg ha^{-1}) fertilizers, which were replicated three times. In this experiment, combined application of blended and compost fertilizer has shown significant ($p\leq0.05$) differences for growth parameters *viz.,* number of leaves per plant, plant height and leaf area index. The highest mean value is recorded as 14.86, 231.80 cm and 5.81 from the combination of 150kg/ha and 1ton ha^{-1}, 150kg/ha and 4 tons ha^{-1}, 100kg/ha blended and 4 tons ha^{-1} of compost fertilizer respectively. From this study it is possible to conclude that integrated application of compost and blended fertilizers increase the growth of QPM.

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