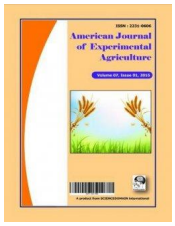

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Growth Response of Maize (*Zea mays* L.) to Different Rates of Nitrogen, Phosphorus and Farm Yard Manure in Morogoro Urban District, Tanzania

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Authors' contributions

This work was carried out in collaboration between all authors. Author UKA designed the study, wrote the protocol, performed the statistical analysis and wrote the first draft of the manuscript. Author JPM reviewed the experimental design and all drafts of the manuscript. Author JJM managed the analyses of the study and identified the plant. All authors read and approved the final manuscript.

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ABSTRACT

Pot experiments were carried out in the Teaching and Research Farm and in the green house of Soil Science Department, Faculty of Agriculture, Sokoine University of Agriculture, Morogoro Tanzania in 2014 and 2015 wet seasons to determine the effects of different levels of organic and inorganic fertilizers on maize. The experiments were conducted in completely randomized (CRD) with three replications. The treatments used consist of three levels of nitrogen (0, 75 and 150 kg Nha^{-1}), three levels of phosphorus (0, 40 and 80 kg Pha^{-1}) and three levels of Farm Yard Manure (0, 5 and 10 t FYM ha^{-1}). Parameters determined includes plant height, number of leaves and stem girth. Results obtained showed that maximum plant height (66.75 and 131.7 cm), number of leaves (10.50) and stem girth (4.90 and 5.85 cm) were achieved with application of 150 kg Nha^{-1} + 80 kg Pha^{-1} + 10 t $FYMha^{-1}$. The effects of treatments on parameters determined were significant ($P \leq 0.05$) in both years. However, application of fertilizers had no significant effect on number of leaves at first

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and second weeks after sowing. Results obtained in 2015 were better than 2014, which could be due to seasonal variation in the weather conditions and soils nutrient contents. The study suggests that, the study soils should be amended with rates of combined organic and inorganic fertilizers for superior maize growth performance.

Keywords: Organic and inorganic fertilizers; maize; plant height; leaves; green house.

1. INTRODUCTION

Maize is grown widely in many countries of the world, Tanzania inclusive. In Tanzania over two million hectares of maize are planted per year with average yields of between 1.2 – 1.6 tonnes per hectare. The crop accounts for 31 percent of the total food production and constitutes more than 75 percent of the cereals consumption in the country [1]. However with continuous cultivation most of the other essential plant nutrients which were previously adequate have declined to deficient levels, hence the need to apply them in the form of fertilizers or other soil amendments. The three nutrients N, P and K are often the most limiting in many soils, in the order N>P>K [2].

Maize requires adequate supply of nutrients particularly nitrogen, phosphorus and potassium for good growth and high yield. Nitrogen and phosphorus are very essential for good vegetative growth and grain development in maize production. The quantity required of these nutrients particularly nitrogen depends on the pre-cleaning vegetation, organic matter content, tillage methods and light intensity [3]. Nitrogen is a vital plant nutrient and a major yield determining factor required for maize production [4,5]. It is very essential nutrient required to increase maize yield consequently, and hence the deficiency of phosphorus is an important as the deficiency of nitrogen in limiting maize performance. Nitrogen and phosphorous are highly limiting nutrients to support good crop growth and development due to the practice of multiple and continuous cropping systems using low fertilizer [6,7]. Regular application of organic manure not only supply all the various macro and micro-nutrients, although in small quantities, but also improves soil physical and biological properties [8,9].

Many studies have reported that the positive effect of both organic and inorganic fertilizers as well as their combinations, in supporting higher growth of maize [10,11,12]. The use of inorganic fertilizers has not been helpful as it is associated with increased soil acidity and nutrient imbalance [13]. On the other hand, organic fertilizer is slow releasing and could hardly supply the quantity needed by crops [14]. However combined application of organic and inorganic fertilizers offers the best advantage because apart from enhancing soil fertility it improves soil physical properties [15,16]. Hence, this study was undertaken with a view to determine the growth response of maize to application of different levels of organic and inorganic fertilizers combinations.

2. MATERIALS AND METHODS

Greenhouse experiments were conducted during the 2014 and 2015 long rainy seasons at green house of the Department of Soil Science Faculty of Agriculture of the Sokoine University of Agriculture, Morogoro, Tanzania. The area lies between latitude 5°58” and 10°0” S and longitude 35°25” and 35°30” E. The area has a sub-humid tropical type of climate with a bi-modal rainfall distribution. The average total annual precipitation is about 895 mm per year with a mean monthly temperature of about 24.0°C.

Bulked surface soil samples were collected from SMC campus, Sokoine University of Agriculture farm at the depth of 0-30 cm, while FYM samples were collected from the dairy house of the farm. The soil samples were thoroughly mixed and sub-divided to obtain a composite sample. The soil samples were air-dried, ground and sieved to pass through 6 mm diameter screen for green house experiment and 2 mm diameter screen for subsamples which were taken for laboratory analysis of selected physical and chemical properties. The FYM used for the study was air-dried, ground, sieved and also analyzed for some chemical properties.

The soil samples were analyzed for particle size distribution using the hydrometer method [17] while soil pH (H_20 and 0.1 M KCl) in a 1:2.5 soil/ solution ratio using the glass electrode of a pH meter. Total N was determined by the Kjeldhal method and organic carbon (OC) was determined by the dichromate wet oxidation method. Ammonium acetate was used for determination of exchangeable bases (Ca, Mg, K

and Na). Organic matter content was obtained by multiplying organic carbon values by a factor of 1.724 [18]. The method advocated by [19] was used for these entire analyses [19]. The sample of FYM was analyzed for N and P content. Total N was determined by the regular macro-Kjeldahl procedure. Available P was determined by Bray P – I method [17].

The experiment is 3*3 factorial fitted into completely randomized design (CRD) with three replications. The treatments consisted of three rates of organic manure (FYM: 0, 5 and 10 t ha^{-1}), three rates of nitrogen (0, 75 and 150 kg N ha^{-1}) and three rates of phosphorus (0, 40 and 80 kg P ha^{-1}). Thus the experiment consisted of 27 treatment combinations of organic and inorganic fertilizers source.

The pot experiments were carried out using the bulk composite soil samples that were taken from the site. Before sowing 4 kg of the processed soil sample was thoroughly mixed with N, P and FYM treatments, except the control pots and assigned to 5 L plastic pots (according to treatments) perforated at the bottom for drainage outlets. A total of 81 green house plastic pots were used. Tap water was then added to each pot to 70% of the soil's water holding capacity to bring them at field capacity. The pots were left in the green house for a period of 10 days to stabilize and begin to decompose organic amendments (Kraal).

After 10 days, four maize (*Zea mays)* seeds of var. Tanzanian maize variety (TMV-1) were sown per pot and later the seedlings were thinned to two per pot at two weeks after sowing (WAS). The sowing dates were 22nd of March for each 2014 and 2015 respectively. Fertilizer application of P and N was done at planting followed by a split dosage of N at two WAS. Weeding was carried out regularly by hand picking. Visual observation was used to identify any abnormal symptoms. The pots were maintained close to field capacity throughout the experiment. There were two experiments and in both experiments the plants were harvested at the end of four weeks (WAS).

The growth parameters measured included plant height, number of leaf and stem girth. The plant heights were measured by using meter scale, while leaves number by counting and stem girth by using rope and 30 cm meter scale. The maize growth data were collected at 1, 2, 3 and 4 WAP. The experiments were repeated and all protocol was the same.

The data collected were analyzed using the analysis of variance (ANOVA) technique and means were separated using the Least Significant Differences (LSD) test at 5% level of probability with the software package [20].

3. RESULTS AND DISCUSSION

The initial properties of soil (before sowing) for the two year trials are shown in Table 1. The textural class of the soils for both years was loamy soil with pH 7.08 and 6.96 which indicate mildly alkaline to slightly acidic in reaction. Organic carbon contents were 0.21 and 0.33%, while total N contents were 0.04 and 0.05% in 2014 and 2015 respectively. The concentrations of exchangeable bases in the soil were higher in 2015 than 2014, while micronutrients Cu, Zn and Mn were higher in 2014 than 2015 and Available phosphorus was higher in 2015 soil. Soil analysis before sowing indicated that the major nutrients (N, P) were found at low levels. The values of soil chemical properties were low indicating that the soils were low in fertility. Therefore, there is needed to apply fertilizers to the soil in order to boost their productivity.

Table 1. Physico-chemical properties of the soils used before sowing

Soil properties	Measured value	
	2014	2015
Clay (%)	12.12	14.12
Silt (%)	3.64	3.68
Sand (%)	84.24	80.24
Text. class	LS	LS
pH (H_20)	7.08	6.96
pH (KCL)	5.68	5.16
Org.C (%)	0.21	0.33
Total N (%)	0.04	0.05
Avail. P.mg kg^{-1}	6.68	10.86
CEC cmol kg^{-1}	10.20	12.40
Ex.Ca cmo kg^{-1}	0.37	0.37
Ex. Mg cmol kg^{-1}	0.80	0.82
Ex. K cmol kg^{-1}	0.33	0.74
Ex. Na cmol kg^{-1}	0.20	0.32
BS (%)	16.68	18.15
Ex. Cu mg kg^{-1}	0.28	0.25
Ex. Zn mg kg^{-1}	0.19	0.12
Ex. Fe mg kg^{-1}	21.20	33.77
Ex. Mn mg kg^{-1}	31.50	27.50
EC dS/m	0.02	0.02

Effect of organic and inorganic fertilizers on plant height shows that application of different rates of organic and inorganic fertilizers had no significant effects ($P<0.05$) on plant height of maize throughout first (WAP) (Table 2). Plot that had treatments T_{25} ($N_{150}P_{40}$ FYM_0) and T_{27}

($N_{150}P_{80}$ FYM_{10}) produced statistically the tallest plants of 68.50 cm and 115.4 cm in 2014 and 2015 respectively, closely followed by T_{24} ($N_{150}P_{40}$ FYM_{10}), and T_{21} ($N_{150}P_0$ FYM_{10}) while the control produced the shortest plant. There is a corresponding increase in the growth of maize as the rate of fertilizers increases. Maize plant heights ranged from 8.58 cm to 67.00 cm and 9.2 cm to 115.4 cm in 2014 and 2015 (Table 2). In both years, fertilizers application did not affect plant height at first and second week after sowing except in T_{26} ($N_{150}P_{80}$ FYM_5) in 2014.

Plant height was highly influenced by the application of organic and an inorganic fertilizer in both years at 3 and 4 WAS. In the 2014 trial, tallest plant were observed in pot treated with full FYM and N rates (67.00 cm) and the control pot gave the least (38.58 cm), while in 2015 of 28 days, pots amended with highest FYM, N and P rates gave the tallest plant (115.4 cm) and the control treatment produced the shortest plant of 56.7 cm respectively.

The results presented in Table 3 show the trend observed in the number of leaves produced by plants at every week interval stages of growth. A similar to the above trend was observed for the number of maize leaves where the application of fertilizers rates did not significantly ($p<0.05$) affect leaves number of maize per plant except at 3 and 4 WAS in 2014.

Table 2. Effects of treatments application rates on the plant height of maize at 1-4 weeks after sowing

Treatments	2014				2015			
	Weeks after sowing				Weeks after sowing			
	1	2	3	4	1	2	3	4
N_oP_o FYM_o	8.50	35.47	35.50	40.25	16.9	40.9	51.4	56.7
N_oP_o FYM_5	10.17	43.67	43.25	49.25*	19.5	46.2	60.2	70.8
N_oP_o FYM_{10}	9.35	41.57	44.50	49.75*	17.9	43.6	60.1	66.7
N_oP_{40} FYM_o	8.97	29.92	45.75*	45.00	20.7	56.0	79.0	90.2
N_oP_{40} FYM_5	7.25	41.50	40.75	44.75	25.7	48.3	69.8	84.0
N_oP_{40} FYM_{10}	8.40	43.60	45.50	56.25*	24.7	47.6	72.3	86.2
N_oP_{80} FYM_o	9.56	41.77	46.50*	47.50	26.5	52.9	73.8	87.8
N_oP_{80} FYM_5	10.00	45.95	47.70*	56.26*	24.7	59.0	77.5	99.0
N_oP_{80} FYM_{10}	9.15	44.20	44.50	56.26*	12.9	38.1	61.1	84.3
$N_{75}P_o$ FYM_o	8.50	43.00	38.75	45.00	21.5	44.3	50.7	50.9
$N_{75}P_o$ FYM_5	9.00	41.57	46.50*	66.00*	26.9	54.1	78.4	97.8
$N_{75}P_o$ FYM_{10}	9.62	45.55	47.25*	66.50*	24.8	54.8	67.9	102.3
$N_{75}P_{40}$ FYM_o	10.75	36.62	41.50	49.25*	20.7	53.2	78.6	102.5
$N_{75}P_{40}$ FYM_5	7.87	44.20	48.00*	61.50*	25.2	62.3	84.4	102.4
$N_{75}P_{40}$ FYM_{10}	8.92	41.12	39.50	61.75*	14.8	46.9	66.6	86.5
$N_{75}P_{80}$ FYM_o	8.10	40.67	39.50	56.75*	14.6	47.6	79.1	112.6
$N_{75}P_{80}$ FYM_5	11.25	44.95	47.25*	66.25	26.4	56.5	81.3	110.3
$N_{75}P_{80}$ FYM_{10}	12.05	46.96	47.75*	63.25*	9.2	38.6	73.1	95.6
$N_{150}P_o$ FYM_o	9.22	39.55	32.00	43.75	18.5	42.2	56.7	65.0
$N_{150}P_o$ FYM_5	10.25	43.77	44.00	62.25*	25.3	62.7	85.2	104.1
$N_{150}P_o$ FYM_{10}	8.82	38.80	45.25	63.75*	27.0	57.0	86.1	115.0
$N_{150}P_{40}$ FYM_o	10.67	46.37	46.75*	66.00*	12.9	43.1	62.6	88.8
$N_{150}P_{40}$ FYM_5	11.00	43.37	46.75*	62.00*	16.1	39.8	66.4	89.7
$N_{150}P_{40}$ FYM_{10}	9.87	41.42	48.25*	67.00*	13.8	42.8	70.5	94.0
$N_{150}P_{80}$ FYM_o	12.37	48.25	51.79*	68.50*	29.1	52.0	81.5	101.4
$N_{150}P_{80}$ FYM_5	10.62	50.12*	51.75*	66.00*	11.8	45.6	76.3	102.6
$N_{150}P_{80}$ FYM_{10}	11.42	46.67	51.50*	66.75*	20.4	61.3	86.6	115.4
LSD (0.05)	4.537	13.516	9.932	8.391	21.37	26.89	27.61	22.67
CV (%)	22.80	15.40	10.70	7.20	51.5	26.5	18.7	12.1

**Indicate the level of significance at 5% probability level*

Table 3. Effects of combination of manure and fertilizer rates on the leaves number of maize at 1-4 weeks after sowing

Treatments	2014				2015			
	Weeks after sowing				Weeks after sowing			
	1	2	3	4	1	2	3	4
N_oP_o FYM_o	3.00	5.00	5.50	6.50	2.00	3.50	5.00	6.00
N_oP_o FYM_5	4.25	5.75	6.50	7.75	3.75	4.75	6.00	7.00
N_oP_o FYM_{10}	3.50	5.00	6.00	7.00	3.50	4.25	5.83	6.67
N_oP_{40} FYM_o	3.50	6.25	7.25	7.50	3.50	5.50	7.50	7.50
N_oP_{40} FYM_5	3.00	5.00	6.50	8.00	2.50	4.50	6.25	7.75
N_oP_{40} FYM_{10}	3.00	5.25	6.75	7.50	3.00	4.75	6.50	7.38
N_oP_{80} FYM_o	3.50	5.50	7.00	8.00	3.75	5.00	6.75	7.75
N_oP_{80} FYM_5	4.00	6.00	7.75	8.25	3.88	6.25	7.25	8.00
N_oP_{80} FYM_{10}	2.00	4.75	6.50	7.75	1.75	3.50	6.25	7.50
$N_{75}P_o$ FYM_o	3.50	5.50	6.50	6.75	3.25	4.25	6.25	7.50
$N_{75}P_o$ FYM_5	3.75	6.75	7.50	8.00	3.25	4.75	7.00	7.00
$N_{75}P_o$ FYM_{10}	4.00	5.50	7.75	8.75	3.88	5.25	7.50	7.50
$N_{75}P_{40}$ FYM_o	3.50	6.00	8.50	9.00	3.50	6.00	8.00	8.50
$N_{75}P_{40}$ FYM_5	3.75	5.50	7.25	8.25	3.50	5.75	6.50	8.50
$N_{75}P_{40}$ FYM_{10}	1.75	5.00	6.75	9.25	1.50	3.00	6.50	7.75
$N_{75}P_{80}$ FYM_o	2.00	5.75	7.25	9.50	1.50	3.25	6.75	9.00
$N_{75}P_{80}$ FYM_5	3.75	5.50	7.25	9.00	3.50	5.25	7.50	9.00
$N_{75}P_{80}$ FYM_{10}	1.50	4.50	7.00	9.oo	1.25	3.25	6.50	8.75
$N_{150}P_o$ FYM_o	3.00	5.00	5.75	7.00	3.00	4.25	5.50	8.50
$N_{150}P_o$ FYM_5	3.75	5.00	8.25	8.50	3.50	5.00	7.75	6.50
$N_{150}P_o$ FYM_{10}	3.50	5.75	8.00	9.25	3.50	5.25	7.00	8.25
$N_{150}P_{40}$ FYM_o	1.50	4.00	6.75	8.25	1.25	4.75	6.50	8.75
$N_{150}P_{40}$ FYM_5	1.50	4.75	6.75	9.25	1.13	3.25	6.50	8.00
$N_{150}P_{40}$ FYM_{10}	2.00	4.50	7.00	8.25	3.00	4.25	6.50	9.00
$N_{150}P_{80}$ FYM_o	4.00	5.00	8.50	9.50	4.50	6.25	8.00	7.75
$N_{150}P_{80}$ FYM_5	1.75	5.00	8.00	9.75	1.75	5.50	7.25	9.00
$N_{150}P_{80}$ FYM_{10}	3.75	6.00	8.75	9.75	3.75	6.50	8.50	9.00
LSD (0.05)	2.752	2.019	2.161	2.300	2.502	2.003	2.065	2.221
CV %	44.1	18.5	14.6	13.6	40.5	17.4	13.8	13.0

**Indicate the level of significance at 5% probability level*

It was observed that at 1 WAS and 2 WAS apart from control, pots with different fertilizers had similar number of leaves compared with those that received higher fertilizers doses. Therefore all treatments had similar number of leaves except control, which recorded the least value (Table 3).

Application of full FYM, N and P rates ($N_{150}P_{80}$ FYM_{10}) in treatment 27 produced statistically the highest mean number of leaves per plant, this was followed by T25 ($N_{150}P_{80}$ FYM_0) while the control had the lowest in all the 3rd and 4th WAS.

Table 4 shows the effect of the different rates of organic and inorganic fertilizers on stem girth of maize. In 2014 the stem girth of T_{27} ($N_{150}P_{80}$ FYM_{10}) had the thickest stems of 4.90 cm while 4.80 cm and 4.73 cm were recorded from the pot received T_{25} and T_{21} respectively and the control had the lowest stem girth of 2.10 cm. The same result was obtained in 2015 with regards to stem girth in which treatment T_{27} recorded the thickest one. The result of the applied treatments on stem girth at the end of green house study revealed that the treatments had significantly increased stem girth ($P<0.05$).

Treatment T_{27} ($N_{150}P_{80}$ FYM_{10}) recorded higher stem girth values in both years at 4 WAS, this was followed by T_{26} ($N_{150}P_{80}$ FYM_5) while control recorded the least stem girth value in all experiments. In both years most of the treatments produced similar stem girth values.

Application of organic and inorganic fertilizers at higher doses produced significantly larger stem girth values compared with the control. Stem girth differed significantly (p = 0.05) among the treatments.

Table 4. Stem girth of maize plant at the end of the green house experiments as affected by organic and inorganic fertilizers in 2014 and 2015

Treatments	2014 Stem girth (cm) pot^{-1}	2015 Stem girth (cm) pot^{-1}
N_oP_o FYM_o	2.10	2.65
N_oP_o FYM_5	3.30	3.05
N_oP_o FYM_{10}	3.23	2.90
N_oP_{40} FYM_o	2.55	3.60
N_oP_{40} FYM_5	2.96	3.60
N_oP_{40} FYM_{10}	3.23	3.95
N_oP_{80} FYM_o	2.85	3.85
N_oP_{80} FYM_5	2.77	3.85
N_oP_{80} FYM_{10}	3.10	3.85
$N_{75}P_o$ FYM_o	2.18	2.60
$N_{75}P_o$ FYM_5	3.93*	3.90
$N_{75}P_o$ FYM_{10}	4.23*	3.90
$N_{75}P_{40}$ FYM_o	3.15	3.90
$N_{75}P_{40}$ FYM_5	3.75	4.00
$N_{75}P_{40}$ FYM_{10}	3.90*	3.95
$N_{75}P_{80}$ FYM_o	3.85	4.20
$N_{75}P_{80}$ FYM_5	4.13*	4.05
$N_{75}P_{80}$ FYM_{10}	4.58*	4.45
$N_{150}P_o$ FYM_o	2.20	2.80
$N_{150}P_o$ FYM_5	4.53*	4.10
$N_{150}P_o$ FYM_{10}	4.73*	4.45
$N_{150}P_{40}$ FYM_o	4.43*	4.10
$N_{150}P_{40}$ FYM_5	4.40*	4.55
$N_{150}P_{40}$ FYM_{10}	4.45*	4.75
$N_{150}P_{80}$ FYM_o	4.80*	4.75
$N_{150}P_{80}$ FYM_5	4.60*	4.30
$N_{150}P_{80}$ FYM_{10}	4.90*	5.85
LSD (0.05)	0.804	0.8013
CV (%)	10.70	10.00

**Indicate the level of significance at 5% probability level*

Plant height, number of leaves and stem girth were generally influenced by the combined application of organic and inorganic fertilizers at various rates at both 2014 and 2015 seasons. This is in agreement with the results obtained by who achieved and the most satisfactory increased maize yield was obtained from the judicious combined use of organic and inorganic fertilizers [21,22,23,24] that use of 120 kg N ha^{-1} recorded taller maize plants with superior number of leaves and leaf area index indicating that the higher N had supported vigorous growth and production of thick canopy, efficient light interception, assimilate production and higher dry matter production. Growth characters like plant height, number of leaves per plant stem diameter, leave area per plant, green fodder yield, and dry matter were influenced by the application of nitrogen [25]. The data recorded in Table 2 showed that plant height increased across the treatments at all stages.

4. CONCLUSION

In conclusion, the soils of the study area were low in major macronutrients. This suggests poor soil fertility that may require some extenuating measures to improve. Furthermore, the results indicated that combined application of organic and inorganic fertilizers had significant effect on all agronomic growth parameters like plant height, number of leaves and stem girth of maize. Maize growth performances as measured in terms of the above parameters were generally enhanced and better with application of 150 kg N ha^{-1} + 80 kg P ha^{-1} and 10 t ha-^{1} FYM and 75 kg N ha^{-1}, 40 kg P ha^{-1} plus FYM 5 t ha^{-1} in both seasons relative to other treatments. For optimum maize growth and vigour, therefore, combined application of organic and inorganic fertilizers at moderate (75 kg N ha^{-1}, 40 kg P ha^{-1} plus FYM 5 t ha^{-1}) rates may be recommended particularly in the study area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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