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Growth and Yield Response Maize (Zea mays L.) to Different Phosphorus Fertilizer Levels at Debre Markos, North West Ethiopia

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Abstract
In order to investigate the effect of different phosphorus levels on the yield and yield components of Maize, an experiment was carried out at Debre Markos University during 2017. The experiment was laid out in randomized complete block design with three replications having a plot size of 3 m x 2 m, with replication distance of 0.75 m and plant to plant distance of 0.25 m. The levels of Phosphorus were 0 (control), 50, 100, 150, 200, 250 and 300 kg ha^{-1}. Results indicated that the different levels of phosphorus had significant effect on maize plant height, number of leaf per plant, leaf area of maize, however the effect was non-significant on number of leafs per plant on some levels of phosphorus. Application of P at the rate of 200 kg ha^{-1} resulted in maximum plant height (92.93 cm), number of Leafs per plant (11.67) and leaf areas (517.57 cm2), as compared to the minimum values in control plots. The results indicated that the response of maize grain yield to the increase of P fertilizer up to 250 kg/ha. This response was observed in all parameters except for number of ears. Therefore, it is concluded that P should be applied at the rate of 250 kg ha-1 for best grain yield in the agro-ecological conditions of Debre Markos.
Keywords: Phosphorus, Zea mays L., Yield

1. INTRODUCTION

Maize (*Zea mays* L.) is an important cereal crop, which ranks third after wheat and rice (FAO, 2010). As one of the most important crops in the world, maize serves as basic raw material for the production of starch, oil and protein, alcoholic beverages and food sweeteners. Maize is an important grain crop of the world and it ranks third, after wheat and rice in hectarage and total production (Mosisa et al., 2001).). In Africa, the bulk of maize produced is used as human food although it has been increasingly utilized for livestock feed (Onasanya *et al.,* 2009) and it is the second important food crop in Ethiopia, which occupied 20% of total cereal land next to teff, which occupies 30%, followed by sorghum (18%), wheat (16%), and barley (12%).

The land area coverage of maize production has been increasing linearly with production in Ethiopia. In spite of the increasing maize production area, yield is still low. Average productivity of maize is 1.9 tonne per hectare, while the potential productivity is 7 to 12 tonne per hectare (Adugna Negeri and Melaku Adisu, 2001). The low productivity of maize in Ethiopia is attributable to many factors: degradation of natural resources, drought, insufficient technology generation, poor seed quality (Adugna Negeri and Melaku Adisu, 2001) and insufficient use of fertilizers resulting in severe nutrient depletion of soils (Christina, 2002) and poor soil fertility (Eltelib et al 2006). The production of maize could be increased by the application of balanced fertilizer in particular with the use of phosphorus fertilizer.

Phosphorus (P) is the second key plant nutrient required in large quantities for growth and productivity of crops (Miller and Donahue, 1997). The importance of phosphorus as yield limiting factor in many soils is well-established (Anonymous, 2000). It is important for seed and fruit formation and crop maturation. Phosphorus hastens the ripening of fruits thus counteracting the effect of excess nitrogen application to the soil. It helps to strengthen the skeletal structure of the plant thereby preventing lodging (Onasanya *et al.,* 2009). In most of the maize producing areas in the world, phosphorus fertilizers are relied upon to improve crop yields and maintain soil fertility. The response of maize plant to application of phosphorus fertilizers varies from variety to variety, location to location and depends on the availability of the nutrients.

The production of maize is highly related to the phosphorus fertilizer applied to it (Alias *et al.,* 2003). But an excessive or deficiency of phosphorus fertilizer application should be avoided. For instance, inadequate phosphorus slows the process of carbohydrate utilization , the leaves of maize develop purple color, delayed maturity of maize and decrease disease resistance. The excessive use of phosphorus affects the environment and the health status of the people. Adequate P results in rapid growth and earlier maturity and improves the quality of vegetative growth. Phosphorus deficiency is responsible for crooked and missing rows as kernel twist and produce small ears in maize (Alias *et al.,* 2002). Because of this reason efficient phosphorus fertilizer applied on maize yield and yield components must be determined. Thus, the purpose of the present investigation was to asses and identify the effect of different levels of phosphorus fertilizer on yield and Yield components of maize.

2. Materials and Methods

2.1.Description of the Study Area

The study was conducted at Debre Markos University, College of Agriculture and Natural Resource demonstration site in the year 2017 cropping season under irrigation condition. Debre Markos University is geographically located at 300 Km North West of Addis Ababa at about 10018'10"north latitude and 37044'53" East longitudes at an altitude of about 2450 meter above sea level (m.a.s.l). The minimum and maximum temperature were 10.6 and 22.30°C, respectively. The mean annual rain fall of the area is about 1100 mm (Planning and Economic Development of East Gojjam, 2004).

2.2. Experimental Design and Treatments

In this study, seven levels of phosphorus (0, 50, 100, 150,200, 250 and 300kg/ha) were used as treatments and laid out in a Randomized Complete Block Design (RCBD) with three replications. The total number of plots was 21. Each treatment was randomly assigned to each plot. The plot size was an area of 2 m x 3 m (6 m^2) and the total area of experimental site was 207m^2 (18m*11.5m). The distance between blocks and plots was 0.75 m and 0.5m, respectively. Seeds of maize were sown on rows by 25cm spaced between seeds, 75cm between rows and each rows was contain 8 plants. The plot had four rows and the middle rows were used for all data collection including final yield performance determination.

2.3. Data Recorded: by taking five random representative samples from the middle rows: Plant height, Number of leaf per plant, Leaf area, Number of ears per row, Number of grains per row, grain weight and grain yield was recorded

2.3.1. Data Analysis

Analysis of variance was performed for all measured data to test the significance difference of maize in different rate of phosphorus. So data recorded from different parameters was subjected to the analysis of variance (ANOVA) and the treatment was compared using LSD test.

3. Results and Discussion

3.1. Plant growth attributes: Table 1 shows plant height, number of leaf per plant and Leaf area affected by different rates of phosphorus fertilizer and their analysis.

Data regarding plant height indicated that the different levels of phosphorus had a significant effect on maize plant height. Application of P at the rate of 200 kg ha-1 resulted in long stature plants (92.93 cm), as expected, followed by P applied at the rate of 250 kg ha-1 (67.27 cm). This meant that P at the rate of 200 kg ha-1 might be the optimum rate to trigger an increase in production per unit area as can be deduced from the control plots. Therefore, further increase in P above 200 kg ha-1 did not have a directly proportional effect on the plant height of maize, which is obvious from the plots with P application at the rate of 250 kg ha-1.

The short stature plants (55 cm) were observed in control plots. The highest plant height was recorded from treatment five and the lowest plant height was recorded from treatment one because Phosphorus improves the root growth which has a great effect on the overall plant growth performance; therefore the regimes of P at the rate of 0 kg ha-1 resulted in the shortest stature plants. Promotion effect of high P level on plant height was probably due to better development of root system and nutrient absorption (Hussain *et al.* 2004). Arain *et al.* (1989) also reported that plant height of maize increased with increase in P application. A significant effect of P application was observed on plant height(Alias *et al.,* 2002). However the results are in contrary to the findings of Anonymous (2000), who reported that plant height of maize plants increased with increasing phosphorus levels. Analysis of variance indicated that plant height was significantly different at 5% among all treatments.

3.2. Leaf Number Per Plant

Data regarding leaf number per plant indicated that the different levels of phosphorus had a significant effect on maize leaf number. Application of P at the rate of 200 kg ha^{-1} resulted in high leaf number (11.67/plant), as expected, followed by P applied at the rate of 250 kg ha^{-1}(11.67/plant). Therefore, the highest leaf number was recorded for phosphorus application at the rate treatment five, as well as four and six because treatment five has the highest mean value, the difference b/n mean value of treatment five with treatment four and six have no significance difference. But the lowest leaf number was recorded at treatment two, three, seven and especially at control treatment one the mean value difference of those were greater than the LSD values.

The mean difference of treatments greater than the LSD values then it has significant difference among treatments. Analysis of variance indicated that number of leaves per plant was not significantly difference at 5% among treatments of four, five and six (table 1) and have significant difference among treatments of one, two three and seven. Therefore, different phosphorus levels had no significance difference on some treatments and had significant difference on some other treatments of the leaf number on maize.

3.3. Leaf Area

The highest leaf area was recorded from treatment five b/c the highest mean value of leaf area was recorded at treatment five (517.57cm^2) and then the difference b/n mean value of leaf area among each treatments was greater than the LSD values. But most especially the lowest leaf area was recorded at control treatment (136.97cm^2). Analysis of variance indicated that leaf area had significantly difference at 5% among all treatments (table 1). Thus, different phosphorus levels had significance difference on all treatments of the leaf area on maize. This may be due to the fact that optimum availability of P has been associated with increased rapid growth and development, thus those plots which received optimum P produced more leaf areas as compared to control plots. Alias *et al.(* 2002) reported that number of leaf area of maize increased with increase in P application; less leaf area in the control plots resulted in minimum grain yield.

Table 1. Plant height, number of leaf per plant and Leaf area affected by different rates of phosphorus fertilizer

Treatments		Plant height	Number of leaf per plant	Leaf area
T1	0 kg/ha	55.00	6.00	136.97
T2	50 kg/ha	61.33	8.00	214.27
T3	100 kg/ha	66.17	9.00	296.03
T4	150 kg/ha	61.00	9.67	269.07
T5	200 kg/ha	92.93	11.67	517.57
T6	250 kg/ha	67.27	10.00	465.77
T7	300 kg/ha	60.73	9.33	430.40
LSD(0.05)		5.76	2.01	15.53
CV (%)		4.88	12.42	2.62

3.4. Grain weight per ear and its components: Table 2 shows number of ears per rows, 100-grain weight, as well as number of grains per ears affected by phosphorus levels. the current finding showed that unlike the number of ears per row, phosphorus levels had significant effect. The failure of the number of ears per row might be due to its control by genetic rather than environmental condition (Yosefi et al., 2011). According to the analysis, number of grains per row, grain weight and 100- grain weight were increased due to increase in phosphorus levels. But further increments beyond 250 kg/ha did not affect grain weight significantly as number of grains and 100- grain weight did not respond to P addition. This might be due to the role of P in crop maturation (Alias et al., 2003).

Table 2. Number of ears, number of grains and grain weight as influenced by different levels of Phosphorus

Treatments		No. of ears per row	100-grain weight	No. grains per ear
T1	0 kg/ha	14.32	35.03	44.35
T2	50 kg/ha	14.12	38.44	48.68
T3	100 kg/ha	14.0	38.49	50.14
T4	150 kg/ha	14.27	38.72	47.81
T5	200 kg/ha	14.22	38.52	49.11
T6	250 kg/ha	14.41	38.49	49.12
T7	300 kg/ha	14.42	38.32	47.82
LSD(0.05)		-	1.212	1.99
f-test		ns	**	**

** and ns : Indicate significant at 0.01 and insignificant respectively

3.5. Grain yield (t/ha): Table 3 shows grain yield per hectare of maize as affected by different rates of P fertilizer. The different P levels up to 250 kg/ha caused significant increase in grain yield per hectare. The result refer to an accumulation effect to phosphorus level increase on grain yield through the grain weight did not respond to the increase in Phosphorus levels beyond 200 kg/ha. The increase in grain yield due to the addition of 250kg/ha compared to the control. the increase in grain yield might be due to the increase in 100- grain weight, no of grains and ears. similar findings were reported by (Hussien, 2009), (Yosefi et al., 2011) and (Omar, 2014).

Table 3: Grain yield of Maize as affected by different P levels

Treatments		Grain yield (t/ha)
T1	0 kg/ha	7.59
T2	50 kg/ha	8.62
T3	100 kg/ha	9.12
T4	150 kg/ha	9.55
T5	200 kg/ha	9.64
T6	250 kg/ha	9.03
T7	300 kg/ha	8.62
LSD(0.05)		0.262
f-test		**

** : indicate significant at 0.01

4. Conclusion

Maize is an exhaustive crop having higher potential than other cereals and absorbs large quantity of nutrients from the soil during different growth stages. Among the essential nutrients, phosphorus is one of the most important nutrients for higher yield in larger quantity and controls mainly the reproductive growth of maize. Results of the present study showed that phosphorus fertilizers up to 250 kg/ha can increase maize yield.

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