AGRICULTURAL JOURNAL

MEDWELL PUBLICATIONS SINCE 2000

Response of Maize (*Zea mays* L.) Varieties to Combined Application Rates of Nitrogen and Phosphorus

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Key words: Growth, maize, nitrogen, phosphorus, yield

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Page No.: 166-170
Volume: 15, Issue 6, 2020
ISSN: 1816-9155
Agricultural Journal

Abstract: The field experiment was conducted at Arba Minch University Agricultural Research Farm in Arba Minch district with the objective of determining response of maize varieties to combined application of nitrogen and phosphorus. The experiment was designed in randomized complete block consisting of ten treatments with three replications. The treatments consisted of five levels of combined NP_2O_5 viz., 0/0, 46/23, 46/46, 92/23 and 92/46 kg ha^{-1} and two maize hybrid varieties, viz., V1 (BH-540) and V2 (BH-140). The results revealed that significant effect of NP_2O_5 rate and maize variety on all parameters. Maize variety BH-140 showed significant effect on number of grain rows per cob, number of grains per row, number of grains per cob, thousand grain weight and grain yield. The highest grain yield was recorded in response to application of 92:23 kg NP_2O_5 ha^{-1} with maize variety BH-140. According to the result of this experiment hybrid maize variety BH-140 gave an optimum and profitable yield at the combined rate of 92:23 kg NP_2O_5 ha^{-1}.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereals cultivated in Ethiopia. It ranks second after teff in area coverage and first in total production. The national average yield of maize is about 3 t ha^{-1}[1] which is by far below the world's average yield of about 4.9 t ha^{-1} Earth Policy Institute from US Department of Agriculture[2]. The low productivity of maize is attributed to many factors like frequent occurrence of drought, declining soil fertility, poor agronomic practices, limited use of inputs, insufficient technology generation, lack of credit facilities, poor seed quality and disease and pest infestation CIMMYT[3]. Maize requires adequate supply of nutrients particularly nitrogen, phosphorus and potassium for good vegetative growth and grain development. The quantity required of these nutrients particularly nitrogen depends on the pre-clearing vegetation, organic matter content, tillage method and light intensity Batiano *et al*.[4].

Nitrogen is the key element in increasing yield and mediates the utilization of potassium, phosphorus and other elements by the plants. The optimum amounts of other elements in the soils cannot be utilized efficiently if nitrogen is deficient in plants. Therefore, nitrogen deficiency or excess can reduce maize yields Brady[5]. Phosphorus is also a major limiting factor for crop production on many tropical and sub-tropical soils Norman *et al*.[6]. Crop response to fertilizer application, however, depends on many factors such as soil characteristics, crop grown, climate, Tillage systems and interactions with other nutrients, crop management and fertilizer management. Given the situations, it becomes important that fertilizer recommendations be site specific Kolawole *et al*.[7].

Considerable research has been carried out to determine the nitrogen and phosphorus requirements of maize. Progressive increase in maize yield with incremental levels of nitrogen and phosphorous was observed at different locations. The effect was particularly pronounced with the first increment of nitrogen and phosphorus than with subsequent increments. Hybrids and improved composites gave higher response to nitrogen and phosphorus application than local varieties. At 100 kg N and 100 kg P_2O_5/ha, hybrids, improved composites and local varieties gave 24.0, 22.6 and 15.6 kg grain kg N^{-1} and P_2O_5 applied Tolessa *et al*.[8].

The earlier studies have reported low status of nitrogen and very high amount of available phosphorus in soils of Arba Minch area Murphy[9], Tuma[10], Tuma[11] and Tuma *et al*.[12]. Accordingly, the application of nitrogenous fertilizers was envisaged for both irrigated and rain-fed land use systems but not of phosphate fertilizers. But fertilizer application to maize is still practiced by most farmers of Arba Minch district as long established blanket recommendation of (64/46) Getahun *et al*.[13]. The objectives of the study were to determine response of maize varieties to combined application rates of nitrogen and phosphorus.

MATERIALS AND METHODS

The experiment was conducted at Arba Minch University Agricultural Research farm land in Arba Minch District of Gamo Gofa Zone, Southern Ethiopia. The geographical coordinates of the site are 60 5"N and 370 35'E and altitude of 1218 m above sea level (m.a.s.l). The rainfall pattern of the study area is a bimodal type with a total rainfall of 928.6 mm per annum. The mean minimum, maximum and average temperatures are 17.1, 30.6 and 23.8°C, respectively. Widely cultivated maize varieties BH-540 and BH-140, well adapted to the agro-ecology of the area were used for the study. They are one of the most successful hybrid varieties released by Bako Agricultural Research Centre through the National Maize Research Program in 1995 and 1988, respectively. They have a wider adaptability and grow well at altitudes ranging from 1000-1800 m.a.s.l with annul precipitation of 1000-1200 mm. They need about 145 days for maturity and perform better under high rainfall, good soil conditions and high dose of fertilizers NSIA[14]. The treatments consisted of combinations of five levels of combined NP_2O_5 fertilizer 0/0, 46/23, 46/46, 92/23 and 92/46 and two maize hybrids varieties V1, BH-540 and V2, BH-140. The experiment was laid out as a Randomized Complete Block Design (RCBD) with factorial arrangements of 5×2 = 10 treatment combinations with three replications. The size of each plot was 3×3.75 m (11.25 m^2) consisting of 6 rows of 3 m length and the distance between adjacent plots and blocks kept at 0.5 and 1.0 m apart, respectively. The specified rate of phospruhs fertilizer was applied at maize planting, whereas nitrogen fertilizer also applied in two splits; half at planting and half at knee height by banding approximately 2-3 cm distance from the seed (plant) and immediately covered with soil. Two seeds per hill were sown into rows of 75 cm apart at the plant spacing of 25 cm. However, to obtain the required plant density, the seedlings were thinned to one plant per hill four weeks after emergence. All other agronomic practices were kept normal and uniform for all the experimental units to produce a successful crop. Data on grain yield, number of grain rows per cob, number of grains per row, number of grains per cob and thousand grain weights were recorded. The data were subjected to analyses of variances using the SAS Software Version 9.1 procedures SAS Institute[15]. Least Significant Difference (LSD) test at 5% probability was used for mean separation when the analysis of variance indicated the presence of significant differences.

RESULTS AND DISCUSSION

Soilphysico-chemical properties of the experimental site: The physical and chemical properties analyzed for composite surface soil (0-20 cm) from the samples collected from every replication before planting are shown in Table 1. The results indicated that the texture of the soil was clay loam with proportion of sand, silt and clay as 21, 41 and 38%, respectively. The pH value was 7.32, indicating near neutral soil. The values of organic carbon and total nitrogen contents were 1.53 and 0.13%, respectively. The available P of the soil was 59.12 mg kg^{-1} and the values of CEC of the soil were 44.41 c moL kg^{-1}. According to Havlin *et al.*[16] and Landon[17] physico-chemical properties of the experimental site were satisfactory for most crops and suitable for deriving maximum benefit from applied fertilizer.

Effect of combined NP_2O_5 levels and maize varieties on number of grain rows per cob: From the analysis of variance, it was clear that there were significant differences in number of grin rows per cob between the NP_2O_5 fertilizer levels and Varieties. However, the interactions between the NP_2O_5 fertilizer levels and varieties were not significant (Table 2). Effect of combined application rates of NP_2O_5 fertilizer and maize varieties on the number of grain rows per cob is presented in Table 3. The greater number of grain rows per cob (14) was obtained with 46/46 of NP_2O_5/ha and the

Table 1: The physical and chemical properties of soil (0-20 cm) before planting

pH	OC (%)	TN (%)	Avail. P (mg kg^{-1})	CEC (c moL kg^{-1})	Sand (%)	Silt (%)	Clay (%)	Soil texture
7.32	1.53	0.13	59.12	44.41	21	41	38	Clay loam

Table 2: Mean squares for yield and yield components of maize varieties supplied with combined application rates of nitrogen and phosphors fertilizer

Source variation	df	Mean squares No. of grain rows per cob	No. of grains per row	No. of grains per cob	Thousand grain weight (gm)	Grain yield t ha^{-1}
Block	2	0.25^{ns}	5.26^{ns}	208.78^{ns}	164.64^{ns}	6.15^{**}
V	1	5.99^{**}	96.77^{**}	49032.70^{**}	1371.74^{**}	1.98^{**}
F	4	3.97^{**}	19.64^{*}	10125.00^{**}	568.62^{**}	2.72^{**}
V*F	4	0.25^{ns}	0.65^{ns}	238.61^{ns}	27.65^{ns}	0.04^{ns}
Error	18	0.32	4.75	1093.03	63.3	0.08
CV%		4.34	5.83	6.75	3.03	6.03

Where, V = Variety; F = Fertilizer; DF = Degrees of Freedom; CV = Coefficient of Variation* and **Stands for significantly different at 5% and 1%, respectively; NS stands for Non-Significant at 5%

Table 3: Mean comparison for yield and yield components of maize varieties supplied with combined application rates of nitrogen and phosphors fertilizer

Treatments	No. of grain rows per cob	No. of grains per row	No. of grains per cob	Thousand grain weight (gm)	Grain yield t ha^{-1}
Variety					
BH-540	12.65^{b}	35.58^{b}	449.53^{b}	255.78^{b}	4.51^{b}
BH-140	13.55^{a}	39.17^{a}	530.39^{a}	269.30^{a}	5.02^{a}
LSD≤5%	0.44	1.67	25.36	6.10	0.22
N/P_2O_5 kg ha^{-1}					
0/0	11.87^{d}	36.82^{b}	431.99^{c}	251.24^{c}	3.85^{d}
46/23	13.07^{bc}	35.51^{b}	483.78^{b}	260.17^{bc}	4.49^{c}
46/46	14.00^{a}	40.27^{a}	478.60^{b}	258.71^{bc}	4.67^{c}
92/23	12.93^{c}	36.49^{b}	541.32^{a}	277.53^{a}	5.60^{a}
92/46	13.63^{ab}	37.78^{ab}	514.12^{ab}	265.04^{b}	5.20^{b}
LSD≤5%	0.69	2.64	40.10	9.65	0.35
CV%	4.34	5.83	6.75	3.03	6.03

Means within a column followed by the same letter are not significantly different at the p≤0.05 level of significant

minimum number of grain rows per cob (11.87) was recorded from control treatment. Application of 46/23 kg NP_2O_5 ha^{-1} increased number of grain rows per cob significantly over that of the control but it is statistically similar with the rate of 92/23 and 92/46 kg NP_2O_5 ha^{-1}. There was also non significant differences in the number of rows per cob between the application rates of 46/46 and 92/46 kg NP_2O_5 ha^{-1}. The maize variety BH-140 gave significantly higher number of rows per cob over the cultivar BH-540. The combination rates of NP_2O_5 ha^{-1} gives maximum number of grain rows per cob which fulfilled the requirement of maize crop for their growth and development. These results confirmed by Ali *et al.*[18] and Asghar *et al.*[19].

Effect of combined NP_2O_5 levels and maize varieties on number of grains per row: From the analysis of variance, it was clear that there were significant differences in number of grins per row between the NP_2O_5 fertilizer levels and varieties. However, the interactions between the NP_2O_5 fertilizer levels and varieties were not significant (Table 2). Data regarding the effect of NP_2O_5 application levels and varieties on the number of grains per row are given in (Table 3). Maximumnumber of grains per row were recorded at application of 46/46 kg NP_2O_5/ha over the minimum from control. NP_2O_5 at 46/46 and 92/46 kg ha^{-1} did not differ significantly in influencing number of grains per row. Application of NP_2O_5at 0/0, 46/23, 92/23 and 92/46 kg NP_2O_5 ha^{-1} did not differ significantly in influencing the number of grains per row. This increment might have been due to better nutrition. As for varieties maximum numbers of grains per row were observed in varieties BH-140 and minimum for variety BH-540. Inherent potential of each digit in the number of rows of kernels is a critical factor in the formation of this part of the performance. The grains per row increment with the NP fertilizer application might be attributed to good physiological activities of the crop to attract assimilates. Maize intrinsic ability of the endosperm to attract assimilates (grain sink capacity) is one of the most important physiological determinants of the grain yield of cereal crops and may be the major limitation to yield[20].

Effect of combined NP_2O_5 levels and maize varieties on number of grain per cob: From the analysis of variance, it was clear that there were significant differences in number of grins per cob between the NP_2O_5 fertilizer levels and Varieties. However, the interactions between the NP_2O_5 fertilizer levels and varieties were not significant (Table 2). The results of the analysis of variance showed that number of grains per cob of maize varieties was significantly influenced by the main effects of combined NP_2O_5 application rates as well as varieties as presented in Table 3. Maximum number of grains per cob was recorded against application of 92/23 kg NP_2O_5 ha^{-1}. Minimum number of grains per cob was observed in control. Application of 46/23 kg NP_2O_5 ha^{-1} increased number of grains per cob significantly over that of the control but it is statistically similar with the rate of 46/46 and 92/46 kg NP_2O_5 ha^{-1}. There was also non significant differences in the number of rows per cob between the application rates of 92/23 and 92/46 kg NP_2O_5 ha^{-1}. Arian *et al*.[21] and Dahiya *et al*.[22] had also reported that number of grains per cob were influenced significantly with NP_2O_5 application. The maize variety BH-140 produced significantly higher number of grains per cob compared to BH-540.

Effect of combined NP_2O_5 levels and maize varieties on thousand grains weight: The results of the analysis of variance showed that the thousand grain weight of maize varieties and NP_2O_5 fertilizer levels were significantly influenced. However, the interactions between the NP_2O_5 fertilizer levels and varieties were not significant (Table 1). Data regarding effect of maize varieties and NP_2O_5 fertilizer levels on thousand grain weight maize was presented in Table 2. The highest thousand grain weight was recorded form the variety BH-140 while the lowest BH-540 recorded. Application rates of 92/23kg NP_2O_5 ha^{-1} produced the maximum 1000-grain weight which was significantly different from the rest of all the treatments. The minimum weight of 1000 grains was obtained in control. Application rates of 92/46 kg NP_2O_5 ha^{-1} also gave a higher 1000-grain weight over control but it is statistically similar with the rate of 46/23 and 46/46 kg NP_2O_5 ha^{-1}. Application of NP_2O_5 at 0/0, 46/23 and 46/46 kg ha^{-1} did not differ significantly in influencing the thousand grain weight. This might be due to the increase in kernel size because of enough food storage and balanced supply of nutrients from the soil because of optimum P throughout the growth and development stages of the plant. These results are in accordance with those by Fareed[23] and Maqsood *et al*.[24] who also observed an increase in thousand grain weights with increase in NP_2O_5 application.

Effect of combined NP_2O_5 levels and maize varieties on grain yield: The results of the analysis of variance showed that the grain yield of maize varieties and NP_2O_5 fertilizer levels were significantly influenced. However, the interactions between the NP_2O_5 fertilizer levels and varieties were not significant (Table 1). Data regarding effect of maize varieties and NP_2O_5 fertilizer levels on grain yield of maize was presented in Table 2. Grain yields were found to increase as the NP_2O_5 application rate increased from 3.85 t ha^{-1} in the control treatment to 5.60 t ha^{-1} in treatments that received 92/23 kg NP_2O_5 ha^{-1}. Application of 46/23 kg NP_2O_5 ha^{-1} increased yields significantly over that of the control while applying 92/46 kg NP_2O_5 ha^{-1} resulted in a further significant yield increase. However, at 46/23 kg NP_2O_5 ha^{-1} the yields were not significantly different from those obtained at the 46/46 kg NP_2O_5 ha^{-1} application rates. A slight decline in yield which was observed when 92/46 kg NP_2O_5 ha^{-1} was applied may be due to increase in the phosphorus rate from 23-46 kg ha^{-1}. Application of high rate of phosphorus was reported to be capable of causing nutrient imbalance and consequently yield depression of maize[25]. Similar report was also given by Adediran and Banjoko[26] on the response of maize to low and high rates of phosphorus. These findings are in line with those by Maqsood *et al*.[24] and Ali *et al*.[18] who reported increase in grain yield with NP application. The highest grain yield was recorded form the variety BH-140 while the lowest BH-540 recorded.

CONCLUSION

Field experiment was conducted at Arba Minch University Agricultural Research Farm Arba Minch, Southern Ethiopia (6°5”N and 37°35’E) to determine response of maize varieties to combined application rates of nitrogen and phosphorus. Results from this trial have revealed that yield and yield components of maize can be influenced by varieties maize and combined rates of nitrogen and phosphorus fertilizer. The maize variety BH-140 significantly influences all parameters of maize than that of BH-540. Fertilizer rate significantly influence all the parameters in different combinations except 1000-grain weight. The analysis showed that higher grain yield were obtained from the application rate of 92:23 kg NP_2O_5 /ha. Therefore, may i recommend a fertilizer rate of 92:23 kg NP_2O_5 /ha and maize variety BH-140 is appropriate for obtaining maximum grain yield of maize under agro ecological conditions of Arba Minch.

ACKNOWLEDGEMENTS

First of all, I would like to thank the Arba Minch University who made the study successfully through the fund grants. Especially thanks goes to my family, for their support during execution of the experiment.

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