Research Article

Nitrogen response and agronomic use efficiency of N fertilizer in diverse commercial maize hybrids at Bako, Western Ethiopia

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Abstract

Agronomic Efficiency indicated the grain yield production potential of variety in response to the applied nutrients. Field experiment was conducted at the research Farm of Bako National Maze Research Center Western Ethiopia during 2020/2021 in order to investigate the nitrogen response and agronomic efficiency of various maize genotypes. Ten maize varieties were tested under two level of nitrogen (N1 = 0 kg/ha and N2 = 184 kg/ha) in factorial arrangement with three replications. Each variety was planted in uniform spacing of 75x30 cm. Then response of each variety for the applied nitrogen were evaluated. Agronomic efficiency of Nitrogen Fertilizer associated with grain yield of various commercial maize varieties was calculated using average grain yield and applied nitrogen to indentify the agronomic efficiency of each maize varieties. Based on calculation result maize hybrid BH661 showed the highest agronomic efficiency (35.42), where as Gibe3 showed the lowest value (4.68) compared to others tested varieties. This result indicated that Gibe3 respond poorly for the applied nitrogen where as Hybrid BH 661 highly responded for the increasing applied N input. The result has indicated the need of specific recommendation for nutrient scarce area, that lack nitrogen or for farmers who lacks money to buy nitrogen fertilizer should be used Gibe3 to get better yield. On other hand in optimum or high nitrogen available condition the hybrids which have high agronomic efficiency should be sown to boost maize grain yield but with taking into account the optimum rain fall and agro ecology of each variety.

Introduction

The importance of nitrogen for plant growth and productivity is increasingly being recognized, and in many cases it is considered as the most growth and yield limiting factor [1]. The application of fertilizer to improved germ–plasm on responsive soils will boost crop yield and improve the agronomic efficiency [2]. However, various maize genotypes respond differently for the applied nitrogen. High yielding maize genotypes performed well where N supply is sufficient [3], whereas some hybrids have shown better performance under different N–levels due to their ability to capture N from both pools (Fertilizer and soil N) more effectively than the susceptible ones [4,5]. The selection of genotypes with adaptation to low N and high N input levels requires an interaction between genotypes and N levels [6]. Therefore, it is necessary to evaluate maize hybrids under the condition of distinct availability in order to be able to identify the more promising hybrids for each condition [7].

The general nitrogen fertilization for maize production in Ethiopia has not been verified the response and agronomic efficiency of each variety. This blanket N recommendation for all maize varieties leads to insufficient N application for highly responding high yielding varieties and excess application with economical and environmental impact for low efficient and low yield varieties. Therefore to identify their yield response for the applied nitrogen it requires refining agronomic efficiency of each variety under different level of nitrogen. The efficiency and responsiveness of agronomic traits to the main macronutrients is becoming increasingly important due to the risk of supply, as it is a finite resource [7]. Since most portion of N lost through leaching, N application should be synchronized with crop need [8,9]. The yield potential of maize continuously shifted with

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modification of plant density and nitrogen level because of high mobile nature of available nitrogen and continues releasing of new hybrid with high nitrogen requirements [10]. In addition most small house holders have cultivated maize without nitrogen application or with insufficient amount of nitrogen due to lack of money to buy fertilizer. Identifying maize varieties which produce better yield under low or no nitrogen application will provide alternative for these small house holders. Maize is mostly grown by resource-poor farmers who cannot afford to fertilize at optimum rates and till now very little effort was made in developing maize genotypes that suit the needs of small-scale farming systems [3].

Food security in Ethiopia, and elsewhere in Africa, is a major socio-political issue on which economic wellbeing is depends on the success of its agriculture [11]. In developing country, particularly in Ethiopia maize is grown majorly for the purpose of food security that emphases on grain production. Maize is one of the major and strategic cereal crops that play an important role in food security and farmers' livelihoods in Ethiopia [12]. Nitrogen Agronomic Efficiency refers the amount of additional grain harvested per kilogram of nitrogen applied to a grain crop. Thus studding agronomic efficiency that reflects the direct production impact of an applied fertilizer is most effective to achieve the goal of grain production or food security.

The aim of this study was to observe the nitrogen response and agronomic efficiency of various commercial maize varieties.

Material and methods

Description of experimental site

The experiment was conducted at Bako Research farm in 2020 to 2021. Bako located at 9⁰ 06' N Latitude and 37⁰ 09' E Longitude. It has mid altitude sub-humid agro-ecological with altitude of 1650 m.a.s.l. The soil type is dominantly nitosol.

Experimental materials

Fertilizer: Nitrogen fertilizer in the form of urea (46% N) was used for this experiment. Triple Supper phosphate (TSP) fertilizers were used as a source of Phosphorus.

Treatments and experimental design

Two levels of N fertilizer (N1 = 0 kg/ha and N2 = 184 kg/ha) were used for this experiment. The levels of the two factors (N levels and cultivars) were combined in factorial arrangement with three replications. The gross plot size was 5 m× 4.5 m (22.5 m²) with row length of 5 m, but net plot size 5 m × 3 m (15 m²) was used for harvesting to minimize the border effects on the crop yields. The treatments were randomly assigned to the experimental unit within a block (replication). The replication was separated by 2 m wide space.

Experimental procedures

Land preparation was done three times from March to May by using tractor plough. Maize sowing was done in the first week of June by placing one seeds per hole in furrows at 20 cm plant spacing and 75 cm row spacing. Replanting was done a week after planting if there were missing holes. Full dose of phosphate fertilizer in the form of TSP at the national recommended rate of 69 kg P_2O_5 ha⁻¹ was applied uniformly to all plots. Half dose of N fertilizer was applied 22 days after sowing and the remaining half dose of N fertilizer was applied 37 days after sowing in side-banding application method. Hand weeding and other crop management practices were applied uniformly to all plots as per the recommendation for maize.

Data recorded

Plant height (cm): It was measured from the soil surface to the base of the tassel of ten randomly taken plants from the net plot area at physiological maturity.

Flowering date: Days to tasseling and silking were counted from sowing time to the day when 50% of the maize plants shed their tassels and extrusion their silks respectively, in each plot.

Number of ears: Total number of harvested ears per net plot was counted then converted in to hectare base using the formula:

$$Harvested\ Ears\ per\ ha = \frac{Number\ of\ Ears\ per\ net\ plot * 10000\left(m2\right)}{Net\ plot\ area\left(m2\right)}$$

Kernels per ear: It was the average number of ten randomly taken ears from net plot area at harvesting time.

Grain yield (kg/ha): Grain yield in kilo gram was harvested at harvested maturity from total plants of net plot area and the converted in to hectare base by using the following formula:

$$Grain\ Yield\ \left(kg/ha\right) = \frac{Grain\ yield\ per\ net\ plot * 10000\left(m2\right)}{Net\ plot\ area\left(m2\right)}$$

Finally, agronomic Efficiency (AE) was calculated from harvested grain yield and applied nitrogen by using the formula

$$AE\ \left(kg/kg\right) = \frac{GF-Gu}{Na}$$ [13-15]: Where, Gf = grain yield of the fertilized plot (kg), Gu = grain yield in the unfertilized plot (kg) and Na = quantity of nitrogen applied (kg).

Soil sampling and analysis

Pre-planting soil analysis was done in order to understand the original characteristics of the experimental soil. For this reason a representative Soil samples was taken 0 to 30 cm depth in a diagonal pattern among each 5 m interval before planting. Uniform slices and volumes of soil were obtained in each sub-sample by vertical insertion of an auger. Then, all subsamples were air-dried and were mixed thoroughly on the plastic mat to obtain working samples (1 kg) and It was analyzed at soil laboratory for physical and chemical properties(soil pH, organic carbon, organic matter, total N and available phosphorus) using standard laboratory procedures. And the result is: PH (H_2O) 1:2.5 = 4.32, %Organic Carbon = 1.79, %Organic Matter = 3.09, %Total N = 0.15, Available P (ppm) = 5.34.

Statistical analysis

Analyses of variances for the data recorded were conducted using the SAS version 9.3. Least significant difference (LSD) test at 5% probability was used for mean separation if the analysis of variance indicated the presence of significant treatment differences.

Results and discussion

The analysis of variance revealed a significant (P<0.01) effect of nitrogen on plant height, flowering date, number of ears, kernels per ear and grain yield of maize varieties.

As indicated in Tables 1,2 all maize genotype responded positively for all parameters when nitrogen level changed from 0kg/ha to 184 kg/ha. Plant height was increased with increased nitrogen where as tasseling and silking date were shortened with increased nitrogen (Table 1). This could be due to the positive effect of nitrogen for rapid growth that resulted reduction in day to tasseling and silking. Similar results were reported by [16,17]. In addition the response varied among each variety. The highest value of plant height, day to tasseling and silking where recorded at hybrid BH66 (Table 2). BHQPY545 produced highest number of ears when nitrogen increased

from 0 to 184 kg N/ha where as the highest number of kernels per ear was recorded at hybrid BH549 (Table 3). However, number of kernels per ear was increased when nitrogen level increased (Table 3). These results are in agreement with those of many other workers [1,18,19].

The result also showed that some varieties has not bring any significant change in their grain yield when N level increased from 0 to 180 kg N/ha, whereas most varieties showed highly significantly difference in their grain yield when N level increased. Compared the grain yield of each variety under 0 kg N/ha and under 180 kg N/ha three varieties (Gibe3, BH549 and Limu) showed the lowest response for the applied N. These varieties showed non-significant grain yield difference between 0 kg N/ha and 180 kg N/ha application that consequent the lowest agronomic efficiency (Table 3).

On other hand the rest varieties showed highly significant yield difference under 0kg N/ha and 180 kg N/ha that consequent the highest agronomic efficiency (Table 3). Hybrid BH661 showed the highest agronomic efficiency (35.42), where as open pollinated Gibe3 showed the lowest agronomic efficiency (4.68) compared to others tested varieties. This result agreed with research work reported by [4,5].

Table 1: Agro climate adaptation and yield potential of ten different maize varieties tested in this experiment.

S.No	Varieties	Area of adaptation		Grain Yield Kg/ha	
		Altitude (m)	Rain Fall (mm)	On research field	On Farmer field
1	BHQPY545	1000-1800	100-1200	8000–9500	5500–6500
2	BH546	1000-2000	1000-1200	75000-9500	5500-6500
3	BH547	1000-2000	1000-1200	75000-9500	5500-6500
4	BHQPY548	1000-2000	1000-1200	7500-8500	5500-7000
5	BH549	1200-1800	1000-1200	9000-12000	8000-11000
6	P3812W(Limu)	1000-1800	1,000–1,200	8500-9500	5500-6500
7	SPRH1	1000-1800	1000-1200	8500-9500	5500-6500
8	BH661	1600-2200	1000-1500	9500–12000	6500–8500
9	Gibe2	300-1000	900–1,200	6500–7000	4500–5000
10	Gibe3	1000-1700	1000-1200	6500-7500	4500-5000

Table 2: Plant height (PH), days to 50% tasseling (DT) and days to 50% silking (DS) of different maize varieties under two levels of nitrogen in 2019/2020 at Bako.

Varieties	PH (cm)		DT			DS		
	0 kg N/ha	184 kg N/ha	0 kg N/ha	184 N/ha	kg	0 kg N/ha	184 N/ha	kg
BHQPY545	218.33	242.67	82.67	82.00		86.33	83.00	
BH546	216.33	267.33	82.67	79.67		84.33	82.00	
BH547	220.67	245.00	81.00	80.67		84.67	82.33	
BHQPY548	217.00	258.67	82..23	82.00		84.33	82.33	
BH549	250.67	253.00	80.67	80.67		82.33	81.67	
P3812W (Limu)	243.33	247.00	75.00	80.00		80.67	81.33	
SPRH1	230.00	243.33	81.33	81.00		82.00	81.67	
BH661	279.33	303.33	84.33	83.67		87.00	85.00	
BHGibe2	220.67	220.67	77.00	76.33		80.33	79.33	
Gibe3	218.33	221.00	79.33	79.33		80.67	80.67	
LSD (5%)	29.95		2.92			3.26		
CV	7.70		2.18			2.37		
t-test	**		**			**		

Table 3: Number of ears per hectare (NE/ha), kernels per ear (KPE), Grain yield per hectare (GY/ha) and Agronomic efficiency (AE) of different varieties under two level of nitrogen in 2019/2020 at Bako.

Varieties	NE/ha				KPE				GY/ha				AE
	0	kg	184	kg	0	kg	184 kg		0	kg	184	kg	
	N/ha		N/ha		N/ha		N/ha		N/ha		N/ha		
BHQPY545	59111.00		93778.00		391.47		431.47		4006.00		7430.00		4.68
BH546	53333.00		60000.00		365.87		442.80		3365.00		7152.00		11.9
BH547	50667.00		62222.00		313.33		380.53		3131.00		6294.00		11.97
BHQPY548	61333.00		69333.00		417.07		433.07		4128.00		8544.00		17.19
BH549	49333.00		60444.00		414.67		495.33		4896.00		7086.00		18.61
Limu	57778.00		61778.00		349.87		462.00		4421.00		6624.00		18.64
SPRH1	66222.00		79556.00		401.20		452.80		4615.00		9379.00		20.58
BH661	50667.00		63556.00		342.13		395.47		4323.00		10840.00		24.00
BHGibe2	59556.00		60444.00		331.33		415.73		4360.00		7789.00		25.89
Gibe3	54667.00		60444.00		391.07		340.67		4863.00		5724.00		35.42
LSD (5%)	16968.00				69.88				2507.70				
CV	17.02				11.06				27.68				
t-test	**				**				**				

Conclusion

This result indicated the response of hybrids for the applied nitrogen. So under optimum or high nitrogen available condition the hybrids which have the highest agronomic efficiency such as BH661 should be sown to boost maize grain yield, whereas under the no N in put condition or for the farmer who have not enough money to buy fertilizer it is better to use varieties with low agronomic efficiency such as Gibe3, which gives better yield without nitrogen application. But with considering other production factors and their adaptation range such as altitude and rain fall. Although these results were based on single growing season and single location it gives clue the varieties efficiency for the applied N.

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