

Morphological Response of Maize (*Zea mays*) to Nitrogen Fertilizer Application Rate at SNNP, Ethiopia

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Abstract: Field experiment was conducted at Arbaminch University College of Agricultural Science Farm, this study was conducted with the objective of evaluating the effect of different nitrogen rate on the vegetative growth of maize. The experiment was laid out in Randomized Complete Block Design with three replication which have four rates of nitrogen (0, 60, 120, 180) kg per hectare with combination of maize variety (BH 140). Data on seedling emergence, number of leaf per plant, leaf length, plant height, Leaf area, leaf area index and stem width were collected from five plant of the two middle row of each plot and subjected to statistical analysis using SAS software. The nitrogen rates showed significant ($p < 0.05$) effect on plant height and leaf length, where as leaf number, leaf area leaf area index and stem diameter were highly significantly ($p < 0.01$) affected. However, the mean separation for seed emergence revealed that there was no significant variation between nitrogen application rates. The present study showed that the maximum mean was recorded from application of 120kg N/ha, which was optimum and economically feasible for improving plant height, leaf length, leaf number, leaf area, leaf area index and stem diameter. In contrast, the lowest means for all growth parameters except plant height was recorded from control plot 0kgN/ha. In conclusion, the present study was the initial for further investigation and conducting an experiment over the years under different location by considering yield and yield component is very relevant.

Keywords: Fertilizer, Growth, Maize, Nitrogen.

1. INTRODUCTION

Maize (*Zea mays* L.) is one of the most versatile crops having wider adaptability under varied agro-climatic conditions and successful cultivation in diverse seasons and ecologies for various purposes. Globally, maize is known as “Queen” of cereals because it has the highest genetic yield potential among the cereals (Anonymous, 2011).

Maize is used in many ways than any other cereals. It is used as a human food, feed for livestock and industrial purposes. Millions of people depend on maize for their daily food in sub-Saharan Africa. Maize grain has greater nutritional value as it contains 72% starch, 10% protein, 4.8% oil, 8.5% fiber, 3.0% sugar and 1.7% ash (Chaudhary, 1983). In Ethiopia, maize is the major and staple food and one of the main sources of calorie in the major maize producing regions (Tolessa *et al.*, 2001). In Ethiopia, about 2.1 million hectares of land was covered with maize with an estimated production of about 7.23 million tons during the 2014/15 cropping season (CSA, 2015). It accounts for 16.80% of the 10.14 million ha (80.78%) of land allocated for all cereals. It ranks second after Teff (*Eragrotis tef*) in area coverage, first in total national production and yield per hectare (CSA, 2015). Maize is the most important crop in Ethiopia in general and particularly in SNNP (Southern Nation Nationality People of Ethiopia). Considering its importance in terms of wide adaptation, total production and productivity, maize has been selected as one of the high priority crops to feed the increasing population of Ethiopia. However, the national average yield, 3.43 tons ha⁻¹ (CSA, 2015) is still far below the world average 5.5 tons ha⁻¹. This is due to biotic and biotic factors which directly or indirectly contribute for low yield. Among those factors use of in appropriate agronomic practice (plant density, planting date, water & soil fertility management, limited use of inputs) are the major one (CIMMYT, 2004). Nitrogen is one of the most yield-limiting nutrients for crop production in the world. It is also the nutrient element applied in the largest quantity for most annual crops and had significant effect on growth, developments and yield of maize (Huber and Thompson, 2007). Increasing levels of nitrogen in the soil under different soil and management condition showed

increased grain yield, above ground biomass, number of kernels per ear, thousand kernel weights and plant height of maize (Merkebu and Ketema 2013; Geremew, 2010; Kidist, 2013). Therefore, enhancing the efficiency and profitability of fertilizer use for smallholder farmers in order to increase maize production and meet the food demand of the rapidly growing population, application of optimum rate of nitrogen fertilizer for grain production is very crucial. However, most of Ethiopian farmers particularly the SNNP part of the country did not have awareness and there is no scientific studies have been documented on the application level of nitrogen fertilizer and its importance. Therefore, the objective of this study was to determine the optimum level of nitrogen fertilizer to get high production, for vegetative growth and make the peasant farmer to adopt this technology for increasing their productivity.

2. MATERIALS AND METHODS

2.1. Description of the Experimental Site

The experiment was conducted in Gamogofa Zone of SNNP region southwestern Ethiopia at specific place Arbaminch University College of Agricultural Science Culfo Campus and the area was geographically located at about 60°0 N 37°38S. Average total annual rainfall is 1485.9 mm and means maximum and minimum temperature of an area is 16.2°C and 32°C respectively.

2.2. Experimental Treatments, Design and Procedures

The experiment was laid out in Randomized Completely Block Design (RCBD) with three replication. There were four (0, 60, 120 and 180) Kg/ha nitrogen levels of application rate and wide adaptable and early matured maize variety BH₁₄₀ (Bako Hybrid 140) was used for this experiment. The recommended rate of nitrogen fertilizer (UREA) for maize is 120-150kg/ha. Nitrogen was applied in split application and the first half was applied at planting day and the remain half was applied after the plant reached knee-height. Phosphorus was applied as a basal dressing each season as triple superphosphate (46% P₂O₅) at rate of 40–50 kg P ha⁻¹, depending on the measurement of soil available P level before sowing. The textural properties of the soil in the experimental area were sandy loam to silt loam which is very suited for maize production; according to Rao *et al.* (1995) maize is best adapted to well-drained sandy loam to silty loam soil. However, the analyzed soil result showed that the Nitrogen content of the area was very low (0.026 %) and it needs additional N dosage.

2.3. Data Analysis

Analyses of variances for all growth parameters were conducted using SAS procedure (SAS, 9.3). Least significant difference (LSD) test at 5% probability was used for mean separation, for parameters those analysis of variance result were significant.

3. RESULTS AND DISCUSSION

The analysis of variance revealed that the Nitrogen application rate did not affect the emergence of seedling significantly (Table 1).

Table1. Mean Separation of Seedling Emergence to Different Nitrogen Levels.

Nitrogen rate Kg /ha	Seedling Emergence
0	78.33
60	71.10
120	65.00
180	63.33
CV	19.64
Significance	Ns
LSD	27.24

Means with the same letters are not significantly different at ((p < 0.05).

LSD: Least Significance Difference, **CV:** Coefficient of variations, **NS:** Non significant

Vegetative Growth Parameters

3.1. Plant Height

Plant height was significantly affected by the Nitrogen application rate, mean values for Nitrogen rates showed that plant height increased with each increment of nitrogen rate. According to indicated result, the application of 120kg N ha⁻¹ increased the plant height by 25% compared to 0kg N ha⁻¹

(Table 2). The increase in plant height with respect to increased N application rate indicates maximum vegetative growth of the plants under higher N availability due to the increase in cell elongation as nitrogen is essential for plant growth process including chlorophyll which is responsible for dark green color of stem and leaves which enhance vigorous vegetative growth (Karasu, 2012., Adeniyen, 2014 and Moges, 2015). The result indicates significant increase in various growth parameters of maize when supplied with higher rates of N fertilizer. However, application of 180 N kg/ha was reduced the height of the plants. This is due to excess application is affected the growth and height of the plant by delaying germination, drying the leaf and damaging the plant (Uhart and Andrane, 1995).

3.2. Leaf Length

The mean value results showed that the leaf length was significantly ($p < 0.05$) affected by Nitrogen application. The application of 60 kg N/ha and 120 kg N/ha increases the length of the leaf by 7% and 10% compared to 0kg N/ha, respectively (Table 2). The present study showed that, as the Nitrogen rate increase the length of leaf also increase, however, at 180kg N/ha the leaf length was become shortened and burned. This is due to excess supply of N could burn and resulting for delayed germination, affected leaf and damage plant (Uhart and Andrane, 1995).

3.3. Leaf Number per Plant

Regarding number of leaf, the application of nitrogen was highly significant at ($P < 0.01$). The highest mean was recorded from 120kg N/ha followed by 60kg N/ha, which were 12 and 8.5 number of leaves per plant respectively. In contrast, the lowest mean (7) was obtained from control treatment 0kg N/ha (Table 2). Higher rate of N fertilization resulted in higher number of leaf per plant, this is due to the increment of nitrogen levels have great role to better uptake of all the nutrients and increased translocation of photosynthetic products from source to sink (Lemcoff and Loomis, 1994). Debebe (2010) reported that increasing nitrogen level from 0 to 105 kg N ha⁻¹ significantly increased the number of leaf per plant.

3.4. Leaf Area and Leaf Area Index

The analysis of variance revealed that leaf area was significantly ($P < 0.01$) influenced by the nitrogen applications. The mean result showed that the maximum values were recorded from 120 kg N/ha and 180 kg N/ha, in contrast, lowest mean was obtained from control treatment 0kgN/ha (Table 2). The result indicated that, as the level of nitrogen increase the leaf area also increase. This because the increase in leaf area with the increase of nitrogen level is attributed to more vegetative growth, as it is a general truth that N enhances vegetative growth in maize. Similarly, the leaf area index was significantly ($p < 0.01$) affected by nitrogen application and the highest value were obtained from 180kg N/ha and 120kgN/ha. In contrast, the lowest mean value was recorded from 0Kg N/ha (Table 2). The significant respond for leaf area and leaf area index to the higher rate of nitrogen fertilizer may indicated that nitrogen is taken up by plant and subsequently utilized in cell multiplication, amino acid synthesis and energy formation that act as structural component of the chloroplast which carries out photosynthesis (Dinh and Imran *et al.*, 2015). Nitrogen insufficient reduces the individual leaf area and leaf area index resulted to reduce surface height interception for photosynthesis (Hafiz *et al.*, 2012).

3.5. Stem Width

The current study revealed that the nitrogen level was highly significantly ($p < 0.001$) affected the stem diameter and the maximum mean results were obtained from 120kg/ha and 180kg/ha. However, the lowest mean values were recorded from 0kg N/ha and 60kg N/ha (Table 2). The results indicated that, as the nitrogen level increase from 0 to 120 kg/ha the fattening of the stem was also increased. The significant respond of stem width to higher chemical fertilizer indicator that as the nitrogen fertilizer increase the stem diameter also increases (Adamu *et al.*, 2015).

Table 2. The Mean Separations of Different Growth Parameters for Nitrogen Application Rates.

Nitrogen rate (kg/ha)	The vegetative growth parameters					
	Plant height (cm)	Leaf length(cm)	Leaf number Per plant	Leaf area Cm ²	Leaf area index	Stem diameter (cm)
0	80.3ab	85.3ab	7.00c	216.67c	0.23b	1.21 c
60	102.67a	91.89a	8.5b	276.30b	0.33a	1.27bc
120	106.67a	94.23a	12a	333.34a	0.4a	1.67a
180	60.4b	71.6b	7.93bc	306.67ab	0.41a	1.54ab

CV	22.5 *	8.5 *	8.30 **	6.94 **	12.2 **	1.01 **
Significance						
LSD	39.4	14.59	1.47	39.30	0.084	0.28

Values followed by same letters within a column are not significantly different at $P \leq 0.05$.

LSD: Least Significance Difference, **CV:** Coefficient of variations, *: Significant, **: highly significant

4. SUMMARY AND CONCLUSION

Maize is one of the most versatile crops having wider adaptability under varied agro-climatic conditions of Ethiopia. In Ethiopia having diversified agro ecology which is highly favorable for maize production, the national average yield is very low. This is due to different factors like climate change and agronomic practices (like fertilizers). Nitrogen is one of the most yield-limiting nutrients for maize production. It also the nutrient element applied in the largest quantity for most annual crops and had significant effect on growth, developments and yield of maize. However, in Ethiopia especially in southern nation nationality of the country, the application of inorganic fertilizer like Nitrogen is limited. The present result indicated that the Nitrogen application was significantly affect the growth parameters of maize. The application of 120kg N ha⁻¹ increased the plant height by 25% compared to 0kg N ha⁻¹. Similarly, the application of 60 kg N/ha and 120 kg N/ha increases the length of the leaf by 7% and 10% compared to 0kg N/ha, respectively. Additionally, the highest leaf number were recorded from 120kg N/ha followed by 60kg N/ha. Furthermore, the maximum mean values of leaf area, leaf area index and stem width were recorded from 120 kg N/ha and 180 kg N/ha. Generally from the present study we conclude that application of 120kg N/ha, were optimum and economically feasible for improving the vegetative growth. However, in order to come up with strong recommendations, conducting an experiment considering factors like location, numbers of years and parameters to be taken are very relevant.

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