P-ISSN: 2659-1561
E-ISSN: 2635-3040

Research Article

Nitrogen Use Efficiency Responses of Maize (*Zea mays* L) Varieties by Different Rates of Nitrogen Supply in Halaba Zone South Ethiopia

Gizaw Bejigo[1] and Firew Kebede[2]

[1]Ethiopian Biodiversity Institute, Hawassa Biodiversity center
[2]Hawassa University, Biology Department
[1]Email: gizawhalaba@gmail.com; [2]Email: firewdag2006@yahoo.com

Received: Nov 15, 2019 **Accepted:** Nov 22, 2019 **Published:** Nov 26, 2019

Abstract: A field experiment was conducted to find out the effect of nitrogen on nitrogen use efficiencies of two varieties of maize (*Zea mays* L.) by different supply of nitrogen (0, 30, 60, 90, and 120 kg N ha^{-1}) with three replications in a randomized complete block design in Halaba zone, Southern Ethiopia. The results of the study indicated that application of nitrogen fertilizer significantly increased the grain yield of maize mainly through its positive effects on the crop‘s yield but, nitrogen use efficiency was observed to decrease with increasing the level of applied nitrogen. Of the two tested maize varieties studied, the maize pioneer shone showed the highest nitrogen use efficiency which increased by 22.274 (68.521%) over the local variety called Sutale.
Keywords: Nitrogen, use efficiency, Varieties, Interaction effect.

Introduction

Nitrogen use efficiency has been defined in several ways although most of them denote the ability of a system to convert inputs nitrogen into outputs. It can be also defined as the maximum economic yield produced per unit of N applied, absorbed, or utilized by the plant to produce grain and straw yields (Fageria and Baligar, 2005). Nitrogen use efficiency is the grain yield produced per unit of N supply from soil or fertilizer (Bock, 1984).

According to Tolessa Delelle, (2006) among the major plant nutrients, N is the most essential for successful cereal production in all environments. Application of inorganic N as fertilizer to the soil-crop system is great importance for enhancing the productivity of cereals. Unfortunately, cereal crops do not recover and use the entire amount of N applied as fertilizer. Nitrogen fertilizer applied to the soil-crop system, in contrast to most other nutrients, is highly soluble and may be lost or made unavailable through the processes of leaching, denitrification, volatilization and immobilization (Bock, 1984).Nitrogen use efficiency may be affected by crop species, soil type, temperature, application rate of N fertilizer, soil moisture condition and crop rotation (Fageria and Baligar, 2005),cultivar (Moll *et al*., 1982), genetic constitution (Jokela and Randall, 1997).

Ethiopia’s is an agrarian country and agriculture is the basis of the Ethiopian economy, contributing 41.4% of the country’s gross domestic product (GDP), 83.9% of the total exports, and 80% of all employment in the country (Matousa, Todob, & Mojoc, 2013). Maize is one of the most important crop in Ethiopia of which the country is Africa’s second biggest maize producer (EUBFE, 2015). In fact, maize productivity has declined over years contributing to food insecurity and ultimately famine. Among others, decline in soil fertility, particularly N is one of the major constrains to maize production in Ethiopia since the growth and yield is highly determined by nitrogen. To overcome low soil fertility problems, most farmers are constrained by shortage of cash to use inorganic fertilizers (Asfaw Negasa *et al*., 1997). For this group of farmers selection and use of maize variety, which can give reasonable yield under low nitrogen supply and optimal conditions is more important than a high yielding variety requiring high investment for fertilizer (Ransom *et al.,* 1993). Since there is sufficient genetic variability in maize genotypes for N uptake and use efficiency, identifying and use of those genotypes that are more productive in the areas of poor nitrogen is of high importance for the majority of resource poor farmers in Ethiopia.

Despite the predominance of maize production in Halaba area, studies on the effects of varying rates of nitrogen supply on crop to identifying varieties with nitrogen use efficiency is scanty. Also there is the knowledge gap in farmers of the study area in the selection of economically better variety. Therefore, the objective of this work is to investigate more nitrogen use efficient maize varieties for the study area farmers.

2. Materials and Methods

2.1 Description of study area

Halaba Zone is located 315 km south of Addis Ababa, at about 65km from shashemane on the main road to Wolayita Sodo-Arbaminch and 85km southwest of Southern Nations, Nationalities, and Peoples Regional (SNNPR) state capital of Hawassa. The zone is geographically located 7^0 17’ N latitude & 38^0 06’ E longitudes. Altitude of the zone ranges from 1154 to 2159 masl, but most of the Zone is found at about 1800 masl. The annual rainfall varies from 857 to 1,085mm while the annual mean temperature also vary from 17.6^0c to 22.5^0c with the highest of 34.45°C and lowest of 16.42°C.

2.2 Site selection and soil characterization

Following a reconnaissance survey, a site suitable for experiment was selected. Then from the selected experimental plot (6.5m x 29m), soil samples were collected from 0-20cm depth by walking the field in “W” pattern. Moreover, soil was also sampled using core sampler for bulk-density determination. Finally, from a composite soil sample physic-chemical properties was determined**.**

2.3 Experimental design, sowing of maize and treatment

The experiment was arranged in complete randomized block design with three replications and experimental treatment consisted of two maize varieties (Improved variety called Pioneer Shone designated as Imp and local variety called Sutale and designated as Lo). Two seeds were planted per hole at a spacing of 75cm x 25cm **(**Ransom *et al.,* 1993). Maize seedlings were later thinned to one at two weeks after sowing (WAS) and five nitrogen rates 0, 30, 60, 90, and 120 kg/ha supplied as urea half of the nitrogen was applied at sowing, while the remaining half was applied as side dress 4 weeks later and phosphorus nutrition was optimized using TSP (Triple Super Phosphate) at a rate of 30kg/ha, by applying it basally to all treatment plots.

2.4 Data Collection

The yield was harvested from the selected five plants of the middle row of each treatment plot were marked and the dry weight of the grain was measured by balance and the nitrogen use efficiency of a plant at each treatment plot was determined using a difference method (Moll *et al.*, 1982) as shown below.

 P-ISSN: 2659-1561
E-ISSN: 2635-3040

NUE = grain yield at N rate applied-grain yield at 0kg N/ha/N applied (gNf)

Where,
NUE= nitrogen use efficiency
gNf = amount of nitrogen applied.

2.5 Data Analysis

The analysis of variance (ANOVA) carried out using SAS statistical packages and procedures out lined by Gomez and Gomez (1984). Means for each parameter were Separated by the least significant difference test at P = 0.05.

3. Results and Discussion

3.1. Physico-Chemical Properties of the soil

Physicochemical characteristics of the soil samples are presented in Table 1 shows that the texture of the soils under investigation can be classified as clay loam with excellent properties for crop cultivation. The moisture content of the soil is moderate, which might attributed to relatively to its higher clay content. The soil pH lies within the preferred range for most crops. The organic carbon content of the studied soil is found to be very low (< 1%). This may be attributed to intensive agricultural practices.

The bulk density of the studied soil is found to be common in cultivated soils. This indicates that the soils are not compacted and have more porosity. The available phosphorus is found to be low indicating there is acute deficiency of this element in the soil studied. At this level, there is a possibility of failure of arable crops if there is no further application of P fertilizer. The CEC value of the soil sample was high, indicating its better capacity to retain the cations. High exchangeable K, high exchangeable Ca, and moderate exchangeable Mg and low exchangeable Na were observed as per the rating by Matson (1961). Analysis of soil samples from planting depth indicated low level of total N (Table 1), indicating that the nutrient was a limiting factor for optimum crop growth.

Table 1. Selected physico-chemical properties of the soil of experimental site

Properties		Values
% Moisture		41.9
Bulk density		1.04
PH		6.6
Ec		0.05
% carbon		0.78
% OM		1.34
Ava. P ppm		8.4
% total N		0.087
Exchangeable Base Cmol /kg	Na	0.26
	K	1.64
	Ca	6.26
	Mg	2.26
CEC Cmol /kg		34.2
% texture	% sand	28
	% clay	32
	% silt	40
Textural class		Clay loam

3.2 The effects of rate of nitrogen application on nitrogen use efficiency of maize varieties

Two way ANOVA result for the effect of nitrogen supply on the nitrogen use efficiency is presented in Table 2 shows nitrogen use efficiency was significantly affected by nitrogen rate and maize variety ($p \leq 0.05$) also the interaction was significant.

The mean NUE in two varieties of maize (Table 2) decreased progressively with increasing rates of nitrogen supply. These results are also in agreement with Tolessa Debelle (2006), reported that the nitrogen use efficiency of maize genotypes declined with higher N applications and also varied from genotype to the other genotype .The highest NUE in both varieties was recorded at 30kg/ha N supply.

The improved variety produced greater number NUE both highest and lowest rates of nitrogen supply. As shown in table 2, the mean difference between the two maize varieties with respect to NUE was also significant ($p \leq 0.05$). Of the two varieties the improved variety (pioneer shone) produces more NUE (54.781) than the tested local variety (32.507).

Ransom *et al.* (1993) stated that N use efficient genotypes are those genotypes that yield well at both low and high N soil fertility conditions, whereas N use inefficient genotypes are those that yield well only at high N soil fertility conditions. Therefore, from the significant difference NUE production between the two maize varieties of the present study improved maize variety can be regarded as best for resource poor farmers as it was able to perform best at both low and high nitrogen supply.

Table 2. Two way ANOVA results of NUE in two maize varieties as influenced by varying rates of nitrogen supply

Source	SS	Df	MS	F	Sig.
Nitrogen	14932.7090	3	4977.5697	1264.3385	0.000
Variety	2975.2275	1	2975.2275	755.7292	0.000
Nitrogen * variety	310.3595	3	103.4532	26.2778	0.001
Error	62.9904	16	3.9369		
Corrected Total	4841.8482	23			

Table 3. Plant NUE in two varieties of maize as influenced by rate of N supply

N-rate (kg/ha)	Variety		
	Local	Improved	Mean
30	41.451	64.693	53.072[a]
60	33.457	63.616	48.5365[a]
90	28.059	53.148	40.6035[b]
120	27.062	37.667	32.3645[c]
Mean values with the same alphabets are not statistically different at p= 0.05 ns: Not Significant			

4. Conclusion

The result The two maize variety are significantly different ($p \leq 0.05$) by their nitrogen use efficiency under the different nitrogen supply and also the main effect varieties are significantly different ($p \leq 0.05$) by their capacity of nitrogen use efficiency and also there is significance difference in their interaction effect ($p \leq 0.05$).The mean values of the NUE of the tested maize varieties, in all treatments of nitrogen (30 Kg N/ha 60 Kg N/ha, 90 Kg N/ha and 120Kg/ha), excluding 0KgN/ha,(because at 0KgN/ha nitrogen is not applied), there is significant difference ($p \leq 0.05$) between the two maize varieties by their nitrogen use efficiencies in each nitrogen rate and improved variety has better nitrogen use efficiency than the local variety.

Appendix

Table 4. Rate of nitrogen application and maize variety interaction effects on nitrogen use efficiency

Category	Nitrogen use efficiency		
Nitrogen rate (Kg/ha)	**Variety**	**Mean**	**SE**
30	Local	41.451^{b}	3.689
	Improved	64.693^{a}	3.689
60	Local	33.457^{b}	3.689
	Improved	63.616^{a}	3.689
90	Local	28.059^{b}	3.689
	Improved	53.148^{a}	3.689
120	Local	27.062^{b}	3.689
	Improved	37.667^{a}	3.689
Mean values with the same alphabets are not statistically different at p= 0.05 ns: Not Significant			

Table 5. Mean nitrogen use efficiency of the two variety of maize with different rates of nitrogen application

Category	Nitrogen use efficiency	
	Mean	**SE**
Nitrogen application rate (Kg/ha)		
30	53.072^{a}	2.608
60	48.537^{a}	2.608
90	40.604^{b}	2.608
120	32.364^{c}	2.608
Variety		
Local	32.507^{b}	1.844
Improved	54.781^{a}	1.844
Mean values with the same alphabets are not statistically different at p= 0.05 ns: Not Significant		

Conflicts of interest: The authors declare no conflicts of interest.

References

1. Asfaw Negasa, Abdissa Gemeda, Tesfaye Kumsa and Gemechu Gedeno. 1997. Agro-ecologocal and socio-economical circumstances farmers in East Wollega Zone of Oromia. Research report No.32 IAR, Addis Ababa, Ethiopia.

2. Bock, B.R. 1984. Efficient use of nitrogen in cropping systems. p. 273-294. In: Hauk, R.D. (ed.). Nitrogen in Crop Production, ASA-CSSA-SSSA, Madison, USA.

3. Dilallessa, T.D. 2006. Effect of tillage system, residue management and nitrogen fertilization on maize production in Western Ethiopia (Doctoral dissertation, University of the Free State).

4. EUBFE. 2015. Ethiopia Economic and Trade Report. Addis Ababa: European Business Forum in Ethiopia. Retrieved from http://bit.ly/2a1uQY6
5. Fageria, N.K. and Baligar V. C. 2005.Enhancing nitrogen use efficiency in crop plants. Advanced Agronomy. 88: 97-185.
6. Gomez, K.A. and Gomez, A.A. 1984. Statistical procedures for agricultural research. 2nd Edition, Joha wiley and sons, NewYork, 680p.
7. Jokela, W.E. and Randall, G.W. 1997. Fate of fertilizer nitrogen as affected by time and rate of application on corn. Soil Science Society of America Journal, 61: 1695-1703.
8. Matousa, P., Todob, Y. and Mojoc, D. 2013. Roles of extension and ethno-religious networks in acceptance of resource-conserving agriculture among Ethiopian farmers. International Journal of Agricultural Sustainability, 11(4): 301-316.
9. Metson AJ.1961. Methods of chemical analysis for soil survey samples. New Zealand Department of Scientific and Industrial Research, Soil Bureau Bulletin No.12. In: Hazelton, P.A., Murphy, B.W. (Ed.), Interpreting soil test results: what do all the numbers mean?. 2nd Edition. New South Wales, (NSW) Department of Natural Resources, Collingwood, Australia: CSIRO Publishing, 168-175 p.
10. Moll, R.H., Kamprath, E.J. and Jackson, W.A. 1982. Analysis and interpretation of factors which contribute to efficiency of nitrogen utilization. Agronomy Journal, 74(3): 562-564.
11. Ransom, J.K., Short, K. and Waddington. S. 1993. Improving Productivity of Maize in Stress Environments. In: Benti, T. and Ransom, J.K. (Eds.), Proceeding of the First National Maize Workshop of Ethiopia, 5-7 May 1992, Addis Ababa, Ethiopia IAR/CIMMYT, Addis Ababa, 30-33 pp.

Citation: Gizaw Bejigo and Firew Kebede. 2019. Nitrogen Use Efficiency Responses of Maize (*Zea mays* L) Varieties by Different Rates of Nitrogen Supply in Halaba Zone South Ethiopia. International Journal of Recent Innovations in Academic Research, 3(11): 71-76.