American Journal of Agriculture and Forestry
2018; 6(6): 237-245
http://www.sciencepublishinggroup.com/j/ajaf
doi: 10.11648/j.ajaf.20180606.21
ISSN: 2330-8583 (Print); ISSN: 2330-8591 (Online)

Growth and Yield Response of Maize (*Zea mays L*) Varieties with Varying Rates of Nitrogen Supply in Halalaba District South Ethiopia

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To cite this article:
Gizaw Bejigo. Growth and Yield Response of Maize (*Zea mays L*) Varieties with Varying Rates of Nitrogen Supply in Halalaba District South Ethiopia. *American Journal of Agriculture and Forestry*. Vol. 6, No. 6, 2018, pp. 237-245. doi: 10.11648/j.ajaf.20180606.21

Received: October 16, 2018; **Accepted**: November 13, 2018; **Published**: December 24, 2018

Abstract: A field experiment involving different N fertilizer rates (0, 30, 60, 90, and 120 kg N ha-1) was conducted to determine the effect of N on two varieties of maize (Zea mays L.) growth, and yield in Halaba district, Southern Ethiopia using a randomized complete block design with three replications of two varieties. The results of the study indicated that application of N fertilizer significantly increased the grain yield of maize mainly through its positive effects on the crop‘s growth and, yield and also the two tested maize varieties are significantly different under different rates of nitrogen by the different agronomic characteristics. In the study, application of 90 kg N ha-1 in pioneer shone variety significantly ($P < 0.05$) increased maize grain yield, number of ears, ear length, leaves per plant, seeds per ear, height of plant. At this N level grain yield increased by 4783.167 kg ha-1 (121.0673%) over its control plot. At the optimum application rate of 90 kg N ha-1, observed highest grain yield (8734kg ha-1), and other growth and yield related agronomic characteristics (number of ears, ear length, leaves per plant, seeds per ear, height of plant). This result implies that the pioneer variety at the application of 90KgN/ha can be recommended for the production of optimum maize yield in the study areas.

Keywords: Nitrogen, Growth, Yield, Varieties, Interaction Effect

1. Introduction

Maize (Zea mays L) originated in Central America and came to West Africa in the near beginning of 1500’s [1]. Maize introduced to Ethiopia during 1600’s to 1700’s [2] . Today, maize is one of the most important food crops world-wide. It has the highest average yield per hectare and is the third major cereal crop in the world after wheat and rice. The crop is used for both livestock feed and human consumption [3]. Maize is the most important staple in terms of calorie intake in rural part of Ethiopia. The 2004/5 national survey of consumption expenditure shows that maize accounted for 16.7 % of the national calorie intake by leading sorghum (14.1 %) and wheat (12.6 %) among the major cereals [4].

In Ethiopia, agriculture provides an employment to 85% of the population, contributes 90% of the total export earnings, supplies over 70% of the total raw materials required by industries and accounts for 60% of the country’s gross domestic product [5]. It plays a great role in Ethiopia’s economic growth and will command the lead for many years to come [6]. Since the Ethiopian agriculture is characterized by low production per unit area and poor agricultural practices, the country is facing a serious and chronic problem of food shortage [7]. Unless something is done to restore soil fertility first, other efforts to increase crop production would end up with little success [8].

In Ethiopia, the bulk of maize produced used as food source also the crop residue is increasingly utilized as animal feed and source of fuel. Despite the importance of crop, maize yields remain low on small scale farmers’ field, as manifested in national mean yield of 1.7 ton /ha [9] . 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. The response of maize plant to application of nitrogen varies from variety to variety, location to location and also depends on the availability of the nutrient and also, various maize cultivars differ markedly in grain yield response to nitrogen fertilization [10]. Increase in maize grain yield after nitrogen fertilization is largely due to an increase in the number of ears per plant, increase in total dry matter distributed to the grain and increase in average ear weight [11]. To overcome low soil fertility problems, most farmers are constrained by shortage of cash to use inorganic fertilizers [12]. For this group of farmers selection and use of maize variety, which can give reasonable yield under low nitrogen supply is more important [13]. 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 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 maize growth and yield is scanty. Also there is knowledge gap in farmers on selection of economically better maize variety. Therefore, the objective of this work is to investigate the growth and yield response of some selected maize varieties under different rates of nitrogen and selection of maize variety that gives reasonable yield relatively under low nitrogen supply to fill these knowledge gap in the study area maize cultivating farmers.

2. Materials and Methods

2.1. Description of Study Area

Halaba special woreda is located 315 km south of Addis Ababa, at about 65km from shashemane on the main road to WolayitaSodo-Arbaminch and 85km southwest of Southern Nations, Nationalities, and Peoples Regional (SNNPR) state capital of Hawassa. The woreda is geographically located 70 17' N latitude & 380 06' E longitudes. Altitude of the woreda ranges from 1154 to 2159 masl, but most of the woreda is found at about 1800 masl. The annual rainfall varies from 857 to 1,085mm while the annual mean temperature also vary from 17.60c to 22.50c with the highest of 34.45°C and lowest of 16.42°C .

2.1.1. 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.

2.1.2. 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 (25cm far one sowing hole from the other in a row and also 75cm apart one row from the other) [14] . 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.

2.2. Data Collection

Measurements of plant growth parameters such as plant height and leaf number were measured starting three weeks after germination of maize seeds. In addition, yield parameters such as number of ear per plant, ear length, number of grains per ear, weight of grain per plot were taken at different plant developmental stages.

For the measurement, five plants from the middle row of each treatment plot were selected and marked. Plant height was measured as the height from the soil surface to the base of the tassel (height from the ground level to the top-most leaf). Number of leaves and ears were determined by visual count. Ear length was measured from the point where the ear attaches to the stem to the tip of the ear. The number of grains was determined by counting and finally the dry weight of grain was determined by weighing using a balance.

2.3. Data Analysis

The analysis of variance (ANOVA) carried out using SAS statistical packages and procedures out lined by Gomez and Gomez [15]. 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

Physico-chemical characteristics of the soil samples are presented in Table 1. The particle size distribution of the soil found to be 28% sand, 40% silt, and 32% clay. The characteristics of a soil largely determine its utilization. From this result, 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 (41.9%), which might attributed to relatively to its higher clay content. The soil pH is 6.6 and lies within the preferred range for most crops. The fertility of soil is intimately linked with its organic matter which has an influence on the physical, chemical and biological properties of the soil. It is well known that under continuous agricultural practice, the organic matter content in the top soil will decrease. The organic carbon content of the studied soil is found to be very low (< 1%). This may be attributed to intensive agricultural practices and biomass harvest at the end of each cropping season. The bulk density of the studied soil is found to be 1.04, which is common in cultivated soils. This indicates that the soils are not compacted and have more porosity. This is beneficial to root activity, water infiltration into soil, and overall growth of crops Soil with very high bulk density can limit root growth, air circulation and availability of less mobile essential plant nutrients such as P and K. The electrical conductivity values is within the normal range found for outdoor soils and poses no restriction for field-crop cultivation nor adversely affect crop yield.

The available phosphorus is found to be low. The CEC value of the soil sample was high (34.200 cmol kg-1 soil), 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 [16]. 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.*

% Moisture	Bulk density gm/cm3	PH	Ec ms	% carbon	% OM	Ava. P ppm	% total N
41.9	1.04	6.6	0.05	0.78	1.34	8.4	0.087

Table 1. *Continue.*

Exchangeable Base Cmol /kg				CEC Cmol /kg	% texture			Textural class
Na	K	Ca	Mg		% sand	% clay	% silt	
0.26	1.64	6.26	2.26	34.2	28	32	40	Clay loam

3.2. Effect of Rate of Nitrogen Supply on Growth Traits of Maize Varieties

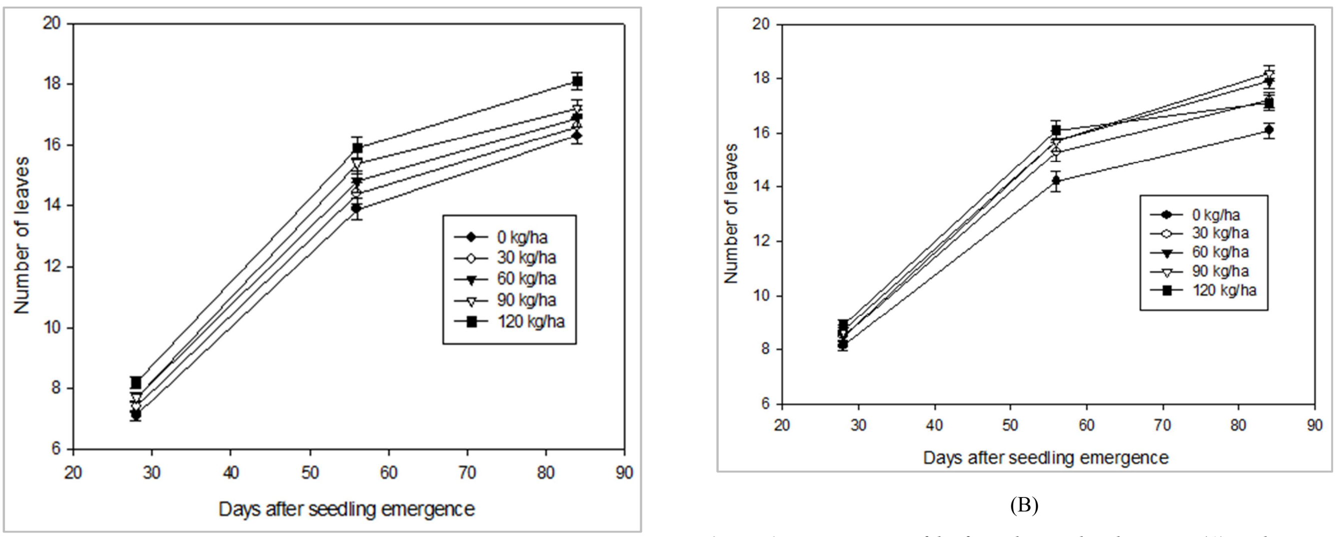
3.2.1. Number of Leaves

Two way ANOVA result for the effect of nitrogen supply on number of leaves at 8th week after seedling emergence is presented in Table 2. as shown that, the effect of nitrogen supply, maize variety and their interaction was significant at P < 0.05 up to 8th weeks after seeding emergence. Figure 1 A and B below shows the time course of leaf number in two varieties of maize as influenced by rate of nitrogen supply. The high sensitivity of leaf emergence and growth to nitrogen availability has also been demonstrated in many studies among these, Ensete ventricosum [17] . The results indicated that the number of leaves in both varieties increased progressively with increasing rates of nitrogen supply, though the rate of increase in leaf number tends to stabilize beyond 64 days after seedling emergence in two varieties of maize studied. In this study, the significant differences observed in number of leaves among nitrogen rates are indications that the number of leaves produced by maize plants was affected by levels of nitrogen supply.

From this result one can also see that the rate of leaf increase was much greater in improved variety than local variety indicating the existence of genetic variation between the two varieties despite exposure to similar nitrogen rates.

Table 2. *Two way ANOVA showing the effect of nitrogen supply on leaf number at 8th week after seedling emergence.*

Source	SS	Df	MS	F	Sig.
Nitrogen	39.907	4	9.977	4.898	0.001
Variety	16.667	1	16.667	8.182	0.005
Nitrogen * variety	25.533	4	6.383	3.134	0.017
Error	281.093	138	2.037		
Corrected Total	383.040	149			



(A)

(B)

Figure 1. *Time course of leaf number in local variety (A) and improved variety (B) as influenced by rates of nitrogen supply.*

3.2.2. Plant Height

As shown in Table 3 below the height of plant was significantly affected by nitrogen rate, maize variety and interaction (P < 0.05). The mean height in two varieties of maize at the maturity (Table 4) increased progressively with increasing rates of nitrogen supply. The increase in plant height with respect to increased N application rate indicates maximum vegetative growth of the plants under higher N availability . These results are in conformity with the results obtained by Akbar et al,[18] who found that plant height in maize increased with increase in N rate.

In this study the highest height in tested local varieties was recorded at 120kgN/ha N supply, while that of tested improved varieties was recorded at 90kg N/ha N supply. The height in local variety increased on average with a factor of 35.533 from 207.8 cm at 0 kg N/ha to 243.333 cm at 120 kg N/ha. The height increase factor of improved variety was 44.867 from 207.6cm at 0 kg N/ha to 252.467cm at 90 kg N/ha. The mean difference between the two maize varieties with respect to the height at maturity was also significant (P < 0.05). Of the two varieties the improved variety (pioneer shone) produces more height (230.973) than the tested local variety (223.933).

Table 3. *Two way ANOVA results of height of maturity in two maize varieties as influenced by varying rates of nitrogen supply.*

Source	SS	Df	MS	F	Sig.
Nitrogen	21154.51	4	5288.627	14.584	0.000
Variety	1858.56	1	1858.56	5.125	0.025
Nitrogen * variety	5226.507	4	1306.627	3.603	0.008
Error	50044.23	138	362.639		
Corrected Total	81095.17	149			

Table 4. *Plant height (cm) in two varieties of maize as influenced by rate of N supply.*

N-rate (kg/ha)	Variety		
	Local	Improved	Mean
0	207.800	207.600	207.700c
30	215.067	228.467	221.767b
60	225.400	233.333	229.367a
90	228.067	252.467	240.267a
120	243.333	233.000	238.167a

Mean values with the same alphabets are not statistically different at p= 0.05
ns: Not Significant

3.3. The Effects of Rate of Nitrogen Application on Yield Traits of Maize Varieties

3.3.1. Number of Ear Per Plant

Two way ANOVA result for the effect of nitrogen supply on number of ears per maize is presented in Table 5 shows that the number of ears was significantly affected by nitrogen rate (P < 0.05), though the difference between maize variety and variety by nitrogen supply interaction was not significant. The highest number of ears in local varieties was recorded at 120kg/ha N supply, while highest number of ears in improved varieties was recorded at 90kg/ha N supply. Of the two varieties the improved variety (pioneer shone) produces more ears than the tested local variety (sutale).

Table 5. *Two way ANOVA results of ear number in two maize varieties as influenced by varying rates of nitrogen supply.*

Source	SS	Df	MS	F	Sig.
Nitrogen	6.093	4	1.523	6.912	0.000
Variety	0.667	1	0.667	3.025	0.084
Nitrogen * variety	0.467	4	0.117	0.529	0.714
Error	30.413	138	0.22		
Corrected Total	37.893	149			

3.3.2. Ear Length

The result for the effect of nitrogen supply on the ear length is presented in Table 6, as shows the ear length was significantly affected by nitrogen rate and maize variety (P < 0.05) though the interaction was not significant. The mean ear length in two varieties of maize (Table 7) increased progressively with increasing rates of nitrogen supply. The highest number ear length in improved varieties was recorded at 90kg/ha N supply but at 120KgN/ha in local variety. From this result one can see that the improved variety produced greater number of ear length at both highest and lowest rates of nitrogen supply. Similar trend was also reported "in [19] that cob length generally decreased with decrease in nitrogen levels". According to this study the nitrogen plays a great role in the increasing of the ear length, which is associated with the increment of grain yield.

The mean difference between the two maize varieties with respect to ear length was also significant (P < 0.05). Of the two varieties the improved variety (pioneer shone) produces more ear length than the tested local variety.

Table 6. *Two way ANOVA results of ear length in two maize varieties as influenced by varying rates of nitrogen supply.*

Source	SS	Df	MS	F	Sig.
Nitrogen	379.693	4	94.923	12.523	0.000
Variety	612.06	1	612.06	80.747	0.000
Nitrogen * variety	49.907	4	12.477	1.646	0.166
Error	1046.04	138	7.58		
Corrected Total	2090.993	149			

Table 7. *Plant ear length in two varieties of maize as influenced by rate of N supply.*

N-rate (kg/ha)	Variety		
	Local	Improved	Mean
0	19.800	22.733	21.267d
30	20.867	24.533	22.700c
60	21.333	26.067	23.700bc
90	22.000	27.933	24.967ab
120	24.267	27.200	25.733a

Mean values with the same alphabets are not statistically different at p= 0.05
ns: Not Significant

3.3.3. Number of Seeds Per Ear

The result presented in Table 8, shows that, the number of seeds was significantly affected by nitrogen rate and maize variety (P < 0.05) though the interaction was not significant. The mean seed number of seeds in two varieties of maize (Table 9) increased progressively with increasing rates of nitrogen supply. These results are also in agreement with "in [20] who concluded that grain number per cob was highest at the highest nitrogen level". The highest number of seeds in improved varieties was recorded at 90kg N /ha supply but in local varieties at 120kg N /ha supply. The mean difference between the two maize varieties with respect to seed number was also significant (P < 0.05). Of the two varieties the improved variety (pioneer shone) produces more seeds than the tested local variety produce

Table 8. *Two way ANOVA results of number of seeds per ear in two maize varieties as influenced by varying rates of nitrogen supply.*

Source	SS	Df	MS	F	Sig.
Nitrogen	14.467	4	3.617	7.638	0.000
Variety	31.740	1	31.74	67.029	0.000
Nitrogen * variety	0.627	4	0.157	0.331	0.857
Error	65.347	138	0.474		
Corrected Total	117.500	149			

Table 9. *Plant seed number in two varieties of maize as influenced by rate of N supply.*

N-rate (kg/ha)	Variety		
	Local	Improved	Mean
0	415.067	430.333	422.7c
30	433.067	494.667	463.867b
60	451	573.6	512.3a
90	459.067	580.867	519.967a
120	474.933	574.667	524.8a

Mean values with the same alphabets are not statistically different at p= 0.05
ns: Not Significant

3.3.4. Weight of Grain Yield (Kg) / ha

As shown in Table 10, below the weight of grain was significantly affected by nitrogen rate and maize variety (P < 0.05) also the interaction was significant. The mean grain weight in two varieties of maize (Table 11) increased progressively with increasing rates of nitrogen supply. A similar trend in yield differences across nitrogen levels have been reported [20, 21], that the weight of grain yield increased with increasing nitrogen level. Increased grain weight with increasing nitrogen levels might be due to the formation of more leaf area which might have intercepted more light and produced more carbohydrates in the source which was probably trans located into the sink (the grain) and resulted in more increased grain weight than the control. Also, increasing N rates increases the enzyme activity in maize which may result in higher grain weight.

The highest number of grain yield weight in local variety was recorded at 120kg/ha N supply but in that of the improved variety, at the 90kgN/ha. This result shows that the improved variety produced greater number of grain yield weight. The mean difference between the two maize varieties with respect to weight of grain yield was also significant (P < 0.05). Of the two varieties the improved variety (pioneer shone) produces more grain yield than the tested local variety.

Table 10. *Two way ANOVA results of grain weight in two maize varieties as influenced by varying rates of nitrogen supply.*

Source	SS	Df	MS	F	Sig.
Nitrogen	62709745.87	4	15677436.47	1039.4066	0.000
Variety	6738337.00	1	6738337.00	446.7486	0.000
Nitrogen * variety	478422.80	4	1196105.70	79.30124	0.000
Error	301661.28	20	15083.07		
Corrected Total	74534166.95	29			

Table 11. *Plant grain weight (Kg) in two varieties of maize as influenced by rate of N supply.*

N-rate (kg/ha)	Variety		
	Local	Improved	Mean
0	4210.338	3950.833	4080.586c
30	5453.943	5890.633	5672.288bc
60	6217.800	7767.783	6992.792b
90	7089.460	8734.00	7911.730ab
120	7457.967	8471.95	7964.959a

Mean values with the same alphabets are not statistically different at p= 0.05
ns: Not Significant.

4. Conclusions

According to the result of this study, there is the significant difference between the two tasted maize varieties. Pioneer (shone) variety (improved) shows more growth and yield response from lower (30Kg nitrogen per hectare) to higher (120Kg nitrogen per hectare) nitrogen treatments than local variety (sutale). As the findings of this study, optimum maize grain yield was observed at the treatment of 90Kg nitrogen per hectare within tested pioneer shone variety. Grain yield is the main target of crop production. Therefore, the pioneer variety is better for those most farmers constrained by shortage of cash to use inorganic fertilizers in the study area . The result of this study implies that the pioneer variety at 90Kg nitrogen per hectare treatment can be recommended for increase maize yield production in the study areas.

Appendix

Table A1. *ANOVA test result regarding the effects of rate of nitrogen application and maize variety on different agronomic characteristics.*

Source	Dependent Variable	SS	df	MS	F	Sig.
Nitrogen	Leaf_4th week	14.467	4	3.617	7.638	0.000
	leaf_8th week	39.907	4	9.977	4.898	0.001
	Leaf/plant	44.493	4	11.123	9.269	0.000

Source	Dependent Variable	SS	df	MS	F	Sig.
	Ear/plant	6.093	4	1.523	6.912	0.000
	Ear length	379.693	4	94.923	12.523	0.000
	Seed/ear	209468.6	4	52367.14	9.241	0.000
	Height (cm)	21154.51	4	5288.627	14.584	0.000
Variety	Leaf_4th week	31.74	1	31.74	67.029	0.000
	leaf_8th week	16.667	1	16.667	8.182	0.005
	Leaf/plant	2.94	1	2.94	2.45	0.12
	Ear/plant	0.667	1	0.667	3.025	0.084
	Ear length	612.06	1	612.06	80.747	0.000
	Seed/ear	301056	1	301056	53.124	0.000
	Height (cm)	1858.56	1	1858.56	5.125	0.025
Nitrogen* variety	Leaf_4th week	0.627	4	0.157	0.331	0.857
	leaf_8th week	25.533	4	6.383	3.134	0.017
	Leaf/plant	28.093	4	7.023	5.852	0.000
	Ear/plant	0.467	4	0.117	0.529	0.714
	Ear length	49.907	4	12.477	1.646	0.166
	Seed/ear	73606.27	4	18401.567	3.247	0.014
	Height (cm)	5226.507	4	1306.627	3.603	0.008
Error	Leaf_4th week	65.347	138	0.474		
	leaf_8th week	281.093	138	2.037		
	Leaf/plant	165.613	138	1.2		
	Ear/plant	30.413	138	0.22		
	Ear length	1046.04	138	7.58		
	Seed/ear	782049.7	138	5667.027		
	Height (cm)	50044.23	138	362.639		
Corrected Total	Leaf_4th week	117.5	149			
	leaf_8th week	383.04	149			
	Leaf/plant	243.393	149			
	Ear/plant	37.893	149			
	Ear length	2090.993	149			
	Seed/ear	1403024	149			
	Height (cm)	81095.17	149			

Leaf-4th and leaf-8th means the number of leaves at end of four and eight week after germination respectively. Leaf/plant, Ear/plant seeds/ear means number of leaves per plant, number of ears per plant and number of seeds per ear respectively

Table A2. *Rate of nitrogen application and variety interaction effect on different agronomic characteristics of the tested maize.*

Dependent Variable	Nitrogen Treatment	variety	Mean	SE
Number of leaf at the 4th week	0 kg/ha	Local	7.133	0.178
		Improved	8.133	0.178
	30 kg/ha	Local	7.400	0.178
		Improved	8.467	0.178
	60 kg/ha	Local	7.733	0.178
		Improved	8.533	0.178
	90 kg/ha	Local	7.733	0.178
		Improved	8.733	0.178
	120 kg/ha	Local	8.200	0.178
		Improved	8.933	0.178
Number of leaves per maize at the 8th week	0 kg/ha	Local	13.933	0.369
		Improved	14.200	0.369
	30 kg/ha	Local	14.400	0.369
		Improved	15.333	0.369
	60 kg/ha	Local	14.800	0.369
		Improved	15.667	0.369
	90 kg/ha	Local	15.400	0.369
		Improved	15.733	0.369
	120 kg/ha	Local	15.933	0.369
		Improved	16.133	0.369
Number of leaves per plant at maturity	0 kg/ha	Local	16.333	0.283
		Improved	16.067	0.283
	30 kg/ha	Local	16.667	0.283
		Improved	17.200	0.283
	60 kg/ha	Local	16.933	0.283
		Improved	17.867	0.283
	90 kg/ha	Local	17.267	0.283
		Improved	18.400	0.283
	120 kg/ha	Local	18.067	0.283

Dependent Variable	Nitrogen Treatment	variety	Mean	SE
		Improved	17.133	0.283
Number of ear per plant	0 kg/ha	Local	1	0.121
		Improved	1	0.121
	30 kg/ha	Local	1.133	0.121
		Improved	1.2	0.121
	60 kg/ha	Local	1.267	0.121
		Improved	1.4	0.121
	90 kg/ha	Local	1.333	0.121
		Improved	1.667	0.121
	120 kg/ha	Local	1.467	0.121
		Improved	1.6	0.121
Ear length (cm)	0 kg/ha	Local	19.8	0.711
		Improved	22.733	0.711
	30 kg/ha	Local	20.867	0.711
		Improved	24.533	0.711
	60 kg/ha	Local	21.333	0.711
		Improved	26.067	0.711
	90 kg/ha	Local	22	0.711
		Improved	27.933	0.711
	120 kg/ha	Local	24.267	0.711
		Improved	27.2	0.711
Number of Seed per ear	0 kg/ha	Local	415.067	19.437
		Improved	430.333	19.437
	30 kg/ha	Local	433.067	19.437
		Improved	494.667	19.437
	60 kg/ha	Local	451	19.437
		Improved	573.6	19.437
	90 kg/ha	Local	459.067	19.437
		Improved	580.867	19.437
	120 kg/ha	Local	447.933	19.437
		Improved	574.667	19.437
Maize Height (cm)	0 kg/ha	Local	207.800	4.917
		Improved	207.600	4.917
	30 kg/ha	Local	215.067	4.917
		Improved	228.467	4.917
	60 kg/ha	Local	225.400	4.917
		Improved	233.333	4.917
	90 kg/ha	Local	228.067	4.917
		Improved	252.467	4.917
	120 kg/ha	Local	243.333	4.917
		Improved	233.000	4.917

***Table A3.** Mean values of different agronomic characteristics of the tested maize variety under the different levels of nitrogen applications.*

Dependent Variable	Nitrogen Treatment	Mean	SE
Number of leaves at 4th week	0 kg/ha	7.633c	0.126
	30 kg/ha	7.933bc	0.126
	60 kg/ha	8.133b	0.126
	90 kg/ha	8.233ab	0.126
	120 kg/ha	8.567a	0.126
Number of leaves at 8th week	0 kg/ha	14.065c	0.261
	30 kg/ha	14.865b	0.261
	60 kg/ha	15.233ab	0.261
	90 kg/ha	15.567ab	0.261
	120 kg/ha	16.033a	0.261
Leaf per plant	0 kg/ha	16.200b	0.200
	30 kg/ha	17.000b	0.200
	60 kg/ha	17.400a	0.200
	90 kg/ha	17.833a	0.200
	120 kg/ha	17.600a	0.200
Ear per plant	0 kg/ha	1.00c	0.086
	30 kg/ha	1.167bc	0.086
	60 kg/ha	1.333ab	0.086
	90 kg/ha	1.500a	0.086
	120 kg/ha	1.533a	0.086
Ear length	0 kg/ha	21.267d	0.503
	30 kg/ha	22.700c	0.503

Dependent Variable	Nitrogen Treatment	Mean	SE
	60 kg/ha	23.700bc	0.503
	90 kg/ha	24.967ab	0.503
	120 kg/ha	25.733a	0.503
Number of Seed per ear	0 kg/ha	422.7c	13.744
	30 kg/ha	463.867b	13.744
	60 kg/ha	512.3a	13.744
	90 kg/ha	519.967a	13.744
	120 kg/ha	524.8a	13.744
Height (cm)	0 kg/ha	207.700c	3.477
	30 kg/ha	221.767b	3.477
	60 kg/ha	229.367a	3.477
	90 kg/ha	240.267a	3.477
	120 kg/ha	238.167a	3.477

Mean values with the same alphabets are not statistically different at p= 0.05 ns: Not Significant.

Table A4. *Mean values of different agronomic characteristics of the two maize varieties.*

Dependent Variable	variety	Mean	SE
Number of leaves at 4th week	Local	7.64b	0.079
	Improved	8.56a	0.079
Number of leaves at 8th week	Local	14.747b	0.165
	Improved	15.413a	0.165
Leaf per plant	Local	17.053a	0.126
	Improved	17.333a	0.126
Ear per plant	Local	1.24a	0.054
	Improved	1.373a	0.054
Ear length	Local	21.653b	0.318
	Improved	25.693a	0.318
Seed per ear	Local	446.627b	8.693
	Improved	530.827a	8.693
Height (cm)	Local	223.933b	2.199
	Improved	230.973a	2.199

Mean values with the same alphabets are not statistically different at p= 0.05 ns: Not Significant.

Table A5. *Rate of nitrogen application and maize variety interaction effects on yield of maize.*

Category		Yield	
Nitrogen rate (Kg/ha)	**Variety**	**Mean**	**SE**
0	Local	4210.383.a	149.097
	Improved	3950.833a	149.097
30	Local	5453.943a	149.097
	Improved	5890.633a	149.097
60	Local	6217.800b	149.097
	Improved	7767.783a	149.097
90	Local	6678.325b	149.097
	Improved	8734.000a	149.097
120	Local	7457.967b	149.097
	Improved	8471.950a	149.097

Mean values with the same alphabets are not statistically different at p= 0.05 ns: Not Significant.

Table A6. *Mean yield (kg/ha) of the two variety of maize with different rates of nitrogen application.*

Category	Yield (kg/ha)	
	Mean	**SE**
Nitrogen application rate (Kg/ha)		
0	4080.608e	105.428
30	5672.288d	105.428
60	6992.792c	105.428
90	7911.730ab	105.428
120	7964.958a	105.428
Variety		
Local	5955.495b	66.678
Improved	6963.040a	66.678

Mean values with the same alphabets are not statistically different at p= 0.05 ns: Not Significant

Acknowledgements

I would like to express my internal appreciation and profound gratitude to Dr. Friew Kebede, Dr. Yosef T/Gorgis, Anteneh Befekedu, Shetaye Helalo, Mesfin Sodano for their valuable technical and financial support to conduct this study.

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