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Research Article

Comparative Growth and Grain Yield Response of Five Maize Varieties to Nitrogen Fertilizer Application

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ABSTRACT

Field trials were conducted at the research field of Institute of Agricultural Research and Training, Moor plantation, Ibadan during 2010 and 2011 cropping season in order to evaluate the performances of five open pollinated maize varieties subjected to two fertility levels 0 and 100 kg Nha^{-1} fertilizer. The trials consisted of split-plots arranged in randomized complete block design of three replicates. The objective was to evaluate and compare the responses of five maize varieties to N fertilizer application. Data were obtained from plant height, ear height, leaf area, ear length, number of kernels per cob, weight of 100 kernels and grain yield. Data were analyzed using ANOVA and means separated by DMRT (P=0.05 and 0.01). The results obtained showed that N fertilizer significantly increased the growth and yield related parameters of all the traits except ear height and ear length while grain yield was higher in 2011. Varieties by nitrogen interactions differed significantly for the various parameters measured except for ear height and kernel/cob. In the fertilized plots ART SW5-OB had highest mean grain yield. Obatanpa and ARTSW6-OB had highest grain yield compared with other varieties in the fertilizer stressed plots while Ile1-OB had highest yield reduction under the two fertility environments. ARTSW5-OB had the highest nitrogen use efficiency while Obatanpa and ARTSW6-OB were least, but produces better grain yield under low nitrogen input. In conclusion, the result indicated a positive and varied response of maize varieties to nitrogen fertilizer application.

INTRODUCTION

Poor organic matter and available nutrients are the major feature of most soils in the humid tropics as they are often been subjected to continuous cropping bringing about great reduction in its productivity and sustainability (Zingore *et al*., 2003). This phenomenon is a major reason for low yields in crop production amidst other constraints like drought, poor crop management, diseases and pest. Nitrogen is an essential macronutrient required by cereals and it is a major yield determining nutrient required for maize production. It is a component of protein and nucleic acid as it also enhances and facilitates the utilization of other nutrients like phosphorus, potassium and other elements (Adediran and Banjoko, 1995; Shanti *et al*., 1997). Nitrogen is the most vulnerable of all the plant nutrients in the soil; it is highly volatile and readily leached. Increasingly high cost of fertilizer has made the knowledge of the effectiveness of its use by maize and other plants inevitable (Moll *et al.,* 1981).The use of nitrogen rich organic based fertilizers had long been clamored for but the challenges lies in its availability, especially when farming is to be done on large scale basis. Developing plant varieties that are better users of available nutrients coupled with appropriate soil management practices remains a reliable method of combating problems of nutrient deficiencies in the tropics. Maize genotypes differ in the rate of nitrogen absorption and utilization (Smith, 1934; Beauchamp *et al.,* 1976; Chevalier and Schrader, 1977; Moll and Kamprath, 1977; Reed *et al.,* 1980, Kamprath *et al*, 1982; Oikeh *et al*., 1997). Efficient use of Nitrogen fertilizer in maize production enhances increased grain yield, appreciable economic return and reduced ground water pollution (Gehl *et al*., 2005). The objective of this study was to evaluate the responses of five open pollinated maize varieties under native soil fertility and N fertilized soil environments with a view to understand their performances under the varying fertility environments, while information provided would assist breeders in developing maize varieties tolerable to low soil nutrient.

MATERIALS AND METHODS

Field experiments were conducted at the Institute of Agricultural Research and Training Ibadan, Nigeria, Latitude 7^{o}22.5‘N and Longitude 3^{o}50.5‘E.The experimental site has been use over the years for continuous maize cropping. Pre planting soil physico-chemical analysis indicated that the soil pH was 6.09%, Organic matter 1.33%, Organic N 0.096 %, and available P 7.36 (ppm), Sand 75.9 % Silt 15.5% and Clay 7.8%. Land preparation was done mechanically by ploughing, harrowing and ridging, using tractor. Five open pollinated maize varieties were planted at two seeds per hill in plot size of 4.5m x 4m at spacing of 75cm between rows and 50cm within rows to make population of 53,333 stands ha^{-1}. The experimental design was randomized complete block design in split plots of three replicates. $P_2O_5$and K_2O were applied as basal dose to both treatments while urea was applied twice to the fertilized plot at the rate of 100kgha^{-1}, first at kneel height and two weeks to tasselling while 0 N kgha^{-1} for the unfertilized plots. Weeding was controlled using pre emergence herbicides and later by rouging.

Data taken: Data obtained in this study include plant height (determine by using meter rule to measure from the base of the plant to the tip of the flag leaf), leaf area (determine by using the formula L x B x 0.75 where L= value of the length; B= value of the broadest part), ear height, field weight, kernel per cob, ear length, 100 seed weight and total seed yield after adjustment to 12 % moisture level and Nitrogen use efficiency was determined by the formula of Moll *et al.* (1982).

$$NUE = \frac{\text{Grain yield (g/plant) at N rate applied} - \text{grain yield at 0 kg N ha-1}}{\text{N applied (g Nf)}}$$

Where NUE = Nutrient Use Efficiency
gNt = total N in above ground biomass
gNf = Amount of N applied.

Data Analysis: Data were analyzed using SAS version 8 to compute analysis of variance (ANOVA) and significant differences were determined by DMRT at probability levels of 5, 1 and 0.1%. Significant interactive means were separated using standard error at P<0.05, while differences in character means were determined at P<0.05.

Table 1: Mean square (MS) for agronomic traits of five maize varieties evaluated under fertilized and unfertilized fertility environments

Source of variation	DF	PHT (cm)	EHT (cm)	LA (cm)	ELT (cm)	K/C	100KW (g)	GY (t/ha)	NUE
Rep	2	625.91	228.84	1471.31	2.155	61.26	0.618	1.76*	24.49
Nitrogen(N)	1	3620.82***	54.53	65428.4***	2.24	14863.28*	25.16**	49.5***	-
Varieties(V)	4	1088.1**	133.28	7648.9	7.54**	6265.88	86.68**	4.45*	227.83**
Years (Y)	1	13.92	54.53	471876.9***	0.05	3899.17	13.56**	132.63***	705.38**
VxN	4	250.7***	73.94	1510.6	12.62***	3121.20	8.45	2.67*	-
YxN	1	43.5	187.97	6482.9	0.001	1147.25	0.74	7.89**	-
YxV	**4**	323.1	73.94	2026.45	0.03	2821.35	14.87*	5.95**	513.96***
YxNxV	**4**	330	57.09	3581.1	0.02	14063.65**	0.98	5.82**	
Error	32	248.48	145.46	3294.20	1.55	2793.2955	3.277	0.44	49.63
Total	53								

Plant height, EHT=Ear height, LA=Leaf area, K/C= Kernel per cob, ELT= Ear length, 100KWT=100 kernel weight, GY= Grain yield, NUE=Nitrogen use efficiency

Table 2: Mean square (MS) for years of evaluation of the agronomic traits of five maize varieties tested in two fertility environments

Years	PHT (cm)	EHT (cm)	LA (cm)	ELT (cm)	K/C	100KW (g)	GY (t/ha)	NUE
2010	162.5	65.82	371.96	13.83	401.19	28.30	5.10	7.218
2011	161.5	63.91	594.32	13.65	380.7	30.70	7.09	16.91
L.S.D$_{(0.05)}$	2.87	2.20	10.47	4.08	9.64	0.33	0.12	1.87

PHT= plant height, EHT=Ear height, LA=Leaf area, K/C= Kernel per cob, ELT= Ear length, 100KWT=100 kernel weight and GY= Grain yield NUE= Nitrogen use efficiency.

Table 3: Mean squares (MS) of Nitrogen fertilizer and agronomic traits of five maize varieties tested in two fertility environments

N kg^{-1}	PHT (cm)	EHT (cm)	LA (cm)	ELT (cm)	K/C	100KW (g)	GY (t/ha)
0	154.26	63.91	`427.62	13.60	375.23	28.85	5.49
100	169.80	65.82	493.66	13.99	406.71	30.14	6.71
S.E$_{(0.05)}$	2.87	2.20	10.47	0.22	9.6	0.33	0.12

PHT= plant height, EHT=Ear height, LA=Leaf area, K/C= Kernel per cob, ELT= Ear length, 100KWT=100 kernel weight and GY= Grain yield.

Table 4: Mean square (MS) for the effect of Nitrogen-variety interactions on grain yield and other agronomic traits of five maize varieties tested in fertilized and unfertilized fertility environments

Varieties	**PHT**		**EHT**		**LA**		**ELT**		**K/C**		**100K WT**		**GY**		NUE
	0 kgN	100 **kgN**	**0 kgN**	100 **kgN**	**0 kgN**	100 **kgN**	**0 kgN**	100 **kgN**	0 **kgN**	100 **kgN**	**0 kgN**	**100 kgN**	**0 kgN**	**100 kgN**	
Ile 1ob	144.73	171.13	61.36	67.36	394.05	494.45	10.72	14.68	358.8	390.30	14.68	29.64	4.52	6.25	17.03
Obatanpa	160.70	177. 13	65.75	60.08	427.12	582.71	14.87	14.93	392.65	438.03	31.59	31.59	6.03	6.79	7.55
ART98 SW5 OB	171.33	178.33	70.36	71.00	472.03	517.87	14.07	14.05	349.26	395.35	29.93	29.93	5.10	7.15	20.18
ART98 SW6 OB	148.25	154.16	61.08	63.46	439.03	503.20	14.10	12.90	374.36	410.50	29.99	29.99	5.93	6.57	6.33
TZPB-OB	146.30	168.5	60.25	42.83	405.83	452.83	14.12	13.5	399.37	410.08	30.25	30.25	5.84	6.77	9.23
Mean	154.26	169.8	63.91	65.82	427.61	493.66	13.60	13.99	375.2	406.7	28.85	30.14	5.49	6.71	12.06
S.E(0.05)	3.43	2.99	2.34	1.78	21.87	17.88	0.34	0.19	12.44	0.19	0.47	0.46	0.22	0.28	1.87

PHT= plant height, EHT=Ear height, LA=Leaf area, K/C= Kernel per cob, ELT= Ear length, 100KWT=100 kernel weight and GY=Grain yield and NUE =Nitrogen use efficiency.

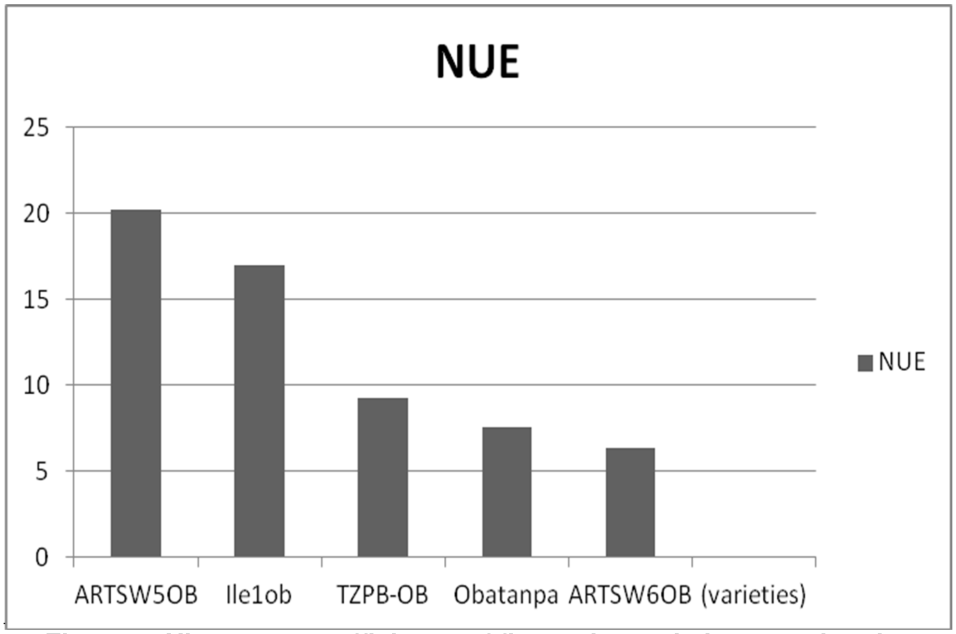

Figure 1: Nitrogen use efficiency of five maize varieties tested under fertilized and unfertilized environments

RESULTS

Table 1 presents the mean square (MS) of the various agronomical traits evaluated across the two fertility environments. Grain yield differed significantly across the replicates at P<0.05. Nitrogen fertilizer had significant effect on plant height, leaf area, grain yield (P< 0.001) weight of 100 kernels(P< 0.01) and numbers of kernels per cob(P<0.05). The varieties differed significantly for plant height, ear length, weight of 100 kernels, nitrogen use efficiency (P<0.01) and grain yield (P<0.05). Years of planting was significantly different for leaf area, grain yield (P<0.001), weight of 100 kernels and nitrogen use efficiency (NUE) (P<0.01). Varieties nitrogen fertilizer interactions were significant for plant height, ear height (P<0.01) and grain yield (P<0.05). Years of planting and nitrogen fertilizer interaction (Y x N) was only significant for grain yield. Years of planting and variety interactions (Y x V) were significant for weight of 100 kernels, grain yield and nitrogen use efficiency. Years of planting, varieties and nitrogen fertilizer application interaction (Y x N x V) were significant for number of kernels per cob and grain yield.

Table 2 presents the over view of the mean square (MS) of the performances of the agronomical traits of the maize varieties over the two cropping seasons. The leaf area, weight of 100 kernels, grain yield and nitrogen use efficiency were significantly higher in 2011 compared with 2010 maize cropping seasons.

Table 3 presents the summary of the performances of the agronomical traits tested under the two fertility environments. Plant height, leaf area, ear length, weight of 100 kernels and grain yield was significantly higher with nitrogen fertilizer application.

Table 4 presents the mean square performances of nitrogen variety interactions of the five evaluated maize varieties. ARTSW5OB had highest mean square of 178.33 and 171.33 for plant heights in both fertilized and unfertilized soil environments. Ile1ob had fairly high plant height in fertilized soil but showed lowest plant height in unfertilized plots, plant height was however not significantly different from TZPB and ART SW6-OB while ARTSW6OB had lowest plant height in the fertilized plots. ART SW5-OB had highest value of 472.03cm^2 for leaf surface area while Ile 1 OB showed the least leaf surface area in unfertilized plots. However, the surface leaf areas of the varieties in the fertilized plot were not significantly different. Ile1ob had the shortest ear length in unfertilized plots compared with TZPB, Obatanpa, ART SW5-OB and ART SW6-OB which were not significantly different from one another. Obatanpa had the longest ear length while ART SW6-OB had the shortest ear length in the fertilized plots. Obatanpa and Ile1ob had highest and lowest weight of 100 kernels in both fertilized and unfertilized plots. Obatanpa had the highest grain yield of 6.03t/ha in unfertilized plots while Ile1ob was least with 4.52t/ha while ART SW5-OB had highest grain yield of 7.15t/ha and Ile 1ob had least grain yield of 6.25t/ha in plots with nitrogen fertilizer application.

Figure 1 presented the nitrogen use efficiencies (NUE) of the five tested maize, ARTSW5OB had the highest NUE, followed by ILE1OB while ARTSW6OB had the least value for NUE.

DISCUSSION

The result of this study showed that years of evaluation and the varieties varied in their responses to the varying fertility environments. Similar study by Mosisa *et al*., 2004 and Oikeh *et al.,* 1997 reported that different genotypes performed differently across different soil fertility levels. Some varieties performed differently across the fertility levels while other showed consistent performance under both conditions. The varieties differ significantly for plant height, ear length, weight of 100 grains, grain yield and nitrogen use efficiency similar observation was reported by Kogbe and Adediran (2003). Increased agronomical traits, grain yield and NUE recorded in 2011 could be attributed to relatively higher precipitation experienced during the maize cropping seasons in 2011 compared with 2010. Available soil moisture enhances nutrient utilization by plants (Power, 1990). ARTSW5OB was superior in nitrogen use efficiency while ARTSW6OB was least as presented in figure 1.

Nitrogen fertilizer had significant effect on plant height, leaf area, numbers of kernels per cob, weight of 100 grains and grain yield. Mean grain yield and other agronomical traits were significantly reduced in the low N soil compared with the N fertilized plots. Several reports had earlier attributed significant increase in the development of vegetative plant part and dry matter accumulation to nitrogen fertilizer application as nitrogen is an important constituent of chlorophyll, amino acid and nucleic acid. Increased leaf area observed with the application of nitrogen fertilizer corroborated the findings of Cox *et al*., (1993) and Sumi and Ketayama, (2000) which reported that nitrogen promotes higher leaf area development and reduced rate of senescence. Onasanya *et al.,* (2009) attributed increase in height of maize plant to nitrogen fertilizer application. The result of this study revealed that the maize varieties used in this study varied in their responses to both the low N and 100 N kg/ha soils.

CONCLUSION

Maize varieties varied in their response to nitrogen fertilizer application across the fertility environments while some were consistent. However, not undermining the role and the importance of inorganic fertilizer in maize production, identifying and developing crop genotypes that are tolerant or produce appreciable yield under low soil nutrient would go a long way in alleviating problems associated with inorganic nutrient supply and environmental issues in the developing countries. In this study Obatanpa and ART SW6-OB had better grain yield than other varieties in N low plots. Planting such maize varieties would be beneficial to rural maize farmers who do not have access to nitrogen fertilizer in Nigeria. or they could form a reliable basis for low soil N tolerant varietal development. ARTSW5-OB and Ile1ob however utilized nitrogen fertilizers better than the other three varieties. There is a need for further evaluation of this trial in other agro ecological zones for valid recommendations.

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