Vol. 15(1), pp. 66-72, January, 2020
DOI: 10.5897/AJAR2016.11875
Article Number: ADB856762696
ISSN: 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Evaluation of yield and yield components of low n maize (*zea mays* l.) varieties under low and high nitrogen conditions

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Received 27 October, 2016; Accepted 30 January, 2018

Field studies were conducted at the teaching and research farm of the Osun State University Ejigbo Campus, Osun State, Nigeria, during the 2015 and 2016 cropping seasons to determine the agronomic performance of low N maize varieties under two nitrogen conditions (low and high). The aim of this experiment was to determine the response of low N maize to two levels of nitrogen fertilizer. Ten low N maize varieties were used in this study. Low and high-N conditions of the soil was induced by application of urea fertilizer at the rate of 30 and 90kg ha^{-1} of nitrogen .The experiments were laid out in a randomized complete block design with three replications. High nitrogen application significantly improved maize vegetative growth, yield components and grain yield. The use of 90 kg ha^{-1} of N gave the highest maize plant height, and number of leaves per plant, as well as grain yields of 3.50 and 3.58 tha^{-1} was obtained with the application of 90 kg ha^{-1} of N in 2015 and 2016 cropping seasons, respectively. The result indicated that application rates of nitrogen (kg ha^{-1} of N) improved growth attributes of all the varieties with SINT MAR 20CA LARGA gave maximum grain yield that is not significantly different from 72PBPROLC$_3$SYN.

Key words: Plant height, agronomic performance, low N maize, nitrogen levels.

INTRODUCTION

Most Africans depend on maize as their stable food (Bänziger and Diallo, 2001) to feed both rural and urban dwellers. Maize cultivation in the tropics is seriously threatened by low nitrogen in the soil which causes low production in yield. Therefore, cultivation of low N tolerance cultivars is superior in the utilization of available N than other varieties.

Most soils in Nigeria are inherently low in N and its

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deficiency is due to the rapidity by which it is taken up or lost from the soil through erosion, volatilization or leaching nitrogen, and hence reducing maize yield by as much as 40% (Baenziger and Lafitte, 1997). Soil fertility problem constitutes a serious constraint to maize food production. Out of the essential soil nutrients, nitrogen is the most limiting factor (Fakorede et al., 2003).

Nitrogen deficiency is one of the most important stresses affecting maize production in tropical areas (Bänziger et al., 1999; Yara, 2009; Law-Ogbomo and Remison, 2008). The soils in Nigeria are low in organic matter and available. However, as a result of high cost of N fertilizer, poor distribution system and low purchasing power (Fakorede et al, 2003). The depletion has been attributed mainly to intensive and continuous cropping with little or no fertilizer application and thus culminating into imbalance between nutrients supply and extraction from the soil (Sanchez et al., 1997). The declining productivity of many tropical soils has been one of the major constraints limiting the realization of the genetic potentials of available improved crop varieties (Dudal and Deckers, 1993).

The need to take appropriate steps to check the declining soil productivity by improving the physico-chemical properties of the soil including its fertility in order to increase maize yield is urgent, because the rate of deterioration is increasing and it is bound to have serious implication on future food security in the region. Adequate inputs of nutrients as fertilizers as well as soil amendments to improve physico-chemical properties are required to overcome the constraints. Maize for example, has high demand for nitrogen thus nitrogen becomes the first limiting nutrient as land use intensifies. This explains why it is almost impossible to grow maize successfully on some soils in the Guinea savannah of Nigeria without nitrogen fertilizers.

In view of importance of maize in Nigeria economy, national and international bodies have developed interest in promoting maize production for households' food security and poverty alleviation. Some of these efforts have been channelled through biological and agronomic research into the development of high-yielding varieties along with best cultural practices. A considerable proportion of maize in the Nigeria is produced under N-stressed conditions (Bias et al., 1997, Chantachume et al., 1997, Sallah et al., 1997).

Farmers do not use much fertilizer because of the high price ratio between fertilizer and grain, limited availability of fertilizer, and the low purchasing power of farmers. Although organic N may be available to maize in some cases but the low yields (1.3 t/ha on average in farmers farm; (Afolabi et al., 2015) indicate that N from organic sources meets the demand of maize to a limited extent only. Several genotypes have been developed on the basis of anthesis-silking interval selection for drought tolerance, and a variety is being developed for soils with low fertility where N is the most limiting nutrient.

It was reported by Tilman et al. (2002) that the use of N fertilizer is not only adding to cost of production but also can negatively impact soil, water and air quality within a given ecosystem. For these reasons, reducing the amount of supplemental N used in maize production by developing low-N tolerance varieties will have positive economic and environmental benefits to world of agriculture. A possible approach to reduce N deficiency in soil is to lower crop demand for N through selection for low-N tolerance (Smith et al., 1995).

Most of the cultivated varieties, especially hybrids, require high doses of fertilizer to produce optimally. The use of these hybrid varieties under low-N condition can sometimes result in total crop failure. The declining use of fertilizer due to high cost and non-availability has limited the use of hybrid maize. A pragmatic strategy to boost productivity of maize is by the use of varieties that are tolerant to low-N soils. These varieties will be able to produce high yield reasonably well under low-N conditions.

In order to increase maize yield in environment with low soil N, Kogbe and Adediran (2003) gave two suggestions. One is the development of agronomic practices that efficiently utilized N from organic matter, N inputs from biological fixation and atmospheric deposition. Secondly, is by working with population that have reservoir of genes for low N tolerance. From where Low N varieties can be produced. CIMMYT research on low N tolerance began in 1985. Lafitte and Bänziger (2003) have led the work, which was done mostly at the Poza Rica station where long-term low nitrogen blocks have been established. It was reported that there are linkages between low N tolerance and drought tolerance.

Several research on maize has been developed to have genotypes that can tolerate low fertility where N is the most limiting nutrient but the breeding programme strategy has not been carried out on genetic dissection on this genotypes in order to have information on the nature of combining ability of parents, their behavior and performance of the hybrid combinations (Prasanna et al., 2001).

Employing an effective breeding procedure depends to a large extent on understanding of the genetic mechanisms controlling the characters to be improved (Malik et al., 2004). Various quantitative genetic approaches have been used for estimating the mode of gene action in controlling low N tolerance in maize. Most of the genetic design used to analyze mode of gene action assume absence of non-allelic interactions, however, there are contrary evidences to this assumption (Ashfa et al*.,* 2006). This will be a better and most cost efficient strategy that can produce reasonable grain yield under poor soil.

The objective of this study is to compare performance of ten (10) maize varieties under low N condition and investigate potential of ten (10) maize populations in Ejigbo, South-West Nigeria, Osun State.

Table 1. The weather conditions during the growing season of this study in 2015 and 2016.

2015	Rainfall	Relative humidity (%)		Temperature (°C)	
Months	**(mm)**	**0600 h**	**1800 h**	**Min**	**Max**
April	112	72.3	62.1	25.4	32.5
May	212	70.1	61.3	25.3	31.7
June	401.32	69.6	60.4	26.5	30.3
July	500.32	70.45	60.7	25.2	29.57
August	525.6	70.3	60.45	25.5	28.7
Mean	350.248	70.55	60.99	25.58	30.55
2016					
April	112	70.23	60.1	26.4	32.52
May	212	69.91	59.3	25.53	31.73
June	401.32	70.6	60.4	26.5	30.43
July	500.32	71.45	61.7	25.32	29.67
August	525.6	71.3	59.45	25.45	28.57
Mean	350.25	70.70	60.19	25.84	30.58

MATERIALS AND METHODS

Experimental site and plot layout

Field studies were conducted during the 2015 and 2016 seasons at the Teaching and Research farm of the Department of Agronomy, Osun State University, Ejigbo Campus. The weather conditions during the growing season of this study in 2015 and 2016 are as shown in Table 1.

Soil testing

At experimental site, eight soil core samples were taken from each plot using soil auger before planting. Cores for each plot were combined and the composite sample was air dried. The soil was passed through a 2 mm, and 0.5 mm sieve for chemical and physical analysis. Table 2 shows the physical and chemical properties of the soil.

Table 2. Physical and chemical characteristics of the soil.

Physical characteristics	Amount
% Clay	6.0
% Silt	19.0
% Sand	72.0
% Organic matter	8.5
Texture	Sandy loam
Chemical characteristics	
% Organic Carbon	8.7g/kg
% Nitrogen	0.5 g/kg
pH	6
Potassium K+	0.29 cmol/kg
Sodium Na+	0.18 cmol/kg
Calcium Ca2+	1.5 cmol/kg
Magnesium Mg2+	1.3 cmol/kg
Available P	6.2 cmol/kg
ECEC	11.90
Total Acidity	1.1cmol/kg

Description of experimental materials

The materials used for this study comprised of 10 open pollinated variety (OPV) of maize developed at International Institute of Tropical Agriculture (IITA), Ibadan for grain yield and adaptation to biotic and abiotic stress factors. The description of these materials was given in Table 3. The 10 maize varieties were evaluated during the planting season of 2015 and 2016 using randomized complete block design (RCBD). Low and high-N conditions of the soil were induced by application of urea fertilizer at the rate of 30 and 90kg ha^{-1} of N. In 2015 and 2016 entries were made in a row plot of 5 m long, spacing was 75 cm inter-rows and 50 cm intra-rows. Three seeds were initially planted on a hill but were later thinned to two weeks after planting to give a planting density of 53,333 plants ha^{-1}.

Cultural practices

Weeding

Manual weeding was done throughout the experiment. Weeding was done regularly with hoes to keep the plots weed-free.

Thinning

This was done two weeks after planting. Hill population was reduced to two vigorously growing plant.

Data collection

Data were collected for the following traits using maize descriptor:

(1) Plant height: This is the distance from the base of the plant to

Table 3. The description of experimental materials.

Varieties	Names	Grain colour	Maturity group
V1	SINT MAR 20CA LARGA	White	Late-intermediate
V2	LN TP YC7	Yellow	Late-intermediate
V3	BR99 72L COMPI	White	Late-intermediate
V4	72PB PROL C_4	White	Late-intermediate
V5	LAPOSTA SEQUIA C_6	White	Late-intermediate
V6	72L COMP IC_6 LNCI	White	Late-intermediate
V7	DMR ESR W LN	White	Late-intermediate
V8	72PB PROL C3 SYN	White	Late-intermediate
V9	LN TP YC6 SYN	Yellow	Late-intermediate
V10	DMR ESR Y LN	Yellow	Late-intermediate

the node bearing the tassel branch (measured in cm).
(2) Ear height: The distance from the base of the plant to the node bearing upper ear (measured in cm).
(3) Days to 50% anthesis: This was taken as the number of days from planting to the time (50%) when the plants shed their pollen grains.
(4) Days to 50% silking: This was taken as the number of days from planting to the time when 50% of the maize plants produce silk.
(5) Anthesis-silking interval: This is the interval between the first day plant shed their pollen grains to the first day plant brought out silk.
(6) Number of leaves per plant: The number of leaves per plant was determined by counting and the data from 10 plants from the middle rows was used to compute the score for each plot at 4, 8 and 16 WAP.
(7) Ear weight (g): The fresh weight of the peeled ear measured to the nearest gram and the mean weight of ears from 10 randomly selected plants from the middle row was used to compute the score for each plot.
(8) Grain yield (t ha^{-1}): Grain yield was computed from ear weight (EWT, kg/m^2), adjusted to 15% moisture content (MOIST) and 80% shelling percentage (Dhillon et al., 1976) using the formula:

$$\text{Grain yield (t ha}^{-1}\text{)} = \text{EWT} \times (100 - \text{MOIST}) / 85) \times (10000 \times \text{SHELL})$$

Data analysis

All data collected were subjected to statistical analysis of variance (ANOVA) using SAS Institute (1995). Significant means were separated using Duncans Multiple Range test at 5% propability level.

RESULTS

The results of this study showed that the application of low and high Nitrogen was significantly improved the growth and yield of maize varieties. The performance of the maize during the 2015 and 2016 growing seasons was not statistically different in all the growth and yield traits evaluated (Tables 4 and 5).

Maize vegetative growth parameters assessed at flowering showed that plant height, number of leaves per plant was significantly higher in 90kgNha-1 than 30 kgNha-1 in both seasons (Table 4). This was associated with reduced nitrogen content in the soil. Considering the overall performance, SINT MAR 20CA LARGA and 72PB PROL C3 SYN were identified as the varieties with high number of leaf and leaf area.

In 90kgNha-1 kgN/ha, SINT MAR 20CA LARGA and 72PB PROL C3 SYN had the highest number of leaf in both season with 15.5, 14.5, 12.44 and 14.9 respectfully. Similarly, mean leaf area for 90kgNha-1 was significantly higher than 30kgN/ha in both seasons. It ranges between 662.59cm2 for SINT MAR 20CA LARGA and 573.44cm2 for DMRESRYLN 90kgNha-1 90kgN/ha for 2015 also for 2016, it ranges between 692.2 for SINT MAR 20CA LARGA and 579 for 72PB PROL C3 SYN.

Low average plant height was observed in 30kgNha-1 for both seasons. The plant height at 90kgNha-1 for 2015 ranges between 165.8 for 72PB PROL C3 SYN and 108 for LA POSTA SEQUIA C6. Likewise for 2016, plant height for 72L COMP IC6 LNCI and 127.40 for LN TP YC6 SYN (Table 5). The ear height and internode for 30 90kgNha-1 and 90kgNha-1 were not significantly different in both seasons.

Generally, average maize grain yield for low N tolerance maize varieties in 90kgN/ha was significantly higher compared with 30kgNha-1 in both seasons. This was associated with increase in plant height and decrease in anthesis-silking interval (Table 6). Considering the overall performance ,SINT MAR 20CA LARGA and 72PB PROL C3 SYN were identified as high yielders with average grain yield of 3.5t/ha and 3.00t/ha respectfully for 2015. This also had a similar trend in 2016 with average grain yield of 3.58t/ha and 3.24t/ha. The results further indicated that 90kgN/ha significantly enhanced maize yield in the two cropping season. The use of higher nitrogen (90kgN/ha) produced more vigorous maize planting having significantly bigger average ear weight, ear length than when 30kgN/ha was applied.

DISCUSSION

Maize growth, yield and yield components for low N maize tolerant maize in 2015 and 2016 were significantly better with the use of 90kgN/ha than the use of30 kgN/ha. There was no significant differences in the effect of the

Table 4. Vegetative parameters of 10 maize varieties under low and high nitrogen.

Varieties	Leaf number				Leaf area (cm^2)			
	2015		2016		2015		2016	
	low N	High N	Low N	High N	low N	High N	low n	High N
SINT MAR 20CA LARGA	10.5	15.5	10.2	14.5	462.59	741.50	465.45	692.05
LN TP YC7	9.78	11.08	10.74	12.08	548.64	648.64	550.04	645.64
BR99 72L COMPI	10.67	13.5	9.67	12.5	595.32	695.32	592.30	692.32
72PB PROL C_4	11.44	12.50	11.5	11.90	541.29	641.29	448.33	638.29
LA POSTA SEQUIA C_6	8.56	10.56	9.50	10.53	496.34	596.34	487.44	593.34
72L COMP IC6 LNC_I	10.44	12.44	10.45	11.53	482.43	582.43	480.50	579.43
DMR ESR W LN	9.11	10.15	9.54	10.55	555.94	647.94	562.59	644.94
72PB PROL C_3 SYN	10.33	13.53	10.00	12.53	542.30	634.3	548.64	631.3
LN TP YC6 SYN	8.67	12.44	9.60	14.49	498.33	590.33	595.32	587.33
DMR ESR Y LN	9.11	11.15	9.15	10.15	481.44	573.44	441.29	570.44
Mean	9.961	12.29	10.04	11.97	530.46	627.26	517.19	624.26
LSD (0.05)	0.95	2.1	1.05	1.95	11	14	10	14

Table 5. Mean of growth parameters of ten maize varieties under low and high nitrogen.

Varieties	Plant height (cm)				Ear height (cm)				Internodes (cm)			
	2015		2016		2015		2016		2015		2016	
	Low N	High N	Low N	High N	low N	High N	low N	High N	Low N	High N	Low N	High N
SINT MAR 20CA LARGA	146.74	184.58	143.73	174.58	106.75	121.75	114.25	123.75	5.45	5.67	5.47	6.07
LN TP YC_7	130.45	159.17	127.40	156.17	89.53	104.53	88.67	106.53	6.41	6.91	6.51	6.75
BR99 72L COMPI	147.08	163.92	149.18	161.00	91.1	106.10	96.33	108.1	6.28	6.54	6.3	5.75
72PB PROL C_4	170.38	179.86	164.38	175.82	94.92	109.92	91	111.92	6.55	6.95	6.50	7.24
LA POSTA SEQUIA C_6	108.55	157.78	121.05	155.68	86.33	101.33	66.78	103.33	5.67	6.07	5.75	6.56
72L COMP IC_6 LNCI	163.09	191.87	173.19	192.87	91	106.00	94.25	107	5.99	6.05	6.00	7.45
DMR ESR W LN	131.19	160.22	135.19	163.00	66.78	81.78	88.67	82.78	5.48	5.75	5.5	5.67
72PB PROL C_3 SYN	135.81	198.47	170.81	200.40	114.25	129.25	76.33	130.25	6.2	7.24	6.5	6.91
LN TP YC6 SYN	165.34	170.67	164.04	172.5	88.67	103.67	91	104.67	5.76	6.56	5.96	6.54
DMR ESR Y LN	137.67	156.33	147.67	158.02	76.33	91.33	76.78	92.33	6.41	7.45	6.55	6.95
Mean	146.63	172.29	149.66	171.00	90.57	105.57	88.41	107.07	6.02	6.52	6.55	6.5
LSD (0.05)	23.5	18.7.	22.4	24.34	21.39	21.32	18.74	22.5	1.05	1.35	0.30	0.5

Table 6. Mean of yield and related parameters of ten maize varieties under low and high nitrogen.

Varieties	Grain yield (T/Ha)				Days to 50% silking (days)				Anthesis silking interval			
	2015		2016		2015		2016		2015		2016	
	low N	High N	Low N	High N	low N	High N	low N	High N	Low N	High N	Low N	High N
SINT MAR 20CA LARGA	2.43	3.50	2.5	3.58	55	56	54	56	3	2	2	2
LN TP YC7	2.07	3.00	1.94	3.65	56	55	55	55	3	2	3	2
BR99 72L COMPI	1.52	2.32	1.53	2.59	56	57	54	57	3	2	2	2
72PB PROL C4	2.04	2.63	1.97	3.10	55	56	56	58	3	2	2	3
LA POSTA SEQUIA C_6	1.38	2.50	1.40	2.52	54	55	54	55	3	3	2	3
72L COMP IC6 LNCI	1.84	2.90	1.55	3.00	56	58	55	58	3	2	3	3
DMR ESR W LN	1.93	2.81	2.00	2.78	54	55	55	55	3	3	2	2
72PB PROL C_3 SYN	2.88	3.00	2.03	3.24	55	57	55	57	3	2	3	3
LN TP YC6 SYN	1.91	2.89	1.73	3.06	55	53	54	53	3	3	2	2
DMR ESR Y LN	1.25	2.30	1.50	2.65	54	55	55	55	3	2	3	3
Mean	1.725	2.885	1.715	3.167	55	55.7	54.7	55.9	3	2.7	2.4	2.7
LSD (0.05)	0.15	0.75	0.23	0.44	0.95	1.2	1.1	1.3	0.01	0.33	0.20	0,23

seasons in the performances in all the yield and yield parameters between the two growing seasons. This may be likely be due to the fact that the same quality of urea fertilizer as well as similar field experimental conditions was used in both season. Also there were also non -significant differences in the weather conditions during the 2015 1nd 2016 growing seasons. The observed significant performance in growth and yield parameters with the application of 90 kgNha^{-1} could be attributed to the sufficient percentage of nitrogen contained in 90 kgNha^{-1} that are associated with increase in photosynthetic efficiencies (Bello et al., 2003). The greater number of leaves, plant height, and leaf area occur at higher rates of nitrogen content. This findings corroborates with the report of Jin et al. (1993), Uddin et al. (2009) and Agbowuro and Salami (2015) who observed significant increase in yield and yield components with the increase in nitrogen fertilizer. Increase in nitrogen fertilizer has the ability to promote vigorous growth, improve meristematic and physiological activities in the plants thereby resulting in the synthesis of increased photo-assimilates that enhanced maize yielding ability. The result also shows that with additional nitrogen to maize, it will help in boosting its vegetative parts which was contrary to the report of Islam 2004.

Conclusion

From the aforementioned results, it could be concluded that yield advantages were gained by cultivating maize with the use of nitrogen fertilizer, albeit at high application rates (90kgN/ha). With the present scarcity of maize, increase in maize production can be attained with the use of more nitrogen fertilizer. Therefore, the yield potential of low N maize can be successfully maximized by application of fertilizer.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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