

Field evaluation of extra early maize varieties in two agro ecological zones of Nigeria

Abstract

Low yield of maize has been attributed to low soil N since maize requires high Nitrogen for optimum productivity. Field study was conducted in the late season of 2014 at International Institute of Tropical Agriculture, Research Farms, in Ibadan (forest-savanna transition) and Mokwa (southern guinea savanna) zones to evaluate the effects of split Nitrogen fertilizer application on growth and yield of extra early maize. The experimental arrangement was 5 x 8 factorial fitted into Randomized Complete Block Design and replicated four times. Five extra early maize varieties and eight rates of Nitrogen fertilizer were used in all treatment. Data collected on growth and yield parameters were subjected to Analysis of Variance procedure and significant means were separated using Duncan's Multiple Range Test at $p < 0.05$. Results showed that maize variety 2013 TZEE-W DT STR at both locations had significant higher number of leaves, plant height, leaf area, cob dried yield and grain yield at both locations. Split application of N fertilizer of 90 kg N ha⁻¹ as (60:30) at 2 and 4 WAS produce significantly ($p < 0.05$) higher 1000 grain weight, grain yield and dried cob yield at Mokwa and Ibadan respectively. The control plot produced significantly reduced dried cob and grain yield in Mokwa and Ibadan by (85, 81%) and (84.4, 80.4%) respectively compared to the best rate of 60:30 split N application. Mokwa (Southern guinea savanna) zone proved to be a favorable location for higher yield of extra early maize varieties. The study concluded that application of N in two split doses at (2 and 4 WAS) as 60:30 kg N ha⁻¹ on extra-early maize is recommended for achieving optimum grain yield in both locations. The 2013 TZEE-W DT STR is the best variety in terms of growth and yield of maize at the two locations and is hereby recommended.

Keywords: maize, ecology, grain yield

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Introduction

Maize (*Zea mays* L.) is the third most important cereal crop in the world after wheat and rice and the most important cereal in Nigeria in terms of production and consumption. Maize is a renowned field crop in all the agro-ecological zones of West and Central Africa (WCA).¹ During the last two decades, production of maize have not coped with population growth due to several reasons includes low soil fertility which is the principal factor, little or no use of improved seed, herbicides, fertilizers, inadequate plant density, weed infestation, poor tillage practices, labour shortages, increased levels of biotic and abiotic constraints, and high costs of inputs are some of the constraints associated with maize production.²

Maize is usually considered to have a high soil fertility requirement to achieve optimal yields^{3,4} and thus large quantities of N is required. Nitrogen being the most yield limiting nutrient, its stress reduces grain yield by delaying plant growth and development.⁵ Maize is a nitro-positive and needs ample quantity of nitrogen for its better production.⁶ However, production is still seriously constrained by low soil fertility especially Nitrogen. Efforts aimed at obtaining high yield of maize would necessitate the augmentation of the nutrient status of the soil through a suitable application technique when it is most efficient and effectively utilized to meet the crop's requirements for optimum productivity and maintain soil fertility. These studies were carried out to evaluate the effect of split N fertilizer application on growth and yield of extra early maize varieties.

Material and methods

The experiment was conducted during late season of 2014 planting season in Ibadan (forest-savanna transition) and Mokwa (southern guinea savanna) zones. Land preparation was done mechanically first and second ploughs, harrowed and marked with mechanical marker of 0.75m inter-row spacing. A factorial experiment fitted into randomized complete block design was used for both locations. The treatment were 5 varieties x 8 fertilizer rates making 40 treatment combinations replicated four times; three row planting of 5m long with inter-row spacing of 0.75mx0.25m intra-row spacing. The plot size was 5m x 2.25m with total experimental area of 90mx27.5m (2475m²). Basal application of P and K at rates equivalent to 30 kg P₂O₅ and K₂O ha⁻¹ respectively were made at time of first N application.

The following parameters were collected plant height, number of leaves, leaf area, stem girth, cob yield (t ha⁻¹), 1000 seed weight (g) and grain yield (t ha⁻¹). Growth parameters were taken at 4 and 8 weeks after sowing (WAS).

$$\frac{\text{Field Weight (kg / plot)} \times (100 - \text{GMC}) \times 80 / 100}{85} \times \frac{10,000}{0.25 \times 0.75 \times 21}$$

Grain yield per hectare (t ha⁻¹):

Grain yield was estimated using the formula⁷

Where:

Fw =field weight of ears at harvest

Gmc=grain moisture content (%)

0.8=shelling coefficient of maize ($100^{-1.5}$)= 15% moisture in grain at dry state $10,000\text{m}^2$ = harvested area conversion into standard unit (ha)

The planting materials used were five cultivated extra early maize varieties comprising of striga tolerant maize varieties obtained from International Institute of Tropical Agriculture, Ibadan, (IITA). Data collected was subjected to analysis of variance (ANOVA) procedures according to the methods described. Treatment means were separated using the Duncan Multiple Range Test (DMRT) at 5% level of probability.⁸

Results and discussion

Pre-cropping soil physiochemical properties analysis; the result showed that the soil used for field trials for both agro-ecology is sandy soil in texture, medium to slightly acidic soil, low in total Nitrogen (N), medium in available phosphorus (P). As result of its low essential macronutrients the soil can be regarded as a poor soil for maize production. The pH of 5.7 and 6.0 was moderate for maize production (Table 1). Very low in total Nitrogen (N of 0.09, 0.04kg^{-1} of soil is less than the critical level of 1.5kg^{-1} , while the available phosphorus (P) of 8.7, 10.3mgkg^{-1} exceeds the critical level of 8.10mgkg^{-1} . The pH of 6.0 was moderate for maize production (Table 1).

Table 1 Pre-cropping soil physico-chemical properties for both locations, 2014

Soil Properties	Ibadan	Mokwa
Sand (%)	92	90
Silt (%)	3	5
Clay (%)	5	5
Textural class	sandy	sandy
pH	6	5.7
Ca (cmol kg^{-1})	21.4	13.4
O.C (%)	1.2	0.35
Mg (cmol kg^{-1})	1.9	0.8
Na (cmol kg^{-1})	0.4	0.3
K (cmol kg^{-1})	0.2	0.2
AL + H (cmol kg^{-1})	0.1	0.1
ECEC (cmol kg^{-1})	30	20.1
Base Sat (%)	99.7	99.5
Total N	0.09	0.04
Av.P (ppm)	8.7	10.3
Cu (ppm)	1.6	0.9
Mn (ppm)	57.5	180
Fe (ppm)	136	59
Zn (ppm)	4.7	9.5

The data presented in Table 2, showed that maize varieties respond differently to Nitrogen fertilizer rates applied for both locations. Split N application rates greatly enhanced the performance of extra-early maize varieties in the various growth parameters measured. Application of nitrogen fertilizer produced significantly higher number of leaves, taller plants height, wider leaf area and thicker stem girth when compared with 0 kg N/ha. Application of 120kgN/ha split (60:60) applied at 2 and 4 WAS produced the highest number of leaves and widest leaf area when compared to other treatments in both locations. The tallest plant height and thickest stem girth was produced with the application rate of 90kgN/ha split (60:30) applied at 2 and 4 WAS. This result is an indication that higher levels of nitrogen fertilizer promote the vegetative growth in maize and its deficiency reduces the vegetative growth of maize. This agrees with Onasanya et al.,⁹ who reported higher application rate of 120kgN/ha to produced the highest number of leaves. Also, Roth et al.,¹⁰ Paradkar et al.,¹¹ reported that higher nitrogen rate promotes vegetative growth in maize. Similar results that plant height increases with increasing levels of fertilizers were reported.¹²⁻¹⁴ But these results are contrary to those of Jones¹⁵ who reported that time of application of N had no significant effect on maize plant characters. The least value for leaf area, number of leaves, plant height and stem girth was recorded in the control plot with 0kgN/ha . This result agrees with Tweneboah¹⁶ who earlier established that nitrogen deficiency retarded growth of maize and resulted into stunted growth and poor root development. For maize varieties, the highest plant height, widest leaf area and the thickest stem girth recorded for variety 2013 TZEE-W DT STR at 8 WAS could be attributed to their genetic make-up. It was also reported by Msarmo et al.,¹⁷ that cultivars grown under the same conditions may have differences in their performance based on the genetic characteristics.

Amendment of soil by nitrogen fertilizer, irrespective of rates or period of application produced significantly better yield than 0kgN/ha . The data presented in Table 3, showed higher number of cobs at 60kgN/ha single applied (55.20×10^3 and 51.60×10^3) in both Mokwa and Ibadan respectively, while the lowest number of cobs produced was in the control plot (28.13×10^3 and 29.2×10^3) for both locations respectively. This result indicate that increase in N application do not show increase in number of cobs produced and environment did not have any effect on number of cobs produced in both locations, though mokwa agroecology brought about higher number in cob produced. The higher number of cobs experienced with N fertilizer application over the control may be due to the availability of Nitrogen nutrients throughout the growing season which is essential for optimum maize growth. This finding agrees with the earlier report^{18,19} that the number of cobs produced by maize did not increase with the increase in nitrogen rates. Maize cob yield was greatly enhanced by varietal differences and split N application rates. Variety 2013 TZEE-W DT STR produced the best cob yield ($3.33, 3.15\text{ t ha}^{-1}$) for both mokwa and Ibadan.

Varieties had no significant ($p>0.05$) effect on grain moisture content among the maize varieties at both locations. TZEE-Y Pop C₄ had the highest grain moisture of (13.99 %) while the least grain moisture content was produced in 2013 TZEE-Y DT STR. Split N application rates showed significant effect on maize grain moisture content at Mokwa. The 90kg N/ha split (60:30) applied at 2 and 4 weeks after sowing produced the highest cob yield (3.91 and 3.73 t ha^{-1}), grain yield (2.99 and 2.80 t ha^{-1}) and 1000 grain weight (432.2 and 414.9 g) in both Mokwa and Ibadan respectively. The least cob yield, grain yield and 1000 grain weight was recorded in the control

plot with 0 kg N/ha in both locations. Cob yield of extra early maize was increased linearly with increase in N rates up to 90 kg N/ha. Split N application rate enhanced grain yield produced by extra early maize. This result agrees with¹⁸ that grain yield increased with increasing nitrogen rates. Similar, findings was reported that found that yield and yield component of maize were increase by increasing the rate of nitrogen application rates. Increase in maize grain yield with an increase in the rates of nitrogen was also reported,²⁰⁻²³ in their investigations on nitrogen levels and maize grain yield.

For 1000 grain weight, the data in Table 3 reveals that the

treatments were significantly different from one another. The different rates of nitrogen fertilizer and time of application influenced the size of maize seed produced. All the treatments where N was applied resulted in higher 1000 grain weight compared with the control. Varietal difference had no significant ($p < 0.05$) effect on 1000 grain weight produced by the extra early maize materials. The 1000 grain weight produced was comparable for both agro-ecologies. 1000 grain weight were increased as N application rate increases up till 90 kg N/ha split (60:30) applied at 2 and 4 weeks after sowing and started decreased at 120 kgN/ha split (30:30:30) applied (Table 4).

Table 2 Effect of split N application rate on growth parameters of maize

Treatments	NL		PH		LA		SG	
	Mokwa	Ibadan	Mokwa	Ibadan	Mokwa	Ibadan	Mokwa	Ibadan
Varieties (V)								
2013 TZEE-W DT STR	11.8a	13.4a	178.3a	184.8a	524.3a	550.5a	2.47	2.57a
2013 TZEE-Y DT STR	10.5c	12.1c	172.7b	178.7b	448.6c	471.1c	2.31	2.39b
TZEE-W Pop C5	11.0b	12.5b	170.7b	176.5b	463.6c	486.7b	2.4	2.47ab
TZEE-Y Pop C4	11.1b	12.7b	173.3b	179.3b	463.2b	486.3b	2.42	2.52a
99 TZEE-Y STR QPR	10.9bc	12.5b	165.6c	171.1c	460.3bc	483.3bc	2.45	2.53a
S.E (+)	0.12**	0.13**	1.68**	1.82**	4.24**	4.45**	NS	0.06*
Urea Rate (R)								
0kgN	6.8f	8.4f	115.3g	119.2g	361.7f	379.8f	1.69e	1.74e
30kgN	8.9e	10.5e	149.6f	156.0f	431.1e	452.7e	2.02d	2.10d
30:30kgN	11.8c	13.3c	179.6c	185.9c	490.4c	514.9c	2.67b	2.76b
60kgN	9.5d	11.0d	170.6d	176.7d	468d	491.4d	2.79b	2.89b
60:30kgN	13.0b	14.3b	217.5a	223.7a	508.1b	533.5b	3.13a	3.24a
30:30:30kgN	12.0c	13.6c	176.7c	183.3c	470.3d	493.8d	2.66b	2.76b
60:60kgN	13.7a	15.3a	205.5b	211.6b	540.5a	567.5a	2.20c	2.28c
30:60:30kgN	12.9b	14.5b	162.2e	168.3e	505.9b	531.2b	2.13cd	2.21cd
S.E (+)	0.16**	0.17**	2.13**	2.30**	5.36**	5.62**	0.05**	0.07**
Varieties x Rate								
S.E (+)	0.38*	0.38*	4.76*	5.15*	11.98*	12.58*	0.11*	0.11*

WAS = Weeks after sowing, *, ** = Significant at 0.05 and 0.01 level of probability, respectively Mean followed by the same letter(s) within the same column and treatments are not significantly different

Table 3 Effect of split N application rate on plant stand at harvest, cob number and cob weight of maize

Treatments	Number of cobs x 103 ha ⁻¹		Cob yield (t ha ⁻¹)	
	Mokwa	Ibadan	Mokwa	Ibadan
Varieties (V)				
2013 TZEE WDT STR	48.25a	45.33a	3.33a	3.15a
2013 TZEE YDT STR	48.00a	44.58ab	2.96b	2.72b
TZEE W POP C5	47.83a	46.42a	2.95b	2.81b
TZEE Y POP C4	48.17a	46.33a	2.69b	2.56b
99 TZEE Y STR QPR	43.42b	41.83ab	2.37c	2.30c
S.E (+)	1.02*	0.99**	0.94**	0.88**
Urea Rate(R)				
0kgN	28.13c	29.2c	0.59d	0.71d
30kgN	52.80a	49.33a	2.59c	2.42c
30:30 kgN	52.67a	49.6a	3.31b	3.07b
60kgN	55.20a	51.6a	2.65c	2.55c
60:30kgN	52.40a	48.8a	3.91a	3.73a
30:30:30kgN	45.47b	44.13b	3.30b	3.13b
60:60kgN	45.33b	43.2b	3.39b	3.13b
30:60:30kgN	45.07b	43.33b	3.14b	2.95b
S.E (+)	1.29**	1.26**	0.119**	0.112**
Varieties x Rate				
S.E (+)	NS	NS	0.266**	0.250**

WAS = weeks after sowing *, ** = Significant at 0.05 and 0.01 level of probability, respectively, Mean followed by the same letter(s) within the same column and treatments are not significantly different.

Table 4 Effect of split N Application rate on grain moisture, grain yield and 1000 grain weight of Maize

Treatments	Grain moisture (%)		Grain yield/ha (t ha ⁻¹)		1000 grain weight (g)	
	Mokwa	Ibadan	Mokwa	Ibadan	Mokwa	Ibadan
Varieties (V)						
2013 TZEE WDT STR	13.76	15.56	2.57a	2.38a	358.21	341.2
2013 TZEE YDT STR	12.69	14.44	2.31b	2.08b	338.85	321.7
TZEE W POP C5	13.92	15.72	2.27bc	2.12b	350.77	333.5
TZEE Y POP C4	13.99	15.94	2.07c	1.93b	351.44	334.3
99 TZEE Y STR QPR	13.75	15.75	1.83d	1.73c	354.98	337.8
S.E (+)	NS	NS	0.73**	0.67**	NS	NS
Urea Rate(R)						
0kgN	12.21	13.61b	0.47d	0.55d	274.11e	257.1e
30kgN	13.36	14.78ab	2.01c	1.84c	325.34d	307.7d
30:30 kgN	12.25	14.56ab	2.60b	2.35b	369.11c	351.3c
60kgN	14.14	16.58a	2.04c	1.91c	395.63b	378.0b
60:30kgN	14.7	16.29a	2.99a	2.80a	432.16a	414.9a
30:30:30kgN	14.35	15.41ab	2.53b	2.37b	372.29c	355.7c
60:60kgN	13.84	16.05a	2.62b	2.36b	322.52d	306.1d
30:60:30kgN	14.15	16.6a	2.42b	2.21b	315.64d	298.9d
S.E (+)	NS	0.72*	0.92**	0.85**	6.39**	6.51**
Varieties x Rate						
S.E (+)	NS	NS	0.206*	0.191**	NS	NS

WAS = Weeks After Sowing * = Significant at 5% level of probability, Mean followed by the same letter(s) within the same column and treatments are not significantly different at 5.

Conclusion

The maize variety 2013 TZEE-WDT STR in both locations had higher number of leaves, plant height, cob dry yield, and grain yield at Mokwa and Ibadan respectively. Split N fertilizer application of 90kgN/ha at 2 and 4 WAS produce significantly higher 1000 grain weight, cob yield and grain yield at Mokwa and Ibadan respectively.

The control produced significantly reduced cob yield and grain yield in both locations compared to the rest treatments, therefore growing extra early maize without adding supplement of N fertilizer should be discouraged. The 2013 TZEE-WDT STR is the best variety in terms of growth and yield of maize at the two locations. Mokwa (9°18'N, 5°04'E) representing Southern Guinea Savanna showed to be a favourable environment to produce higher yield of maize using extra early maize varieties. Application of N in two split doses at (2 and 4 WAS) as 60:30kgN/ha on extra-early maize is recommended for achieving optimum grain yield in both locations.

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Conflicts of interest

The author declares there is no conflicts of interest.

References

- Adetimirin VO, Vroh BI, Menkir A, et al. Diversity analysis of elite maize inbred lines adapted to West and Central Africa using SSR markers. *Maydica*. 2008;53:143–149.
- Menkir A, Akintunde AO. Evaluation of the performance of maize hybrids improved open pollinated and farmers local varieties under well-watered and drought stress conditions. *Maydica*. 2001;46:227–238.
- Paponov IA, P Sambo, GE Schulte, et al. Grain yield and kernel weight of two maize genotypes differing in nitrogen use efficiency at various levels of nitrogen and carbohydrate availability during flowering and grain filling. *Plant Soil*. 2005;272(1–2):111–123.
- Uribelarrea M, SJ Crafts Brandner, FE Below. Physiological N response of field-grown maize hybrids (*Zea mays* L.) with divergent yield potential and grain protein concentration. *Plant Soil*. 2009;316:151–160.
- Uhart SA, FH Andrade. Nitrogen deficiency in maize: I. Effects on crop growth, development, dry matter partitioning, and kernel set. *Crop Science*. 1995;35(5):1376–1383.
- Rizwan M, M Maqsood, M Rafiq, et al. Maize (*Zea mays* L.) response to split application of nitrogen. *International Journal of Agricultural Biology*. 2003;5(1):19–21.
- Carangal VR, SM Ali, AF Koble, et al. Comparison of S1 with test cross evaluation for recurring selection in maize. *Crop Science*. 1971;11(5):658–661.
- Duncan BB. Multiple Range Test and multiple F Tests. *Biometrics*. 1955;11(1):1–42.
- Onasanya RO, Aiyelari OP, Onasanya A, et al. Effect of Different Levels of Nitrogen and Phosphorus Fertilizers on the Growth and Yield of Maize (*Zea mays* L.) in Southwest Nigeria. *International Journal Agricultural Resources*. 2009;4(6):193–203.
- Roth GW, Fox RH. Soil nitrate accumulations following nitrogen fertilizer corn in Pennsylvania. *Journal Environmental Quality*. 1990;19(2):243–248.
- Paradkar VK, RK Sharma. Effect of nitrogen fertilization on maize (*Zea mays*) varieties under rainfed condition. *Indian Journal Agron*. 1993;38(2):303–304.
- Maqsood M, AM Abid, A Iqbal, et al. Effect of variable rate of nitrogen and phosphorus on growth and yield of maize (golden). *Online Journal Biological Science*. 2010;1(1):19–20.
- Ayub M, MA Nadeem, MS Sharar, et al. Response of maize (*Zea mays* L.) fodder to different levels of nitrogen and phosphorus. *Asian Journal of Plant Science*. 2002;1(4):352–354.
- Sharar MS, M Ayub, MA Nadeem, et al. Effect of different rates of nitrogen and phosphorus on growth and grain yield of maize. *Asian Plant Science*. 2003;2(3):347–349.
- Jones MJ, Wild A. Soils of the West African savannah. Technical Communication No.55, Commonwealth Bureau of Soils, Harpenden. 1975.
- Tweneboah CK. *Modern Agriculture in the Tropics*. Ghana: Co-Wood Publishers, Accra. 2000.
- Msarmo K, W Mhango. Yields of Maize as Affected by Fertiliser Application Practices. *Bunda College of Agriculture*. 2000.
- Bangarwa AS, Kairon MS, Singh KP. Effect of plant density and level of nitrogen fertilizer on growth, yield and yield component of winter maize. 1988.
- Khalily M, Moghaddam M, Kanouni H, et al. Dissections of Drought Stress as a Grain Production Constraint of Maize in Iran. *Asian J Crop Sci*. 2010;2(2):60–69.
- Luchsinger LA, Opazo AJD, Netra VO. Response of sweet corn to nitrogen fertilization investigation Agricola. 1999.
- Sabir MR, Ahmad I, Shahzad MA. Effect of nitrogen and phosphorus on quality of two hybrids of maize (*Zea mays* L.). *Journal of Agricultural Research*. 2000;38(4):339–346.
- Younas M, H Rehman, Hayder G. Magnitude of variability for yield and yield associated traits maize hybrids. *Asian Journal of Plant Science*. 2002;1(6):694–696.
- Abd El Lattief EA. Nitrogen management Effect on the Production of Two Sweet Sorghum Cultivars under Arid Regions Conditions. *Asian J Crop Sci*. 2011;3(2):77–84.