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Effect of Time and Quantity of N-Fertilizer Application on Growth and Yield of Maize in Forest-Savannah Agro-Ecological Zone of Nigeria

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Abstract
Field experiments were carried out to determine the effects of application regimes of nitrogen fertilizer on growth and yield characteristics of two maize varieties (TZSR-Y-1 and DMR-LSR-Y) at the Students' Project Farm, Federal College of Agriculture, Ibadan, Nigeria. The experiments were conducted in a factorial randomized complete block design with three replications with three planting dates during the early season of 2015 and 2016. The treatments are F1 (60 kg N ha^{-1} basal application and 60 kg N ha^{-1} at 45 days after planting), F2 (40 kg N ha^{-1} basal application, 40 kg N ha^{-1} each at 45 and 60 days after planting), F3 (30 kg N ha^{-1} basal application, 30 kg N ha^{-1} each at 30, 45, and 60 days after planting), F4 (30 kg N ha^{-1} each at 30, 45, 60, and 75 days after planting) and F5 (Control). The results of the experiments revealed that, responses of the maize varieties to the basal application of 40kg N ha^{-1} before planting and 40kg N ha^{-1} at 45 and 60 days after planting had the significant highest plant heights for both varieties in 2015 and 2016. The control recorded the least significant values for both maize varieties and in both years. The regime and time of nitrogen fertilizer use significantly affected the yield parameters and yield of maize in both years of experimentation. Also, the two maize varieties had similar yield characteristics. The combined application of nitrogen fertilizer at the rate of 40 $kgha^{-1}$ at basal, 40 $kgha^{-1}$ at 45 and 60 days after planting is advised for optimum maize yield in the Nigeria forest-savannah.

Key words: Basal, Coping, Optimum regime, Savannah.

Introduction
Maize is a cereal crop that is grown widely throughout the world in a range of agro-ecological environments. Maize, commonly known as corn, is one of the most popular food crops in Africa. Maize is cooked in various ways and millions of Africans rely on it. Also, lot of daily diets would not have been possible without maize; a lot of animal products like eggs, meat, and milk production depend on maize. Maize has been in the diet of Nigerians for centuries and it is a versatile crop on which many agro-based industries depend as raw materials. For many people and civilizations, maize has since ancient times been a food, feed, commodity, construction materials, fuel, medicine or decorative plant. Its grain, stalk, leaves, cobs, tassels and silks have commercial values in most settings, though that of the grain is the greatest. With the industrial development, it is increasingly becoming an industrial raw material for the production of starch, gluten, oil, flavour, grits, alcohol and lingo-cellulose for further processing into a whole range of products and by-products (Skaggs *et al*, 2010).. About 75 percent of the kernel in starch, but the content depends on the maize type and variety. Maize cultivation is found in areas with adequate moisture. Life cycle of maize crop depends much upon water availability, the water deficit at any

phonological stage i.e. vegetative, reproductive and maturity stages have different response and can damage the grain yield (Chang *et al*, 2006).

In the present face of climate change due to global warming, the adoption of both research and operational use sustainable land and water management techniques is one of the absolute option to challenges of food insecurity across the globe. Climate is changing and the choice of coping strategies will depend on how regional and local climate in particular area is expected to change. For each degree (^{0}C) rise in air temperature, 6% state-averaged yield reduction has been predicted (Xu et al., 2016). Research results suggested that even if maize receives its entire water requirement under strong climate force scenario yields will still decrease by 10–20% by the end of the 21st century (Xu et al., 2016).

In Nigeria, several biotic and abiotic stresses are underpinning to confine the maize yield (Babatola, 2006). Generally, adaptation to climatic impacts on the agricultural sector has been a well introduced phenomenon. Different natural and socioeconomic systems have continuously been adapting autonomously where as in some places adaptation is in accordance with a plan of changing environment (Rehman *et al*, 2011). Short term adaptation strategies include activities like improved nutrient management (Adunni-Sanni and Werner, 2007; Iken and Amusa, 2004), changing the sowing time and time of fertilizer application (Ojeniyi, *et al* 2006). Incorporating this knowledge could play significant role in mitigating increasing risk of changing climate in Nigeria (Nnaji, 2001). The successive crop production depends not only on total, seasonal and annual rainfall but also on proper distribution of rainfall that best suits the agricultural calendar of maize Bello (2010). Bauder (2003) reported that 2-5% drop in grain yield of maize was noticed when planting date is moved by 12 day before and after optimum planting dates.

Application of chemical fertilizers in smallholder tropical farming systems has become mandatory because of soil degradation, and nitrogen (N) is the most abundantly used nutrient. Increasing the use of inputs like fertilizer is germane to raising agricultural productivity and reducing poverty in Nigeria. However, based on recent empirical evidence from Nigeria, simply increasing the quantity of fertilizer used by smallholders is not likely to successfully drive this process. A more holistic approach that addresses the constraints to fertilizer profitability in Nigeria with appropriate consideration of the factors which will increase the efficiency of fertilizer use is necessary. Fertilizer management is thus crucial for maize cultivation (Baral *et al*., 2015). Nitrogen is also a vital plant nutrient as well as major yield determining factor for maize production (Shanti *et al,* 1997). Its availability in sufficient quantity throughout the growing season is essential for optimum growth and yield of maize. Stewart et al. (2005) also reported that response of nitrogen and its application time to maize differs due to growing periods as losses of nitrogen takes place due to several reasons like leaching as well as volatilization from most of the soils.

This work is thus justified from the need to adequately synchronize the optimum time of nitrogen fertilizer application with the planting date of maize. This would be part of the holistic approach to climate change effects' mitigations. This study is therefore aimed at investigating the response of maize to time of nitrogen fertilizer application and planting time in forest-savannah agro-ecology of Nigeria.

Materials and Methods

Forest savannah eco-climatic zone of Nigeria has an average annual rainfall of about 1225mm, average annual maximum and minimum temperature of 34.8^{0}C and 24.3^{0}C respectively. The raining season commences around the end of the third dekad (10 days) of March and ends around the first dekad of November (NIMET, 2015). The experiment was carried out at students' project farm of the Federal College of Agriculture Ibadan, Nigeria (Longitude 7^{0}22$'$N, Latitude 3^{0}30$'$E) during the early planting season of 2015 and 2016. Preliminary soil assessment indicated that the soil of the experimental site was a well drained tropical soil classified as sandy-loam. Sand particles ranged from 586g kg^{-1} to 775 g kg^{-1}, clay ranged from 98g kg^{-1} to 256 g kg^{-1}and silt ranged from 117g kg^{-1} to 149g kg^{-1}. The pH of the soil ranged from 4.50 in subsoil to 5.4 in top soil. Organic carbon content ranged from 1.22g kg^{-1} in subsoil to 14.70g kg^{-1} at the surface. The corresponding total Nitrogen ranged from 0.14g kg^{-1} to 1.26g kg^{-1}. Available phosphorus was 8.47 mg kg^{-1} at the surface. Calcium ranged from 0.48 cmol kg^{-1} to 1.47cmol kg^{-1} while magnesium ranged from 0.80cmol kg^{-1} to 1.10cmol kg^{-1}. Sodium ranged from 0.33cmol kg^{-1} to 2.29cmol kg^{-1} while the exchangeable potassium ranged from 0.06cmol kg^{-1} to 0.15cmol kg^{-1}.

The land was ploughed twice and harrowed once during the planting seasons. Three planting dates selected during the early seasons of both years. The selected dates are 4th April (D1), 18th April (D2) and 2nd May (D3) for 2015 and 7th April (D1), (21st April (D2) and 5th May (D3) for 2016. The experiment was a factorial experiment distributed in a randomized complete block design with 3 replicates during the two planting seasons. One early maturing and one late maturing varieties of maize were used as test crops. These were TZSR-Y-1 (Streak Resistant) and DMR-LSRY (Downy Mildew & Streak Resistant). The seeds were sown to a soil depth of 3 – 5 cm. Seeds were sown per spot at a spacing of 50 cm within the row and 75 cm between rows. Thinning of excess seedlings and supplying of un-germinated seeds were carried out 2weeks after planting while weeding was carried out using cutlass and hand removal of weeds two weeks after planting and at two weeks interval. Also, five metre wide around the farm plot was also manually slashed to prevent rodent attacks, especially grass-cutters.

Data on growth and yield parameters of randomly selected maize plants in each plot were collected. Growth parameters determined include plant height, leaf area, and number of leaves and stem girth. Plant height was measured from soil level up to the tip of highest leaf with a tape meter rule. Stem diameter was measured with the aid of Vernier Caliper from top middle and bottom portion of the same stem and the averages calculated. The leaf area per plant was calculated using:

$$\text{Leaf Area (LA)} = x \times y \times 0.75$$

Where *x* is the leaf length, *y* is the widest middle portion of the leaf and 0.75 is the correction factor

Yield parameters considered include ear height, cob length, cob diameter, 100 seed weight and grain yield at 12.5% moisture content. Harvesting took place at 13weeks after planting and the yield components of maize determined include weight of stover, number of harvested cobs, weight of dehusked cobs, and weight of shelled grain at 15 % moisture content. Data collected on growth and yield parameters were subjected to analysis of variance (ANOVA) using Statistical Analysis System Package (Version 9) and significantly different means were separated using Duncan's Multiple Range Test (DMRT).

Results and Discussion

Table 1 shows the results of the effects of quantity and time of Nitrogen fertilizer application on growth of TZSR-Y-1 variety of maize planted at different dates. The results showed that quantity and time of Nitrogen fertilizer application have a significant effect on growth parameters of maize. Maize planted at the onset of rainfall with the treatment 40kg/ha of N-fertilizer at basal, 40 $kgha^{-1}$ of N-fertilizer at 45 and 60 days after planting having the highest plant height (155cm) and (149cm) for TZSR-Y-1 maize variety of maize planted in the years 2015 and 2016 respectively. Plant height was least at plots where no treatment (control) was applied irrespective of the dates and year of planting. Plant height has been described as a measure of growth related to the efficiency in exploration of environmental resources (Alhimohamadhi *et al.,* 2011). There is a high correlation between plant height and yield parameters of maize (Saheed *et al.*, 2001). Also in Table 1, it was noticed that other growth parameters considered in this study (stem girth, number of leaves and leave area) followed the same trend as that of plant height.

Generally, DMR-LSRY variety of maize subjected to F2 (40 $kgha^{-1}$ of N-fertilizer at basal, 40 $kgha^{-1}$ of N-fertilizer at 45 and 60 days after planting having the highest) has the highest vegetative growth irrespective of the time and year of planting. This was followed by the variety of maize subjected to F3 (30 kg Nha^{-1} basal application, 30 kg Nha^{-1} each at 30, 45, and 60 Days after planting). It was shown on the table that, there was a decrease in the vegetative performance of the variety of maize planted with delayed planting irrespective of the treatment it was subjected to. This is in accordance with previous work carried out by Adetayo and Dauda (2006) that maize vegetative growth decreased with delayed planting.

The results of the effects of planting date, quantity and time of Nitrogen fertilizer application and time of planting on growth of DMR-LSRY variety of maize is shown in Table 2. Similar trend in terms of vegetative growth was common among the varieties planted at the onset of rainfall with treatment 40 $kgha^{-1}$ of N-fertilizer at basal, 40 $kgha^{-1}$ of N-fertilizer at 45 and 60 days after planting having 142.8cm and 138.5cm during the years 2015 and 2016, respectively. This was also followed by TZSR-Y-1 maize subjected to F3 (30 kg N ha^{-1} basal application, 30 kg N ha^{-1} each at 30, 45, and 60 Days after planting) and lastly maize planted with no treatment (control)

The results of the yield parameters of TZSR-Y-1 variety maize planted during the 2015 and 2016 planting season is as presented in table 3. The result further ascertain the work carried out by Saheed et al., 2001 that there is a high correlation between plant height and yield parameters of maize.

Table 1: Effects of time and quantity of Nitrogen application and planting time on growth parameters of TZSR-Y-1

Treatment	Plant height (cm)		Stem girth (cm)		No. of leaves		Leaf area (cm^2)	
	2015	2016	2015	2016	2015	2016	2015	2016
$V_1F_1D_1$	126.4	120.2	2.4	2.3	13	13	662.5	636.2
$V_1F_1D_2$	124.3	115.8	2.4	2.3	13	13	598.6	603.5
$V_1F_1D_3$	120.8	109.5	2.3	2.3	13	12	564.4	572.6
$V_1F_2D_1$	155.7	149.2	2.9	2.2	13	13	750.4	724.5
$V_1F_2D_2$	148.6	142.6	2.8	2.1	12	13	742.6	705.3
$V_1F_2D_3$	140.2	137.8	2.6	2.1	13	12	712.2	664.5
$V_1F_3D_1$	149.6	140.4	2.1	2.0	13	13	665.6	622.8
$V_1F_3D_2$	144.2	133.5	1.9	1.9	13	12	624.2	601.5
$V_1F_3D_3$	138.4	125.4	1.7	1.8	13	13	602.8	586.3
$V_1F_4D_1$	146.5	140.1	2.0	2.2	12	13	588.2	564.3
$V_1F_4D_2$	141.2	130.7	1.8	2.0	13	13	542.6	532.4
$V_1F_4D_3$	130.4	124.5	1.6	1.8	12	12	504.3	498.7
$V_1F_5D_1$	116.4	107.2	1.3	1.0	12	11	324.5	306.5
$V_1F_5D_2$	109.6	100.1	1.0	0.8	11	12	302.6	287.3
$V_1F_5D_3$	98.5	96.4	0.8	0.6	10	10	297.8	254.2
LSD	10.3	9.7	0.7	0.6	0.3	0.4	11.4	12.4

V1- Variety 1(TZSR-Y-1); F1 – 60 kg Nha^{-1} basal application and 60 kg Nha^{-1} at 45 DAS F2 – 40 kg Nha^{-1} basal application, 40 kg Nha^{-1} each at 45 and 60 DAS; F3 – 30 kg Nha^{-1} basal application, 30 kg Nha^{-1} each at 30, 45, and 60 DAS; F4 – 30 kg Nha^{-1} each at 30, 45, 60, and 75 DAS; F5 – Control; D1 – Day 1 (4th April,2015); D2 - Day2 (18th April, 2015); D3 – Day3 (2nd May, 2015) for 2015 and D1 – Day 1 (7th April, 2016); D2 - Day2 (21st April, 2016); D3 – Day3 (5th May, 2016) for 2016.

Table 2: Effects of time of Nitrogen application and planting time on growth parameters of DMR-LSRY

Treatment	Plant height (cm)		Stem girth (cm)		No. of leaves		Leaf area (cm^2)	
	2015	2016	2015	2016	2015	2016	2015	2016
$V_2F_1D_1$	123.5	121.5	2.5	2.4	13	13	624.5	612.3
$V_2F_1D_2$	120.7	115.6	2.4	2.4	13	13	602.6	594.5
$V_2F_1D_3$	116.3	109.4	2.4	2.3	13	12	588.8	568.7
$V_2F_2D_1$	142.8	138.5	2.8	2.6	14	14	668.2	642.5
$V_2F_2D_2$	139.2	132.7	2.7	2.5	13	13	623.5	615.8
$V_2F_2D_3$	135.7	124.9	2.6	2.5	13	12	604.3	586.7
$V_2F_3D_1$	137.4	125.4	2.4	2.3	13	14	608.2	596.4
$V_2F_3D_2$	136.2	122.2	2.4	2.3	12	12	586.3	574.5
$V_2F_3D_3$	129.8	112.9	2.3	2.3	12	13	548.5	541.7
$V_2F_4D_1$	136.2	121.4	2.1	1.9	13	13	589.4	572.8
$V_2F_4D_2$	133.5	120.2	1.9	1.8	13	13	556.3	543.4
$V_2F_4D_3$	128.7	109.5	1.9	1.9	12	12	534.8	521.6
$V_2F_5D_1$	105.9	100.1	1.2	1.0	10	11	309.5	300.2
$V_2F_5D_2$	100.4	97.5	0.9	0.9	10	10	285.3	274.5
$V_2F_5D_3$	92.7	93.5	0.8	0.7	10	10	222.5	202.3
LSD	10.1	9.5	0.3	0.3			11.4	12.1

V2- Variety 2 (DMR-LSRY); F1 – 60 kg Nha^{-1} basal application and 60 kg Nha^{-1} at 45 DAS F2 – 40 kg Nha^{-1} basal application, 40 kg Nha^{-1} each at 45 and 60 DAS; F3 – 30 kg Nha^{-1} basal application, 30 kg Nha^{-1} each at 30, 45, and 60 DAS; F4 – 30 kg Nha^{-1} each at 30, 45, 60, and 75 DAS; F5 – Control; D1 – Day 1 (4th April,2015); D2 - Day2 (18th April, 2015); D3 – Day3 (2nd May, 2015) for 2015 and D1 – Day 1 (7th April, 2016); D2 - Day2 (21st April, 2016); D3 – Day3 (5th May, 2016) for 2016.

Table 3: Effects of time of Nitrogen application and planting time on yield parameters of TZSR-Y-1

Treatment	Cob height (cm)		Cob diameter (cm)		100 grain wt (g)		Grain yield (kg ha^{-1})	
	2015	2016	2015	2016	2015	2016	2015	2016
$V_1F_1D_1$	16.5	16.2	4.3	4.2	25.4	25.0	3002.4	2997.5
$V_1F_1D_2$	16.2	15.8	4.3	4.1	24.8	25.0	2984.5	2852.2
$V_1F_1D_3$	15.9	15.0	4.2	4.1	24.6	24.0	2847.6	2684.5
$V_1F_2D_1$	17.6	17.1	4.8	4.6	27.5	26.8	3102.6	3052.2
$V_1F_2D_2$	16.8	16.4	4.2	4.0	27.5	25.8	3091.2	3005.7
$V_1F_2D_3$	16.4	15.2	4.2	4.0	26.8	28.4	2986.3	2892.5
$V_1F_3D_1$	16.2	15.9	4.0	4.0	25.5	26.1	2946.2	2894.2
$V_1F_3D_2$	15.8	15.2	3.8	4.0	24.6	25.1	2764.5	2772.8
$V_1F_3D_3$	14.4	14.7	3.7	3.8	24.0	24.0	2648.3	2688.3
$V_1F_4D_1$	15.8	15.2	4.0	3.8	25.1	25.0	2842.5	2746.5
$V_1F_4D_2$	15.2	14.3	4.0	3.8	25.0	24.5	2686.7	2734.7
$V_1F_4D_3$	14.8	13.9	3.8	3.6	24.1	24.5	2548.3	2556.8
$V_1F_5D_1$	12.4	11.4	3.2	2.8	18.1	15.4	1902.1	1842.5
$V_1F_5D_2$	11.2	10.5	2.8	2.1	15.5	15.1	1603.3	1651.2
$V_1F_5D_3$	10.1	9.8	2.6	2.0	15.1	12.4	1504.8	1487.3
LSD	1.4	1.6	1.1	0.9	2.4	1.6	12.4	13.5

V1- Variety 1(TZSR-Y-1); F1 – 60 kg Nha^{-1} basal application and 60 kg Nha^{-1} at 45 DAS F2 – 40 kg Nha^{-1} basal application, 40 kg Nha^{-1} each at 45 and 60 DAS; F3 – 30 kg Nha^{-1} basal application, 30 kg Nha^{-1} each at 30, 45, and 60 DAS; F4 – 30 kg Nha^{-1} each at 30, 45, 60, and 75 DAS; F5 – Control; D1 – Day 1 (4th April,2015); D2 - Day2 (18th April, 2015); D3 – Day3 (2nd May, 2015) for 2015 and D1 – Day 1 (7th April, 2016); D2 - Day2 (21st April, 2016); D3 – Day3 (5th May, 2016) for 2016.

The yield parameters of maize (cob weight, cob diameter, 100g weight and grain yield) were highest when the maize planted were treated with 40kgha-1 of N-fertilizer at basal, 40 kgha-1 of N-fertilizer at 45 and 60 days after planting (17.6cm, 4.8cm, 27.5g and 3102kg/ha respectively in 2015 and (17.1cm, 4.6cm, 26.8g and 3053.2kg/ha) in 2016. This is followed by the maize variety treated with 30 kg N ha-1 basal application, 30 kg N ha-1 each at 30, 45, and 60 days after planting, while the least was found with the one with no treatment (F5). Table 4 shows the results of the yield parameters DMR-LSRY varieties of maize planted during the 2015 and 2016 planting season. The results further indicates that growth parameters have strong influence on yield characteristics of maize. The highest ultimate yield was found with maize treated with F2, followed by those treated with F3 and the least found with those with no treatment (F5). Also, grain yield decreased with delayed planting irrespective of the year of planting.

Conclusion

Planting time, quantity and time of Nitrogen fertilizer application were established to have significant influence on the growth and yield of maize. It was also revealed that maize growth and yield was enhanced by the application of Nitrogen fertilizer at the rate of 40kgha^{-1} at basal, 40 kg/ha at 45 and 60 days after planting. Varietal responses of maize selected for test

Table 4: Effects of time of Nitrogen application and planting time on yield parameters of DMR-LSRY

Treatment	Cob height (cm)		Cob diameter (cm)		100 grain wt (g)		Grain yield (kg ha^{-1})	
	2015	2016	2015	2016	2015	2016	2015	2016
$V_2F_1D_1$	16.0	15.8	4.3	4.0	26.3	26.0	2974.5	2967.5
$V_2F_1D_2$	15.6	15.0	4.2	4.0	26.0	26.0	2842.7	2756.3
$V_2F_1D_3$	15.1	14.6	4.2	4.0	26.2	26.1	2751.3	2586.4
$V_2F_2D_1$	17.2	16.8	4.5	4.1	28.7	28.5	3006.5	2986.5
$V_2F_2D_2$	16.7	16.1	4.3	4.0	28.5	28.5	2975.3	2846.2
$V_2F_2D_3$	15.2	15.2	4.3	4.2	28.6	27.5	2804.5	2792.5
$V_2F_3D_1$	15.8	15.2	4.0	3.9	27.4	27.4	2862.5	2842.3
$V_2F_3D_2$	15.0	14.6	3.8	3.8	27.2	27.1	2654.3	2632.8
$V_2F_3D_3$	14.4	14.0	3.8	3.8	27.1	27.0	2546.8	2495.7
$V_2F_4D_1$	15.2	14.8	3.8	3.7	26.5	26.5	2764.2	2758.3
$V_2F_4D_2$	14.8	14.0	3.9	3.8	26.6	25.1	2552.8	2457.3
$V_2F_4D_3$	13.9	13.4	3.6	3.7	27.0	25.0	2486.3	2256.8
$V_2F_5D_1$	10.8	9.8	2.6	2.4	15.2	14.8	1802.3	1794.5
$V_2F_5D_2$	9.2	9.0	2.6	2.1	14.9	14.1	1497.5	1539.2
$V_2F_5D_3$	8.4	8.0	2.1	2.0	15.0	13.5	1336.5	1357.8
LSD	2.4	2.2	1.4	1.2	2.5	2.6	12.8	13.4

V2- Variety 2 (DMR-LSRY); F1 – 60 kg Nha^{-1} basal application and 60 kg Nha^{-1} at 45 DAS F2 – 40 kg Nha^{-1} basal application, 40 kg Nha^{-1} each at 45 and 60 DAS; F3 – 30 kg Nha^{-1} basal application, 30 kg Nha^{-1} each at 30, 45, and 60 DAS; F4 – 30 kg Nha^{-1} each at 30, 45, 60, and 75 DAS; F5 – Control; D1 – Day 1 (4th April,2015); D2 - Day2 (18th April, 2015); D3 – Day3 (2nd May, 2015) for 2015 and D1 – Day 1 (7th April, 2016); D2 - Day2 (21st April, 2016); D3 – Day3 (5th May, 2016) for 2016.

was however not significantly different. The combined application of Nitrogen fertilizer at the rate of 40kg ha^{-1} at basal, 40 kg ha^{-1} at 45 and 60 days after planting and early planting is therefore advised for optimum maize yield in forest-savannah eco-climatic region of Nigeria. The study is also recommended to be conducted in other agro-ecological zones of Nigeria.

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