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Research paper

Growth and yield performances of three maize cultivars *(Zea mays* L.) as influenced by time of N-fertilizer application

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The sufficient supply of N-fertilizer in maize crop is imperative for optimum performance. However, timing of application of this nutrient may create variation in yield performances of the crop. A field experiment was conducted during the 2021 raining season to investigate the effect of time of N-fertilizer application on growth and yield of three maize cultivars at Prince Abubakar Audu University Research and Demonstration farm, Anyigba. The experiments which were laid in a Randomized Complete Block Design (RCBD) consisted of 9 treatment combination; 3 maize cultivars [(Oba-Super 6 (hybrid), Samaz-52 (OPV) and Local cultivar] and 3 stages of N- fertilizer (3WAS, at tasseling and at silking). Time of N-fertilizer application does not significantly influence ($P \geq 0.05$) the number of leaves/plant, plant height at 4 and 6WAS, days to first flowering, days to 50% flowering cob length and number of cobs/plant. However, application of N-fertilizer at 3WAS significantly produced ($P \leq 0.05$) higher biomass and application of N-fertilizer at silking stage significantly improved number of seeds produced per cob, 100-seed weight and final grain yield followed by application at tasseling stage. Similarly, Varieties had no significance on the leaf area except the yield and yield components. However, Samaz-52 (OPV) displayed earlier days to first flowering and days to 50% flowering respectively. Oba-super-6 (hybrid) produced significantly higher number of seeds/cob. Samaz-52 (OPV) produced significantly higher grain yield (3398.16 kg/ha) followed by the Local Cultivar (2537.05 kg/ha) and the Oba-Super 6 (hybrid) which recorded the least grain yield (1851.86 kg/ha). Finally, it appears that application of nitrogen at silking stage gave a yield as high as its' application at 3 weeks after sowing. Therefore, application of N-fertilizer in two split doses (first at 3WAS and top dress at silking stage) is highly recommended for the planting of Samaz-52 (OPV) which appears to be promising in grain yield than Oba super-6 and the local variety.

Key words: *N-fertilizer, days to first flowering, days to 50% flowering, final grain yield, 100-seed weight, cultivar and interaction*

INTRODUCTION

Maize productivity is a complex trait dependent on several factors, varying from genetic cultivar characteristics, meteorological conditions during cultivation and different fertilization managements. Modern maize genotypes are highly responsive to the use and time of N-fertilizer application which translate directly or indirectly yield (Rizzardi et al., 2008; Queiroz et al., 2011). Nitrogen presents great dynamics in the soil due to numerous chemical and biological reactions (Cantarella & Duarte, 2004) that result in a complex management of N fertilization Schiavinatti et al. (2011). Only a part of the N applied is absorbed by the plants as the remainder is lost in the soil-plant-atmosphere system by leaching, volatilization, erosion and denitrification processes, with a fraction remaining in the soil in the organic form (Dhital et al., 2016). Improper timing of Nitrogen use may cause crop to be less productive and making Nitrogen unfavorable for use during the reproductive stage of the plants' growing season. Therefore, deriving a proper time for application of Nitrogen during the phonology of the crop when the fertilizer could be most efficiently and effectively utilized by the crop while ensuring minimal losses is essential in management of the crop. However, the domain of knowledge related to time of N-fertilizer application is essential to better understand and improve the efficiency of Nitrogen use by plants, maximize productivity and reduce their excess in the environment (Hurtado et al., 2009; Cui et al., 2010; Prando et al., 2013). Apparently, definitions of the time of application are the main alternatives for increasing nitrogen use efficiency and mitigating its losses and hazard to the environment (Cantarella, 2007; Schiavinatti et al., 2011). However, an alternative for mitigating N losses is through the application of "Slow-release Urea"; a recent technology in production of Polymer-coated Urea reported in several studies (Cahill et al., 2010; Civardi et al., 2011; Almeida & Sanches, 2012). Despite the higher cost of its acquisition, coated Urea is able to provide a gradual release of this nutrient to the plants throughout the growing cycle which in turn reduces loss to the environment (Valderrama et al., 2009; Drinkwater and Snapp, 2007; Cantarella, 2008; Valderrama et al., 2011). According to Vitti & Reirinchs (2007), this gradual release is the result of the slower dilution process in the soil compared to common urea, in addition to meeting the N requirement of the crop over the time (Zheng et al., 2017).

Conventionally, two split dose methods (half N as basal dose and other half at the Knee high stage) have been made inevitable basically in maize production. Hanway (2003), reported that the use of smaller quantity of nitrogen at initial growth stages of plant greatly lowers the rate of N absorption by the plant. In maize, Nitrogen uptake becomes faster at the mid-point of its vegetative growth, and gets to its peak point at silking stage. Therefore, applying N at early growth stage improves yield, growth and development of plants vegetative parts. However, delayed application of N (i.e at later stage of plant growth) consequently delays maturation which does not adequately translate to final yield. Grain nitrogen may however increase and be used in later growth stages (Sankaran & Subbiah 2017). Application of Nitrogen during the tasseling and silking stages has proven to be an excellent method of fulfilling a higher demand for Nitrogen use in maize production. Several authors have experimented varying N-application time on maize crop. Bhattarai et al. (2014) reported maximized yield of corn grain from 3 split equal doses up to 60 kg/ha nitrogen applied at sowing, earthling up and silking stages respectively. Peak grain yield and increased yield of plant biomass has been reported on application of 80 kg N/ha in two split doses (first as basal application at planting, second as side-dress during knee-high stage respectively), which result to a higher cost-benefit ratio of 1:5 (Nurudeen et al., 2015).

This research seeks to investigate and establish the best time of N-fertilizer application on maize varieties in Anyigba environment to help maize farmers undertake a profitable venture in maize production, reduce wastage of fertilizer as well as environmental degradation (pollution).

MATERIALS AND METHODS

This experiment was undertaken during the 2021 farming season at Prince Abubakar Audu University Student Research Farm, Anyigba, Kogi State, Nigeria, (Lat 7^{o} 29' N; Long 7^{o} 11' E) on elevation of 420 m above sea-level, which is located within the Southern Guinea Savannah Ecological Zone of Nigeria. It is characterized by an average rainfall of about 180 mm mostly distributed between the months of April and October. Mean monthly minimum and maximum temperature of about 17^{o} C and 36.2^{o} C respectively. The soils generally are sandy to sandy-loam. Temperature shows some variation throughout the years. Mean Monthly temperature varies between 15.1^{o} C and 31.3^{o} C. (Metrological Station Data, 2019). Soil sample from the experimental location was obtained using tubular auger, bulked and analyzed for its physio-chemical properties at the Soil and Environmental Management Laboratory, Prince Abubakar Audu University, Anyigba (results presented in Table 1). Conventional land preparation was conducted with a tractor, seed beds were made into ridges of 3m long and 0.75m from each other.

Treatment and experimental design

The experiment consisted of; 3 maize cultivars [(Oba-Super 6 (hybrid), Samaz-52 (OPV) and Local cultivar] and time of N-fertilizer application (at 3WAS, at tasseling and at silking), factorially combined to give a total of 9 treatments altogether. The experiment was laid out in a Randomized complete block design (RCBD) and replicated 3 times; a total of 27plots was obtained. Each plot measured 3m x 3m (9m^2) containing about 4 ridges. Each replicate was separated 1m apart while an inter plot spacing of 0.2m was adopted. To avoid being biased, treatments were assigned to each plot using a random number system. Total land area used for the experiment measures 28.6m × 11m = 314.6m^2.

120kg N/ha equivalent to 260kg Urea/ha fertilizer was used. Applied in 3split dose; first 86kg/ha (eq. 77.4 gm/plot) at 3WAS, second dose 86kg/ha (eq. 77.4 gm/plot) at tasseling and third dose 86kg/ha (eq. 77.4 gm/plot) at silking stages respectively.

Cultural practices and data collection

Maize seeds were sown by precision method manually on ridges using a cutlass at a spacing of 25cm x 75cm and seedlings were thinned to two (2) plants per stand after germination. Caterpillar force was used in the control of army worms and stem borer at 100 – 150g a.i /ha. Ten (10) plants per plot were tagged, and all measurements taken from the three plants were averaged. Data on growth and yield characters and yield such as plant height (cm); days to 1st and 50% flowering; leaf area; number of leaves/plant; number of grains/cob; 100-seed weight; number of cobs/plant; grain weight/cob; length of cob/plant; final grain weight (yield kg/ha) were measured.

Analysis of data

Data on growth and yield parameters were subjected to Analysis of Variance (ANOVA) using Statistical Analysis System (SAS) and significantly different treatment means ($P<0.05$) were separated using the Fisher's Least Significant Difference (F-LSD) procedure.

RESULTS AND DISCUSSION

Table 1 shows the physical and chemical characteristics of the soil taken from the experimental Site before the conduct of the experiment. The result shows that experimental site revealed weak acidity (pH 6.13), sandy-clay loam with very low available nitrogen, organic matter and carbon and a bit higher phosphorus with the presence of other exchangeable cations.

Plant Height and Days to Flowering

Table 2 shows the effect of time of N-fertilizers, cultivars and interaction T x V on plant height and days to emergence. At 4 and 6WAS, time of N-fertilizer application, cultivar, and interaction had no significant influence ($P \geq 0.05$) on plant height and days to flowering (first and 50%). However, there was a significant effect observed at 8WAS as N-application at 3WAS produced the tallest plants (146.98cm) which was close to the heights produced when N was applied at tasseling (138.82cm).

Table 1. Response of Maize growth characters to time of N-fertilizer application and Cultivars in Anyigba Environment

Soil Properties	Depth (0-30cm)
Physical properties	
Sand (%)	86.24
Silt (%)	2.61
Clay (%)	11.15
Textural Class	Sandy-Clay-Loam
Chemical Properties	
pH in H_2O (1:2:5)	6.13
Organic Carbon (%)	0.51
Organic Matter (%)	0.88
Total Nitrogen (%)	0.03
Available Phosphorus (mg/kg)	9.00
Exchangeable Cation (meg/100gm Soil)	
K^+	2.75
Mg^{2+}	1.97
Ca^{2+}	4.16
Na^+	0.95

N-application at silking stage produced the shortest plant though (136.34cm), but this was not significantly different from those obtained when N was applied at tasseling. Similarly, the Local cultivar produced the tallest plants (148.09cm). heights obtained with Samaz-52 (OPV) and Oba-Super 6 (hybrid) were statistically at par. Variety significantly influenced days to first and 50% flowering as time of N application showed no significant differences. Oba-Super 6

Table 2. Maize height, days to 1st and 50% flowering of three maize varieties *(Zea mays. L.)* as influenced by time of N-fertilizer application in Anyigba, Kogi State

Treatment	Sampling Periods				
	Plant Height (cm)			Days to first flowering	Days to 50% flowering
	4WAS	6WAS	8WAS		
Time of N-application					
At 3WAS	40.04	76.21	146.98a	46.67	54.56
At tasseling	34.40	77.74	138.82ab	47.00	54.56
At silking	40.01	69.81	136.34b	45.56	54.67
Significance	ns	ns	*	ns	ns
LSD $_{(0.05)}$			8.64		
Variety					
Oba-Super 6 (hybrid)	35.89	71.09	135.58b	48.33a	55.00a
Samaz-52 (OPV)	37.32	72.19	138.48b	42.11b	52.33b
Local cultivar	41.24	80.49	148.09a	48.78a	56.44a
Significance	ns	ns	*	*	*
LSD $_{(0.05)}$			8.64	2.18	1.50
Interaction					
T × V	ns	ns	*	ns	*
C.V (%)	**16.49**	**16.99**	**13.48**	**5.01**	**2.82**

WAS = Weeks After Sowing
ns = not significant at 5% level of test
* = significant at 5% level of test

(hybrid) and the Local cultivar performed the same as their first flower and 50% flower was achieved earlier than the Samaz-52 (OPV).

Table 3. Interaction of three maize varieties and time of N-fertilizer application on plant height (cm) of maize crop at 8WAS in Anyigba, Kogi State

Variety	Time of Nitrogen application		
	3WAS	At tasseling	At silking
Oba-Super 6 (hybrid)	144.70^{b}	137.16^{bc}	124.86^{c}
Samaz-52 (OPV)	144.72^{b}	138.20^{b}	132.50^{bc}
Local cultivar	151.50^{ab}	133.66^{bc}	159.10^{a}
		SE ± = 4.48	

Means followed by the same latter(s) within a sampling period are not significantly different at 5% level of probability using N-DMRT

Table 4. Interaction of three maize varieties and time of N-fertilizer application on days to 50% flowering of maize crop in Anyigba, Kogi State

Variety	Time of N-application		
	3WAS	At tasseling	At silking
Oba-Super 6 (hybrid)	55.33^{ab}	54.33^{b}	55.33^{ab}
Samaz-52 (OPV)	51.00^{b}	53.00^{b}	53.00^{b}
Local cultivar	57.33^{a}	56.33^{ab}	55.66^{ab}
		SE ± = 0.93	

Means followed by the same latter(s) within a sampling period are not significantly different at 5% level of probability using N-DMRT

Table 5. Leaf Area and Number of Leaves of three maize varieties *(Zea mays. L.) as* influenced by the time of N-fertilizer application in Anyigba, Kogi State

Treatment	Sampling Periods					
	Leaf Area (cm)			Number of Leaves		
	4WAS	6WAS	8WAS	4WAS	6WAS	8WAS
Time of N-application						
At 3WAS	308.19a	333.46a	338.88a	8.78	10.00	12.11
At tasseling	247.03b	271.93b	279.83b	8.00	9.44	11.33
At silking	254.83b	278.56b	269.39b	8.11	10.11	11.22
Significance	*	*	*	ns	ns	ns
LSD $_{(0.05)}$	46.19	36.70	48.98			
Variety						
Oba-Super 6 (hybrid)	263.72	294.04	279.83b	7.78b	9.78	10.56b
Samaz-52 (OPV)	253.04	280.59	274.22b	8.44ab	9.67	11.67a
Local cultivar	293.29	309.31	334.04a	8.67a	10.11	12.44a
Significance	ns	ns	*	*	ns	*
LSD $_{(0.05)}$			51.42	0.70		1.01
Interaction						
T × V	ns	ns	ns	ns	ns	ns
C.V (%)	**18.11**	**13.82**	**14.86**	**7.61**	**9.54**	**7.42**

WAS = Weeks after sowing, ns = not significant at 5% level of test

* = significant at 5% level of test

Interaction of T x V was significant for days to 50% flowering. T × V interaction was significant at 8WAS. The Local cultivar responded to N-application at 3WAS and at silking stage more than other times of application (table 3), by producing taller plants (151.5cm, 159.1cm) respectively. Responses by other cultivars at varying time of N-application were statistically not significant. Oba-Super 6 (hybrid) and Samaz-52 (OPV) behaved poorly at tasseling and silking stage of N-fertilizer application. Similarly, Local cultivar had the highest response to 50% flowering under the influence of N-fertilizer application at 3WAS. This was however not significantly different from those obtained at tasseling and silking stage (Table 4). Other cultivars behaved in similar manner.

Leaf area and number of leaves

Time of N-fertilizer application significantly influenced Leaf area at 4, 6 and 8WAS ($P \leq 0.05$) but had no significant influence ($P \geq 0.05$) on number of leaves at all sampling stages respectively (table 5). The highest leaf area was obtained throughout the sampling periods when N was applied at 3WAS. N application at tasseling and silking stages produced leaf areas that are statistically at par. Variety had significant effect on leaf area only at 8WAS, Local cultivar produced plants with the highest leaf area (334.04cm^2). leaf area produced by Oba-Super 6 (hybrid) and Samaz-52 (OPV) are not significantly different. Similarly, number of leaves was significantly influenced by variety only at 4 and 8WAS, the Local cultivar produced plants with the highest number of leaves (8.67, 12.44) respectively. At 4WAS, the two other cultivars produced leaves that are significantly not different. Leaves produced by Local cultivar were significantly not different from those of Samaz-52 (OPV) at 8WAS. Interaction of T x V had no significant influence on both leaf area and number of leaves at all sampling stages (Table 5). Significant influence of time of N fertilizer application on the growth characters supports the fact that N essentially influenced grain purity and viability which translates to better grinding characteristics of the grain (Blumenthal et al., 2018). Nitrogen is also a key player in efficient regulation of nutrients absorption in the plant therefore, influencing various plant cells activities, physiologically and biochemically and ultimately, growth and development (Brady, 2010). Our results corroborate with the findings of Hanway, (2003), who stated that late application of N cause reduction in crop performance and unfavorable availability of N during growing seasons of maize.

Table 6. Influence of time of N-fertilizer application on number of seeds/cob, cob length, number of cobs/plant and grain weight/cob of three maize varieties *(Zea mays. L.)* in Anyigba, Kogi State

Treatment	Number of seeds/cob	Cob length (cm)	Number of cobs/plant	Grain weight/cob (cm)
Time of N-application				
At 3WAS	301.42b	13.08	1.53	71.88
At tasseling	300.89b	12.58	1.53	69.18
At silking	322.26a	12.46	1.61	65.84
Significance	*	ns	ns	ns
LSD $_{(0.05)}$	18.83			
Variety				
Oba-Super 6 (hybrid)	327.88a	12.77	1.61	67.22
Samaz-52 (OPV)	294.40b	12.27	1.61	68.13
Local cultivar	302.29b	13.08	1.46	71.54
Significance	*	ns	ns	ns
LSD $_{(0.05)}$	18.83			
Interaction				
T × V	*	ns	ns	ns
C.V (%)	**13.63**	**13.22**	**19.56**	**15.94**

ns = not significant at 5% level of test
* = significant at 5% level of test

Table 7. Interaction of three maize varieties and time of N-fertilizer application on number of seeds per cob of the crop in Anyigba, Kogi State

Variety	Time of Nitrogen application		
	3WAS	At tasseling	At silking
Oba-Super 6 (hybrid)	318.76^{c}	301.76^{d}	363.10^{a}
Samaz-52 (OPV)	291.53^{de}	266.23^{e}	325.43^{c}
Local cultivar	193.96^{f}	334.66^{b}	278.23^{e}
		SE± = 4.53	

Means followed by the same latter(s) are not significantly different at 5% level of probability using N-DMRT.

Table 8. Influence of time of N-fertilizer application on 100-seeds weight and final grain yield of three maize varieties *(Zea mays. L.)* in Anyigba, Kogi State

Treatments		
Time of N-application	**100-Seeds Weight (g)**	**Final Grain Yield (kg $^{-1}$)**
At 3WAS	25.56b	2601.85b
At tasseling	26.67ab	2981.50ab
At silking	27.78a	3203.72a
Significance	*	*
LSD $_{(0.05)}$	2.10	504.15
Variety		
Oba-Super 6 (hybrid)	27.78a	1851.86c
Samaz-52 (OPV)	25.56b	3398.16a
Local cultivar	26.67ab	2537.05b
Significance	*	*
LSD $_{(0.05)}$	2.10	504.15
Interaction		
T × V	ns	ns
C.V (%)	**30.30**	

ns = not significant at 5% level of test; * = significant at 5% level of test

Response of maize yield characters to time of N-fertilizer application and cultivars in Anyigba environment

Results of time of N-fertilizer application, cultivar and T x V interaction on number of seeds/cob, cob length, number of cobs/plant and grain weight/cob are presented in table 6. Time of N-fertilizer application, variety and T x V interaction significantly influence ($P \leq 0.05$) number of seeds/cob as other characters such as cob length, number of cobs/plant and grain weight/cob had no significant influence ($P \geq 0.05$). Application of N-fertilizer at silking yielded the highest seed/cob followed by those obtained at tasseling. However, yield at 3WAS and at tasseling was statistically indifferent for number of seeds/cob. Oba-Super 6 (hybrid) produced the highest number of seeds/cob. However, yields obtained with local variety and Samaz-52 (OPV) was statistically at par. Table 7 present the T x V interaction on number of seeds/cob. Oba-Super 6 (hybrid) responded better to N-application at silking than others. However, the Local cultivar responded to N-application for number of seeds/cob at tasseling while the highest response recorded for Samaz-52 (OPV) was at silking.

100-seed weight and final grain yield

Time of N-fertilizer application and Cultivar on 100-seed weight and final grain yield was significant (table 8). Highest 100-seed weight and final grain yield was achieved when N-fertilizer was applied at silking stage. This was followed by yield obtained when N was applied at tasseling stage which was not significantly different from those obtained with N at 3WAS for these characters. Oba-Super 6 (hybrid) produced plants with the highest 100-seed weight followed by the Local cultivar. Although weight of 100 seeds of Oba-Super 6 (hybrid) was not significantly different from those of the Local cultivar. Similarly, weight of 100 seeds of Samaz-52 (OPV) was not significantly different from those obtained with the Local cultivar. Alternatively, Samaz-52 (OPV) produced the highest yield (3398.16 kg/ha) followed by the Local cultivar (2537.05 kg/ha). However, Oba-Super 6 (hybrid) gave the least yield (1851.86 kg/ha). T x V interaction on weight of 100 seed and final grain yield was insignificant (Table 8).

Significant effect of time of N-fertilizer application on yield and yield characters has been reported by Queiroz et al., (2011) who described maize productivity as a complex trait dependent on several factors upon which time of N-fertilizer greatly influence. Ogunboye (2020) and Sitthaphanit (2010) had suggested that timely application of N improves yield as N plays significant role in photosynthetic activity and protein synthesis which translate to final grain yield. This is supported by Gallais & Hirel, (2014) and Kogbe & Adediran (2013) who also reiterated that N represent the major yield determining factor in maize production and thus availability at the right time translate to high yield. Response of cultivar to 100-seeds weight might be due to the variation among seed sizes. This corroborate with Ali (2014) findings. Alternatively, variation in the cultivars' growing cycle which directly influences grain filling may distort the overall grain yield of maize lines. This is also in corroboration with the findings of Shafiullah et al. (2018). Variations resulting from yield differences and respective yield characters may also be explained by variation resulting from genetic background of these cultivars tested (Ahmad et al., 2015) and their response to environmental condition (Hussain et al., 2011). Significant interaction of T x V on number of seeds/cob may translate to the fact that maize cultivars vary in their photosynthetic abilities, response to environmental conditions and propensities to assimilate production maximally and its consecutive conversion into starch which could translate to higher weight of grains. This result corroborates with Kandil (2013) and Derby et al. (2004) respectively.

CONCLUSION

This experiment shows that time of N - fertilizer application had great influence on the growth and yield of maize in Anyigba environment. For most of the significant growth characters, N application at 3WAS gave the best performance while application of N at silking stage gave the best result for mostly significant yield and yield characters. Similarly, Local cultivar responded more than its counterparts to time of N – fertilizer for growth characters, Oba-Super 6 (hybrid) responded more than others for yield characters. However, Samaz-52 (OPV) emerged with the outstanding yield and thus recommended. Nitrogen fertilizer application prove to be more effectively utilized at both 3WAS and at silking stage for overall growth and development of maize in Anyigba environment and therefore this research recommends application in two split doses (at 3WAS and at silking stage).

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AUTHOR CONTRIBUTIONS

This research was undertaken by the collaborating authors. Author Musa, Umaru Tanko designed the study, wrote the protocol and interpreted the data. Author Yusuf Momohjimoh anchored the field study, gathered the initial data and performed preliminary data analysis. Both authors managed the literature searches and produced the initial draft. Both authors read and approved the final manuscript.

COMPETING INTERESTS

The authors have declared that no conflict of interest exists.

ETHICS APPROVAL

Not applicable

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