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YIELD PERFORMANCE OF THREE MAIZE (*Zea mays* L.) VARIETIES AS INFLUENCED BY TIME OF NITROGEN FERTILIZER TOPDRESSING IN SAVANNAH ZONE OF NIGERIA

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ABSTRACT

Two field trials were conducted during 2016 wet season at Institute for Agricultural Research Farm, Samaru-Zaria and Jaji Military cantonment farm, both in Northern Guinea Savannah of Nigeria, to study the effect of time of second dose of Nitrogen (N) fertilizer application (topdressing)on maize varieties. The treatments consisted of three maize varieties (SAMMAZ 14, SAMMAZ 15 and SAMMAZ 16) and six timings of N fertilizer application at (4,5,6,7,8 and 9 weeks after sowing (WAS)). The treatments were factorially combined and laid out in a Randomized Complete Block Design (RCBD) and replicated three times. The results showed that SAMMAZ 16 outperformed SAMMAZ 14 and SAMMAZ 15 in terms Plant height, number of cobs/plant, cob/row, number of grains per row, 100 grain weight(g) and grain yield(kg)ha^{-1} which were significantly affected by the treatments. SAMMAZ 16 recorded the higher number of cobs per plant (1.911), number of rows per cob (14.93), number of grains per row (36.67), 100 grain weight(g) (38.89) and grain yield (kg)ha^{-1} (3887) over other varieties.

Keyword: Maize Varieties; Topdressing; second dose; N fertilizer; grain yield

INTRODUCTION

Maize (*Zea mays L.*) is the third most important cereal crop in the world next to rice and wheat (Tilahon *et al.*, 2013) and has the highest production potential among cereals (Muthukumar *et al.*, 2007). It is the most important food for humans in South America, Africa and China (Khalily *et al.*, 2010). Maize is utilized as food for human consumption and feed for livestock and for industrial uses. More than 50% of the annual maize production is used to produce animal feeds worldwide and over 200 million Nigerian are involved in its production (USDA, 2014). Worldwide production of maize is continually on the increase. United States of American the world's largest producer of the crop/commodity produced 313.39 and 353.699 million tons in 2011 and 2013, respectively. Similarly, Nigeria produced 9.18 million and 11.450 million tons in 2011 and 2013 respectively. The average yield per hectare is also on the increase worldwide. USA produced 9.230 and 9.969 ton ha-^{1} in 2011 and 2013 respectively. Nigeria produced 1.52 tons ha^{-1} and 2.00 ton ha^{-1} in 2011 and 2013 respectively (FAO, 2014).

The average yield per hectare increased worldwide where USA realized up to 9.96 tonnes per hectare and Nigeria 2.0 tonnes per hectare in 2013 (FAO, 2013). The yield recorded for Nigerian still falls below the global and African average of 5 and 3 tonnes per hectare (Bello and Ganiyu, 2012) in contrast to higher yield of between 5 to 7 tons ha^{-1} reported in research station across Nigeria (Fakorede *et al*., 2003). Even within African continent, Malawi with an average yield of 2.170 tons ha^{-1} has a higher yield per hectare than Nigeria. Despite worldwide increase in production, especially in places like USA where it's used as feed and industrial raw material, it is worrisome that Nigeria (with its high population) in which the crop serves as food, feed, etc still produces a paltry 1.5 to 2.0 tons ha^{-1} which is below the 2.17 tons ha^{-1} recorded in less populated Malawi.

This could be as a result of non-implementation of some basic improved practices such as utilization of improved varieties with good yield potential such as SAMMAZ 14- a medium maturing open pollinated variety with a maturity period between 106 and 110 days (Anon, 2004), this variety has yield potential of 5.8 tons/ha. It has a high lysine and tryptophan content, SAMMAZ 15 has intermediate maturity characteristics (110 days) with a yield potential of 6-9 tons/ha and SAMMAZ 16 is a non-tillering, erect and late maturing variety with a maturity period of 120 days (Anon, 2004) and recommended time of N fertilizer Topdressing (second dose application). The time of second dose of N fertilizer application is the critical period (42-46 days after emergence) when all plant parts were present and well established, the growing point and tassel are above ground, the stalk is almost at the end of elongation period and degeneration of lower leaves begins. This is also the period when potential kernels/grain rows are determined. At this stage, the number of rows is set, number of ovules on each ear and size of ear are determined. At any of the growth/reproductive stages above, availability of moisture and nutrients is of paramount importance particularly N fertilizer second dose to be applied at the right time otherwise it will hamper the development of Maize grain which will invariably affect the final yield (Tanaka and Hara, 1974).

It is therefore on this basis that this study was designed to compare the yield performance of three improved maize varieties as affected by time of N fertilized second dose application or topdressing in savannah zone of Nigeria.

MATERIALS AND METHOD

Study Area

Field experiments in two locations were conducted during the 2016 wet season at the Research Farm of Institute for Agricultural Research Farm (Lat.11^{o} 11' N, Long. 07^{0}38' E, 686m above sea level), Samaru-Zaria and Jaji Military Cantonment Farm located at 30 Km from Zaria along Kaduna – Zaria road (Lat. 10^{o} 49' 25" N, Long. 07^{o} 34' 10" E, 600m above sea level), both in Northern Guinea Savannah of Nigeria, to evaluate the yield performance of three improved maize varieties (SAMMAZ 14, SAMMAZ 15 and SAMMAZ 16) as influenced by time of N fertilizer topdressing.

Treatments and Experimental Design

The treatments consisted of three maize varieties (SAMMAZ 14, SAMMAZ 15 and SAMMAZ 16) and six times of nitrogen second dose fertilization at 4 5, 6, 7, 8, 9 weeks after sowing (WAS). The experiments were laid out in randomized complete block design (RCBD) with three replications; the net plot size was 3 x 4.5m. The crop was sown manually on 11 June, 2016 at Samaru and 18th June, 2016 at Jaji with 25 x 75cm spacing. Fertilizer (NPK 15:15:15) was applied at the rate of 120kg, 60kg, 60kg of N, P_20_5 and K_2O. 75% of N and 100% P_2O_5 and K_2O were applied as basal dose or first dose at 1 week after sowing (WAS) while the remaining nitrogen was top-dressed at 4, 5, 6, 7, 8 and 9 WAS with 4 WAS as the control in both locations. The crop production system for both locations is subsistence farming, also the vegetation type for both locations is the Savannah type which is sparsely distributed. Sowing of maize was carried out on 11th June and 18th June for Samaru and Jaji respectively. Manual weeding was carried out using hoe at 6 and 10 WAS followed by earthing up after each weeding. There was no incidence of pests and diseases observed at both locations. Harvesting was also carried out at physiological maturity.

Data Collection and Analysis

Data were recorded on plant height, number of leaves per plant, total leaf area per plant, leaf area index and dry matter production. Details of physical and chemical properties of the soil taken from the experimental sites (Samaru and Jaji) for analysis during 2016 rainy season are shown in Table 2. Appendices I and II are the 2016 wet season meteorological data for both Samaru and Jaji which will also be used to analyze the results.

Data were collected on plant height at 12 WAS while for the yield and yield components such as number of cobs per plant, number of row per cob, number of grains per row,100 grain weight(g) and grain yield (kg) /ha were collected at the end of the experiment at both locations. The data collected were subjected to analysis of variance (ANOVA) as described by Snedecor and Cochran (1967). Where F-values were found to be significant, the treatment means were compared using Duncan's Multiple Range Test (DMRT) (Duncan, 1955).

RESULTS AND DISCUSSION

The soil textural class (Table 2) is an important edaphic factor which played an important role in this trial as it affects the overall performance of the maize crop at both locations, thus, the differences observed from soils of both Samaru and Jaji could offer some explanation as to different results obtained at the end of the trial. The soil at Samaru is of sandy loam textural class while that of Jaji is loamy soil. Sandy loam soil allows better soil aeration that enhances better soil microbial activities as well as good soil water retention capacity and better root zone penetration for maximum uptake and utilization of moisture and nutrients by plants than loamy soil of Jaji. Thus, the sandy loam soil of Samaru is more favorable and ideal for maize cultivation than loamy soil of Jaji (Uruk,2015). Appendices I and II show the record of meteorological data of the two locations for 2016 wet season. Rainfall received among other factors examined had better distribution, intensity, duration evenness and amount at Samaru than that received at Jaji thus, aiding the release of more moisture which enhances nutrient uptake for better performance (growth, yield and yield components) by the crop. According to Bello *et al*. (2012), rainfall amount and distribution plays significant role in stimulating process of plant growth, development and maturity.

Plant height at 12 WAS for both locations and those for yield and yield components is presented in Table 1. The maximum plant height (241.49cm) was recorded by SAMMAZ

16 which was statistically at par with SAMMAZ 14(241.17cm), while, the least plant height was recorded by SAMMAZ 15 (230.89cm). This could be attributed to the fact that SAMMAZ 16 is a variety (120 days to maturity) that takes a longer time to mature than other varieties, which means that it takes a longer time to grow in the field thereby utilizing more moisture, sunlight and nutrients e.t.c for better growth and development than SAMMAZ 15(110 days) and SAMMAZ 14(96-110 days). SAMMAZ 16 as a late maturing variety takes a longer time to grow and effectively using environmental resources to fully mature while SAMMAZ 14 and SAMMAZ 15 are of medium/intermediate maturing characteristics. These results are in accordance with the results of Ali (1994) and Hassan *et al.* (2011) who reported differences in plant height in maize varieties.

A significant difference in number of cobs per plant is evident from Table 1. Maximum number of cobs per plant (2) was recorded for SAMMAZ 16 and SAMMAZ 14 at Samaru while SAMMAZ 15 (1) recorded the least. At Jaji however, SAMMAZ 16 recorded (1.48) the highest number of cobs per plant while SAMMAZ 14 and SAMMAZ 15 have statistically similar number of cobs. These findings were also in line with the findings of Wang *et al.,* (2011) who reported that late maturing maize varieties are taller with more cobs/plant and higher yield and yield components than early/intermediate maturing varieties.

The number of cobs/row is presented in Table 1. At Samaru, a significant difference in number of rows per cob was recorded in SAMMAZ 16 had the highest number of rows per cob, which did not significantly differ with SAMMAZ 14 while SAMMAZ 15 had least number of cobs per plant. This result was in line with report of Gambin *et al.* (2006) who stated that late maturing maize variety had a maximum number of grains/cob than early or medium maturing varieties due to full utilization of environmental resources and full expression of its genetic makeup. At Jaji however, no significant difference among the varieties was recorded.

The number cobs/row is a genetically controlled factor but environmental as well as nutritional level may also influence the number of grains per row per cob. Grain yield is directly related to the number of rows per cob. A perusal of Table 1 shows SAMMAZ 16 recorded the highest number of grains per row which is statistically at par with that of SAMMAZ 14 while SAMMAZ 15 recorded least number of grains per row at Samaru. These is in accordance with the findings of Abendroth *et al.* (2011) who reported that late maturing variety (SAMMAZ 16) had an extended/longer grain formation and filling period for higher yield than early/intermediate maturing varieties. While a no significant difference among the maize varieties was recorded at Jaji.

Cob length (cm) and cob diameter (cm) are genetically controlled factor in relation to final grain yield but environmental as well as nutritional level may also influence the growth of cob length and expansion of cob diameter. Grain yield is directly related to cob length as well as cob diameter. A further perusal of Table 1 shows that cob length values were not significant at Samaru but at Jaji SAMMAZ 16 and SAMMAZ 14 were statistically similar with each other while SAMMAZ 15 had shorter cobs. In term of cob diameter, the results from Table 1 further shows the cob diameter values differ significantly at both locations. At Samaru, SAMMAZ 16 and SAMMAZ 14 had cobs with widest girth than SAMMAZ 15 with least cob diameter. Results in Jaji is also similar with that of Samaru where SAMMAZ 16 and 14 has the highest diameter values followed by SAMMAZ 15. This is in line with the findings of Wang *et al.* (2011) who reported that late maturing variety takes a longer time to grow, develop and mature, therefore had more time to develop longer cobs with wider diameter with adequate environmental and nutritional resources.

Table 1 indicates highly significant results in terms of 100 grain weight(g) at Samaru while non-significant results were recorded at Jaji. At Samaru, SAMMAZ 16 and SAMMAZ 14 recorded maximum 100 grain weight while SAMMAZ 15 had least 100 grain values. This was due to the fact that 100grain weight is a genetically controlled factor so 100 grain weight of different varieties was different. This is in line with the findings of Zamir *et al.* (2011) who reported that increase in 100 grain weight for SAMMAZ 16 and 14 might be due to the variety's genetic potential as well as being a late maturing variety and availability of more resources (nutrients and water) for efficient utilization by the maize crop.

Grain yield of a crop is the ultimate objective of all research of grain crops. It is a factor which is related to many other factors such as plant height, number of cobs per plant, number of rows per cob, number of grains per rows. Others are cob lengths, cob diameter, 100 grain weight. Table 1 further showed that the maize varieties differed significantly for gain yield (kg) ha^{-1}. At both Samaru and Jaji, SAMMAZ 16 had the highest grain yield which was followed by SAMMAZ 14, these two were statistically at par while SAMMAZ 15 had lower grain yield. More grain yield in SAMMAZ 16 was due to the fact that it is a late maturing variety which takes a longer time to grow and fully mature over others (SAMMAZ 14 and SAMMAZ 15) who are of intermediate maturing characters. This is in line with the report of McCutcheon *et al.* (2001) who reported significant difference among maize varieties in grain yield between late and early/late maturing varieties.

Table 1 also reveals that time of application of second dose of N fertilizer or topdressing N fertilizer significantly affected the plant height, yield components and yield at both Samaru and Jaji. Application at 6 WAS appears to be the most ideal time to apply the second dose fertilizer as most of the fertilizer applied earlier including those residuals in the soil must have been used up by the rapidly growing crop. Application at 6 WAS coincides with the most appropriate time N fertilizer is needed by the growing crop as it was the period of robust vegetative growth leading to reproductive growth (Post Anthesis) stage. It is also at this stage where roots, rootlets development of the plant is enhanced for anchorage and nutrient/water uptake for photosynthesis (Valero *et al.*, 2015).

Hafiz *et al.* (2011) reported that application of N fertilizer second dose at 6 WAS further enhances the development of roots and other photosynthetic apparatuses just prior to the commencement of reproductive growth stage leading to long accumulation of higher pre-anthesis assimilates stored within the plant which can then be shifted or translocated into higher grain yield during grain filling stage.

Table 1: Comparative Yield and yield components performance of Maize (*Zea mays*) varieties as affected by time of N fertilizer topdressing at Samaru and Jaji in 2016 wet season

Treatments	Plant Height (12WAS) (cm)		No. of Cobs per Plant		No. of Cobs per row		No. of Grains per row		Cob length (cm)		Cob diameter (cm)		100-gram weight (g)		Grain Yield kg/ha	
	Samaru	Jaji	Samaru	Jaji	Samaru	Jaji	Samaru	Jaji	Samaru	Jaji	Samaru	Jaji	Samaru	Jaji	Samaru	Jaji
Variety (v)																
SAMMAZ 14	241a	221a	2a	1	12ab	14	36ab	36	13	14ab	5a	5a	39a	25	3731a	2274ab
SAMMAZ 15	230b	210b	1b	1	11b	13	35b	36	12	13b	4b	4b	35b	24	3243b	1784b
SAMMAZ 16	241a	231a	2a	1	14a	14	37a	38	15	15a	5a	5a	39a	26	3887a	2587a
SE ±	2.944	3.77b	0.0964	0.0402	0.508	0.139	0.40b	0.507	1.656	0.107	0.053	0.063	0.001	0.001	96.96	84.11
Significance	*	*	*	NS	*	NS	*	NS	NS	*	**	*	*	NS	*	**\
Time of Second Fertilizer Dose (T)																
4 WAS	219b	201c	1c	1.d	11d	13d	33c	31d	12b	13c	5	4	30d	22d	2647e	1519d
5 WAS	241b	288b	2b	2b	14b	14b	37a	40b	13ab	14b	5	4	41ab	26b	4198a	2428b
6 WAS	250a	251a	3a	2a	16a	15a	38a	43a	19a	15a	5	4	44a	30a	4352a	27800a
7 WAS	239a	223b	2b	2bc	14bc	14b	37ab	39b	13ab	14b	5	4	40b	27b	4037ab	2352b
8 WAS	239a	214bc	2b	1c	12cd	13bc	36ab	36c	13ab	14b	5	4	36c	25bc	3872bc	2106bc
9 WAS	239a	205c	1c	1d	11cd	13c	35b	33d	12b	13c	5	4.	34c	24cd	3333d	1709c
SE ±	4.15a	5.340	0.1364	0.0569	0.718	0.191	0.573	0.717	2.342	0.151	0.076	0.090	0.002	0.001	138.54	118.95
Significance	*	**	**	**	**	**	*	**	*	**	NS	NS	**	**	**	**
Interaction																
VXT	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within the same treatment group and location are statistically the same using DMRT at 5% level of significance.

NS: Not Significant

*: Significant at 5% level

**: Significant at 1% level

Table 2: Physical and Chemical properties of soils (0-30 cm) taken from Samaru and Jaji during 2016 wet season

Particle size distribution gkg^{-1}	Samaru	Jaji
Sand	580	410
Silt	340	460
Clay	80	130
Textural class	Sandy loam	Loam
Chemical composition		
pH in water (1:2.5)	6.05	6.15
pH in 0.01M$CaCl_2$ (1:2.5)	5.60	5.78
Organic carbon (g kg^{-1})	1.04	1.19
Total nitrogen (g kg^{-1})	0.27	0.30
Available phosphorus (mg kg^{-1})	6.00	9.29
Exchangeable bases (cmol kg^{-1})		
Calcium (Ca)	2.61	3.91
Magnesium (Mg)	0.41	0.71
Potassium (K)	0.09	0.13
Sodium (Na)	0.17	0.26
Cation Exchange Capacity (C.E.C)	3.21	4.90

Source: Soil Analytical Laboratory, Department of Agronomy, ABU Zaria

Table 3: Interaction effect between maize variety and time of N fertilizer topdressing on cob length (cm) during 2016 wet season at Jaji

	Time of N Fertilizer Topdressing (WAS)					
Maize Variety	4	5	6	7	8	9
SAMMAZ 14	12.70c	13.40c	15.76a	14.09b	13.81b	13.45c
SAMMAZ 15	12.31d	13.22c	14.72b	13.63b	13.79b	12.60c
SAMMAZ 16	12.64c	14.30b	15.81a	14.05b	13.40bc	13.24c
SE ±			1.102			

Means followed by different letters in a column or row of any set of treatment are significantly different at $p<0.05$ using DMRT, WAS-weeks after sowing

Table 3 showed the interaction effect between maize variety and time of second dose of fertilizer application at Jaji only. SAMMAZ 16 and SAMMAZ 14 had the longest cobs followed by SAMMAZ 15 at time 6 WAS, while, the shortest cobs were produced when SAMMAZ 15 was top-dressed with N fertilizer at 4 WAS. There was no interaction effect between maize variety and time of second dose of fertilizer application at Samaru.

CONCLUSION

From this study, it could be concluded that SAMMAZ 16 had out performed SAMMAZ 14 and SAMMAZ 15 in plant height, number of cobs per plant, number of rows per cob, number of grains per row, cob length, cob diameter values, 100 grain weight and grain yield (kg)/ ha. Similarly, the time of fertilizer topdressing at 6 WAS gave the highest grain yield among the maize varieties evaluated at both locations relative to other timings evaluated.

Appendix I: Meteorological data showing monthly and mean annual rainfall, monthly air temperature, relative humidity and sunshine hours in 2016 wet season at Samaru

Month	Rainfall (mm)	Temperature (^{0}C)		Relative humidity (%)	Average monthly Sunshine hours (from 6am-6pm)
		Max.	Min.		
January	0.00	31.1	14.31	20.11	124.2
February	0.00	33.2	16.68	22.06	116.1
March	24.34	35.19	18.13	46.51	123.8
April	15.16	36.27	21.53	52.92	118.5
May	132.21	32.35	23.5	64.82	120.3
June	249.93	30.63	20.13	74.20	113.8
July	307.06	28.63	19.79	66.21	102.5
August	349.90	27.67	19.50	68.52	89.5
September	282.81	29.62	19.45	69.31	110.8
October	16.97	31.23	18.23	54.45	123.5
November	0.00	30.83	12.80	20.83	9.30
December	0.00	29.10	14.58	20.94	8.86
Mean	134.25	31.44	19.06	53.88	114.2

Appendix II: Meteorological data showing monthly and mean annual rainfall, monthly air temperature, relative humidity and sunshine hours in 2016 wet season at Jaji

Month	Rainfall (mm)	Temperature (^{0}C)		Relative humidity (%)	Average monthly Sunshine hours (from 6am-6pm)
		Max.	Min.		
January	0.00	30.44	18.93	23.43	124.1
February	0.00	34.89	17.76	27.32	114.5
March	95.11	36.84	22.23	47.03	122.4
April	29.40	36.67	23.10	54.80	117.5
May	24.40	33.94	22.58	68.39	120.1
June	215.80	30.23	21.33	79.73	97.3
July	298.80	29.42	21.06	66.74	71.6
August	304.20	28.16	20.32	72.83	66.4
September	208.41	30.04	21.44	70.34	92.5
October	54.40	32.81	21.52	58.68	121.4
November	0.00	30.53	18.23	28.83	10.51
December	0.00	26.97	14.42	28.61	9.98
Mean	129.01	32.17	21.23	56.04	104.6

Source: Meteorological Unit of Jaji military sub aerodrome,Jaji-Kaduna.

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