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Performance of Maize Varieties as affected by Time of Topdressing Nitrogen Fertilizer Doses under Irrigation Scheduling

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Abstract
Two field trials were conducted during the 2021 dry season, under irrigation schemes at the National Agricultural Extension and Research Liaison Service zonal irrigation research farm at Badeggi (NAERLS/ABU) and Mokwa farm located 75km from Badeggi along Ilorin. All the experimental trial farms are in the Southern Guinea Savanna zone of Nigeria. The experiment was designed to assess the effect of varieties and time for a second dose of nitrogen fertilizer at a different time of application on the growth and yield of Maize. The treatment consisted of three varieties of Maize (SAMMAZ 50, SAMMAZ 51, and SAMMAZ 61) and six topdressings at 4, 5, 6, 7, 8, and 9 weeks after sowing (WAS) under irrigation scheduling. Data were collected on total dry matter (TDM), plant height, Leaf Area Index, and grain yield. The results showed that SAMMAZ 51 is superior in terms of growth and yield over the other varieties while SAMMAZ 50 was statistically at par with SAMMAZ 61 in terms of grain yield only. However, the second nitrogen fertilizer (N) application at 6 resulted in better growth and higher yields. Therefore SAMMAZ 51 and top dressing at 6 WAS are recommended for better and higher yield in Nigeria Southern Guinea Savana ecological zone.

Keywords: Nitrogen Doses, Varieties, growth, yield, Irrigation

Introduction

Maize is a cereal grain crop in the tropic and belongs to the family *Poaceae* (*Gramineae* tribe *maydeace* (Wickes, 1989). Maize can grow on a wide range of soil though it performs best in well-drained aerated loam or silty loam or alluvial soils with a pH 5.5-7. It can grow in a wide range of agro-ecological zone. Nitrogen fertilizer is one of the most important inputs contributing to crop production by increasing the productivity of the soil for plant growth and thus improving the quality and quantity of the produce. It makes up to 4% of the dry matter of plants and is a component of protein, nucleic acids, and many other compounds essential for plant growth processes which include chlorophyll and enzymes (Tisdale *et al*., 1999). Its availability in sufficient quantity throughout the growing season is essential for optimum maize growth. The optimal amounts of other essential elements such as phosphorus in the soil cannot be utilized efficiently if N is deficient in plants (Jehan *et al*., 2006; Festus *et al*., 2007; Hafiz *et al*., 2011). Muhammad and Hassan, (2011) ascribed lower yield in maize when the crop was subjected to a high dose of N; with early N application improved uptake and protect the soil environment. Similarly, at low N supply, the crop growth rate slows down causing the reproductive structure to decline and these results in lower maize grain yield and its components (Ronald *et al*., 2005 and Hafiz *et al*., 2011). Time of N application at appropriate crop growth stage is also another main focus to enhance N use efficiency and increase maize productivity. Among several functions, nitrogen plays a key role in plant metabolism. This element takes part in different metabolism pathways of great importance to plants (Sangoi *et al*., 2011). Among the crop of agronomic interest maize express nutrition dependence especially on Nitrogen (Cancellier *et al*., 2011). Ferreira *et al.* (2001) concluded that nitrogen fertilization improved grain quality, increasing protein, and mineral nutrients content, intervening positively in the number of ears per plant weight of ears as the mass of a thousand seeds increase according to the nitrogen doses. Precious and Namo, (2015) reported that an estimated value of 3.93 t/ha was recorded for grain yield at the application of the time of second dose of fertilizer at 2 WAS. The mean number of days to 50% tasseling and silking decreased when fertilizer was applied at six weeks after

planting and the mean number of barren plants increased with delay in fertilizer application at six weeks after planting (Precious and Namo, 2015). It was observed that farmers are not consistent in the proper timing of fertilizer application especially topdressing. This usually results in N deficiency particularly when the nutrient is most needed; accordingly, the N application period is critical and is regarded as the most important decision for high yield of improved maize varieties. Therefore, it is based on the above-mentioned problems that, this study was proposed to investigate the effect of variety and time for second dose nitrogen fertilizer application on the growth and yield of maize in the southern Guinea savanna agroecological zone of Nigeria.

Materials and Methods

Experimental location and treatment

Two field trials were conducted simultaneously during 2021 at the irrigation Research Station of the National Agricultural Extension and Research liaison service (NAERLS/ABU) zonal station Badeggi (9° 45N, 7° 42E, and 500m above sea level) and Mokwa (8° 35^{1}N, 7° 20^{1}E, 420m above sea level) located 75km away from Badeggi along Ilorin, both in the Southern Guinea Savanna Agro-ecological zone of Nigeria. The treatments consisted of three maize varieties SAMMAZ 50, SAMMAZ 51, and SAMMAZ 61, and six periods of second fertilizer (N) application (at 4, 5, 6, 7, 8, and 9 WAS). Soil samples were collected with a soil auger at both sites at a depth of 0-30cm before sowing and the soil samples were analyzed for physical and chemical properties following the procedures outlined by Agbine (1995). Total nitrogen was determined using the Kjeldahl digestion method as described by Bremner and Mulvaney (1982). Available P was determined by Bray 1 method (Anderson and Ingram, 1998). Soil pH was determined electrometrically in a 1:1 soil water suspension. Total soil organic carbon was determined using the acid dichromate wet-oxidation procedure of the Walkley and Black method (1934), and soil organic matter was determined by multiplying with a factor (1.72). Exchangeable bases (Ca, Mg, Na and K) were extracted with 1M ammonium acetate (1M NH4OAc) solution buffered at pH 7.0, as described by Anderson and Ingram (1998). The exchangeable sodium (Na^{+}) and potassium (K^{+}) contents of the filtrates were determined by the flame photometer while the exchangeable calcium (Ca^{+}) and magnesium (Mg^{+}) were determined by the EDTA titration method and were read using the atomic absorption spectrophotometer (AAS). The cation exchange capacity of the soil was determined with 1M NH4OAc (1M ammonium acetate), buffered at pH 7.0 (Rhoades, 1982). The land was cleared, and trash to the boundary, followed by ploughing and harrowing twice size was 60m x 25m which was cleared and prepared manually. The experimental site was divided into 54 plots. The maize varieties used were obtained in the Institute for Agricultural Research, Ahmadu Bello University Zaria, (IAR/ABU). Two seeds were sown per stand at rows 75cm apart and 30cm along the rows respectively. Weeds were controlled with pre-emergence herbicide (Atrazine) with CP_3 knapsack sprayer in about 240L/ha spray liquid volume at a pressure of 2.1kg/cm^{2} using a deflector nozzle immediately after sowing followed by manually weed control using hoes at 3, and 8 WAS weeks after sowing in the experimental plots. Thinning to one per stand was done at 2WAS respectively. This was done to maintain a uniform plant population per hectare. The first dose, of nitrogen and basal phosphorus, and potassium were applied in the form of N:P:K by side dressing. Phosphorus and Potassium were applied at 30kg each of P_2O_5 and K_2O was applied one week after sowing. The second dose of Nitrogen was applied using Urea 46% N to supply the balance of nitrogen as dictated by the treatment combinations at 4,5,6,7,8, and 9 WAS by side dressing. The design of the experiment was a 3x7 factorial arrangement fitted to Randomized Complete Block Design and replicated three times. Irrigation treatment was imposed 2WAS when the young plants were established. The irrigation schedule was 5 days intervals. The crops were harvested at physiological maturity when the leaves and ears turned brown. Data collected were plant height (measured using a meter rule from the ground level to the tip of the uppermost leaf or the tip of the tassel). Total dry matter (TDM): the whole plant material at harvest was dried in an oven at 60°C for 5 days and the average weighed was recorded. The leaf area index was measured by multiplying the length and breadth and was multiplied by a factor (0.75). (Watson 1958).

$$L = \frac{A}{P}$$

Where; L =Leaf Area Index, A =Assimilating Surface, P =Ground Area/Plant

Grain yield (Kg/ha): Grain yield was determined at harvest. The harvested net plot was sun-dried, threshed and clean grains weighted and mean weight/plot was expressed in kilogram/hectare. Data collected were subjected to analysis of variance and means were separated using Duncan multiple range test at 5% level of probability.

Results and Discussion

Results

Physical and Chemical Properties of the Soil before sowing

Table 1 The results revealed that the soil texture of the experimental site were loamy sand. At Badeggi, the total N content was 0.42%meq/100g available Phosphorus 2.62 meq/100g, Calcium 0.23 meq/100g. Magnesium 0.20 meq/100g. While at Mokwa, the total N content was 0.17%, available Phosphorus 3.60 meq/100g, Calcium 0.83 meq/100g and Magnesium 0.20 meq/100g.

Table 3 showed the effect of time for second dose of fertilizer application and variety on plant height at Badeggi and Mokwa in 2021 dry season. The result showed that among the varieties, SAMMAZ 51 produced significantly the tallest plant while the shortest tall was seen in SAMMAZ 61 in both locations.

Although, there was no significant effect between SAMMAZ 50 and SAMMAZ 51 at 12WAS in Badeggi. There was significant effect when increasing the time of second dose of fertilizer application from 4WAS to 6WAS increased taller plants. However, increasing the time of second dose of fertilizer application from 7WAS to 9WAS significantly decreased plant height in both locations.

Table 4: showed effect of variety and time of second dose of fertilizer application on the leaf area index of maize at Badeggi and Mokwa during 2021 dry season. There was no significant effect on variety throughout the sampling periods except at 12WAS in Badeggi and Mokwa. At 12WAS, SAMMAZ 50 and 51 produced significantly wider leaf area index than SAMMAZ 61. The second dose of fertilizer application at 6 WAS produced significantly widest leaf area index in all the sampling periods in the two locations. The narrowest leaf area index was recorded at the second dose of fertilizer application at 4WAS throughout the sampling periods in both locations.

Table 5: Showed the significant effect of variety and time for second dose of fertilizer (urea) application on total dry matter of maize in Badeggi and Mokwa during 2021 dry season. In variety, SAMMAZ 51 produced significantly the highest total dry matter throughout the sampling periods in both locations while the lowest total dry matter values ranging from 24.19-36.80 was observed in SAMMAZ 61. The time of second dose of fertilizer application at 6 WAS produced significantly the highest total dry matter in all the sampling periods in Badeggi and Mokwa. The least total dry matter was noticed at 4WAS of the second dose of the fertilizer application throughout the sampling periods.

Table 6: showed the effect of time for second dose of fertilizer application and variety on yield of Maize at Badeggi and Mokwa during 2021 dry season. In Badeggi and Mokwa, SAMMAZ 50 and 51 produced significantly higher yield than SAMMAZ 61. The application of second dose of fertilizer at 5, 6 and 7 WAS which are statistically at par produced significantly highest yield per hectare at both locations. There was no significant interaction between variety and time of second dose of fertilizer application at both locations.

Discussion

The variations in the growth indicators such as plant height, leaf area and total dry matter where SAMMAZ 51 appeared superior over SAMMAZ 50 and 61 could be due to genetic variability, probably as enhanced by environmental factors like temperature, and Sunshine which were optimum throughout the growing periods of the crop at both locations. The yield of SAMMAZ 50 and 51 were positively affected by the genetic makeup of the crop and time of second fertilizer application, probably due to the efficient use of nitrogen by the plants at the right time for growth and production assimilate which had direct bearing on the yield production. In a similar study, Ladan and Hassan, (2020), attributed significant increase in plant height with more leaves for more dry matter has been observed to be controlled by length of growing season which is an integral part of the expression of many genes and the interaction between these genes. Ladan and Hassan, (2020) reported that there is a highly significant variability in plaint height, number of leaves and total dry matter production in various maize varieties genotype in terms of the length of growing season among maize varieties. The no significantly value for most of the growth parameters obtained at early stage of the crop growth indicates low nutrient demands during the initial stage of crop growth and development which implies that the soil might have satisfied all the crop needs. However, the positive response to applied nitrogen fertilizer at later stages for some of the growth parameters could be due to the fact that at this stage available nutrients in the soil could no more meet the crop requirements without the use of fertilizer. This confirmed the observation made by Abubakar *et al.* (2014) who reported that maize growth expressed in terms of plant height, stem girth, total dry matter showed a positive response to applied fertilizer at 6WAS with the recommended N rates. The positive effect of second application of the nitrogen fertilizer dose of 6 WAS over other periods on the plant growth could be due to the provision of the nutrients to the plants when it was most needed for physiological processes as the soil texture was good enough for moisture and nutrients holding and supply to the plants. This result is in line with the findings of Hussain (2000) who reported that topdressing with nitrogen amplifies varietal responses to growth indices such as leaf area index, relative growth rate and plant height. The increased in growth and yield of maize with be as a result application at the second dose of fertilizer at 6 WAS coincide with the most appropriate time N fertilizer is needed by the growing crop, as it was the period of robust vegetative growth enhancing to reproductive growth. Ladan and Hassan, (2020) suggested the timing for nitrogen fertilizer Second dose application to be between 4-6 weeks after sowing (WAS) enhances improved maize varieties in the growth and dry matter production of maize. Hafiz *et al*. (2011) further reported that application at 6 WAS was for further development of roots and other photosynthetic apparatuses first prior to commencement of reproductive growth stage leading to higher and longer accumulation of higher pre anthesis assimilates stored within the plant which can be shifted or translocated into higher dry matter yield and grain yield during grain filling stage. This result is in line with that of Jalali *et al*. (2010) who reported that timely application of nitrogen as topdressing on maize crop recorded the highest grain yield.

Conclusion

The results obtained from this study revealed that SAMMAZ 51 is superior in term of growth and yield while topdressing at 6 WAS resulted to better growth and yield and recommended to practice within southern guinea ecological zone of Nigeria.

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Table 1: Physical and Chemical Soil Properties (0-30cm) depth before sowing

Soil Properties	Badeggi	Mokwa
Properties Size (g/kg)		
Sand	626	655
Silt	240	210
Clay	134	135
Exchangeable Bases (emol)	**Loamy Sand**	**Loamy Sand**
Ca	1.42	1.64
Mg	0.20	0.20
Na	0.32	0.42
K	2.26	2.48
H^+Al	0.10	0.10
ECEC	6.60	5.46
Base Saturation (%)	63.64	86.81
C (%)	0.23	0.83
N (%)	0.42	0.17
Organic Matter (%)	0.43	1.13
Av. P (mg/kg)	2.62	3.60

Source: Soil samples as analyzed at the Soil Department, Federal University of Technology (FUTMinna), Nigeria

Table 2: Maximum and Minimum Temperature and Relative Humidity at 10days intervals during the experimental periods at Badeggi and Mokwa in 2021 dry season

		Temperature (ºC)				Relative Humidity (%)			
		Maximum		Minimum		Maximum		Minimum	
		2015	2016	2015	2016	2015	2016	2015	2016
Jan.									
	1-10	33.3	38.7	42.2	15.3	15.0	16.0	8.0	7.0
	11-20	29.8	30.1	14.5	16.0	14.0	15.0	8.0	10.0
	21-30	30.0	31.0	15.0	16.6	14.0	15.0	8.0	10.0
Feb.	1-10	30.5	30.6	16.5	17.1	14.0	15.0	9.0	10.0
	11-20	34.0	35.1	17.5	19.4	15.0	14.0	7.0	8.0
	21-28	35.2	36.0	18.5	19.5	13.0	14.0	7.0	8.0
	1-10	35.2	40.1	19.0	21.4	15.0	17.0	9.0	7.0
March	11-20	36.5	41.9	20.5	23.3	16.0	49.0	8.0	7.0
	21-30	35.4	37.5	18.5	256.4	13.0	82.0	7.0	29.0
	1-10	35.5	37.2	22.5	24.9	18.0	.0	8.	32.0
April	11-20	37.7	38.5	23.0	26.2	16.0	51.0	7.0	32.0
	21-30	35.8	37.5	22.7	25.4	15.0	41.0	7.	38.0
	1-10	30.5	33.1	20.4	22.9	35.0	43.0	9.0	40.0
May	11-20	31.2	34.2	19.5	22.2	37.0	70.0	1.0	43.0
	21-30	30.9	33.6	20.0	22.6	39.0	91.0	11.0	50.0

Source: Nigeria Meteorological Agency; Bida Aerodrome, Bida. Niger State

Table 3: Effect of Time of Second Dose of Fertilizer (Urea as top dressing) application and variety on plant height of Maize at Badeggi and Mokwa during 2021 dry season

Treatment	Badeggi			Mokwa		
	4WAS	8WAS	12WAS	4WAS	8WAS	12WAS
Variety						
SAMMAZ 50	60.11b	203.98b	241.17a	45.44b	166.39b	221.32b
SAMMAZ 61	54.366c	193.94c	230.89b	45.22b	160.98c	210.13c
SAMMAZ 51	63.79a	210.37a	241.49a	51.56a	181.06a	230.82a
SE±	1.265	3.717	2.944	0.616	2.991	3.776
Time (T)						
4 WAS	56.69d	211.56b	239.67b	41.11e	146.24e	201.80e
5 WAS	63.20b	206.60bc	240.53a	49.78b	181.12b	288.34a
6 WAS	67.31a	277.49a	250.33a	55.67a	207.03a	251.22b
7 WAS	59.98c	213.60b	238.67b	47.90c	170.40c	233.39c
8 WAS	59.18c	208.22b	238.56b	47.11c	162.08d	214.42d
9 WAS	50.22e	149.11d	219.33bc	43.78d	149.88e	205.38e
SE±	1.789	5.249	4.159	0.871	4.229	5.340
Interaction						
V X T	ns	ns	ns	ns	ns	ns

Mean within a column followed by same letter (s) do not differ significantly at 5% level of probability using Duncan multiple range test (DMRT).NS = not significant, Time= Time of Second Dose of Fertilizer Application (T)

Table 4: Effect of time of second dose of fertilizer (urea as top dressing) application and variety on leaf area index of maize at Badaggi and Mokwa during 2021 dry seasons

Treatment	Badeggi			Mokwa		
	4WAS	8WAS	12WAS	4WAS	8WAS	12WAS
Variety						
SAMMAZ 50	0.64	2.22	2.53a	0.56	2.40	2.72a
SAMMAZ 61	0.70	2.03	2.36b	0.53	2.20	2.65b
SAMMAZ51	0.73	0.23	2.47a	0.58	2.59	2.76a
SE±	0.31	0.56	0.67	0.02	0.04	0.73
Time (T)						
4 WAS	0.46f	1.68d	1.87d	0.37d	1.95e	2.20e
5 WAS	0.83b	2.43b	2.63b	0.63ab	2.41b	2.94b
6 WAS	1.04a	2.90a	2.99a	0.78a	2.76a	3.43a
7 WAS	0.69c	2.36b	2.46b	0.58b	2.37c	2.73bc
8 WAS	0.59d	2.20c	2.56b	0.49bc	2.30c	2.56c
9 WAS	0.51e	2.07c	2.20c	0.42c	2.17d	2.24d
SE±	0.05	0.08	0.94	0.02	0.05	0.09
Interaction						
V X T	ns	ns	ns	ns	ns	ns

Mean within a column followed by same letter (s) do not differ significantly at 5% level of probability using Duncan multiple range test (DMRT).NS = not significant, Time= Time of Second Dose of Fertilizer Application (T)

Table 5: Effect of time of second dose of fertilizer (urea as top dressing) application and variety on Total Dry Matter of Maize at Badeggi and Mokwa during 2021 dry season

Treatment	Badeggi			Mokwa		
	4WAS	8WAS	12WAS	4WAS	8WAS	12WAS
Variety						
SAMMAZ 50	25.60b	33.90b	38.26	25.99	34.04a	37.27a
SAMMAZ 61	24.22c	29.21c	38.16	24.98	20.08b	36.80b
SAMMAZ 51	27.75a	38.17a	39.37	25.70	34.56a	37.61a
SE±	0.24	0.88	0.14	0.29	0.65	0.16
Time (T)						
4 WAS	4.19d	20.22f	4.06e	4.06	25.52e	35.90d
5 WAS	6.90b	40.51b	6.43b	6.43	34.36b	47.96b
6 WAS	7.97a	48.82a	7.17a	7.17a	38.78a	58.91a
7 WAS	6.11b	36.09c	5.31c	5.31c	32.74bc	47.39b
8 WAS	5.60c	31.19d	4.93cd	4.93cd	30.73cd	46.89c
9 WAS	5.11cd	25.72e	4.64cd	4.64cd	27.25d	36.37cd
SE±	0.33	1.24	0.41	0.43	0.91	0.27
Interaction						
V X T	ns	ns	ns	ns	ns	ns

Mean within a column followed by same letter (s) do not differ significantly at 5% level of probability using Duncan multiple range test (DMRT).NS = not significant, Time= Time of Second Dose of Fertilizer Application (T)

Table 6: Effect of time of second dose of fertilizer application (Urea) and variety on the yield of Maize at Badeggi and Mokwa during 2021dry seasons (Yield kgha^{-1} at 12 WAS)

Treatment	Badeggi	Mokwa
Variety		
SAMMAZ 50	3730.9a	2274.1a
SAMMAZ 61	3243.2b	1784.3b
SAMMAZ 51	3887.4a	2587.2a
SE±	97.96	84.11
Time (T)		
4 WAS	3333.4b	1907.4ab
5 WAS	4198.3a	2477.8a
6 WAS	4352.3a	2799.6a
7 WAS	4036.6a	2351.8a
8 WAS	3872.3b	2105.6b
9 WAS	2647.3c	1518.5c
SE±	138.54	118.95
Interaction		
V x T	ns	ns

Mean within a column followed by same letter (s) do not differ significantly at 5% level of probability using Duncan multiple range test (DMRT).NS = not significant, Time= Time of Second Dose of Fertilizer Application (T)