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Full Length Research Article

EFFECT OF PLANT POPULATION, TIME OF SECOND DOSE OF NITROGEN FERTILIZER APPLICATION ON GROWTH AND YIELD OF MAIZE (*Zea mays* L.) VARIETIES IN NORTHERN GUINEA SAVANNAH OF NIGERIA

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ABSTRACT
The Study was conducted during 2023/2024 cropping season at Institute for Agricultural Research IAR, A.B.U., Samaru- Zaria (11°11'N 07°38E and 686m above sea level) and College of Agriculture and Animal Science, Irrigation Farm Mando, Kaduna (Lat 10°43'N, Long 06°34'E 500m above sea level) both located in the Northern Guinea Savannah Ecological Zone of Nigeria respectively, to evaluate the effect of plant population and time of nitrogen second dose fertilizer application on growth and yield of maize varieties in Nigerian savannah. Treatments consisted of Three maize varieties; SAMMAZ 15, SAMMAZ 16, and SAMMAZ 17, three plant population; P_1 (40,000 p ha^{-1}), P_2 (60,000 p ha^{-1}) and P_3 (80,000 p ha^{-1}) and five times of nitrogen second dose application; 4, 5, 6, 7 and 8 weeks after sowing (WAS). Treatments were factorially combined in a randomized complete block design (RCBD) and replicated three times. Data on growth parameters were collected on plant height (cm), number of leaves, leaf Area index (LAI), crop growth rate (CGR), Relative Growth Rate (RGR), and dry matter weight (g), while the yield parameter collected was grain yield kg ha^{-1}. Results showed that 2 plants stand^{-1}had the best performance on both growth and gave the highest maize grain yield kg ha^{-1}, followed by 1 and 3 plants stand^{-1} respectively. Second dose of nitrogen application at 6 WAS resulted in higher growth attributes and gave the highest grain yield kg ha^{-1} and SAMMAZ 16 outperformed the other varieties in terms of growth attributes and gave the highest grain yield in kg ha^{-1}. The study suggests that farmers should adopt a plant population of P_2 (60,000) plants ha^{-1}in combination with time of nitrogen second dose application at 6 WAS with SAMMAZ 16 for better performance on growth and yield of maize in the Agro-ecological zone

Keywords: Maize, Variety, Plant population, Time of nitrogen second dose application, growth, yield and Nigerian Savannah.

INTRODUCTION

Maize (*Zea mays* L.) a member of grass family *Graminae*, is one of the three most important cereal crops of the world after wheat (*Triticum aestivum* L.) and rice (*Oryza sativa* L.) and hence it may be acceptable as third cereal crop in world for its higher productivity (Rokon *et al*, 2024). Maize is high yielding, easy to process, readily digested and cheaper than other cereal crops. It is also a versatile crop that is more extensively distributed globally than other cereal crops, growing across a wide range of agro-ecological zones (Hassan *et al*., 2013). Worldwide production of maize in 2017/18 was 1.17 billion tons with the largest producer being United States of America producing 488 million tons in 2018 (USDA, 2018). Nigeria produced about 14.3 million tons in 2017 making it the largest producer after South Africa which produces 17.5 million tons as the largest in Africa (FAOSTAT, 2018). Its grain has high nutritive value containing 66.2% starch, 11.1% protein, 7.12% oil and 1.5% minerals. Moreover, it contains 90 mg carotene, 1.8 mg niacin, 0.8 mg thiamin and 0.1 mg riboflavin per 100 g grains (Mahat *et al*., 2023). Maize oil is used as food, feed and for industrial purposes. So, maize can contribute in food and nutritional security program in Nigeria because of its higher productivity and nutritional value.

The current average maize yield for subsistent farmers in Nigeria is between 1-2 tons/ ha but has a yield potential of 3 - 4 t ha^{-1}(Begham *et al*., 2018). This low production in Nigeria is probably as a result of farmers not adhering to the recommended agronomic/cultural practices like the use of unimproved (local) maize varieties, use of inappropriate plant population and fertilizer application practices particularly non adherence to proper timing of nitrogen second dose application or nitrogen topdressing application to mention a few. The feasibility to increase yield of maize in Nigeria is however more likely because the yield potential of the crop has not being realized so far, as there is a large gap between potential and actual yield (Khan *et al*., 2012). Since maize is an important cereal crop that contribute immensely to the sustenance of our teaming population, efforts should be intensified to narrow the gap between potential and actual farm yield in Nigeria.

There are a number of biotic and abiotic factors those affect maize yield considerably; however, it is more affected by variations in plant population density than other member of the grass family (Vega *et al*., 2001). Maize differs in its responses to plant population density (Luque *et al*., 2006). Liu *et al*. (2004) also reported that maize yield differs significantly under varying plant population density levels due to difference in genetic potential. Correspondingly maize also responds differently in quality parameters like crude starch, protein and oil contents in grains (Munamava *et al*., 2006). Plant populations affect most growth parameters of maize even under optimal growth conditions and therefore it is considered a major factor determining the degree of competition between plants (Sangakkara *et al*., 2004). The grain yield per plant is decreased (Luque *et al*., 2006) in response to decreasing light and other environmental resources available to each plant (Ali *et al*., 2003). Stand density affects plant architecture, alters growth and developmental patterns and influences carbohydrate production. At low densities, improved maize varieties do not tiller effectively and quite often produce only one ear per plant. Whereas, the use of high population increases interplant competition for light, water and nutrients, which may be

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detrimental to final yield because it stimulates apical dominance, induces barrenness, and ultimately decreases the number of ears produced per plant and kernels set per ear (Sangoi, 2001).

Split application of fertilizer doses of 120:60:60 kg N, P_20_5 and K_20 ha^{-1} has been recommended for improved open pollinated maize varieties production in the savannah ecology (Ewenzor *et al*., 1989). Even though farmers in the ecology recognize the need to fertilize their maize crops to achieve high yield on a sustainable basis, timing of N fertilizer second dose application to their maize crop has been variable. This is more so because farmers always try to adhere to the timing of first or basal application as they prepare well in advance for the coming rainy season with their fertilizer and other inputs at hand. But the timing of the second dose of N fertilizer application is not strictly followed which may be a determining factor for final yield and probably one of the reason that can lead to low yield or no yield at all to the farmers at the end of the cropping season. This is the time (time of fertilizer second dose to be applied) that occurs at the peak period of vegetative growth leading to the commencement of early reproductive growth stage in Maize plant.

Maize variety is usually affected by crop environment, which influence crop growth and yield. Due to different genetic makeup, varieties differ in response to biotic and abiotic stress they are exposed to. Unimproved local varieties are almost always low yielding with poor response to drought, low soil fertility, pest and diseases to mention a few, while improved and or hybrid varieties responds positively to environmental challenges as reported by Kwaga (2014) . Maize varieties have great impact on yield. Hybrid varieties produce more than double than local varieties. Cultivation of hybrid varieties along with various plant population can increase production of maize. Adjustment of proper plant population in the maize field is important to ensure maximum utilization of solar energy by the crop and reduce evaporation of soil moisture (FAO, 2012). Appropriate population levels should be sustained to exploit maximum natural resources, such as nutrients, sunlight, soil moisture., and to ensure satisfactory yield. Very closest planting (Higher plant population) is undesirable because it encourages inter-plant competition for resources. Biomass production of a crop largely depends on the function of leaf area development and consequential photosynthetic activity (Rokon *et al*, 2024). Thus different varieties, appropriate plant population and appropriate timing of nitrogen fertilizer second dose application have to be ensured with a view to maximizing maize growth and yield. With the above view, an experiment was carried out to study the effect of variety, plant population and proper time of nitrogen second dose application on the growth and yield performance of maize in the Nigerian savannah.

MATERIAL AND METHODS

Field trials were conducted during the cropping season of 2023/2024 at two locations simultaneously namely; Institute for Agricultural Research Farm Samaru – Zaria (latitude 11⁰11'N, longitude 07⁰38'E, 686m above sea level and College of Agriculture and Animal Science, Irrigation Farm Mando, Kaduna (Lat 10ᵒ43'N, Long 06ᵒ34'E 500m above sea level) both in Northern Guinea Savannah agro-ecological zone of Nigeria. The treatments consisted of three maize varieties (SAMMAZ 15, SAMMAZ 16 and SAMMAZ 17), three plant populations levels; P_1 (40,000 plants ha^{-1}), P_2 (60,000 plants ha^{-1}) and P_3 (80,000 plants ha^{-1}) and five times of nitrogen second dose application; 4, 5, 6, 7 and 8 weeks after sowing (WAS). Treatments combination were laid out in a randomized complete block design (RCBD) and replicated three times. Seeds were obtained from seed unit of IAR and seeds were treated with Apron Star (10gram) for 3kg of seeds. After land preparation, seeds were sown per hole on 2nd may 2024 at Samaru and 8th may 2024 at Mando, and later thinned to the various plant populations as per treatment at 2 WAS at a spacing of the desired plant population densities were achieved with intra-row spacing of 33.33cm for P_1, 22.70cm in P_2, 18.60cm in P_3 and 75cm inter-row spacing in all treatments in all locations. Fertilizer was applied in two split doses, the first dose was applied at the rate of 74kgN, 60kg P_205 and 60kgK_2O (75% N, 100% P_2O5 and 100%K_2O) was carried out one week after sowing by side placement 5cm away from the plant stand. The remaining 25%N as second dose application with N (Urea 46%N) was applied at 4, 5, 6, 7, 8 WAS by side placement 5cm away from the plant stand as per treatment. Manual weeding was carried out using land held hoe at 6 and 10 WAS then followed by earthen up after each weeding. There was no incidence of pest and disease observed at both locations. Harvesting was also carried at physiological maturity at 2nd Sept 2024 at Samaru and 8th Sept 2024 at Mando. Data was collected at 4, 8and 12 week after sowing (WAS) ,were recorded on growth parameters like plant height, number of leaves, leaf area index, crop growth rate, total dry matter produced and grain yield kg ha^{-1}.Data was subjected to analysis of variance and treatments mean were analyzed following procedures as described by Duncan (1955). Details of soil analysis is presented as Table 1.

RESULTS

Details of the soil physical and chemical properties of the experimental site was presented as table 1.The soil at Mando was loam textural class while that of Samaru was found to be of sandy loam textural class. The soil at Mando had a moderate N content, low level of available phosphorus (P), potassium (K) and Cathion exchange capacity (CEC). The Mando soil had a moderate level of Organic carbon, calcium, magnesium and sodium with a slightly acidic pH in water and moderately acidic in calcium chloride solution ($Cacl_2$). The soil at Samaru has a moderate N and P content with moderate calcium, magnesium and sodium content, also low level of organic carbon, potassium and CEC were observed. pH was slightly acidic in both water and $Cacl_2$ solution.

Table 1: Physical and Chemical Properties of the Soil at both Mando and Samaru during 2023/2023 Wet Season

	Mando	Samaru
Physical Properties		
Clay	14.0	10.0
Silt	27.0	39.0
Sand	52.0	67.0
Textural Class	Loam	Sandy Loam
Chemical Properties		
PH (H_2O) 1:2,5	6.24	6.12
PH 0.01m $CaCl_2$	5.86	5.63
Total Nitrogen (gkg^{-1})	3.7	4.0
Available Pmg Kg^{-1}	1.65	5.24
Organic Carbon	1.67	1.01
Exchangeable		
Bases (Cmol Kg^{-1})	2.59	2.12
Calcium Meq/100g	0.71	0.80
Magnesium	0.01	0.13
Meq/100g	0.17	0.61
Potassium Meq/100g	3.48	3.64
Sodium Meq/100g		

CEC Meq/100g

Source: Analytical Lab of department of Agronomy, ABU Zaria

Plant Height (cm)

Table 2 showed the effect of maize variety, plant population and time of second dose of fertilizer application on plant height (cm) at both Samaru and Mando during the 2023/2024 cropping season. At Samaru, the varietal effect on plant height was significant throughout the sampling periods where Sammaz 16 was significantly taller but statistically similar to Sammaz 17, Sammaz 15 recorded shorter plants relative to other varieties evaluated, while at Mando however, Sammaz 16 significantly recorded taller plants than other varieties evaluated. While at 12WAS at Mando, Sammaz 16 and Sammaz 17 had statistically similar height which were taller than Sammaz 15.

The effect of plant population in plant height was also significant at all sampling periods at both locations where 60,000 plant population recorded taller plants over other populations at both locations at all sampling periods while 40,000 plant population recorded shorter plants in all location at all sampling periods

Similarly, the effect of time of topdressing N-fertilizer on plant height was significant at all the sampling periods at both locations. At all sampling dates and at both locations, application of second dose of fertilizer at 4WAS, (the control) consistently resulted in shorter maize plants. Application at 6WAS however consistently resulted in taller maize plants at both locations, though this was comparable with topdressing at other dates at Samaru.

The interaction between variety and plant population significantly affected plant height at 8WAS at Samaru (table 3).It showed that for all the maize varieties evaluated, increasing plant population from 40,000 to 60,000 induced a progressive increase in plant height but application beyond 60,000 induced reduction in plant height for all the varieties. The interaction between the treatments recorded the tallest plant between Sammaz 16 and 60,000 plant population.

Table 2: Effect of Varieties, Plant population and Time of Second dose of Nitrogen fertilizer application on plant height (cm) and number of leaves per Maize plant at Samaru and Mando during 2023/2024 wet season

Treatment	Plant Height (cm)						Number of Leaves Per Plant					
	4 WAS		8 WAS		12 WAS		4 WAS		8 WAS		12 WAS	
	Samaru	Mando	Samaru	Mando	Samaru	Mando	Samaru	Mando	Samaru	Mando	Samaru	Mando
Variety (V)												
SAMMAZ 15	53.36c	45.33b	194.49b	158.94b	228.98b	210.13b	8.19b	7.93	11.72b	12.05c	12.56	12.02c
SAMMAZ 16	63.79a	51.59a	209.89a	180.22a	242.49a	232.82a	9.11a	8.36	13.67a	12.38a	13.28	13.61a
SAMMAZ !7	60.22ab	46.22b	202.76ab	165.44b	241.17a	228.43a	8.77a	8.21	12.14ab	12.66b	12.82	12.61b
SE ±	1.265	0.616	3.717	2.991	2.944	3.776	0.136	0.135	0.250	0.085	0.334	0.047 0.047
Plant Population (P)												
P_1 (40,000 p ha^{-1})	62.33c	52.77c	196.99c	189.56c	209.32b	208.45b	8.76	8.65	10.66c	9.54c	12.34c	12.77c
P_2 (60,000 p ha^{-1})	71.33a	68.72a	216.43a	203.78a	249.65a	233.87a	9.04	8.89	12.89a	11.45a	13.88a	13.99a
P_3 (80,000 p ha^{-1})	68.54b	60.55b	204.67b	200.21b	231.44ab	209.98b	8.86	8.74	11.65b	10.55b	12.98b	12.88b
SE ±	1.301	0.812	3.211	2.677	2.444	3.566	0.121	0.131	0.202	0.082	0.322	0.034
Time of Second Application (T) WAS												
T4	49.22d	43.78d	154.11c	148.24d	216.33b	201.70c	8.26	8.00	11.92d	9.59d	13.30d	10.99c
T5	59.20c	47.11c	207.60b	164.08c	238.56a	205.38c	8.67	8.11	12.96b	12.78b	14.28b	13.93b
T6	67.13a	55.67a	257.49a	206.54a	258.67a	283.39a	8.86	8.56	13.61a	13.58a	15.37a	14.88a
T7	63.31ab	49.78b	213.60ab	182.56b	240.53a	251.22a	8.62	8.09	12.90b	12.83b	14.45b	14.21b
T8	52.89c	47.90c	211.56b	170.40bc	230.32a	228.38b	8.58	8.03	12.46c	12.27c	13.92c	13.60c
SE ±	1.789	0.877	5.249	4.299	4.159	5.340	0.192	0.190	0.356	0.124	0.479	0.067
INTERACTION												
V x P	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS
V x T	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
P x T	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
V x P x T	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

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

Table 3: Interaction of Maize Varieties and Plant population on Plant height at 8 WAS at Samaru during 2023/2024 wet season

	Plant population		
Variety	**40,000**	**60,000**	**80,000**
SAMMAZ 15	106.61i	205.76d	217.83bc
SAMMAZ 16	185.32g	249.66a	231.73b
SAMMAZ 17	163.22h	195.43f	222.44bc
SE ±		2.459	

Means followed by different letter(s)in a column or row are significantly different at P≤0.05 using DMRT. WAS weeks after sowing

Number of leaves

Table 2 further showed the effect of maize variety, plant population and time of second dose of fertilizer application on number of leaves at both Samaru and Mando during the 2023/2024 cropping season. At Samaru, the varietal effect on number of leaves was significant throughout the sampling periods where Sammaz 16 significantly had more leaves that was statistically similar to Sammaz 17 at 4 and 8 WAS at Samaru, Sammaz 15 recorded shorter plants relative to other varieties evaluated, while at Mando however, Sammaz 16 significantly recorded plants with more leaves than other varieties evaluated. The effect of plant population on number of leaves was also significant at all sampling periods at both locations where 60,000 plant population recorded plants with more leaves over other populations at both locations at all sampling periods while 40,000 plant population recorded plants with fewer leaves in all location at all sampling periods. Similarly, the effect of time of topdressing N-fertilizer on plant height was significant at all the sampling periods at both locations. At all sampling dates and at both locations, application of second dose of fertilizer at 4WAS, (the control) consistently resulted in plants with fewer leaves while. Application time of N fertilizer second dose at 6WAS however consistently resulted in plants with highest number of leaves at both locations. There was no interaction between the variables on number of leaves.

Table 4: Effect of Varieties, Plant population and Time of Second dose of Nitrogen fertilizer application on Leaf area index (LAI) and Crop growth rate (CGR) of Maize at Samaru and Mando during 2023/2024 wet season

Treatment	**Leaf Area Index (LAI)**						**Crop Growth Rate (CGR)**					
	4 WAS		**8 WAS**		**12 WAS**		**4 WAS**		**8 WAS**		**12 WAS**	
	Samaru	**Mando**	**Samaru**	**Mando**	**Samaru**	**Mando**	**Samaru**	**Mando**	**Samaru**	**Mando**	**Samaru**	**Mando**
Variety (V)												
SAMMAZ 15	0.6351	0.5307b	1.2233a	0.9646a	2.4201	2.1040b	5.60b	5.59	33.90b	34.04a	7.29	7.27ab
SAMMAZ 16	0.7253	0.5814a	1.3108a	1.2814a	2.7611	2.5873a	7.75a	5.70	38.17a	34.56a	7.37	7.61a
SAMMAZ !7	0.6965	0.5646a	1.0287b	0.9307a	2.5508	2.2140a	4.22c	4.98	30.21c	27.08b	7.10	6.87b
SE ±	0.0310	0.0166	0.0557	0.0166	0.0734	0.0370	0.236	0.292	0.838	0.292	0.138	0. 0.157
Plant Population (P)												
P_1 (40,000 p ha^{-1})	0.6731b	0.5887	0.9988b	1.0455	2.0332b	2.0021	5.32	6.32	29.43b	34.76	6.98b	7.14b
P_2 (60,000 p ha^{-1})	0.7844a	0.6344	1.1223a	1.2334	2.3445a	2.2333	6.87	6.87	37.67a	35.77	7.23a	7.56a
P_3 (80,000 p ha^{-1})	0.7122b	0.6344	1.0988b	1.1233	2.2117a	2.1432	6.34	6.54	37.56a	35.23	7.14a	7.52a
SE ±	0.3455	0.0112	0.0455	0.1544	0.0634	0.0322	0.143	0.145	0.923	0.265	0.1433	0.142
Time of Second Application (T) WAS												
T4	0.4554d	0.3687d	0.8715d	1.2408d	1.9820e	1.9453d	4.19d	4.06c	20.22f	25.52d	5.56e	5.96e
T5	0.8317b	0.6338b	1.6314b	1.9421b	2.4326b	2.3133b	6.90b	6.43ab	40.51b	34.36b	8.02b	7.96b
T6	1.0364a	0.7832a	1.9879a	2.4308a	2.8983a	2.4599a	7.97a	7.17a	48.82a	38.78a	8.98a	8.91a
T7	0.6929c	0.5792b	1.4611bc	1.7317bc	2.3569c	2.2704c	6.11bc	5.31bc	36.09c	32.74bc	7.47bc	7.39bc
T8	0.5859c	0.4913c	1.3568bc	1.4852cd	2.1989cd	2.3008c	5.64c	4.93c	31.19d	30.73	7.01c	6.89cd
SE ±	0.0493	.0.0234	0.0944	0.1038	0.0789	0.0524	0.334	0.413	1.240	0.913	0.195	0.223

INTERACTION												
V x P	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
V x T	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	NS	NS
P x T	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
V x P x T	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

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

Leaf Area Index (LAI)
Table 4: showed the effect of maize variety, plant population and time of second dose of fertilizer application on leaf area index at both Samaru and Mando during the 2023/2024 cropping season. At Samaru, the varietal effect on number of leaves was significant throughout the sampling periods where Sammaz 16 significantly had higher leaf area index values that was statistically similar to Sammaz 17 at 4 and 8 WAS at Samaru, Sammaz 15 recorded plants with lower leaf area index values relative to other varieties evaluated, while at Mando however, Sammaz 16 significantly recorded plants with higher leaf area index values than other varieties evaluated.
The effect of plant population on leaf area index was also significant at all sampling periods at Samaru only where 60,000 plant population recorded plants with higher leaf area index values over other populations at both locations at all sampling periods while 40,000 plant population recorded plants with lower leaf area index values in all location at all sampling periods
Similarly, the effect of time of topdressing N-fertilizer on leaf area index was significant at all the sampling periods at both locations. At all sampling dates and at both locations, application of second dose of fertilizer at 4WAS, (the control) consistently resulted in plants lower leaf area index values while. Application time of N fertilizer second dose at 6WAS however consistently resulted in plants with higher leaf area index values at both locations. There was no interaction between the variables on leaf area index.

Crop Growth Rate (g/cm^2/wk)
Table 4 further showed the effect of maize variety, plant population and time of second dose of fertilizer application on crop growth rate at both Samaru and Mando during the 2023/2024 cropping season. At Samaru, the varietal effect on number of leaves was significant throughout the sampling periods where Sammaz 16 significantly had higher leaf area index values that was statistically similar to Sammaz 15 at Mando (8WAS), and 12 WAS at both Samaru and Mando. The effect of plant population on crop growth rate was also significant at all sampling periods at Samaru (8WAS) and 12 WAS at both Samaru and Mando where 60,000 plant population recorded plants with higher crop growth rate that was statistically similar to 80,000 while 40,000 plant population recorded plants with lower leaf area index values in all location at all sampling periods
Similarly, the effect of time of topdressing N-fertilizer on leaf area index was significant at all the sampling periods at both locations. At all sampling dates and at both locations, application of second dose of fertilizer at 4WAS, (the control) consistently resulted in plants lower crop growth rate while application time of N fertilizer second dose at 6WAS however consistently resulted in plants with higher crop growth rate at both locations. The interaction between variety and time of topdressing N-fertilizer application significantly affected crop growth rate at 8WAS at Mando (table 6).It showed that for all the maize varieties evaluated Sammaz 16 had the highest crop growth rate while 6WAS time of N second dose application also had the highest crop growth rate.

Table 5: Interaction Maize Varieties and Time of Second dose of F application on Crop growth rate at 8WAS at Mando during 2023/2024 wet season

Maize Variety	Tine of second dose of nitrogen fertilizer application (WAS)				
	4	**5**	**6**	**7**	**8**
SAMMAZ 15	19.83j	32.67f	45.33b	31.67d	29.33h
SAMMAZ 16	28.200g	47.88cd	52.80a	45.67c	36.40f
SAMMAZ 17	21400j	41.77d	43.33b	33.47e	32.93g
SE ±			1.795		

Means followed by different letter(s)in a column or row are significantly different at P≤0.05 using DMRT. WAS weeks after sowing.

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Table 6: Effect of Maize Varieties, Plant population and Time of Second dose of Nitrogen fertilizer application on Total dry matter produced at Samaru and Mando during 2023/2024 wet season

Treatments	Total Dry Matter Production (g)					
	Samaru			Mando		
	4 WAS	8 WAS	12 WAS	4 WAS	8 WAS	12 WAS
Variety (v)						
SAMMAZ 15	24.90b	149.50b	195.73b	23.30	156.65a	158.18ab
SAMMAZ 16	33.41a	188.96a	224.78a	26.03	164.11a	178.84a
SAMMAZ 17	15.84c	131.67c	166.13c	19.53	125.62b	164.42b
SE ±	0.953	3.837	3.958	1.73	2.834	3.389
Plant Population (P)						
P_1 (40,000 p ha^{-1})	22.54	138.87c	189.66b	19.88	128.55c	161.77c
P_2 (60,000 p ha^{-1})	33.54	188.76a	212.87a	24.02	162.77a	169.65a
P_3 (80,000 p ha^{-1})	31.43	158.43b	170.06c	23.23	155.54b	164.33ab
SE ±	1.458	3.766	3.766	1.689	2.776	3.256
Time Fertilizer Application (T) WAS						
T 4	16.88d	95.64d	112.40f	16.29c	127.51c	134.93d
T 5	26.56b	183.61b	225.48b	25.23ab	160.79b	186.97b
T 6	31.58a	237.81a	266.54a	28.62a	193.84a	221.28a
T 7	24.72bc	158.74c	203.97c	21.27bc	143.23bc	159.76c
SE ±	1.334	5.431	5.599	1.658	4.020	4.807
Interaction						
V x P	NS	NS	NS	NS	NS	NS
V x T	NS	*	NS	NS	NS	NS
P x T	NS	NS	NS	NS	NS	NS
V x P x T	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.

Table 7: Interaction of Maize Varieties and Plant population on Total dry matter produced at Samaru at 8 WAS during 2023/2024 wet season

Maize Variety	4	5	6	7	8
SAMMAZ 15	89.33j	151.67f	225.33b	130.67i	119.33h
SAMMAZ 16	110.00h	220.80b	250.80a	205.67c	175.40f
SAMMAZ 17	98.00i	198.33d	241.33a	159.47e	169.93f
SE ±			3.795		

Means followed by different letter(s)in a column or row are significantly different at P≤0.05 using DMRT. WAS weeks after sowing.

Dry Matter production (g)

The effect of maize variety, Plant population and time of application of the second dose of fertilizer on dry matter production was statistically significant at both locations and is presented in Table 6. At Samaru, SAMMAZ 16 consistently produced heaviest dry matter throughout the sampling periods and was followed by SAMMAZ 15 and 17 in that order. While at Mando SAMMAZ 16 recorded heaviest dry matter at 8 and 12WAS sampling periods and was statistically similar to SAMMAZ 15 at the same sampling periods.

The effect of plant population on Total dry matter produced was also significant at all sampling periods at 8 and 12 WAS at both Samaru and Mando where 60,000 plant population recorded plants with more dry matter that was statistically similar to 80,000 at 12 WAS at Mando while 40,000 plant population recorded plants with less dry matter in all location at all sampling periods

The time of second dose of N-fertilizer application significantly influenced total dry matter production of the Maize variety at both locations across the sampling periods. Application of second dose of N-fertilizer at 6WAS significantly led to the production of more (heavier) dry matter which was consistent across both locations at all sampling periods. While the control N-fertilizer top dressing at (4WAS) recorded the least dry matter produced across the sampling periods at both locations relative to other timings evaluated.

The interaction effect between maize variety and time of second dose of fertilizer application on total dry matter production at Samaru at 8WAS is shown in Table 7. All the Maize varieties differed across all the time of N- fertilizer second dose application with SAMMAZ 16 producing the heaviest dry matter followed by SAMMAZ 15 then SAMMAZ 17.

Grain yield (kg) per hectare

Table 8 further showed the effect of maize varieties, plant population and time of second dose of fertilizer application on Grain yield (kg) per hectare at both Samaru and Mando for 2023/2024 wet season.

Sammaz 16 at Mando recorded the highest values of grain yield (kg) per hectare which was followed by Sammaz 17 and lastly Sammaz 15 recorded the least value. At Samaru there was no much difference within the varieties Sammaz 16 and 17 are statistically similar and recorded highest grain yield (kg) per hectare values while the least value was recorded for Sammaz 15.
In terms of grain yield kgha^{-1} response to time of second dose of fertilizer application, both locations showed significant difference. At Samaru application time 6WAS consistently recorded the highest value of grain yield per hectare while the control 4WAS recorded the least value relative to other timings evaluated. At Mando the trend almost replicate what was observed in Samaru. Application timing 6WAS also recorded the highest value for grain yield per hectare while the control 4WAS recorded the least value relative to other timings evaluated. There was no interaction effect between the maize varieties and time of second dose of fertilizer application on grain yield kg per hectare at both Samaru and Mando.

Table 8: Effect of Maize Varieties, Plant population and Time of Second dose of Nitrogen fertilizer application on Grain yield kgha^{-1} at Samaru and Mando during 2023/2024 wet season

Treatment	Grain yield kgha^{-1}	
	Samaru	**Mando**
Variety (V)		
SAMMAZ 15	3450.90b	2010.13b
SAMMAZ 16	3778.22a	2632.82a
SAMMAZ !7	3634.99ab	2228.43a
SE ±	96.44	83.77
Plant Population (P)		
P_1 (40,000 p ha^{-1})	3229.32b	3208.45b
P_2 (60,000 p ha^{-1})	4249.65a	4233.87a
P_3 (80,000 p ha^{-1})	3231.44b	3221.98b
SE ±	132.44	131.56
Time of Second Application (T) WAS		
T4	2465.32d	2201.70c
T5	3677.43b	2405.38c
T6	4225.34a	2883.39a
T7	4133.62a	2251.22a
T8	3427.33bc	2228.38b
SE ±	137.59	115.34
INTERACTION		
V x P	NS	NS
V x T	NS	NS
P x T	NS	NS
V x P x T	NS	NS

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

DISCUSSION

Varietal Influence on Growth and Yield of Maize

The varieties responded differently in growth parameters as observed in this trial at both locations in terms of growth indices (plant height, number of leaves, LAI, CGR and total dry matter produced. Sammaz 16 had the best performance in the above mentioned growth indicators recorded than sammaz 15 and 17. This is probably because Sammaz 16 takes a longer time to grow and mature, thereby expressing its full growth potential by having taller plants with more number of leaves that produce heavier dry matter, thus enhancing the full development of its photosynthetic apparatuses and a longer time accumulation of pre-anthesis assimilate which were mobilized at grain filling stage into the chief sink (grains) at later stage of development than other varieties.

Sammaz 16 also outperformed the other varieties in terms of growth characteristics like LAI, CGR, RGR and NAR probably as a result of its longer growing period which is part of its inherent late maturing characteristics and genetic makeup that allows it take a longer time to grow thereby leading to an increase in both length and number of internodes, increase in number of leaves, size and height of plant and leaves leading to taller and bigger plants with more dry matter produced (Hassan.,2011). This is in line with the report of Valadabal and Farahani (2010), who reported that total leaf area and leaf area index development and maturation is influenced by length of growing season, rainfall amount and distribution.

The result further indicated that Sammaz 16 being a medium maturing variety which took maximum number of days to tassel reached late to silking and physiological maturity as compared to early maturing variety. This is in accordance with the report of Valero *et al* (2005) who stated that variation in or variable response in the number of days to 50% tasseling and silking among maize varieties was attributed to the genetic/location effect and prevailing climatic condition. Sammaz 16 as a medium maturing variety and it exhibited late tasseling and silking compared to Sammaz 15 and 17. Late maturing variety took more days to tassel/silk hence a better chance to utilize more nutrients and thus undergo more photosynthetic activities for more assimilate formation and accumulation which will ultimately result in better growth and higher yield. In this study, Sammaz 16 recorded the highest number of cobs per plant, number of row per cob, number of grains per row, longer cob length, wider cob diameter and heavier100 grain weight than others evaluated. This could probably be due to its inherent late maturing characteristics as well as favorable environmental condition.

Effect of Plant Population on growth and yield of Maize

The study revealed that area the increase in LAI explains the general crop trends that increasing plant density increases leaf area index on account of more area occupied by green canopy of plants per unit area. Previous research findings also indicated that in high maize density, leaf area index, total dry weight and crop growth rate increased than low maize density throughout crop growth season (Saberali, 2007). Plant height is an important component which helps determining the growth attained during the growing period. The data showed that plant height was significantly affected by plant population densities (Table-1). The tallest plants (249.65cm) were recorded in P_2 (60000 plants ha^{-1}), which were, however, statistically at par (231.44cm) with P_1 (40000 plants ha-$^{-1}$). Short statured plants (209.98cm) were recorded in T_3 (80,000 plants ha-$^{-1}$) due to crowding effect of the plant and higher intra-specific competition for resources. This trend explains that as the number of plants increased in a given area the competition among the plants for nutrients uptake and sunlight interception also increased (Sangakkara et al., 2004). Grain yield is a function of integrated effects of genetic make-up of cultivars and the growing conditions. The data on grain yield revealed that grain yield was significantly affected by plant population densities (Table-8). The maximum grain yield (4249.65 kg ha^{-1}) was recorded in T2 (60000 plants ha-1) followed by T3 (80000 plants ha-1) which produced grain yield of 3231.44 kg ha^{-1} . The higher grain yield in T2 and T3 was possibly due to higher number of ears ($plant^{-1}$) and number of grain rows (ear^{-1}) in these two treatments. These results are supported by Emam (2001) who verified that kernels ear^{-1} and kernels ear^{-1} row are the most important yield adjustment components in response to plant population density in maize. The minimum grain yield of 746.3 kg ha^{-1} was recorded in T_1 having population of 40,000 plants ha^{-1} .

Effect of Time of N Fertilizer Topdressing Growth, Yield and Yield Components of Maize.

Application of fertilizer at 6WAS consistency in outperforming the other timings was probably because it was the most appropriate time nitrogen fertilizer is needed as most nutrient content of the cotyledon of the growing seedling were used up and the root , rootlets were developed needing anchorage, nutrition, water for photosynthesis. Therefore application of timely N (6WAS) coincides with the period of high rainfall (Aug- Sept 2023/2024) for subsequent release of more moisture to the plant, this is coupled with the sandy loam soil at Samaru which aid the release of moisture for the manufacture of more leaves and further development of roots and other photosynthetic apparatuses just prior to the commencement of reproductive growth stage leading to higher and longer carbon assimilation and thus higher yield than at Mando. The extended assimilation will warrant the accumulation of higher pre- anthesis assimilation stored within the plant which can then be shifted or translocated into higher yield later during grain filling. Hafiz *et al*.,(2011) reported that the length or longer growing season also allows for longer duration of translocation of pre- anthesis assimilate into the chief or main sink which is ultimately the grain, thus warranting higher yield for this variety. Valero *et al*.,(2005) also reported that plots receiving topdressing at 6WAS which coincides with initiation of reproductive growth(post- anthesis) will benefit from timely application of nitrogen for the development of yield attributes which will ultimately contribute to higher yield (Ladan, 2018).

The delayed anthesis observed in plots receiving topdressing at 4WAS may be ascribed to luxuriant consumption of Nitrogen during the vegetative phase of growth of the crop, thus prolonging vegetative growth against reproductive development. Topdressing N fertilizer at 4WAS seemed too early as first dose of fertilizer was recently applied had not been exhausted for development of growth apparatuses. Later application of second dose of fertilizer beyond 6WAS, probably when too late for further development of appropriate photosynthetic apparatuses consequently may not be as effectively used as should be because the effective period of fertilizer use may have passed and the response may not be too effective. Application at 4WAS may warrant leaching, seepage underground, volatilization may be wasteful as the roots of the crop might not have been properly developed to take up all applied nutrients, thus leading to degradation of the fertilizer so applied as reported by Ladan,(2018).

Conclusion

From the results obtained, Maize varieties responded positively to plant population densities and time of nitrogen second dose application of both locations. This response is more prominent in terms of plant growth, yield and yield components at Samaru than at Mando. This could be due to the higher level of moisture available at Samaru than that obtained at Mando as explained in Appendix 1, thus the remarkable different in both growth and yield parameters. Based on the result obtained from the study, it can be concluded that SAMMAZ 16 had an edge over SAMMAZ 15 and 17 in terms of grain yield at both locations. Similarly, the period of fertilizer second dose application at 6WAS gave the highest grain yield among the Maize varieties evaluated in combination with 60,000 plants ha^{-1}at both locations. Therefore, SAMMAZ 16, 60,000 plants ha^{-1} and 6WAS time of second dose of fertilizer application are the best combination for good maize growth, yield components and yield under similar soil and weather conditions that prevailed during the study.

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Appendix I : Weather Data of the Mando and Samaru during 2023/2024 Raining Season

Months	Mando					Samaru			
	Rainfall mm	Temperature (^{0}C)		Relative Humidity (%) 0900Hrs	Sunshine (Hrs)	Rainfall mm	Temperature (^{0}C)		Relative Humidity (%) 0900Hrs
		Max	Min				Max	Min	
May	13	3	2	42	4.8	147.	3	2	40
Jun	3.7	0	3	41	4.0	7	1	1	39
e	18	3	2	47	3.1	239.	2	2	39
July	5.2	0	3	39	2.1	5	9	3	34
Aug	34	3	2	38	2.4	236.	2	2	38
ust	4.2	0	3	37	2.3	4	8	2	33
Sep	18	2	2	42	2.5	193.	2	2	33
tem	0.1	9	3	41	2.1	14	9	2	31
ber	18	3	2			194.	2	2	
Oct	5.1	0	3			05	8	4	
obe	85.	3	2			142.	2	2	
r	2	0	3			34	9	1	
Nov	58.	3	2			95.2	3	2	
em	2	1	3			3.6	0	3	
ber	0.0	3	2				3	2	
Dec		3	1				1	1	
em									
ber									
Total	**1171.7**					**1362.9mm**			

Source: IAR Weather Station Samaru and Kaduna international airport aerodrome, Mando-Kaduna.