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YIELD AND YIELD COMPONENTS OF MAIZE (*ZEA MAYS* L.) VARIETIES AS INFLUENCED BY PLANT POPULATION AND TIME OF NITROGEN SECOND DOSE APPLICATION IN GUINEA SAVANNAH OF NIGERIA

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ABSTRACT

The Study was carried out simultaneously at two location namely; Institute for Agricultural Research IAR, A.B.U., Samaru- Zaria (11011'N 07038E and 686m above sea level) and College of Agriculture and Animal Science, Farm Mando, Kaduna (Lat 10o43'N, Long 06o34'E 500m above sea level) both located in the Northern Guinea Savannah Ecological Zone of Nigeria respectively during 2023/2024 cropping season, to evaluate the effect of plant population and time of nitrogen second dose application on yield and yield attributes of three maize varieties in Nigerian savannah. Treatments consisted of Three maize varieties; SAMMAZ 15, SAMMAZ 16, and SAMMAZ 17, three plant populations levels; P1 (40,000 plants ha-1), P2 (60,000 plants ha-1) and P3 (80,000 plants ha-1) and five times of nitrogen second dose application; 4, 5, 6, 7 and 8 weeks after sowing (WAS). Treatment were factorially combined in a randomized complete block design (RCBD) and replicated three times. Data on yield parameters collected were number of cobs plant-1, number of kernels pod-1,cob length, cob diameter and kernel yield kg ha-1. Results showed that 60,000 plants ha-1had the best performance on yield parameters and gave the highest maize yield kg ha-1, followed by 40,000 plants ha-1 and 80,000 plants ha-1 respectively. Second dose of nitrogen application at 6 WAS resulted in higher growth attributes and gave the highest grain yield kg ha-1 over other timings evaluated and SAMMAZ 16 outperformed the other varieties in terms of yield attributes and gave the highest grain yield in kg ha-1. The study recommends that farmers should adopt a plant population of 60000 plants ha-1in combination with time of nitrogen second dose application at 6 WAS on SAMMAZ 15 for better performance on yield and yield parameters of maize in the Agro-ecological zone

Keywords: Maize, Nigerian Savannah, Plant population, Time of nitrogen second dose application, Variety, Yield

INTRODUCTION

Maize (*Zea mays* L.) belongs to family Poaceae, it is one of the all-important cereal crops grown in Nigeria, Africa and the World. Maize is one of the most important food crops together with rice and wheat, provides at least 30% of the food calories to more than 4.5 billion people in 94 developing countries (FAOSTAT 2019). Its grain can be used for human consumption in various ways, such as boiled corn, roasted corn, corn meal, fried grain and flour. The corn 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 (Rokon *et al*., 2019); Chowdhury and Islam, (1999). Maize oil is used as the best quality edible oil. The green parts of the plant and grain are used as livestock and poultry feed, respectively. Stover and dry leaves are used as good fuel for cooking. Globally, Maize is cultivated on about 190mha with a production of 1124mt in the year 2018-2019 (FAOSTAT 2020). United States is the leading producer and exporter of Maize in the world (FAOSTAT, 2020). Despite maize relevance needed for food and animal feed resulting in high demand in Nigeria, maize yield across the country continues to decrease with despite increase our rapidly growing population with an average of about 1 t/ha which is the lowest African yield recorded (Rokon *et al*., 2019). The steady decline in maize yield can be attributed to rapid reduction in soil fertility specifically time of second dose of nitrogen fertilizer application, failure to identify high yielding varieties, use of inappropriate plant population which determines final yield (Zamir *et al*., 2011). The average yield of maize in the Nigeria is not satisfactory. It is rather very low compared with leading maize growing countries of the world as observed by Shiferaw *et al*. (2011). The average yield in Nigeria is less than 1 t ha^{-1}, whereas, the newly released varieties have the potential to produce more than 3.0 t ha^{-1} Adhikari *et al*.2021). Maize differs in it's responses to plant population density (Luque *et al*., 2006). Adhikary *et al*. (2020) and 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). Yield is a function of inter-plant and intra-plant competitions.

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 they are subjected to 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. Adhikari, *et al*. (2021) stated that the different crop varieties have different adaptability in a specific region. Plant variety and planting spacing usually affect crop environment, which influence crop growth and yield. Maize varieties have great impact on yield. Hybrid varieties produce more than double than local varieties as reported by Saberali. (2007). Cultivation of hybrid varieties along with various planting spacing can increase production of maize. Adjustment of proper plant spacing in the maize field is important to ensure maximum utilization of solar energy by the crop and reduce evaporation of soil moisture (FAO, 2012). 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 (Ladan.,2018). 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 producers are widely practicing a blank recommended split-application (1/2 of the dose at planting and the remainder at knee high stage). In order to improve efficiency of nitrogen utilization, and improve luxuries consumption, split application had been recommended in semi-arid zones of Central Rift valley for maize production (Girma, 2013). Grain yield response was generally maximized when applying N prior to stem elongation where rapid N-uptake occurs and most responsive status of the growing maize crop (Mossedaq and Smith, 1994). According to Olaoye and Adegbesen (1991), the International Centre for Maize and Wheat Improvement Mexico (CIMMYT) reported that maize yield in West Africa has stagnated at about 1 t ha^{-1} as compared to the global average grain yield of 2.2-3.5 t ha^{-1}.

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.

MATERIALS 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 10°43'N, Long 06°34'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 $P_2 0_5$ and 60kgK_2O (75% N, 100% P_2O_5 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 harvest on the following parameters; Number of cobs $plant^{-1}$, Number of rows cob^{-1}, number of grains row^{-1} Cob length (cm), Cob diameter (cm) 100 grain weight (g) 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 AND DISCUSSION

Details of the soil physical and chemical properties of the experimental site was presented as table 1.The soil at Mando was loam 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 (Cacl2). 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 cacl2 solution.

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

	Mando	Samaru
Physical Properties gkg^{-1}		
Clay	140.0	100.0
Silt	270.0	390.0
Sand	520.0	670.0
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})		
Calcium Meq/100g	2.59	2.12
Magnesium Meq/100g	0.71	0.80
Potassium Meq/100g	0.01	0.13
Sodium Meq/100g	0.17	0.61
CEC Meq/100g	3.48	3.64

Source: Analytical Lab of department of Agronomy, ABU Zaria

Number of Cobs Per plant

Table 2 showed the effect of maize variety, plant population and time of second dose of fertilizer application on number of cobs plant^{-1} at both Samaru and Mando during the 2023/2024 cropping season. At Samaru, the varietal effect on number of cobs plant^{-1} was significant at harvest where Sammaz 16 had more cobs that were statistically similar to Sammaz 17, Sammaz 15 recorded fewer cobs relative to other varieties evaluated, while at Mando however, Sammaz 16 also recorded significantly higher number of cobs plant^{-1}than other varieties evaluated. While at Mando, Sammaz 16 and Sammaz 17 had statistically similar with more cobs than Sammaz 15.

The effect of plant population on number of cobs plant^{-1} was also significant at Samaru only where 60,000 plant population recorded higher number of cobs plant^{-1} over other populations evaluated at harvest, while 40,000 plant population recorded fewer cobs plant^{-1} in all location at harvest.

Similarly, the effect of time of topdressing N-fertilizer on plant height was significant at harvest at both locations. At both locations, application of second dose of fertilizer at 4WAS, (the control) consistently resulted in fewer cobs plant^{-1}. Application at 6WAS however consistently resulted in higher number of cobs plant^{-1} at both locations relative to other timings evaluated. There was interaction between the variables.

Number of Row per Cob

Table 2 further showed the number of row per cob as influenced by maize variety, plant population and time of second dose of fertilizer application in Samaru and Mando during 2023/2024 cropping season.

Variation in number of row per cob was statistically significant only at Samaru where SAMMAZ 16 recorded the highest number of row par cob and was at par with SAMMAZ 17 but significantly higher than SAMMAZ 15.

The effect of plant population on number of row cob^{-1} was also significant at all sampling periods at both locations where 60,000 plant population recorded higher number of row cob^{-1} over other populations at both locations at all sampling periods while 40,000 plant population recorded fewer row cob^{-1} in all location at harvest.

Application of second dose of N- fertilizer topdressing at 6WAS consistently resulted in the production of higher number of rows cob^{-1} at both locations. While the control 4WAS had the least number of rows cob^{-1} at both locations.

There was an interaction effect between the maize varieties and time of second dose of fertilizer topdressing on number of row per cob at Samaru only. Keeping the maize varieties to a constant and increasing the time of nitrogen second dose application resulted in an increase in the number of rows cob^{-1} up to 6WAS and further increase beyond 6WAS resulted in decrease in number of rows cob^{-1}so also by keeping the time of nitrogen second dose application to a constant and evaluating the varieties, number of rows cob^{-1} was found to be highest on SAMMAZ 16 followed by SAMMAZ 15 and lastly by SAMMAZ 17. The highest number of rows cob^{-1} was obtained at the combination of SAMMAZ 16 and time of nitrogen second dose application at 6 WAS.

Number of Grains per Row

Table 2 further showed the maize the effect of variety, plant population and time of second dose of fertilizer application on number of grains row^{-1} of maize at Samaru and Mando during 2023/2024 cropping season. The varietal variation was significant at both locations where SAMMAZ 16 recording the highest number of grain row^{-1} which was statistically at par with SAMMAZ 17 and SAMMAZ 15 significantly had the fewer number of grains row^{-1}.

The effect of plant population on number of row cob^{-1} was also significant at all sampling periods at both locations where 60,000 plant population recorded higher number of grains row^{-1} over other populations at both locations at all sampling periods while 40,000 plant population recorded fewer grains row^{-1} in all location at harvest.

The time of second dose of fertilizer application was significant at both locations. The application period 6WAS recorded the highest number of grains per row values while the control 4WAS recorded the least values number of grains per row relative to other timings evaluated.

There was no significant interaction between the variables on number of grains per row at both locations

Table 2: Effect of Maize Varieties, Plant Population and Time of Second Dose of Nitrogen Fertilizer Application on No of Cob Plant^{-1}, No of Grain Row^{-1}, No of Grain row^{-1}at Samaru and Mando During 2023/2024 Wet Season

Treatments	Samaru			Mando		
	No of cob plant^{-1}	No of row cob^{-1}	No of grain row^{-1}	No of cob plant^{-1}	No of row cob^{-1}	No of grain row^{-1}
Variety (v)						
SAMMAZ 15	24.90b	149.50b	195.73b	23.30b	156.65a	158.18ab
SAMMAZ 16	33.41a	188.96a	224.78a	26.03a	164.11a	178.84a
SAMMAZ 17	15.84c	131.67c	166.13c	19.53c	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})	27.54b	138.87c	189.66b	19.88	128.55c	161.77c
P_2 (60,000 p ha^{-1})	33.54a	188.76a	212.87a	24.02	162.77a	169.65a
P_3 (80,000 p ha^{-1})	31.43ab	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 3: Interaction Effect Between Maize Variety AND Time of Second Dose of Fertilizer Application on Number of Row Cobs^{-1} (Cm) at Samaru During the 2023/2024 Wet Season

Maize variety	Time of N fertilizer second dose application (WAS)				
	4	5	6	7	8
SAMMAZ 15	122.70c	128.40c	149.76a	145.09b	133.81bc
SAMMAZ 16	124.31c	139.22b	156.72a	148.63a	139.79b
SAMMAZ 17	122.64c	132.30c	145.81a	142.05b	132.46bc
SE+		3.102			

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

Cob Length (cm)

Maize varietal response to plant population and time of second dose of N-fertilizer application on cob length (cm), cob diameter (cm) and 100 grain weight at both Samaru and Mando during 2023/2024 cropping season is presented in Table 4.

At Mando, the maize varieties with respect to cob length did not differ significantly. While at Samaru however, SAMMAZ 16 recorded the highest cob length (cm) and was at par with SAMMAZ 17 but significantly higher than SAMMAZ 15. The effect of plant population on Maize cob length was not significant at all sampling periods at both locations. The effect of time of second dose of N-fertilizer topdressing on cob length was significant at both locations. Application period 6WAS consistently recorded the longest cob length relative to other timings evaluated while the control 4WAS recorded the least cob length at both locations.There was no interaction between the variables in terms of maize cob length at both locations

Cob Diameter (cm)

Table 4 further showed the maize varietal response to plant population and time of second dose of fertilizer application with respect to cob diameter. At both locations, SAMMAZ 16 and 17 had statistically similar cob diameter and were significantly higher with respect to the same character when compared to SAMMAZ 15.

The effect of plant population on Maize cob diameter was also significant at all sampling periods at both locations where 60,000 plant population recorded wider Maize cob diameter over other populations at both locations at all sampling periods while 40,000 plant population recorded narrower cob diameter in all location at harvest

The time of second dose of fertilizer application with respect to cob diameter was significant at both locations. At Samaru, the application period 4WAS recorded the least cob diameter value which was significantly smaller than the other timings 4, 5, 6, 7, and 8WAS that were statistically similar. At Mando, the 6WAS gave the highest cob diameter compared to other timings but 5, 7 and 8WAS were statistically similar and control 4WAS produce the least. There was no interaction between the maize varieties, plant population and time of second dose of fertilizer topdressing on cob diameter in both locations.

100 Grain Weight (g)

Table 4 further showed the response of maize variety, plant population and time of second dose of fertilizer application on 100 grain weight at both Samaru and Mando during 2023/2024 wet season. The varietal response with respect to 100 grain weight was significant at both locations. SAMMAZ 16 and 17 at Samaru were statistically at par recorded the higher 100 grain when compared with SAMMAZ 15.

The effect of plant population on Maize 100 grain weight was also significant at all sampling periods at both locations where 60,000 plant population recorded heavier 100 grain weight over other populations at both locations at all sampling periods while 40,000 plant population recorded lighter 100 grain weight in all location at harvest

At both locations, application time of 6WAS recorded the highest value of100 grain weight followed by 5 7,8 and the control 4WAS in descending order.

There was no interaction between the maize varieties, plant population and time of second dose of fertilizer application on 100 grain weight at both locations

Table 4: Effect of Maize Varieties, Plant population and Time of Second dose of Nitrogen fertilizer application on No of cob plant^{-1}, No of grain row^{-1}, No of grain row^{-1}at Samaru and Mando during 2023/2024 wet season

Treatments	Samaru			Mando		
	Cob length	Cob diameter	100 grain weight	Cob length	Cob diameter	100 grain weight
Variety (v)						
SAMMAZ 15	24.90b	179.50a	195.73ab	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	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.

Grain Yield kg ha^{-1}

Table 5 showed the response of maize varieties, plant population and time of second dose of fertilizer application in term of grain yield (kg) per hectare at both Samaru and Mando during 2023/2024 wet season.Sammaz16 at Mando recorded the highest values of grain yield (kg) per hectare which was followed by Sammaz17 and lastly Sammaz 15 recorded the least value. At Samaru, SAMMAZ 16 and 17 were statistically similar and recorded higher grain yield (kg) per hectare and were significantly higher than SAMMAZ 15.

The effect of plant population on grain yield (kg) per hectare was also significant at all sampling periods at both locations where 60,000 plant population recorded heavier 100 grain weight over other populations at both locations at all sampling periods while 40,000 plant population recorded grain yield (kg) per hectare in all location at harvest

In terms of maize varietal response to time of second dose of fertilizer application, both locations showed statistical difference. At Samaru application time of 6WAS consistently recorded the highest grain yield per hectare whiles the control 4WAS recorded the least. At Mando , the trend almost replicated what was observed in Samaru. Application time of 6WAS also recorded the highest value for grain yield per hectare while the control 4WAS recorded the least.

There was no interaction between the maize varieties and time of second dose of fertilizer application on grain yield (kg) per hectare at both Samaru and Jaji.

Table 5: 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	3050.90c	2010.13bc
SAMMAZ 16	3778.22a	2632.82a
SAMMAZ !7	3634.99ab	2228.43b
SE ±	96.44	83.77
Plant Population (P)		
P_1 (40,000 p ha^{-1})	3049.32b	3008.45b
P_2 (60,000 p ha^{-1})	4249.65a	4133.87a
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

General

Appendix I shows the record of meteorological data of the two locations for the 2020/2021 wet season. Rainfall distribution, intensity, duration, evenness and amount at Samaru were much better than that received at Mando thus, aiding the release of moisture which enhances nutrients uptake for better performance (growth and yield) by the crop. According to Bello *et al*., (2012), Rainfall amount and distribution plays significant role in stimulating process of plant growth and maturity. From the meteorological data collected, monthly rainfall was more evenly and fairly distributed during the 2020/2021 wet season at Samaru than Mando.

Effect of Variety on yield and yield components of Maize

This study revealed the different effect Maize varieties had played in boosting not only vegetative growth of the crop but also enhancing the yield components that ultimately contributed to the grain yield. Maize yield components such as number of cobs plant^{-1}, number of row cob^{-1}, number of grain row^{-1}, cob length, cob diameter and 100 grain weight responded differently to maize varieties accordingly. SAMMAZ 16 recorded the highest number of cobs per plant which was also comparable to SAMMAZ 14 at both locations, while SAMMAZ 15 produced least number of cobs per plant. The study also revealed that SAMMAZ 16 had the higher number of grain row^{-1} at both location This could probably be due to the genetic makeup of SAMMAZ 16 that has inherent late maturing characteristics and stays longer in the field harnessing and utilizing all the resources needed for growth and ultimately better yield performance than other varieties evaluated. This is in line with the findings of Song *et al*., (2010) and Wang *et al*, (2011) who reported that late maturing maize varieties mature after a longer time, had higher plant height, more cobs per plant, heavier cob weight per plot and higher yield and yield components than early maturing varieties. Late season growing conditions affects cob weight because final cob weight is determined at physiological maturity. A stressful environment during grain formation stage can result in reduced cob weight while good condition can increase number of rows cob^{-1} (Abendroth *et al*., 2011). Number of rows cob^{-1} is influenced by source – sink relationship during grain formation with increase cob weight being caused by irradiance level, duration of grain formation and crop growth rate (Novacek *et al.,*2013).

This study further showed that maize varieties vary in their yield components like number of row per cob and number of grains per row. SAMMAZ 16 and 14 outperformed SAMMAZ 15 at Samaru in terms of yield components probably because SAMMAZ 16 variety exhibited higher growth indices and more assimilate build-up due to its late maturing characteristics, it also had higher pre- anthesis generation capacity for higher yield obtainable via higher yield components such as number of cobs/plant, number of rows cob^{-1}, number of grains row^{-1}, cob length and diameter. Being a late maturing variety therefore, it had an extended/longer grain filling period for higher final yield (Gambin *et al*.,(2006). SAMMAZ 16 also had enough time to take up and utilize all the resources needed for growth particularly with higher mean (monthly) rainfall at Samaru than Mando for better growth and yield parameters.

The late maturing character of SAMMAZ 16 had a strong influence on number of rows per cob as part of the genetic makeup of SAMMAZ 16. The full genetic potential of this variety could be attained when the environmental condition are readily available for use by the crop. This in line with the report of the following researchers Svecnjak *et al*., 2006 and Abendroth *et al*., 2011. SAMMAZ 16, a late season variety having the highest grain yield via longest cobs could be as a result of its genetic makeup which the variety was programmed for as to allow enough time for maximum utilization of growth resources for more assimilate production which probably led to production of longer cobs with wider girth than other varieties. This is also in line with the findings of Wang *et al*., (2011) who reported that late maturing maize varieties mature after a longer time, had more cobs per plant, heavier cob weight per plot, longer cobs with wider diameter and higher yield than early maturing varieties.

This report also showed the differences Maize varieties had on 100grain weight. SAMMAZ 16 and 14 had the heaviest 100 grain weight at both Samaru and Mando. This could be as a result of its genotype which was programmed to be a late season crop and with adequate environmental resources for growth it will give a much heavier yield than others. This is in line with the findings of Zamir *et al*., (2011) who stated that the increase in 100 grain weight might be due the varieties genetic potential and availability of more resources (nutrients + water) for efficient utilization by the Maize crop.

Effect of Plant Population on Yield and Yield Components of Maize

The study revealed 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) reported that plant height is an important component which helps determining the growth attained during the growing period. This trial showed that plant height was significantly affected by plant population densities. 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 trial recorded similar trend which 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 from this trial revealed that grain yield was significantly affected by plant population densities (Table-8). The maximum grain yield (4249 kg ha^{-1}) was recorded in T2 (60000 plants ha^{-1}) at Samaru followed by T3 (80000 plants ha^{-1}) which produced grain yield of 3231 kg ha^{-1} and lastly 3049 kg ha^{-1} in T1(40000 plants ha^{-1}).The higher grain yield in T2 and T3 was possibly due to taller plants with higher number of ears (plant^{-1}) and number of grain rows (ear^{-1}) in these two treatments. These results are supported by Emam (2001) and Allessi and power (2004) 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 3008.3 kg ha^{-1} was recorded in T_1 having population of 40,000 plants ha^{-1} at Mando.

Effect of Time of Second Dose of Fertilizer Application on Growth, Yield and Yield Components of Maize

The study revealed that time of second dose of N- fertilizer application or topdressing Nitrogen fertilizer at 6 WAS resulted in positive response in virtually all growth, yield and yield components at both locations (Samaru and Mando). Application of second dose of N fertilizer at 6WAS was advantageous for most of the evaluated growth and yield characters, but was comparable to application at other periods for a few other characters. Since the first dose of fertilizer was applied at one (1) WAS, applying second dose at 6WAS seem ideal as most of the fertilizer applied earlier including those residual fertilizer in the soil, must have been used up by the rapidly growing crop as reported by Ladan.(2018). While those nutrients not accessed by the crop might have been washed or leached away beyond the root zone, or volatilized into the atmosphere thus, leaving the soil barren with no nutrients hence the requirement of second dose of N- fertilizer to maintain growth in order to generate and develop adequate Photosynthetic apparatuses to harness adequate sunshine and Carbon dioxide (CO_2) for assimilation of Carbon. This will subsequently lead to better growth and hence higher yield of the crop relative to latter application of second dose when the crop might have exceeded the requisite growth/vegetative phase of growth and might be too late to develop Photosynthetic apparatuses for carbon assimilation for higher yield since Maize is a determinate crop.

Application of fertilizer at 6WAS consistency in outperforming the other timings was probably because SAMMAZ 16 is a late maturing variety allows more time for carbon assimilation than the other varieties. The extended assimilation will warrant the accumulation of higher pre-anthesis assimilation which can then be shifted or translocated into higher yield later.

SAMMAZ 16 being a late maturing variety had the best response with 6WAS in growth, yield parameters and yield at Samaru than Jaji probably because of availability of more rainfall coupled with sandy loam soil when compared to loam soil with less rainfall at Jaji. This is in conformity with, and validate the report by Anon,(2012) who reported that the best time of N fertilizer second dose application is between 4-6 WAS.

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 N fertilizer second dose at a time 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.

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 that was recently applied had not been exhausted for development of growth apparatuses. Application of second dose at 4WAS may be prone to leaching, volatilization or wash off by runoff etc. Furthermore, 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 etc.

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 that led to better performance in 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 1: Weather Data of the Mando and Samaru during 2023/2024 Raining Season

Months	Mando					Samaru				
	Rainfall mm	Temperature (^0C) Max	Temperature (^0C) Min	Relative Humidity (%) 0900Hrs	Sunshine (Hrs)	Rainfall mm	Temperature (^0C) Max	Temperature (^0C) Min	Relative Humidity (%) 0900Hrs	Sunshine (Hrs)
May	133.7	30	23	42	4.8	147.7	31	21	40	
June	185.2	30	23	41	4.0	239.5	29	23	39	
July	344.2	30	23	47	3.1	436.4	28	22	39	
August	180.1	29	23	39	2.1	193.14	29	22	34	
September	185.1	30	23	38	2.4	194.05	28	24	38	
October	85.2	30	23	37	2.3	92.34	29	21	33	
November	58.2	31	23	42	2.5	65.2	30	23	33	
December	0.0	33	21	41	2.1	9.6	31	21	31	
Total	**1557.1**					**2302.9mm**				

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