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Variability of elite maize (*Zea mays* L.) varieties at different row spacing in Guinea Savannah Region of Nigeria

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ABSTRACT

Varieties and spacing are among the factors determine crop yield. Field experiment was carried out at the North Core College of Agronomy Teaching and Research, Joseph Sarwuan Tarka University, Makurdi to determine the effects of intra row spacing on the performance of three maize varieties in Makurdi. The experimental design used was 3 x 4 factorial arrangement laid out in a Randomized Complete Block Design, replicated thrice. The treatments were three (3) maize varieties and four (4) different intra-row spacing (20 cm, 30 cm, 40 cm and 50 cm). Data were collected on growth, yield and yield component parameters were subjected to analysis of variance. Significant means were subjected to least significant difference (LSD). The result showed significant differences among the maize varieties, row spacing and treatment interactions which indicated the presence of genetic and environmental effects on maize performance. The superiority of Sammaz-51 over the other varieties was observed as it produced significant seed yield. Result showed increase in intra row spacing with increase in more number of leaves per plant which were significantly longer and wider while least was recorded in a closer spacing. Increase in plant spacing beyond 40 cm intra-row was found to reduce cob weight, weight of seeds per cob as well as 1000-seed weight. Based on the study findings, maize farmers were advised to adopt increase intra-row spacing up to 40 cm for optimum yield of maize in savannah region of Nigeria.

1. Introduction

Maize (*Zea mays* L.) belongs to the family *poaceae*. It ranked second after cassava as the most cultivated crop in terms of harvested area (5.8million ha) in Nigeria (FAOSTAT, 2014). Maize production in Nigeria amounted to 12.75 million metric tons in 2021. This slightly increased in 2022 by 12% in 2022 (CBN, 2023). According to FAO (2022) report, the global production of primary crop commodities reached 9.5 billion tonnes in 2021, increasing by 54 percent since 2000 and 2 percent since 2020 while. The global production of cereals went up 64 million tonnes, or 2.1 percent, between 2020 and 2021, driven by a 4.1 percent increases in maize production. Maize, wheat and rice accounted for 90 percent of the total cereals production in 2021 (FAO, 2022). Maize showed the highest production (1.2 billion tonnes in 2021) and fastest growth over the period (+104 percent since 2000) compared to the other major cereals. Maize use in the production of biofuel and animal feed. Rice and wheat had very similar production levels and growth rates: 787 million tonnes in 2021 and +32 percent since 2000 for rice, compared to 771 million tonnes and +31 percent for wheat. Barley and sorghum had a fairly stable production over time, with a drop of 8 percent between 2020 and 2021 for barley (FAO, 2022). In 2021, the Americas were the top producing region for maize, with the United States of America and Brazil accounting together for 39 percent of the world production (FAO, 2022). China was the second largest producer, with a share of almost 23 percent.

Nigeria is among the top ten (10) maize producers in Africa, and is ranked second after South Africa, with an estimated quantity of about 10.8 million tonnes produced in 2014 (FAOSTAT, 2014). It is widely cultivated in many agricultural zones of Nigeria (Idem *et al*., 2013). Maize is also widely believed to have the greatest potential among food production in tropical regions (Kamara & Sanginga, 2010; Esang *et al*., 2021). The production of maize is very popular among farmers, because of its high value in food security, short maturation period, grow all year round and source income to both subsistence and commercial farmers.

Maize grain yield is highly dependent on plant population and optimum plant populations must be attained in order to maximize yield (Idem *et al*., 2013). In order for farmers to achieve their desired plant population they must adjust their seeding rate so that it is 5-10% higher than the desired plant population to account for germination and plant death during the growing season. Plants population affect most growth parameters of maize and other cereals such as rice even under optimal growth conditions and therefore it is considered a major factor determining the degree of competition between plants within rows (Esang & Ikeh, 2021). Spatial distribution of crops affects canopy structure, light interception and radiation use efficiency and crop biomass as well as grain yield.

Most research indicates that increasing plant population increases grain yield quadratic ally (Novacek *et al*., 2013; Novacek *et al*., 2014). Adequate plant row spacing provides favorable environment for growth, development and yield of the crop; it minimizes plants competition for available resource nutrients in the soil, moisture and solar radiation due to equidistant plant arrangement. According to Muranyi and Pepo (2013), closer row spacing enhances maize growth rate during the earlier growth period of the crop which lead to higher interception of solar radiation and efficient utilization which translate to higher biomass accumulation. It also enhances faster and early covering of the soil surface against detachment and displacement of the soil particles, conserved soil moisture and promotes shading of weeds germination and growth. In the contrast, closer row spacing may hinder performance of some agronomic practices such as manual weeding, fertilizer application etc. Also, in over populated crops stands, the inter plant competition is usually intense for light, air and available nutrients, whole outcome is mutual shading, promotion of apical growth and depressed productivity. In addition, it predisposes plants to lodging due to weak stems and it may also favor biomass yield at the expense of grain yield. Idem *et al.* (2013), observed reduced row spacing in maize could enhance production per unit area of land by raising plant population provided there exist favorable weather conditions and proper crop nutrition (balance soil nutrients).

The main objective of study is to determine the effect of intra row spacing on the performance of maize; to determine the effects of intra row spacing on the performance of maize and to determine interactive effects of intra row spacing and variety on performance of maize.

2. Methods

The experiment was conducted at the North-Core College of Agronomy Teaching and Research Farm of Joseph Sarwua Tarka University, Makurdi (Latitude 07 47.45 N and longitude 08 36.48 E). Field experiment was carried out during the 2022 cropping season between June to September. Three varieties of maize namely; Sammaz 15, Sammaz 27 and Sammaz 51 were obtained from the International institute for Tropical Agriculture, through the Molecular Biology Laboratory of Joseph Sarwuan Tarka Unuversity, Makurdi.

The experimental design was a 3 x 4 factorial arrangement laid out in a Randomized Complete Block Design (RCBD) with three replications. The treatment consists of three (3) varieties of maize and four (4) different intra-row spacing (20 cm, 30 cm, 40 cm and 50 cm). Glyphosate herbicide was applied to the weed and after two weeks the land was cleared manually with cutlasses. Ridges were manually made one week after land clearing using hoes. The experimental field was marked out into plots. Each plots consists of four rows (ridges) measuring four meters long comprising of boarder row and net plot. Seed were sown on the 24th June, 2022. Three seed were sown per hill and later thinned to 2 plants per hill at one week after planting (WAP). Compound fertilizer (N P K 15:15:15) was applied at the rate of 300kg per hectare at two weeks after planting and urea was top dress at 100kg per hectare at four weeks after planting. Deep-hole method was used as method of application.

After sowing pre and post emergence herbicides (Antrizin and Glyphosate) were applied at the rate of 200mls and 100mls per 20 litres of water using knapsack sprayer. Manual weeding was done at four weeks after planting (WAP). Fall army warms was controlled by application of apmligo 150 ZC (100g/I chlorantraniliprole, 50g/I Lambda-cyhalothrin) at one sachet per knapsack at two and five weeks after planting. The maize was harvested went all the cobs were turn from green to brown, the cobs were detached from plant by hand. The husk was removed from the cob and the seeds were removed from the cob.

Data were collected on the following parameters: Plant height after sowing: Plant height was measured from the soil surface to the base of the last flag leaf at 2 and 5 weeks after sowing (WAS). Five plants from the two middle rows were used for the measurement using a graduated (cm) meter ruler. The mean of the five plants was calculated and recorded as plant height (cm). Days to first anthesis: The days from sowing to when the first plant in the net plot have reached anthesis and was recorded as the number of days to anthesis. Days to 50% anthesis: The number of days taken by half of the plants that reached anthesis was recorded as the number of days 50% anthesis. Plants height at anthesis: Plants were measured at 50% anthesis using graduated meter ruler. The mean of five plants from two middle rows were calculated and recorded as plant height at anthesis. Leaf length at first anthesis: Five plants were taken from the two middle rows were measured and mean calculated as plant height at anthesis. Leaf width at first anthesis: Five plants from the two middle rows were measured and mean calculated recorded as plant leave width at anthesis. Number of leaves at first anthesis: Five plants were taken from the two middle rows were counted and mean calculated recorded as number of leaves per plant. Cob length: Five maize cobs from the middle rows of each plot were selected and measured using graduated rule. The mean of five measured length of cobs were recorded as length of cob (cm).

Cob weight: Five cobs selected from each plot were shelled and weighed using Beam Balance in the laboratory and mean weight recorded as grain yield per plant (g). Unshelled weight per plot: All cobs in the two middle rows were harvested and weigh as unshelled weight per plot (kg/ha). Cobs weight per plot: The harvested cobs were husked and weigh as cob weight per plot (kg/ha). Seed weight per plot: The cobs were shelled and weigh as seed weight per plot (kg/ha). The weight of 1000 grains from each plot was determined using Beam Balance.

3. Results and Discussion

Mean square from analysis of variance for yield and yield component characters of maize varieties evaluated in Makurdi at different plant spacing is presented in Table 1 below. The result showed significant difference in varieties for all parameters measured (plant height at 2 weeks after planting, plant height at 5weeks after planting, days to first anthesis, days to 50 percent anthesis, plant height at first anthesis, leaf length at first anthesis, leave width at first anthesis, number of leaves at first anthesis, cub length, cub weight, weight of seed per cub, seed weight and 1000 seed weight) except dehusking percentage and shelling percentage.

Also, significant differences in plant spacing were observed for plant height at 2weeks after planting, plant height at 5weeks after planting, plant height at first anthesis, leaf length at first anthesis, leave width at first anthesis, number of leaves at first anthesis, cub weight, weight of seed per cub, seed weight, dehusking percentage, shelling percentage and 1000 seed weight. However, there was no significant difference in plant spacing for days to first anthesis, days to 50 percent anthesis and cub length.

Variety x plant spacing interaction showed significant difference for plant height at 2 weeks after planting, plant height at plant height at first anthesis, leaf length at first anthesis, leave width at first anthesis, number of leaves at first anthesis, cub length, cub weight, weight of seed per cub, seed weight, dehusking percentage, shelling percentage and 1000 seed weight. There was however no significant difference in variety x plant spacing interaction for plant height at 5 weeks after planting, days to first anthesis, days to 50 percent anthesis.

Figure 1. Maize crop of the experiment

Table 1. Mean squares from analysis of variance for yield and yield component in maize varieties at different plant spacing

Source of Variation	df	Plant Height at 2weeks (cm)	Plant Height at 5weeks (cm)	Days to first anthesis	Days to 50% first anthesis	Plant height at first anthesis (cm)	Lea length at first anthesis (cm)	Leave width at anthesis	Number of leaves at first anthesis
Rep	2	0.00	0.30	0.36	0.86	0.04	0.05	0.00	0.02
Variety (V)	2	0.32**	623.43**	16.44**	12.03**	292.17**	3.77**	0.51**	0.21**
Plant Spacing (PS)	3	0.09**	1.54**	0.32^{ns}	0.37^{ns}	275.18**	0.68**	0.08**	0.19
VxPS	6	0.04**	0.32^{ns}	0.07^{ns}	0.18^{ns}	15.52**	0.38**	0.01**	0.11**
Error	22	0.01	0.22	0.24	0.22	0.76	0.01	0.01	0.02
Total	35								
CV		0.1	0.4	1.1	1.0	0.6	0.1	0.5	1.1

Table 2. Mean squares from analysis of variance for yield and yield component in maize varieties at different plant spacing

Source of Variation	df	Cob length (cm)	Cob weight (g)	Weight of seed per cob (g)	Seed weight (kg/ha)	Dehusking %	Shelling %	Weight of 1000 seeds (g)
Rep	2	1.07	118.64	35.50	12352.00	104.79	46.73	30.56
Variety (V)	2	2.71*	833.16**	143.44**	244253.00**	38.96^{ns}	22.62^{ns}	633.03**
Plant Spacing (PS)	3	0.43^{ns}	444.55**	333.93**	878556.00**	1328.51**	1002.38**	905.68**
VxPS	6	1.20*	1657.40**	857.66**	35301.00**	371.40**	126.31*	269.25**
Error	22	0.76	56.95	13.05	3499.00	73.98	44.41	34.46
Total	35							
CV		8.1	8.2	5.0	6.4	26.4	24.1	2.4

3.1 Effect of variety on yield and yield components of maize

The mean performance of maize varieties for yield and yield component characters are presented in table 2 above. Significant difference in plant height at two weeks after planting (2WAP) showed that Sammaz 51 recorded the highest seedling height of 27.41 cm, significantly different from seedling height of 27.19 cm and 27.09 cm recorded for both Sammaz 15 and Sammaz 27 respectively. Similar response was observed for plant height at five weeks after planting as Sammaz 51 recorded the highest plant height of 126.58 cm, significantly different from plant height of 112.94 cm and 115.71 cm recorded for both Sammaz 15 and Sammaz 27 respectively. Also, significant difference in plant height at anthesis showed that Sammaz 51 maintained the highest height (139.89 cm), significantly taller than plant height of 134.61 cm and 130.03 cm recorded for both Sammaz 15 and Sammaz 27 respectively.

The effect of variety on days to first anthesis showed that Sammaz 51 reached first anthesis at 44.42 days, significantly earlier that the number of days recorded for Sammaz 15 and Sammaz 27 (46.75 days and 45.75 days respectively). Similar trend was also observed for days to 50% anthesis as Sammaz 51 reached fifty percent anthesis at a significantly shorter period of time (46.58 days), earlier than the number of days recorded for Sammaz 15 and Sammaz 27 which both reached fifty percent anthesis at 48.58 days and 47.50 days respectively.

Variation in leaf length at first anthesis was also observed among the different varieties evaluated. Result showed that leaf length was significantly longer in Sammaz 27 (91.36 cm), when statistically compared to the length of leaves recorded in Sammaz 15 (90.34 cm) and Sammaz 51 (90.45 cm). Also, significant difference among the maize varieties in leave width at anthesis showed that Sammaz 51 recorded wider leaves (9.26 cm), significantly different from leave width of 8.91 cm recorded in both Sammaz 15 and Sammaz 27. Similarly, the number of leaves were found to be significantly more in Sammaz 51 (11.43 leaves) than the number of leaves counted in Sammaz 15 (11.30 leaves) and Sammaz 27 (11.17 leaves).

Variations in cub length as shown in table 2 reveals that longer cubs produced in Sammaz 51 (11.15 cm) were significantly better than cub lengths of 11.00 cm and 10.26 cm produced in Sammaz 15 and Sammaz 27 respectively. With respect to cub weight however, Sammaz 15 weighing an average of 101.41 g was found to be statistically better than cub weights obtained in Sammaz 27 (86.39 g) and Sammaz 51 (87.65 g).

Similarly, genotypic differences observed for weight of seed per cub also showed that Sammaz 15 recorded higher weight (76.53 g), statistically better than weight of seeds per cub obtained in Sammaz 27 (69.88 g) and Sammaz 51 (71.56 g). Variations in seed weight among the different genotypes showed that seed weight was higher (1079.11 kg ha^{-1}) in Sammaz 51, significantly different from the reduced seed weight of 915.69 kg ha^{-1} and 794.83 kg ha^{-1} obtained in Sammaz 15 and Sammaz 27 respectively.

Similarly, variation in 1000 seed weight was found to follow similar trend as Sammaz 51 recorded the highest 100 seed weight of 257.91 grams, significantly better than 1000 seed weight values (246.50 gram and 244.42 gram) recorded in Sammaz 15 and Sammaz 27 respectively.

The effect of plant population on yield and yield component characters of maize varieties is presented in Table 3 below. Significant difference in plant height at two weeks after planting showed that plant height for maize planted at 40 cm spacing were significantly higher (27.36 cm) than plant height recorded at plant spacing of 20 cm (27.12 cm), 30 cm (27.22 cm) and 50 cm (27.22 cm). However variation in plant height at five weeks after planting showed that maize planted at 40 cm and 50 cm spacing recorded significant taller plants (118.68 cm and 118.84 cm respectively), statistically better than plant heights of 117.97 cm and 118.15 recorded at 20 cm and 30 cm plant spacing respectively. This trend was consistent for the effect of plant spacing on plant height at first anthesis, as maize planted at 40 cm and 50 cm spacing recorded significant taller plants (138.11 cm and 138.34 cm respectively), statistically better than plant heights of 126.67 cm and 136.26 recorded at 20 cm and 30 cm plant spacing respectively.

The effect of plant spacing on maize leaf length showed that maize planted at 50 cm spacing produced longer leaves (91.12 cm), significantly better than leaf lengths of 90.52 cm, 90.61 cm and 90.60 cm recorded for 20 cm, 30 cm and 40 cm plant spacing respectively

Table 3. Main Effect of variety on yield and yield components of maize

Variety	Plant height at 2 weeks (cm)	Plant height at 5 weeks (cm)	Days to first anthesis	Days to 50% anthesis	Plant height at first anthesis (cm)	Leaf length at first anthesis (cm)	Leave width at anthesis	Number of leaves at first anthesis	Cob length (cm)	Cob weight (g)	Seed weight Per Cob (G)	seed weight (kg/ha)	Dehusking %	Shelling %	1000 seed weight (g)
Sammaz 15	27.19	112.94	46.75	48.58	130.03	90.34	8.91	11.30	11.00	101.41	76.53	915.69	30.65	26.34	246.50
Sammaz 27	27.09	115.71	45.75	47.50	134.61	91.36	8.91	11.17	10.26	86.39	69.88	794.83	33.00	29.07	244.42
Sammaz 51	27.41	126.58	44.42	46.58	139.89	90.45	9.26	11.43	11.15	87.65	71.56	1079.11	34.19	27.50	257.91
LSD (0.05)	0.02	0.39	0.41	0.40	0.74	0.09	0.03	0.10	0.74	6.38	3.05	50.08	7.28	5.64	4.97

Table 4. Main Effect of plant spacing on yield and yield components of maize

Plant Spacing	Plant height at 2 weeks (cm)	Plant height at 5 weeks (cm)	Days to first anthesis	Days to 50% anthesis	Plant height at first anthesis (cm)	Leaf length at first anthesis (cm)	Leave width at anthesis	Number of leaves at first anthesis	Cob length (cm)	Cob weight (g)	Seed weight Per Cob (G)	seed weight (kg/ha)	Dehusking %	Shelling %	1000 seed weight (g)
20 cm	27.12	117.97	45.67	47.67	126.67	90.52	8.88	11.11	10.54	91.72	76.53	650.64	47.84	35.00	236.33
30 cm	27.22	118.15	45.44	47.78	136.26	90.61	9.06	11.27	10.72	82.50	64.08	688.95	36.94	36.92	247.67
40 cm	27.36	118.68	45.56	47.33	138.11	90.60	9.07	11.38	10.89	99.45	77.42	1086.17	22.05	24.55	258.97
50 cm	27.22	118.84	45.89	47.44	138.34	91.12	9.09	11.44	11.05	93.58	72.59	1293.75	23.62	14.07	255.47
LSD	0.03	0.45	0.47	0.46	0.85	0.10	0.04	0.11	0.85	7.37	3.53	57.82	8.40	6.51	5.73

Differences in leaf width as influenced by plant spacing showed similar pattern, with maize planted at 50 cm spacing producing wider leaves (9.09 cm), significantly better than leaf widths of 8.88 cm, 9.06 cm and 9.07 cm recorded for 20 cm, 30 cm and 40 cm plant spacing respectively.

Variation in the number of leaves at different plant spacing showed that significant greater number of leaves (11.44 leaves) were counted at a wider spacing of 50 cm, statistically better than the number of leaves counted at first anthesis for 20 cm plant spacing (11.11 leaves), for 30 cm plant spacing (11.27 leaves) and 40 cm plant spacing (11.38 leaves).

Different intra row spacing also showed differential response in cub weight. Planting at 40 cm spacing produced better cob weight (99.45 g), statistically similar to cob weight produced from planting at 50 cm (93.58 g). But was however different from cob weight produced from planting at 20 cm (91.72 g) and at 30 cm (82.50 g).

Similar response was observed with the effect of plant spacing on weight of seeds per cub. Planting at 40 cm spacing produced higher seed weight per cub (77.42 g), statistically different from the weight of seeds per cub produces from planting at 30 cm (64.08 g) and at 50 cm (72.59 g).

Significant difference in total seed weight showed that planting at 50 cm spacing produced significant higher seed weight (1293.75 kg ha^{-1}), significantly different from seed weights of 650.64 kg ha^{-1}, 688.95 kg ha^{-1} and 1086.17 kg ha^{-1} obtained from planting at 20 cm, 30 cm and 40 cm respectively.

The effect of plant spacing on 1000-seed weight showed that significant higher weights (258.97 g and 255.47 g) were obtained from seeds planted at 40 cm and 50 cm spacing respectively. Both weights were found to differ significantly from 1000-seed weights of 236.33 g and 247.67 g obtained from seeds planted at 20 cm and 30 cm spacing respectively.

Differences in dehusking percentage as influenced by plant spacing showed that maize plants harvested from 20 cm spacing recorded higher dehusking percentage (47.84 %) significantly different from dehusking percentage recorded from maize plants harvested from 30 cm spacing (36.94 %), from 40 cm spacing (22.05 %) and from 50 cm spacing (23.62 %).

Also, differences in shelling percentage as influenced by plant spacing showed that higher shelling percentages (35.00 % and 36.92 %) were recorded from maize plant cultivated at 20 cm and 30 cm intra-row spacing respectively. Lower shelling percentages were recorded from plants cultivated at 40 cm (24.55 %) and 50 cm (14.07 %).

The effect of variety x plant spacing interaction on the yield and yield components of maize is presented in table 5 below. The result showed significant difference for plant height at 2weeks after planting, plant height at plant height at first anthesis, leaf length at first anthesis, leave width at first anthesis, number of leaves at first anthesis, cub length, cub weight, weight of seed per cub, seed weight, dehusking percentage, shelling percentage and 1000 seed weight.

Variety x spacing interaction effect on plant height at two weeks after planting showed that when planted at 40 cm intra row spacing, significant plant heights (27.51 cm and 27.47 cm) were recorded for Sammaz-15 and Sammaz-51 respectively, significantly different from Sammaz-15 and Sammaz-27 which both recorded the least plant height of 27.03 cm and 27.05 cm respectively when planted at intra-row spacing of 20 cm.

The significant response of maize varieties to variety x plant spacing interaction showed that taller plants at first anthesis measuring 142.10 cm, 143.70 cm and 143.40 cm were produced when Sammaz-51 was planted at 30 cm, 40 cm and 50 cm respectively significantly better than plant height of 130.40 when same variety was planted at 20 cm intra-row spacing. At all plant spacing's, Sammaz-15 and Sammaz-27 produced considerably lower plant height at first anthesis, with the lowest plant height at anthesis (119.50 cm) recorded when Sammaz-15 was planted at 20 cm intra-row spacing.

Significant variety x spacing interaction effect on leaf length at first anthesis showed that leaf length in Sammaz-27 was significantly longer for all plant spacing. In Sammaz-15 however, leaf length was significantly longer (91.33 cm) for 50 cm spacing, statistically different from leaf lengths of 89.97 cm, 90.15 cm and 89.91 cm recorded for 20 cm spacing, 30 cm spacing and 40 cm spacing respectively. Also in Sammaz-51, leaf length was significantly longer (90.63 cm) for 50 cm spacing, and differed only from leaf lengths of 90.29 cm and 90.35 cm recorded for 20 cm spacing and 30 cm spacing respectively.

Variation in leaf width as influenced by variety x plant spacing interaction showed that in Sammaz-51, planting at 30 cm, 40 cm and 50 cm produced significant wider leaves (9.31 cm, 9.35 cm and 9.37 cm respectively), statistically better than leaf width of 9.01 cm recorded for 20 cm spacing. Similar pattern was observed in Sammaz-27, with planting at 30 cm, 40 cm and 50 cm producing significant wider leaves (8.91 cm, 8.95 cm and 8.95 cm respectively), statistically better than leaf width of 8.82 cm recorded for 20 cm spacing. In Sammaz-15 also, the result of leaf width followed same trend as planting at 30 cm, 40 cm and 50 cm producing significant wider leaves (8.95 cm, 8.91 cm and 8.95 cm respectively), statistically better than leaf width of 8.81 cm recorded for 20 cm spacing.

The effect of variety x plant spacing interaction on the response to number of leaves showed that the number of leaves counted in Sammaz-51 planted at 50 cm spacing was higher (11.73 leaves), significantly more than the number of leaves counted for all other variety x plant spacing combinations. The lowest number of leaves count was recorded in Sammaz-27 at 20 cm intra-row spacing.

Similarly, the effect of variety x plant spacing interactions on cub length showed that Sammaz-51 planted at 50 cm spacing produced longer cubs (12.02 cm), significantly better than cub lengths of 10.18 cm in Sammaz-15 planted at 50 cm, cub length of 10.01 cm recorded in Sammaz-27 planted at 20 cm and cub length of 9.68 cm in Sammaz-27 planted at 30 cm.

The effect of variety x plant spacing interaction was also significant on cub weight. The result showed that in Sammaz-15, significant greater cub weight (123.67 g) was obtained when planted at 40 cm spacing and was significantly better than cub weights of 104.55 g, 108.67 g and 68.74 g obtained in Sammaz-15 when planted at 20 cm, 30 cm and 50 cm respectively. In Sammaz-27 however, both 20 cm and 50 cm intra-row spacing produced higher cub weights (102.65 g and 103.09 g respectively), and were significantly better than cub weights of 59.07 g and 80.74 g produced for 30 cm and 40 cm spacing.

Similar effect of variety x plant spacing interaction was observed on the weight of seeds per cub. The result showed that the weight of seed per cub was higher in Sammaz-15 planted at 40 cm intra-row spacing (97.37 g), significantly better than weight of seeds per cub obtained in Sammaz-15 when planted at 20 cm spacing (75.22 g), at 30 cm spacing (81.11 g) and at 50 cm spacing (52.41 g). In Sammaz-27, weight of seeds per cub was higher at 50 cm (83.13 g) and 20 cm spacing (81.37 g), statistically better than weight of seeds per cub obtained at 30 cm (47.50 g) and at 40 cm spacing (67.51 g). However, in Sammaz-51, planting at 50 cm spacing produced significant higher weight of seeds per cub (82.23 g), and was better than weight of seeds produced at 20 cm (72.99 g) at 30 cm (63.63 g) and at 40 cm spacing (67.39 g).

With respect to seed weight, the differential response caused by variety x plant spacing interaction reveals that in Sammaz-15, significant higher seed weight was recorded at 50 cm spacing (1273.10 kg/ha), statistically different from seed weights obtained at 20 cm (711.90 kg/ha), at 30 cm (683.20 kg/ha) and at 40 cm spacing (994.60 kg/ha). Similar trend was observed in Sammaz-27 with significant higher seed weight recorded at 50 cm spacing (1089.70 kg/ha), statistically different from seed weights obtained at 20 cm (608.60 kg/ha), at 30 cm (555.40 kg/ha) and at 40 cm spacing (925.50 kg/ha). Also in Sammaz-51, significant higher seed weight was recorded at 50 cm spacing (1518.50 kg/ha), statistically different from seed weights of 631.40 kg/ha, 828.30 kg/ha and 1338.30 kg/ha obtained at 20 cm, 30 cm and at 40 cm spacing respectively.

Table 5. Effect variety and plant spacing on yield and yield components of maize

Variety	Plant Spacing	Plant height at 2 weeks (cm)	Plant height at 5 weeks (cm)	Days to first anthesis	Days to 50% anthesis	Plant height at first anthesis (cm)	Leaf length at first anthesis (cm)	Leave width at anthesis	Number of leaves at first anthesis	Cob length (cm)	Cob weight (g)	Seed weight Per Cob (G)	seed weight (kg/ha)
sammaz 15	20 cm	27.03e	119.50g	89.97f	8.81d	11.27bc	11.27abc	104.55bc	75.22cd	711.90f	37.22bcd	33.26ab	229.60e
sammaz 15	30 cm	27.11d	132.10e	90.15e	8.95bc	11.27bc	10.77abc	108.67b	81.11bc	683.20f	48.35ab	34.21ab	243.80d
sammaz 15	40 cm	27.51a	135.00cd	89.91f	8.91c	11.33bc	11.77ab	123.67a	97.37a	994.60cd	12.29e	25.15bc	262.90ab
sammaz 15	50 cm	27.11d	133.60de	91.33a	8.95bc	11.33bc	10.18bc	68.74ef	52.41g	1273.10b	24.74cde	12.72d	249.70cd
sammaz 27	20 cm	27.05e	130.10f	91.31a	8.82d	10.73d	10.01c	102.65bc	81.37bc	608.60fg	47.53ab	38.97a	229.20e
sammaz 27	30 cm	27.10d	134.60cd	91.33a	8.91c	11.33bc	9.68c	59.07f	47.50g	555.40g	39.78bc	33.89ab	233.30e
sammaz 27	40 cm	27.10d	135.70c	91.39a	8.95bc	11.33bc	10.40abc	80.74de	67.51ef	925.60de	26.65cde	33.01ab	253.40bcd
sammaz 27	50 cm	27.11d	138.00b	91.41a	8.95bc	11.27bc	10.95abc	103.09bc	83.13b	1089.70c	18.05e	10.42d	261.70ab
sammaz 51	20 cm	27.29c	130.40f	90.29de	9.01b	11.33bc	10.34abc	91.15cd	72.99de	631.40fg	58.76a	32.78ab	250.20cd
sammaz 51	30 cm	27.43b	142.10a	90.35cd	9.31a	11.20c	11.72ab	79.77de	63.63f	828.30e	22.69de	42.68a	265.90a
sammaz 51	40 cm	27.47ab	143.70a	90.52bc	9.35a	11.47b	10.51abc	70.76ef	67.39ef	1338.30b	27.23cde	15.48cd	260.60abc
sammaz 51	50 cm	27.44b	143.40a	90.63b	9.37a	11.73a	12.02a	108.92b	82.23b	1518.50a	28.08cde	19.07cd	255.00abc
LSD (P≤0.05)		1.48	0.04	1.47	0.18	0.07	0.20	1.48	12.77	6.11	100.16	14.56	11.28

Variation in 1000-seed weight as influenced by the effect of variety x plant spacing interaction showed that in Sammaz-15, planting at 40 cm produced higher 1000-seed weight (262.90 g), significantly different from 229.60 g, 243.80 g and 249.70 g recorded for 20 cm, 30 cm and 50 cm intra-row spacing's respectively. In Sammaz-27, 1000-seed weight was found to higher from planting at 50 cm (261.70 g), significantly better that 1000-seed weight obtained from planting at 20 cm (229.20 g), at 30 cm (233.30 g) and from planting at 40 cm (253.40 g). In Sammaz-51 however, planting at 30 cm spacing produced higher 1000- seed weight (265.90 g) and was only significantly better than 1000-seed weight obtained from planting at 20 cm (250.20 g).

Significant effect of variety x plant spacing interaction on dehusking percentage showed that in Sammaz-15, dehusking percentage was higher at 30 cm spacing (48.35 %), statistically same with 37.22 percent recorded at 20 cm spacing, but differed significantly from dehusking percentage recorded at 40 cm (12.29 %) and at 50 cm spacing (24.74 %). In Sammaz-27 dehusking percentage was higher at 20 cm (47.53 %) and differed only from dehusking percentages recorded at 40 cm (26.65 %) and 50 cm intra-row spacing (18.05 %). Similar trend was observed in Sammaz-51 as 20 cm spacing recorded higher dehusking percentage (58.76 %), differing significantly from dehusking percentages recorded at 30 cm (22.69%), at 40 cm (27.23 %) and 50 cm intra-row spacing (28.08 %).

Significant variety x plant spacing interaction on shelling percentage showed that in Sammaz-15, shelling percentage was higher (33.26 % and 34.21 %) at both 20 cm and 30 cm spacing respectively and differed significantly from shelling percentage recorded at 40 cm (25.15 %) and at 50 cm spacing (12.72 %). Similarly in Sammaz-27, shelling percentage was higher from plots planted at 20 cm spacing (38.97 %) and was only statistically different from shelling percentage of 10.42 percent recorded from plots planted at 50 cm spacing. Also in Sammaz-51, shelling percentage was found to be higher at 30 cm spacing (42.68 %), statistically same with shelling percentage at 20 cm spacing (32.78 percent) but differed significantly from shelling percentage at 40 cm (15.48 %) and at 50 cm spacing (19.07 %).

Discussion

Maize grain yield is highly dependent on the inherent genetic make-up of the variety as well as plant population plant population and optimum plant populations must be attained in order to maximize yield (Idem *et al*., 2013). This is confirmed from the result of the current study which showed significant effects of variety, plant spacing and the interaction between the two factors on almost all parameters measured. The significant differences in variety for most measured parameters indicate inherent genetic variability among the evaluated materials. Several authors (Okoli & Nworji, 2021; Bastola, *et al*., 2021; Abba *et al*., 2020; Nassar *et al*., 2019) have reported significant differences in yield and yield components of maize. Nassar et al. (2019) evaluated some maize genotypes for yield and yield components and reported significant variety effect on grain yield, 100-seed weight, number of seeds per row, number seeds per cob, and cub weight. Similarly, Upadhyay et al. (2009) evaluated eleven maize genotypes and reported significant difference for yield and yield component traits. In Nigeria, Okoli & Nworji (2021), evaluated the performance of 21 maize hybrids for yield and other agronomic attributes and reported significant difference in plant height, cob length, seeds per cob, 1000-seed weight and grain yield. From the findings of the present study, the superiority of Sammaz-51 over other varieties was observed as it produced the highest seed weight and 1000- seed weight. This difference could be attributed to yield contributing characters such as plant height, leaf width, number of leaves and cob length which were superiorly better in Sammaz-51. Ikenganyia et al. (2015) noted that leaf number and leaf area were good measures of the photosynthetic capacity in plant.

The findings of the current study also showed that maize responds differently to plant spacing which determines plant population. According to Idem et al. (2013) plants population 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. Maize plant in a field situation are always influenced by competition with other plants for resources such as light, nutrients, and water (Idem *et al*., 2013). This competition influences the plant's growth and development which in turn affects yield and its components.

Variations in plant height due to different planting spacing were found to be significant at all stages of growth. From the current study, plant height at five weeks after planting and at anthesis increased with increasing plant spacing. This result contradicts the reports of Ukonze et al. (2016) who reported increase in plant height of maize with decreasing plant spacing. Ukonze et al.(2016) suggested that as the number of plants increased in a given area, the competition among the plants for nutrients and sunlight interception also increased. In contrast however, increasing plant spacing leads to the reduction of plant population. With the number of pant reduced, the amount of available nutrient supplied for plant growth and development will be sufficient for optimum development. Hence nutrients are made available to plants at increased spacing.

Also, planting at an increased intra row spacing was found to produce more number of leaves that are significantly longer and wider. Maize has been reported as a heavy feeder, requiring large amount of nitrogen for plant growth and reproduction. Hence planting a closer spacing with increased plant population, will lead to nutrient competition and slow growth. In addition, increased spacing which makes for less competition, was found to influence the production of higher seed weight. This may be attributed to increase in the number of leaves produced at increased plant spacing which are significantly longer and wider. Ukonze et al. (2016) reported that the number of leaves and nodes on the plant coincided with the increase in the plant height. In a similar study, Rate (2014) reported that there was reduction in yield components at high plant population density (reduced plant spacing), which might be due to lesser photosynthetic rate and accumulation of lesser assimilates, which in turn decreased cob length, cob diameter and grain size which is directly responsible for low yield. Increased plant population with space reduction significantly decreased the grain yield. This happens because of plant competition for space, sunlight, nutrient, moisture. This finding corroborates the different experiment by Kanakdurga et al. (2012) and Ryan (2012). However, increasing plant spacing beyond 40 cm intra-row was found to reduce cob weight, weight of seeds per cob as well as 1000-seed weight. The significant variety x plant spacing interaction for almost all parameters measured confirms the studies carried out by Sharifi et al. (2009) which showed that plant population density influences the performance of maize dry matter yield and thus, maize grain responded to population density and spacing.

4. Conclusions

The study showed that maize responds differently to plant spacing which determines plant population. Planting at 50 cm spacing produced significant higher seed weight which was significantly different from yield from the other spacing. However, increasing plant spacing beyond 40 cm intra-row was found to reduce maize yield. Among the maize varieties, Sammaz-51 is therefore recommended for increase maize production in the Makurdi environment. Farmers can adopt increase intra-row spacing of up to 40 cm for optimum maize yield.

5. References

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