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Appropriate Spacing: A Catalyst To Bumper Maize (*Zea mays*) Production In Mubi Adamawa State, Nigeria

Mohammed. D. Toungos

Department of Crop Production and Horticulture,
Modibbo Adama University of Technology, Yola, Nigeria

Corresponding Author:
Email address: toungosm@mautech.edu.ng; dahiru.toungos@gmail.com
Cell Phone: +2348034392406

ABSTRACT

A field experiment was conducted at Food and Agricultural Organization/Tree Crop Programme (FAO/TCP) Teaching and Research Farm, Faculty of Agriculture, Adamawa State University, Mubi, Northern Guinea Savannah zone of Nigeria, during the 2019 cropping season. Mubi is geographically located at latitude 10^0 05" N of the equator and longitude 13^0 16" E Green Meridian time on altitude of 696m above sea level. The research was conducted on sandy loam soil to determine appropriate spacing aa a catalyst to bumper maize (Zea mays) production in Mubi, Adamawa State Nigeria. Sammaz17, Sammaz24, Admiralla 'A' varieties and a Local cultivar obtained from Mubi market were used for the research. The experiment was laid in a factorial split plot in a Randomized Complete Block Design (RCBD) and replicated three times. Planting was done at the spacing of 75 x 25 cm, 75 x 50cm and 80 x 20cm,with the local cultivar as a control respectively. Data were collected on, plant height, number of leaf/plant, days to 50% tasseling, days to 50% silking, weight of fresh biomass, weight of fresh shoot, weight of fresh root, weight of fresh ear, weight of fresh cobs, weight of dry cobs, leaf area, leaf area index, number of ear per plant, cob length, cob diameter, 100 seed weight, grain yield per plot and grain yield per hectare. Data collected were subjected to analysis of variance (ANOVA) and significant means were separated using Duncan's Multiple Range Test (DMRT) using SAS. The interaction between spacing and varieties indicated that, the improved varieties outperformed significantly ($p<0.05$) better than the local cultivar. However, wider inter row spacing of 20cm (80×20cm) recorded the highest yield of 8.02 tons per hectare with Sammaz24. Base on the results, farmers in Mubi and the surroundings are advised to adopt Sammaz 24 at the spacing of 80×20 cm for optimum growth and maximum seed yield.
Keywords: Sammaz 24, spacing, Local cultivar, maximum, leaf area index.

INTRODUCTION

Maize (*Zea mays*) is an important cereal crop in Nigeria after sorghum and millet based on the amount produced area and under cultivation (Uzozie, 2001). It is the most efficient plant for capturing sun energy and converting it to food. Maize is cultivated across a wide range of agro-ecological zones in Nigeria, extending from costal swamps of south to the dry savanna lands of the north (Remision, 2005). The protein content of maize is higher than that of paddy and polished rice. Similarly the fat content of maize is higher than those of wheat, sorghum and rice (Ado *et al* 1999). Therefore maize is popular crop among other arable crops because in addressing food insecurity in Nigeria (Bamire *et al* 2010).

Most Nigerian farmers especially in the guinea savannas still use varieties of maize saved from previous harvest. These landraces have yield potentials which contribute to low maize production in Nigeria.

Cropping system is another major problem affecting maize and other cereals production in Nigeria. Cropping system is the pattern in which crops are grown in a given area over a period of time including the ethical managerial resources utilized (Onwueme and Simiha 1991). One of the cropping systems that affect maize production is mostly spacing. Roja (2001) reported that raising maize population from 53,333 to 88888 plant per ha significantly increased the fresh ear yield. However, Akbar *et al* (1996) was of the view that the most proper sowing density in maize was 100000 plant per ha.

However, Mureithi *et al*. (2005) asserted that raising the yield per unit area of individual crops was the way forward. Yield potentials have usually been represented in parts under the most favorable combination of soils, climate and crop management in certain places without considering spacing which is a major factor in increased yield potential of maize. With the statistics and records available on maize production in Nigeria, there is no doubt it is one of the three most useful crops in the nation. Exploiting all avenues to increase its production under any condition to meet the demands of the teeming population would not be out of order, thus the need for a good choice of spacing. Reports of inconsistent yield effects of plant spacing uniformity could be the consequence of plant density difference and the method through which plant spacing variability was measured (Fowler 2012; Thompson, 2013). Yield increases are dependent on many factors ranging from water availability and distribution, nutrient supply as well as spacing which is a major determinant of yield addition or subtraction. Increasing population density remains the most effective way to increase whole-plant yield in short-season maize with 13% advantage Trik (2009). Narrow row spacing was found not to have a negative effect on whole-plant yield and nutritive value (Baron *et al.,* 2006; Boloyi, 2014). Wider spacing encourages growth of weed and thus more labor and increase in cost of production. Sharifi *et al.* (2009) concluded that plant population density influenced maize dry matter yield. Moderate densities were seen as good, and significant reduction occurred only at very high densities.

Maize grains seem to respond to population densities and spacing. However, according to Boloyi (2014), 75 x 25 cm is the best spacing for mechanized farming. But Tri (2009) observed that the best spacing was 20 to 25 cm along rows and 70 to 80 cm between rows, though the popular spacing was 75 x 25 cm at one plant per stand and 75 x 50 cm at two plants per stand. Anyanwu (2013) was of the opinion that maize should be sown at 90 x 45 cm spacing on ridges and 90 x 30 cm when staggered, and that maize spacing should actually be determined by the soil fertility of an area. Rui *et al.* (2011) recommended a spacing distance of 30 cm along the row and 90 cm between rows, while Leebass (2012) recommended 90 x 60 cm along and between rows at two seeds per hole. Futuless *et al.* (2010) compared four spacing (75 x 25, 75 x 20, 75 x 15 and 75 x 10 cm) in Mubi, Nigeria and found out that maize planted at 75 x 25 cm gave the highest grain yield of 1900 kg/ha. They therefore recommended that farmers in Mubi should adopt the spacing of 75 x 25 cm for maximum productivity. However, Zamir *et al.* (2011) recommended 60 x 20 cm for farmers in Faisalabad in Pakistan as it gave the highest average yield of 7.6 kg/ha. They further observed that the yield was determined by the agro-climatic condition of the area after comparing the spacing of 60 x 20 cm, 60 x 25 and 60 x 30 cm. Boloyi (2014) recommended a spacing of 90 x 25 cm for farmers in Ibadan, Nigeria since it gave the highest average yield of 232.3 kg/ha in comparison with the other spacing of 75 x 50 and 75 x 25 cm that produced lower yields. However, many farmers in Yola, Adamawa State plant maize indiscriminately without due consideration of appropriate spacing, thus, the need for this study on comparative analysis of three different spacing (75 x 25cm), (75 x 50cm) and (80 x 20 cm) on the performance and yield of some maize varieties in Yola Adamawa State was adopted with the objectives to determine the effect of plant spacing on the growth and yield of maize and to identify the best variety and spacing for maize cultivation in Yola

Morphology: Maize is a 2-3m high grass with a solid single stem (stalk), 3-4 cm in diameter, with clearly defined nodes and internodes. The number of internodes ranges from 15 to 20. These are short and fairly thick at the base, but become longer and thinner near the terminal male inflorescence. The leaves arise from the nodes, alternately on opposite sides on the stalk. Emergence after planting is quite fast and range from 4 days in warm soil to 20 days in cool soil. In moist warm soil the radicle emerges 2-3 days after planting, and the plumule breaks through the seed-coat 1-2 days later. The radicle grows out to produce the first seminal root, after which three or four adventitious roots grow out sideways from the embryo; they supply most of the soil-derived nutrition during the first few weeks. The permanent or coronal roots arise from the crown just below the soil surface once the seedling is growing well. Later on, more adventitious roots develop from above-ground nodes and grow into the soil, their function being to anchor the plant and support its upright position. Maize is a monoecious grass with male and female flowers borne in separate inflorescences on the same plant. Although it is self-fertile, the plant's monoecious character and protandry ensure a cross-pollination of 90-95%. The tassel male inflorescence is a terminal panicle, up to 40 cm long, which stretches out from the enclosing leaves at the top of the stalk. The male or staminate flowers are present within spikelet on the branches (Marius *et al.,* 2011). The stamens elongate at anthesis and the pollen is released by the anthers. The female inflorescence, called the ear, develops on a short side-branch, which emerges from the axil of one or more of the middle leaves. An ear is a modified spike of which the central axis or cob bears paired spikelet's, with one fertile flower each, in longitudinal rows. Hence, each ear will always have an even number of rows of kernels. The styles, called silks, are long and un-branched with short outgrowths called trichomes, which emerge from the husks at the top of the ear. Maize pollen is anemophilous, i.e. dispersed by wind. In calm weather and because of its large settling velocity most pollen falls within a few meters of the tassel; with high wind however, pollen can be carried distances of up to 500 meter. Pollen is shed over a number of days. It is very sensitive to high temperature and low air moisture.

Uses of maize: Maize is an important cereal in many developed and developing countries of the world. It is widely used for animal feed and industrial raw material in the developed countries where as the developing countries use it in general for feed. Because of its worldwide distribution and relatively lower price maize has wider range of uses. It is used directly for human consumption, in industrially processing foods, as Live-stock feed and in industrially nonfood products such as starches, acids and alcohols. Recently, there has been interest in using maize for production of ethanol a substitute for petroleum based fuels.

Forage and Feed: The next important field where maize finds extensive use is for livestock feeds viz: cattle Poultry and piggery both in the form of seeds and fodder. The green fodder can be fed to milk cattle to boost the milk production of a considerable extent; "South African Maize" is a best suited variety for fodder. The crop has to be harvested when the grains are in milky stage, this variety is supposed to have Lactogenic effect hence especially suited for milk cattle. The digest ability of maize fodder is higher than sorghum, and other non-leguminous forage crops. Maize plant does not have any problem of hydro genic acid or prussic acid production, hence of necessary crop can be harvested and fed to cattle at any stage of its growth, of course ideal stage of harvest for green fodder mid dough stage, when the dry matter content and digestibility are more desirable. The high carotene content of yellow maize is considered to be very useful in importing yellow color to egg yolk and yellow tinge to the milk. No other concentrate is yet to known to substitute maize in this respect.

Food: In most of the developing countries maize is consumed directly as food. In India, over 85 percent of the maize production is used as food. Most commonly used forms are as (i) Chapattis (ii) porridges of various forms, (iii) boiled or roasted green ears, (iv) breakfast foods like corn flakes and (v) Popcorn. For the (iii) and (v) category sweet and popcorn varieties are especially grown in USA and Europe.

Other Uses includes: The maize cob, the central rachis to which the grains are attached remains as an agricultural waste after threshing; it finds many important agricultural and industrial uses. Approximately it forms 15 to 18% of the total ear weight and contains 35% cellulose, 40% pentose and 15% lignin's. Their uses in agriculture includes as a litter for poultry and as a soil conditioner.

Industrial Uses: The industrial uses based on the physical properties of the cob when ground to powder are as fillers for explosives in the manufacture of plastics, glues, adhesives, rayon, resin, vinegar and artificial leather and as diluents and carrier in the formulation of insecticides and pesticides. Based on the chemical properties the processed cobs find their use in the manufacture of fermentable sugars, solvents, liquid fuels, charcoal gas and other chemicals by destructive distillation, and also in the manufacture of pulp, paper and hard boards. The water in which in which the maize grains are

Effect of Spacing on Maize Growth parameters: Plant spacing is one factor that determines the efficiency of use of land, light, water and nutrients. In this way, highest total yield potential can be achieved in the smallest possible area (Oseni and Fawusi, 1986). Plants spaced equidistantly from each other compete minimally for nutrients, light and other factors (Laver, 1994). The utilization of higher plant densities within the row could be a limiting factor in wide rows, preventing the full expression of the yield potential of new cultivars. Narrower spacing of rows is a partial mean of achieving equidistant spacing between maize plants (Laver, 1994). Narrower rows make more efficient use of available light and also shade the surface soil more completely during the early part of the season while the soil is still moist (Bullock *et al*. 1998). This results in less water being lost from the soil surface by evaporation. However, Roy and Biswas (1992) found that plant height at maturity was not affected by plant population. With regard to leaf-stem ratio it was found that plants that had delayed emergence or emerged in a double or triple stand were observed to have long and narrow leaves with short and thin stems. Therefore, in general, the leaf-to-stem ratio was lower for the plants in narrow spacing and higher for the plants in wider spacing (Liu, *et al.* (2004).

Effect of Spacing on Yield Parameters: The yield of maize as a forage crop is always expressed as dry weight or fresh weight. The term dry weight is preferred than fresh weight because the fresh weight of the plant is subjected to considerable fluctuation according to moisture content. The distribution of the dry matter during the development of the plant is a function of environment and genetic factors that influence leaf area development (Deinum and Struik, 1986). Dry matter yield of maize is positively related to plant population. Greater dry matter yield was obtained under high population compared to low population (Fisher and Wilson, 1975). Brown *et al*. (1964) and Caravetta *el al*. (1990) reported that decrease within-row plant spacing and narrow row spacing are effective means of increasing dry matter production. Dry matter yield on an individual plant basis decreased with increasing plant density, since higher densities contained more plants per unit land area. Dry matter yield per unit area increased with plant density (Eschie, 1992).

Varieties: National Bureau of Plant Genetic Resources (NBPGR) gene bank conserves around 9000 accessions of maize landraces including indigenous collection, exotic material, genetic stocks, inbred lines etc. in long term storage. The ecology and genetic diversity of maize, the diversity and dynamics of maize populations, and the maintenance of maize landraces and genotypes have been well-studied, particularly among subsistence farmers in Mexico, maize's center of origin (Sajjan A.L *et al.*, 2002). At present there is increased interest of plant genetic resources users for accessing information related to characterization and evaluation descriptors. Maize genetic resources represented by local populations originating from different areas, represent important useful genes sources for improving species as opined by (Marius *et al.*, 2011).

MATERIALS AND METHODS

Experimental site: A field experiment was conducted at Food and Agricultural Organization/Tree Crop Programme (FAO/TCP) Teaching and Research Farm, Faculty of Agriculture, Adamawa State University, Mubi, Northern Guinea Savannah zone of Nigeria, during the 2019 cropping season. Mubi is geographically located at latitude 10^0 05" N of the equator and longitude 13^0 16" E Green Meridian time on altitude of 696m above sea level. The research was conducted on sandy loam soil to determine appropriate spacing as a catalyst to bumper maize (*Zea mays*) production in Mubi, Adamawa State Nigeria. Sammaz17, Sammaz24 varieties; Admiralla 'A' obtained from Sebore Farms and a Local cultivar obtained from Mubi market were used for the research.

Experimental Design and Layout: The experiment was laid in a factorial split plot in a Randomized Complete Block Design (RCBD) and replicated three times. Planting was done at the spacing of 75 x 25 cm, 75 x 50cm and 80 x 20cm, with the local cultivar as a control respectively. The annual rainfall of Mubi ranges from 900 to 1100mm and the length of the rainy season ranges from 150-160 days, mostly from May to October (Adebayo and Tukur, 1999).

Land preparation and Crop Management: The experimental site was cleared, ploughed and demarcated into plot manually in May 2019. Manual hoe weeding was done at 2, 4, 6 and 8 weeks after sowing to ensure weed-free growth environment. Fertilizer application was done at exactly two weeks after sowing at the rate of 75kgN, 75kg P_2O_5 and 75kg K_2O and 75kgN/ha at five weeks after sowing as top dressing using NPK 15:15:15 and Urea respectively.

Data Collection: Data were collected from 5 randomly selected plants from the middle of each plot on the following parameters:

i. **Plant height (cm):** the plant height was measured from the ground level to the last flag leaf at 4 and 8 weeks after sowing (WAS) while at 12 WAS and harvest and mean recorded.
ii. **Number of Leaves per Plant:** the number of leaves in quadrat was counted and the mean number of leaves per plant was obtained.
iii. **Number of Days to 50% tasseling:** this was taken at interval between date of sowing and the time when 50% of the plants per plot have tasseled.
iv. **Number of days to 50% silking:** this was taken at interval between date of sowing and the time when 50% of the plants per plot have silk.
v. **100 seed weight:** the randomly selected 100 seeds was weighed and recorded.
vi. **Weight of dry cobs:** the dry cobs of maize were measured with weighing balance in kilogram.
vii. **Cob diameter:** the diameter of selected cob was measured using a vernier caliper. The diameters was added and then divided by the number of cobs to find the average.
viii. **Grain yield per net plot:** the grain yield per plot of maize was measured with weighing balance in kilogram.
ix. **Grain yield tone per hectare:** the grain yield per hectare of maize was measured with weighing balance in kilogram.

Statistical analysis: Data collected were subjected to Analysis of Variance (ANOVA) and significant means was separated using Duncan's Multiple Range Test (DMRT) as described by Gomez and Gomez (1984).

RESULT AND DISCUSSION

Table 1: Effect of spacing and variety on the number of leaves of maize

TREATMENT	4	6	8	10	12
SPACING					
S1	7.73a	9.13a	10.43a	11.77a	12.83a
S2	7.62a	8.97a	10.18a	11.60a	12.40ab
S3	7.42a	8.73a	10.22a	11.65a	12.17b
P of F	0.594	0.512	0.806	0.862	0.078
S. E	0.092	0.116	0.78	0.049	0.195
VARIETY					
V1	7.76a	9.11a	10.33a	11.53a	12.51a
V2	7.73a	9.11a	10.22a	11.84a	12.33a
V3	7.76a	8.96a	10.18a	11.56a	12.51a
V4	7.11a	8.60a	10.38a	11.76a	12.51a
P of F	0.238	0.536	0.971	0.786	0.918
S. E	0.159	0.121	0.047	0.076	0.044
S×V	Ns	Ns	Ns	Ns	*

Means with the same letter are not significantly different ((P< 0.05). Key= S_1= 80 x 20cm, S_2= 75 x 50cm S_3= 75 x 25cm, V_1= Sammaz 17, V_2= Sammaz 24 V3= Admiral 'A', V_4= local variety

The effects of variety and spacing on number of leaves are shown in Table 1, the result showed that number of leaves was not significantly affected by spacing at 4, 6, 8 and 10 weeks after planting, however at 12 weeks after planting where the spacing 80 x 20cm significantly (P< 0.05) produced more number of leaves than 75 x 25cm. There was no significant difference observed in the number of leaves among the varieties. This is contrary to the findings of Sajjan *et al*., (2002) who reported that growth characters of crops varied because of differences in their genetic make-up. Maize plant sown at 15cm spacing had higher number of leaves than their counterparts which were sown at wider spacing, possibly because of increased growth rate in search for space, sunlight and other environmental resources. This is consistent with the findings of Al-Rudha and Al-Youmis (1998) and Ali *et al.* (2003) that made similar reports on 15cm-spaced maize plants.

Table 2: Effect of spacing and variety on plant height of maize at 4-12WAS

TREATMENT	4	6	8	10	12
SPACING					
S1	45.92a	60.90a	126.05b	159.81a	169.68a
S2	48.60a	63.88a	122.18b	154.48a	168.68ab
S3	48.37a	61.97a	135.70a	165.47a	170.62b
P of F	0.652	0.525	0.009	0.599	0.954
S. E	0.858	0.872	4.019	3.171	0.558
VARIETY					
V1	52.24a	68.29a	130.20a	165.24ab	173.51a
V2	50.49a	64.29a	122.54a	139.33b	158.80a
V3	50.20a	64.07a	132.27a	168.98a	176.40a
V4	37.68b	52.36b	126.80a	166.20ab	169.93ab
P of F	0.006	0.001	0.168	0.106	0.136
S. E	3.380	3.439	2.104	6.914	3.854
S×V	*	*	*	*	*

Means with the same letter are not significantly different ((P< 0.05). Key= S_1= 80 x 20cm, S_2= 75 x 50cm S_3= 75 x 25cm, V_1= Sammaz 17, V_2= Sammaz 24, V3= Admiral 'A', V_4= local variety.

The effect of variety and spacing on plant height is shown in Table 2, shows that, plant height was not significantly affected by spacing at 4, 6, and 10 weeks after planting except at 8 and 12 weeks where a the spacing of 75 x 25cm significantly (P< 0.05) produced the tallest plants. On the different variety significant difference was observed at 4, 6, 10 and 12 WAS. At 4 and 6 WAS Sammaz 17recorded the tallest plant and at 10 and 12 WAS, Admiral 'A' recorded the tallest plant. There was no significance difference observed among the varieties in 8 WAS. This observation is similar to the findings of Teasdale (1995), Widdicombe and Thelen (2002), and Dalley *et al.* (2006) who all attributed the increased growth rates and earlier canopy closure of narrow row spaced crops to quest for increased light interception as well as increased availability of soil moisture because of equidistant distribution of crop plants. It is also in agreement with the reports of Al-Rudha and Al-Youmis (1998) that maize sown at 15cm had maximum plant height compared with their counterparts sown at wider intra-row spacing.

Table 3: Interaction of spacing and variety number of leaves

	S1	S2	S3
V1	8.40a	7.07ab	7.80ab
V2	8.33a	7.80ab	7.07ab
V3	7.47ab	8.13ab	7.67ab
V4	6.73b	7.47ab	7.13ab

Means with the same letter are not significantly different ((P< 0.05). Key= S_1= 80 x 20cm, S_2= 75 x 50cm S_3= 75 x 25cm, V_1= Sammaz 17, V_2= Sammaz 24 V3= Admiral 'A', V_4= local variety.

The interaction of difference spacing and varieties of maize on number of leaves are presented in table 3; the result showed that at the spacing of 75 x 25cm and 75 x 50cm, there was no significant difference in the number of leaves among the maize varieties. However, at the spacing of 80 x 20cm, Sammaz 17 and Sammaz 24 produced significantly (P< 0.05) more number of leaves than the local variety. Generally, at the spacing of 80 x 20cm, the improved varieties of maize produced more leaves than the local variety.

Table 4: Effect of spacing and variety on plant height of maize at 4-12WAS

TREATMENT	4	6	8	10	12
SPACING					
S1	45.92a	60.90a	126.05b	159.81a	169.68a
S2	48.60a	63.88a	122.18b	154.48a	168.68ab
S3	48.37a	61.97a	135.70a	165.47a	170.62b
P of F	0.652	0.525	0.009	0.599	0.954
S. E	0.858	0.872	4.019	3.171	0.558
VARIETY					
V1	52.24a	68.29a	130.20a	165.24ab	173.51a
V2	50.49a	64.29a	122.54a	139.33b	158.80a
V3	50.20a	64.07a	132.27a	168.98a	176.40a
V4	37.68b	52.36b	126.80a	166.20ab	169.93ab
P of F	0.006	0.001	0.168	0.106	0.136
S. E	3.380	3.439	2.104	6.914	3.854
S×V	*	*	*	*	*

Means with the same letter are not significantly different ((P< 0.05). Key= S_1= 80 x 20cm, S_2= 75 x 50cm S_3= 75 x 25cm, V_1= Sammaz 17, V_2= Sammaz 24, V3= Admiral 'A', V_4= local variety.

The effect of variety and spacing on plant height is presented in Table 4 shows that, plant height was not significantly affected by spacing at 4, 6, and 10 weeks after planting except at 8 and 12 weeks where a the spacing of 75 x 25cm significantly (P< 0.05) produced the tallest plants. On the different variety significant difference was observed at 4, 6, 10 and 12 WAS. At 4 and 6 WAS Sammaz 17 recorded the tallest plant and at 10 and 12 WAS, Admiral 'A' recorded the tallest plant. There was no significance difference observed among the varieties in 8 WAS. This observation is similar to the findings of Teasdale (1995), Widdicombe and Thelen (2002), and Dalley *et al.* (2006) who all attributed the increased growth rates and earlier canopy closure of narrow row spaced crops to quest for increased light interception as well as increased availability of soil moisture because of equidistant distribution of crop plants. It is also in agreement with the reports of Al-Rudha and Al-Youmis (1998) that maize sown at 15cm had maximum plant height compared with their counterparts sown at wider intra-row spacing.

Table 5 : Interaction of spacing and maize varieties plant height

	S1	S2	S3
	4WAP		
V1	52.53ab	48.67a	55.53a
V2	50.33ab	50.07ab	51.07ab
V3	47.13ab	54.33a	49.13ab
V4	33.67c	41.33abc	37.73bc
	6WAP		
V1	68.33a	68.40a	68.13a
V2	63.53ab	68.00a	61.33ab
V3	62.27ab	66.73a	63.20ab
V4	49.47b	52.40ab	55.20ab
	8WAP		
V1	117.73b	126.47b	146.40a
V2	118.20b	119.93b	129.80ab
V3	136.47ab	124.57b	135.47ab
V4	131.80ab	117.47b	131.13ab
	10WAP		
V1	164.40ab	156.13ab	175.20a
V2	144.33ab	123.67b	150.00ab
V3	160.40ab	171.73a	174.80a
V4	170.33a	166.40ab	161.87ab

Means with the same letter are not significantly different (($P< 0.05$). Key= S_1= 80 x 20cm, S_2= 75 x 50cm S_3= 75 x 25cm, V_1= Sammaz 17, V_2= Sammaz 24, V3= Admiral 'A', V_4= local variety

The interaction of different spacing and varieties of maize on plant height is presented in Table 5 above. There was significance difference in interaction between spacing and variety on plant height at 4, 6, 8 and 10. At 4WAS; S_1 (80 x 20cm) Sammaz 17 recorded the tallest plant while in S_2 (75 x 50cm) Admiral A' recorded the tallest plant and S_3 (75 x 25cm) Sammaz 17 recorded the tallest plant. At 6WAS; S_1 (80 x 20cm) Sammaz 17 recorded the tallest plant, while S_2 (75 x 50cm) Admiral 'A, recorded the tallest plant and S_3 (75 x 25cm) Sammaz 17 recorded the tallest plant. At 8WAS S_1 (80 x 20cm) Admiral 'A' recorded the tallest plant, while in S_2 (75 x 50cm) Sammaz 17 recorded the tallest plant, and S_3 (75 x 25cm) Sammaz 17 recorded the tallest plant. At 10 WAS; S_1 (80 x 20cm) Sammaz 17 recorded the tallest plant while S_2 (75 x 50cm) and S_3 (75 x 25cm) Admiral 'A, recorded the tallest plant. Boomsma *et al*. (2009) found out that plant height declined with increase in plant population while Sangoi *et al*. (2011) observed that reducing plant space increased crop yield and performance and such output was dependent on the interactions between management and environment.

Table 6 : Interaction of spacing and variety on days to 50% tasseling

	S1	S2	S3
V1	52.33bc	54.33abc	53.00abc
V2	51.67c	51.67c	52.06bc
V3	51.33c	52.00bc	51.67c
V4	56.00a	54.67abc	55,33ab

Means with the same letter are not significantly different ((P< 0.05). Key= S_1= 80 x 20cm, S_2= 75 x 50cm S_3= 75 x 25cm, V_1= Sammaz 17, V_2= Sammaz 24, V3= Admiral 'A', V_4= local variety

The interaction of spacing and variety as presented in Table 6, reveals that, there was no significant difference in respect to days to 50% tasseling. However, at the spacing of 80 x 20cm, the local variety was significantly (p<0.05) different from the improved varieties.

Table 7 : Effect of spacing and variety on day to 50% Tasseling

TREATMENT	
SPACING	
S1	52.83a
S2	53.17a
S3	53.00a
P of F	0.909
S. E	0.096
VARIETY	
V1	53.22b
V2	51.78b
V3	51.67b
V4	55.33a
P of F	0.004
S. E	0.85
S×V	*

Means with the same letter are not significantly different ((P< 0.05). Key= S_1= 80 x 20cm, S_2= 75 x 50cm S_3= 75 x 25cm, V_1= Sammaz 17, V_2= Sammaz 24, V3= Admiral 'A', V_4= local variety.

The results of the effect of spacing and variety on days to 50% tasseling are presented on Table 7. It was indicated that, spacing levels had no significant difference with respect to 50% tasseling. However, number of days to 50% tasseling range from 51.67 Admiral A' to 55.33 local cultivar which different significantly from the improved cultivars.

Table 8 : Effect of spacing and variety on days to 50% silking

TREATMENT	
SPACING	
S1	55.42a
S2	56.25a
S3	56.25a
P of F	0.486
S. E	0.278
VARIETY	
V1	55.67b
V2	55.67b
V3	54.56b
V4	58.00a
P of F	0.016
S. E	0.725
S×V	*

Means with the same letter are not significantly different ((P< 0.05). Key= S_1= 80 x 20cm, S_2= 75 x 50cm S_3= 75 x 25cm, V_1= Sammaz 17, V_2= Sammaz 24, V3= Admiral 'A', V_4= local variety

The effect of variety and spacing on days to 50% silking is presented in Table 8; there was no significant difference on the spacing recorded in the varieties.. However, the local cultivar recorded the longest number of days to 50% silking differ significantly from the other varieties.

Table 9 : Effect of spacing and variety on weight of fresh cobs

TREATMENT	
SPACING	
S1	0.261a
S2	0.240a
S3	0.258a
P of F	0.67
S. E	0.007
VARIETY	
V1	0.274a
V2	0.260a
V3	0.231a
V4	0.247a
P of F	0.507
S. E	0.009
S×V	Ns

Means with the same letter are not significantly different ((P< 0.05). Key= S_1= 80 x 20cm, S_2= 75 x 50cm S_3= 75 x 25cm, V_1= Sammaz 17, V_2= Sammaz 24, V3= Admiral 'A', V_4= local variety

The effect of variety and spacing on weight of fresh cobs is also presented in Table 9; statistical analysis showed that weight of fresh cobs was significantly affected by spacing. However, there was no significant difference among the varieties. This result is contrary to the finding of Zamir *et al*. (2011). Their work on two hybrids maize varieties H 1 (30 Y 87) and H 2 (31 R 88) having density levels S 1 (15 cm), S 2 (20 cm), S 3 (25 cm) and S 4 (30 cm) were sown at row spacing of 60cm. The hybrid 30 Y 87 matured early, produced more number of cobs per plant, more number of grain rows per cob, less number of grains per row and less cob length than the hybrid 31 R 88. Similarly 1000-grain weight, grain yield and straw yield of hybrid H 1 (30 Y 87) was significantly greater than the hybrid H 2 (31 R 88 Although narrow plant spacing (15, 20 cm) caused substantial reduction in yield components such as grains/cob, number of cobs/plant and 1000-grain weight compared to the wide plant spacing (30 cm) yet it gave the maximum yield (7.69 t ha -1) against the minimum of (5.01 t ha $-^{1}$).

Table 10 : Effect of spacing and variety on number of ear per plant of maize

TREATMENT	
SPACING	
S1	1.167b
S2	1.083b
S3	1.417b
P of F	0.016
S. E	0.1
VARIETY	
V1	1.22a
V2	1.33a
V3	1.22a
V4	1.11a
P of F	0.045
S. E	0.341
S×V	*

Means with the same letter are not significantly different ((P< 0.05). Key= S_1= 80 x 20cm, S_2= 75 x 50cm S_3= 75 x 25cm, V_1= Sammaz 17, V_2= Sammaz 24, V3= Admiral 'A', V_4= local variety

The effect of variety and spacing on number of ear per plant is presented in Table 10; statistical analysis showed that number of ear per plant was not significantly affected by spacing. Similarly, there was no significant difference among the different varieties. However, there was significant interaction effect between the spacing and variety.

Table 11 : Effect of spacing and variety on cob length

TREATMENT	
SPACING	
S1	14.75a
S2	15.25a
S3	14.58a
P of F	0.595
S. E	0.2
VARIETY	
V1	15.00b
V2	17.00a
V3	17.00a
V4	14.66b
P of F	0.854
S. E	0.001
S×V	*

Means with the same letter are not significantly different ((P< 0.05). Key= S_1= 80 x 20cm, S_2= 75 x 50cm S_3= 75 x 25cm, V_1= Sammaz 17, V_2= Sammaz 24, V3= Admiral 'A', V_4= local variety.

The effect of variety and spacing on cob length is shown in Table 11; the results reveal that, cob length was not significantly affected by spacing. However, on the varieties, there were significant difference observed especially on Sammaz 24, and Admiral 'A' which recorded the highest cob length. A similar result was also reported by Zamir *et al*. (2011). Where two hybrids maize varieties H 1 (30 Y 87) and H 2 (31 R 88) having density levels S 1 (15 cm), S 2 (20 cm), S 3 (25 cm) and S 4 (30 cm) were sown at row spacing of 60 cm. The hybrid 30 Y 87 Matured early, produced more number of cobs per plant, more number of grain rows per cob, less number of grains per row and less cob length than the hybrid 31 R 88.

Table 12 : Effect of spacing and variety on cob diameter of maize

TREATMENT	
SPACING	
S1	14.25a
S2	14.72a
S3	14.25a
P of F	0.732
S. E	0.166
VARIETY	
V1	15.00b
V2	16.22a
V3	13.88c
V4	12.55d
P of F	<. 0001
S. E	0.702
S×V	*

Means with the same letter are not significantly different ((P< 0.05). Key= S_1= 80 x 20cm, S_2= 75 x 50cm S_3= 75 x 25cm, V_1= Sammaz 17, V_2= Sammaz 24, V3= Admiral 'A', V_4= local variety

The effect of variety and spacing on cob diameter as shown in Table 12 showed that, cob diameter was not significantly affected by spacing. However, significant difference was observed in Sammaz 24 which recorded the highest cob diameter. This is in line with the work of Zamir *et al*. (2011) on two hybrids maize varieties H 1 (30 Y 87) and H 2 (31 R 88) having density levels S 1 (15 cm), S 2 (20 cm), S 3 (25 cm) and S 4 (30 cm) which were sown at row spacing of 60 cm.

Table 13 : Interaction of spacing and variety on days to 50% silking of maize

	S1	**S2**	**S3**
V1	55.00bc	56.00abc	56.00abc
V2	55.00bc	55.33abc	56.67abc
V3	54.00c	55.33abc	54.33c
V4	57.67ab	58.33a	58.33ab

Means with te same letter are not significantly different ((P< 0.05). Key= S_1= 80 x 20cm, S_2= 75 x 50cm S_3= 75 x 25cm, V_1= Sammaz 17, V_2= Sammaz 24, V3= Admiral 'A', V_4= local variety

The interaction of spacing and variety (Table 13), the result showed that there was significant difference in respect to days to 50%. (80 x 20cm), (75 x 50cm) and S (75 x 25cm) while the local variety recorded the highest number of days to 50% silking.

Table 14 : Effect of spacing and variety on 100 seed weight

TREATMENT	
SPACING	
S1	32.67b
S2	35.00a
S3	33.75ab
P of F	0.021
S. E	0.674
VARIETY	
V1	34.56b
V2	37.67a
V3	32.11c
V4	30.88c
P of F	<. 0001
S. E	0.702
S×V	*

Means with the same letter are not significantly different ((P< 0.05). Key= S_1= 80 x 20cm, S_2= 75 x 50cm S_3= 75 x 25cm, V_1= Sammaz 17, V_2= Sammaz 24, V3= Admiral 'A', V_4= local variety.

The results on the effect of variety and spacing on 100 seed weight is presented in Table 14. The statistical analysis showed that 100 seed weight was significantly affected by spacing; 75 x 50cm significantly (P< 0.05) produced the heaviest weight of 100 seed while 80 x 20cm recorded the lowest weight. On the varieties, significant difference was observed in Sammaz 24 which recorded the highest weight of 100 seed and local variety recorded the higher weight of 100 seed. As can be seen from the table. This agrees with Silva *et al.* (2008) findings, which reported an increase in yield with an increase in plant population of the hybrid 30K75 from 40 to 80 000 plants ha-^{1}, whose yield reached 6,239 and 8,703 kg ha-^{1}, respectively. With the spacing of 0.60 m between lines, Silva *et al*. (2012) achieved an increase of 11% in yield with an increase of plant density from 78 to 100 thousand plants ha-^{1}.

Table 15 : Effect of spacing and variety on grain yield per plot

TREATMENT	
SPACING	
S1	2.22a
S2	2.07a
S3	2.19a
P of F	0.083
S. E	0.43
VARIETY	
V1	2.54a
V2	2.56a
V3	2.28a
V4	1.25b
P of F	0.0005
S. E	0.62
S×v	*

Means with the same letter are not significantly different ((P< 0.05). Key= S_1= 80 x 20cm, S_2= 75 x 50cm S_3= 75 x 25cm, V_1= Sammaz 17, V_2= Sammaz 24, V3= Admiral 'A', V_4= local variety.

The effect of variety and spacing on grain yield per plot is shown in Table 15; statistical analysis showed that grain yield per plot was not significantly affected by spacing. This result is similar to the findings of Kim (1997) and Olakojo *et al*. (1993) who reported that, highest number of cobs and higher grain yield were obtained from higher plant density due to narrow spacing. It further agrees with the findings of Widdicombe and Thelen (2002) who reported yield increase of 10% on narrow spacing.

CONCLUSION AND RECOMMENDATION

Findings from the study showed that the different spacing and varieties of maize studied in Mubi agro-ecologic zone did not show any significant difference in respect to number of leaves. Based on the results of the study, it is recommended that the best spacing for maize cultivation is 80 x 20cm and the best variety is Sammaz 24; as wider inter row spacing of 20cm (80×20cm) recorded the highest yield of 8.02 tons per hectare with Sammaz24. Based on the results, farmers in Mubi and the surroundings are advised to adopt Sammaz 24 at the spacing of 80×20 cm for optimum growth and maximum seed yield in the study area.

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