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EFFECTS OF DIFFERENT SPACING ON THE GROWTH AND YIELD OF WHITE MAIZE (*Zea mays L.*) IN MUBI, NORTHERN GUINEA SAVANNA

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Abstract: *The study examined the effect of spacing on the performance and yield of white maize variety M-R (Manoma Seed) in Mubi Adamawa State with the objective of finding the most appropriate spacing for optimum yield. The effect of four spacing viz: 75cm x 25cm, 75cm x 30cm, 75cm, x 35cm and 75cm x 40cm respectively were evaluated. The experiment was laid in a randomized complete block design (RCBD) replicated three times. Data were taken on nine parameters. Plant height, plant leaves, stem girth, dry matter weight, length of cob, diameter of cob, 100 seed weight, days to 50% tasseling, and yield per plot. Results were obtained after subjecting the data to analysis of variance (ANOVA). Results shows that spacing of maize S1 (75cm x 35cm) significantly gave higher yield per hectare of (2.455t/ha). It also produced bigger cobs. 100 seed weight of 31.69kg and a kernel depth of 0.87cm) whereas spacing 75 x 30cm produced significantly the tallest plant of 144.42cm, stem girth of 3.33cm and also have the higher number of leaves (14cm) respectively. The research therefore advices that 75 x 35cm spacing should be adopted in the northern guinea savannah of Nigeria.*
Keywords*: Effects, sowing, White Maize, Adamawa state*

Introduction: Maize (*Zea mays* L.) is an important crop that is used worldwide as human food, as a raw material for starch and as animal feed. It is one of the most important grains in Nigeria, not only on the basis of the number of farmers that are engaged in its cultivation, but also in its economic value [1,2]. Stated that Maize has been in the diet of Nigerians for centuries [3]. It started as a subsistence crop and has gradually become an important commercial crop on which many agro-based industries depend on for raw material prepared and used for different types of foods. Described maize as one of the most valuable cereal grains because of is high net energy content [4]. Due to the important uses of maize, the effort towards increasing its production has grown and the study of the agronomic practices that will enable farmers adapt to the effective productivity in West Africa [5].

Have shown that maize farm of 1.2 hectares can overcome hunger in the household and the aggregate effects can double food production in Africa [6]. Stated that the decline in maize production over the years was based on Rapid reduction in soil fertility, Failure to identify and plant high yielding maize varieties, use of inappropriate plant spacing which determine the plant population and the final yield [7].

For that season, asserted that, raising the yield per unit area of individual crops was the way forward [8]. 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 [9, 10]. 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 [11].

Narrow row spacing was found not to have a negative effect on whole-plant yield and nutritive value [12, 13]. Wider spacing encourages growth of weed and thus more labor and increase in cost of production. Conclude that plant population density influenced maize dry matter yield [14]. Moderate densities were seen as good, and significant reduction occurred only at very high densities. Grains (maize) seem to respond to population densities and spacing. Therefore revealed 75 x 25 cm as the best spacing for mechanized farming [13]. Observed that the best spacing was 20 to 25 cm along rows and 70 to 80 cm between rows, but the popular spacing was 75 x 25 cm at one plant per stand and 75 x 50 cm at two plants per stand [15]. The opinion that maize should be sown at 90 x 45 cm spacing on ridges and 90 x 30cm when staggered, and that maize spacing should actually be determined by the soil fertility of an area [16]. Recommended a spacing distance of 30 cm along the row and 90 cm between rows [17], while [18] recommended 90 60 cm along and between rows at two seeds per hole. 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 900 kg/ha and recommends farmers to adopt the spacing in Mubi [19]. Also recommended a spacing of 90 x 25 cm for farmers in Ibadan [13], 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.

The distance between rows, the distance between plants in a row, and the number of plants in a hill influence the number of plants per unit area. Select an optimal plant spacing that allows for ease of field operations, such as fertilizer application or weeding, minimizes competition among plants for light, water, and nutrients, and creates a favorable microclimate in the canopy to reduce the risk for pests and diseases. As the world's population grows as demographics and food habits change we find ourselves in greater need for corn grain to satisfy the demand. It is projected that there will be an increase in global maize demand. In order to satisfy the growing demand seed supplying companies have been quick to introduce technologies to help the farming communities increase productivity and also to add value to their business. In view of the rapidly expanding population in Nigeria and general acceptability of corn as a popular staple food among small scale farmers in Mubi, there is need to increase production through the use of correct spacing and appropriate variety to ensure optimal productivity because in Mubi, farmers plant maize indiscriminately without due consideration of appropriate spacing, thus, the need for this study effect of different spacing (7525, 7530, 7535, 7540 cm) on the performance and yield of white maize in Mubi.

One of the major problems that impedes higher corn yield is using improper spacing. If higher yield of maize is to be achieved on sustainable basis, there is a need therefore to use the appropriate spacing for the production [20].

Materials and Methods

The experiment was conducted at the Research and Teaching farm of Department of Crop Science Faculty of Agriculture Adamawa State University Mubi during the 2017 cropping season during rain fed condition. Mubi lies within latitude of 10 $_0$8'N and 10 30' N and longitude 13^0 10'E and 13^0 25' E at 696m above sea level is located in the northern guinea savanna zone of Nigeria with annual rainfall ranges of 700mm-1000mm with peaks in July to September.

Land Preparation and Experiment Layout: The land was ploughed using a disc plough, and then followed by leveling and ridging. The maize variety M-R used for the experiment was purchased from farm fields agro allied services Jalingo, Taraba State. The experimental design consists of four different spacing viz: 75cm x 25cm, 75cm, x 30cm, 75cm x 35cm, and 75cm x 40cm respectively which was replicated three times. The experiment was laid in a Randomized Complete Block Design (RCBD) on a 17m x 15m land area. Two seeds were planted per hole by dibbling method, and later thinned to one, two weeks after sowing (WAS). Sowing was done after the experimental site was ploughed, harrowed then leveled. Each plot measured 3m x 3m ($9m^2$) with 0.5m between each plot and 1m between replicates. Records were taken from 4 randomly chosen plants from two central rows of each plot. Data were collected on plant height, number of leaves, and number of days to physiological maturity, diameter of cob, length of cob, 100 seed weight and yield.

Data Collection

Plant Height (cm): Four plants were chosen at random from the central ridges of each plot or net plot. Plant height for each plant was measured form the base of the plant to the tip of central spike tassel. The mean height of the 4 plants was recorded.

Stem Girth (cm): The stem girth of 4 randomly selected maize plant were measured with a venire caliper for each plot and the average values taken were recorded

Dry Matter Weight (g): Two plants were uprooted with the help of a hand hoe from each plot and then taken to the laboratory and was oven dried. The leaves and the stems of each sample were placed in separate paper bags and then air dried to a constant weight. The leaves and the stems of each sample were weighed on a sensitive balance, and then the mean leaves and stems of dry weight/plant were obtained.

Number of Leaves Per Plant: Four plants were randomly selected and number of leaves in each selected plant was counted. The mean number of leaves per plant was obtained.

Days to 50% And 100% Tasseling: The tasseling started on the 18th of August and the 50% was complete on the 2nd of September. And the 100% tasseling was complete on the 9th of September.

Number of Plant: This was the total number of plant that has been harvested. This is gotten by counting the total number of plant harvested per each plot.

Number of Cob: This was the sum of cob harvested per plot.

Cob Weight (g): This was the sum of weight of four harvests of cob per plots.

Number of Row Per Cob: This was determined from the tagged plants randomly selected within each plot. The row was counted from two randomly selected dry pods from the harvest of the tagged plants.

Cob Length (cm): This was determined from the 4 tagged plant randomly selected in the net plot. The length was measured with a meter rule and the average mean was calculated.

Cob Diameter before Shelling (cm): It was determined by measuring the selected 4 tagged plant cob from the net plot by a venire caliper, the average was taken and this was done before shelling.

Kernel Depth: The diameter of 4 cobs randomly selected from the net plot were measured using a vainer caliper before and after threshing to determine the kernel depth of each treatment.

$$kd = \frac{D_1 - D_2}{2}$$

Grain Yield Per Plot (g): This was the yield of grain harvested from the 4 plant selected from each sub plot after drying and shelling. Then the average yield was taken.

100-Grain Weight (kg): This was gotten by counting 100 seed from every treatment, weighted. This will be determined by subtracting the grain weight per plot out of 100

Yield Per Hectare (t/ha): This was the sum of weights of the grain harvests per each plot, thereafter extrapolated to tone per hectare (t ha-1).

Statistical Analysis: Data collected were subjected to Analysis of Variance (ANOVA) to evaluate treatment effects using the procedure outlined by Gomez and Gomez (1984) for randomized complete block design. Mean separation was based on the least significant differences (LSD) at the 5% probability level Appropriate Analysis of Variance (ANOVA) was applied for data analysis. Means of significant treatment difference were separated using the least significant difference (L.S.D) Procedure.

Results and Discussion

Result obtained from the study on the effects of different spacing (75 x 25, 75 x 30, 75 x 35 and 75 x 40cm) and their effects on the morphological parameters of the maize plants are presented in (Tables 1 to 5).

Plant Height, Number of Leaves, Stem Girth at 3, 6, 9WAS and Days to 50% tasseling: The Plant Height, number of leaves, stem girth at 3, 6, 9 WAS and days to 50% tasseling is presented in (table 1). The response of plants to the various spacing showed that, 75 x 30 cm gave the highest values of plant height, number of leaves and plant diameter at 3, 67, weeks after sowing. Whereas 75 x 25 cm gave the highest number of tasseled plant at days to 50% tasseling. There was a significant difference ($p \leq 0.05$) in the plant height among the different spacing at 6 and 9 WAS. The other morphological parameters considered showed no significant differences ($p \leq 0.05$) in the different spacing.

Table 1: Effect of Spacing on Plant Height (cm), Number of leaves, plant diameter (cm), at 3,6, 9 WAS and Days to 50% Tasseling on white Maize Variety (Manoma Seed).

Spacing		Ph		Sg		Nil				D50%
	3WAS	6WAS	9WAS	3WAS	6WAS	9WAS	3WAS	6WAS	9WAS	
T_1=75 25CM	5.51^{a}	32.58^{c}	138.08^{b}	0.49^{a}	2.19^{a}	3.30^{a}	5.00^{a}	7.00^{a}	12.00^{a}	61^{a}
T_2=75 25CM	5.98^{a}	38.00^{a}	144.42^{a}	0.54^{a}	2.17^{a}	3.33^{a}	5.00^{a}	6733^{a}	13.67^{a}	63^{a}
T_3=75 25CM	5.68^{a}	31.83^{d}	142.83^{a}	0.54^{a}	2.32^{a}	3.29^{a}	5.00^{a}	6.67^{b}	13.67^{a}	60^{a}
T_4=75 25CM	5.40^{a}	34.77^{b}	127.67^{c}	0.48^{a}	2.24^{a}	3.32^{a}	4.33^{b}	6.67^{b}	13.33^{a}	62^{a}
LSD$_0$.05	NS	4.89	6.52	NS	NS	NS	NS	NS	NS	2.08
SE $\pm$	0.0	0.0	0.0	0.02	0.05	0.0	0.21	0.15	0.27	1.45

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability using LSD. NS= Not significant

Key:

T= treatment
Ph= plant height
NL= number of leaves
Ns: not significant

Kg= kilogram
Ha= hectare
Cm= centimeter

SG=stem girth
D50%= days to 50% tasseling
WAS= weeks after sowing
LSD= least significance figure

Effect of Spacing on Dry Mater Weight: The effect of various spacing on dry matter is presented in Table 2. The response of spacing on Dry mater showed that, there was a significant difference among the treatments. Spacing of 75 x 35cm gave the highest weight value at 6WAS and in 3WAS, 75 x 30cm gave the highest weight value. There was a significant difference ($p \leq 0.05$) in the dry matter weigh among the different spacing at 3 and 6WAS.

Table 2: Effect of Spacing on the dry matter weight (g) of white maize variety.

Spacing	Dry matter weight	
	3was	6was
T1=75 25cm	1.92^{a}	17.56^{c}
T2=75 30cm	2.24^{a}	22.41^{b}
T3= 75 35cm	1.74^{b}	27.10^{a}
T4= 75 40cm	1.45^{c}	26.62^{a}
LSD 0.05	1.70	7.62
SE$\pm$	0.22	2.79

Means followed by unlike letter are significantly different at 5% level of probability using LSD.

Effects of Spacing on Number of Row and Seeds Per Row: The effect of spacing on the number of row and seed per cob is presented in Table3. The response of number of row and seeds to spacing showed that, there was no significant difference among the treatments. From the result obtained, spacing of 75 x 40cm gave highest number of row and seed per cob.

Table 3: Effect of Spacing on number of seed/cob and number of row/cob on white maize variety.

Spacing	NUMBER OF SEED/COB	NUMBER OF ROW/COB
T1=75 25cm	35.33^{b}	14.33^{b}
T2=75 30cm	38.33^{a}	14.33^{b}
T3= 75 35cm	38.33^{a}	14.00^{b}
T4= 75 40cm	38.67^{a}	15.00^{a}
LSD$_{0.05}$	NS	NS
SE$\pm$	0.23	0.75

Means followed by the same letter within a treatment group are not significantly different at 0.05% level of probability using LSD. NS = Not significant.

Effect of Spacing on Cob Length, Cob Diameter, Cob Weight, and Kernel Depth: The effect of spacing on cob length, cob diameter, cob weight, and Kernel depth is presented in Table 4. The response of spacing on cob length showed that, there was no significant difference among the treatments. Spacing of 75 x 40 cm gave the highest cob length of (21.73 cm) while 75 x25 cm produced the shorter cobs. Responses of cob diameter to spacing showed that, there was highly significant difference among the treatments except of 75 x 40 cm which produced the bigger cobs of (5.98cm) followed by 75 x 35cm (4.88cm) and 75 x 30cm (4.20cm) respectively. Response of spacing on cob weight showed that, there was no significant difference among the treatments. Spacing of 75 x 35cm gave the highest cob weight (2.83kg) followed by 75 x 30cm (2.71kg). Furthermore, response of spacing on kernel depth showed that, there was no significant difference among the treatments 75 x 35cm gave the highest kernel depth.

Table 4: Effect of Spacing on Length of Cob (cm), Diameter of Cob (cm), cob weight (g), and kernel depth on white maize variety (Manoma seed).

Spacing	Cob length	Cob diameter	Cob weight	Kernel depth
T1=75 25cm	19.103^{b}	3.9800^{c}	2459.007^{b}	0.743^{a}
T2=75 30cm	20.7067^{a}	4.283^{b}	2709.586^{a}	0.8033^{a}
T3=75 35cm	20.9033^{a}	4.8800^{a}	2826.610^{a}	0.870^{a}
T4=75 40cm	21.730	5.9100^{a}	2562.296^{b}	0.726^{a}
SE±	0.38	0.09	110.16	0.05
LSD (0.05%)	NS	NS	NS	NS

Means followed by the same letter within a treatment group are not significantly different at 0.05 level of probability using LSD. NS = Not significant.

Effect of Spacing on Growth Rate, 100 Seed Weight, and Yield Per: The Effect of spacing on growth rate, 100 seed weight, and yield is presented in Table 5. The response of spacing on growth rate showed that, there was a significant difference among the treatment. Spacing of 75 x 40cm produced relatively higher growth rate of (155.213). The response of spacing on 100 grain weight showed that, there was a significant difference among the treatments. Spacing of 75 x 40cm gave the highest value of 100-grain weight yielded (36.790kg) at harvest followed by 75 x 35 cm spacing (33.79kg) and 75 x 30cm (29.20kg) respectively whereas 75 x 25cm gave the least value (27.73kg. Nevertheless, response of grain yield per hectare showed that, there was a significant difference among the treatments. Spacing of 75 x 35 gave the highest yield per hectare (2455.55kg/ha), followed by 75 x 30cm 2348.15kg/ha), 75 x25cm (2151.85kg/ha) respectively whereas 75 x 40cm gave the least yield value of (1966.67kg/ha).

Table 5: Effect of Spacing on Growth rate, 100 Seed Weight/Plot, Yield/Plot (kg/ha) on white maize variety.

Spacing	Growth rate	100 seed weight	Yield/plot (kg/ha)
T1=75 25cm	115.580^{d}	27.726^{d}	2151.853^{c}
T2= 75 30cm	133,313^{c}	29.200^{c}	2348.150^{b}
T3=75 35cm	142.436^{ab}	33.690^{b}	2455.553^{a}
T4=75 40cm	155.213^{a}	36.790^{a}	1966.666^{d}
$LSD_{0.05}$	0.81	2.06	45.24
SE±	7.90	0.58	109.44

Means followed by unlike letter are significantly different at 5% level of probability using LSD.

Association Among Maize Characters: The relationship between maize growth, yield and yield component are presented in table 6. The result shown that, maize grain yield was positively and strongly correlated to plant height at 3,6, and 9 WAS, number of leaves, stem girth, dry mater weight, number of row, cob length, cob diameter, grain yield, 100 seed weight and kernel depth (r=0.725, 0.507, 0.659, 0.333, 0.499, 0.859, 0.142, 0.669, 0.822, 0.473 and 0.302 respectively).

The result also showed that, plant dry mater was positively and strongly correlated to plant height, number of leaves, stem girth, dry mater weight, number of row, cob length, cob diameter, grain yield, 100 seed weight and kernel depth (r=0.328, 0577, 0.254, 0.33, 0.321, 0.577, 0.446 and 0.333, respectively). There was no correlation between dry mater and number of leaves (0.003 and 0.069), respectively. The result also revealed that, cob diameter was positively and strongly correlated to number of leaves, stem girth, cob length, cob diameter, grain yield, 100 seed weight and kernel depth (r=0.319, 0.313, 0.213, 0.377, 0.223, 0.421, and 0.254 respectively. There was no correlation record between kernel depth and number of row (0.047 and 0.040). furthermore, 100 seed weight showed positive correlation with plant height, number of leaves, stem girth, dry mater weight, number of row, cob length, cob diameter, grain yield, and kernel depth (r=0.160, 0.259, 0.500, 0.446, 0.766, 0.454, 0.400, 0.134, 0.703, 0.316 and 0.649 respectively). No correlation was recorded between plant height and number of row (0.040 and 0.047).

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