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Comparative analysis of three different spacing on the performance and yield of late maize cultivation in Etche local government area of Rivers State, Nigeria

Ukonze, Juliana Adimonye[1]*, Akor, Victor Ojorka[1] and Ndubuaku, Uchenna Marbeln[2]

[1]Department of Vocational Teacher Education, University of Nigeria, Nsukka, Enugu State, Nigeria.
[2]Department of Crop Science, University of Nigeria. Nsukka, Nigeria.

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This study was carried out to compare and analyze how spacing influenced the performance and yield of late maize in Egwi, Etche Local Government Area (LGA) of Rivers State, Nigeria between September-December in 2013 and 2014. The study adopted experimental research design. The experiment was laid out in a randomized complete block design (RCBD) with three replicates. One maize variety was evaluated under three spacing for performance data such as plant heights, stem girths, number of leaves, number of nodes and leaf area and for the yield, data were collected on cob length, cob weight, cob + husk weight, cob diameter and 1000-grain weight (yield). The results obtained 56 days after planting (DAP) in the two years of study showed significant differences (p < 0.05) in plant height, stem girth and leaf area. The 70 x 30 and 60 x 40 cm spacing gave higher values of the morphological parameters than 80 x 20 cm. With regard to yield, 80 x 20 cm gave the highest average cob weight of 0.74 kg and 1000-grain weight (yield) of 0.27t/ha. Based on the findings of the study, the 80 x 20 cm spacing was recommended for local farmers in Etche for maximum yield and economic returns.

Key words: Etche Local Government Area (LGA), maize plant, Nigeria, Rivers State, spacing.

INTRODUCTION

Maize (*Zea mays*) is a member of the grass family Graminae. It originated from South and Central America. It was introduced to West Africa by the Portuguese in the 10th century. It arrived Nigeria in the 16th century (FAO, 2012). 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 (Adeniyan, 2014; Olaniyi and Adewale, 2012). Maize has been in the diet of Nigerians for centuries. 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 (Ike and Amusa, 2004). In Nigeria, maize is prepared and used for different types of foods and it also has some medicinal values.

*Corresponding author. E-mail: juliana.ukonze@unn.edu.ng.

Khawar et al. (2007) described maize as one of the most valuable cereal grains because of its high net energy content. 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 early and late production is important for increased productivity in West Africa (Drechsel et al., 2004). Studies have shown that maize farm of 1.2 ha can overcome hunger in the household and the aggregate effect can double food production in Africa (Ogunsumi et al., 2005). According to Ogunsumi et al. (2005), about 561397.24 ha of Nigerian lands are planted with maize yearly. This constitutes about 61% of total cultivable land in Nigeria. Maize cultivation in Nigeria, unlike temperate regions, is mainly done in intercropping system. Intercropping has long been recognized as a common practice among subsistence farmers in the traditional semi-intensive system of agriculture due to the flexibility of labor used (Ighalo and Alabi, 2005). One of the cultural practices in a sustainable maize cultivation is irrigation (Anyadike and Obeta, 2013). Irrigation in Nigeria has become an issue of vital importance considering present population growth rate. Virk et al. (2004) noted that Asia's food security depended largely on irrigated rice fields. In the United Kingdom and America, there have been well articulated institutional frameworks for irrigation and water supply since the past 150 years or thereabout (Anyadike and Obeta, 2013). Enujeke (2013) stated that the decline in maize production over the years were based on the following:

1. Rapid reduction in soil fertility
2. Failure to identify and plant high yielding maize varieties
3. Use of inappropriate plant spacing which determine the plant population and the final yield.

Hence, 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 (TLC, 2009). Increasing population density remains the most effective way to increase whole-plant yield in short-season corn with 13% advantage. 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. Grains (maize) seem to respond to population densities and spacing. Boloyi (2014), therefore showed 75 x 25 cm as the best spacing for mechanized farming. Tri (2009) 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. 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. Futlless 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. 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 observed further 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, in Etche, farmers plant maize indiscriminately without due consideration of appropriate spacing, thus, the need for this study on comparative analysis of three different spacing (80 x 20, 70 x 30 and 60 x 40 cm) on the performance and yield of late maize cultivation in Etche.

MATERIALS AND METHODS

The experiment was conducted in Etche in Rivers State of Nigeria, during the late planting seasons of 2013 and 2014 between September and December. Etche lies between longitude 6°45' and 7°18'E and latitude 4°45' and 5°15'N and 169 m above sea level. It is located in the ecological zone of Southern Nigeria with mangrove vegetation and an average annual rainfall of 2000 mm, relative humidity above 80% and a mean temperature of 28.14°C.

Etche land is chosen for this research because its soil is very good for agriculture, there is also favorable weather condition to

Table 1. Physio-chemical properties of experimental site particle size distribution in percentage.

Soil property	Value interpretation
Coarse sand	34%
Fine sand	41%
Silt	11%
Clay	14%
Texture	Sandy loam
pH H_20	6.6 Acidic
Cacl	5.9 acidic
Organic carbon g kg-1	0.93
Organic matter g kg^{-1}	0.2 very low
Total Nitrogen g kg^{-1}	0.125 low
Available phosphorus (ppm)	28.3
Exchangeable bases	
Na^+	0.58 moderate
K^+	1.2 low
Ca^{2+}	3.1 low
Mg^{2+}	1.1 low
Cation exchange capacity	5.32
Exchangeable acidity	**(cmol kg^{-1})**
Al^{3+}	Trace
H^+	1.6
Effective Exchangeable Capacity (cmol kg^{-1})	6.2

support agricultural practice at any time of the year but the people have been found to practice maize cultivation indiscriminately without due consideration of spacing. The maize variety used for the study was yellow flint TZSR-Y maize.

The experiment was done on a land area of 4 x 6 m (24 m^2). Soil samples were collected from different portions of the land and aggregated into composite sample for laboratory analyses of the soil physical and chemical properties. The physio-chemical properties of the experimental site are shown in Table 1. The result showed that sand was predominant in the study area, and that it gradually decreased down the soil profile. The texture of the experimental site is classified as sandy loam. The soil is acidic with a pH of 6.6 in H_2O and 5.9 in $CaCl_2$. The organic matter content and total nitrogen were low with values of 1.43 and 0.125 g kg^{-1}. The available phosphorus was high with a value of 28.3 mg kg^{-1}. The exchangeable cation (Ca, Mg, Na and K) were also low in status with values of 3.1 cmol kg^{-1} for Na^+, 0.58 cmol kg^{-1} for $Ca^{2+,}$ 1.2 cmol kg^{-1} for k and 1.1 cmol kg^{-1} for Mg. The exchangeable acidity was only trace Al^{3+} with features low for H^+ and a value of 1.6 cmol kg^{-1}. The layout of the experiment was in a randomized complete block design with three replications. Three seeds were planted per hole at a depth of 3 cm on the side of the ridges and later thinned down to two plants per stand soon after emergence. The different spacing used were 80 x 20 cm with plant population size of 62500 plants/ha, 70 x 30 cm with population size of 45524 plants/ha and 60 x 40 cm with population size of 41667 plants/ha. Germination was first observed five days after planning (DAP) and 100% emergence recorded seven days after planting (DAP). Regular routine check was carried on in the farm. Two weeks after planting (WAP), ring application of chemical N.P.K (15:15:15) fertilizer (at the rate of 300 kg/ha) was carried out 15 cm away from the plants to avoid injuries to the roots. Weeding and earthening up was also done on the thirty-fifth day to further inhibit the growth of weeds and avoid lodging of the plants.

Morphological data collection

Forthnighly, random sampling of six plants from each of the three blocks (replicates) was done for data collection on plant height, stem girth, leaf area, number of leaves per plant and number of nodes per plant.

The height of each plant was measured in centimeters from the ground level to the tip of the topmost leaf. The measurement was later expressed as a mean of the selected plants. Stem diameters of the randomly selected six plants were taken using a pair of Venier calipers. The measurement was taken 10 cm from the ground level and converted to girth with the following formula:

Stem girth (SG) = stem diameter (D) x π (*pi*)

Where π = 22/7 (constant)

Data collected were later expressed as a mean of the six selected stands. The leaf area was measured with centimeter tape. This was achieved by measuring the widest part of each leaf per plant and the leaf length and multiplying by 0.75 according to Ndubuaku et al. (2006). The formula used was as follows:

Leaf area = leaf length x leaf breadth x 0.75 (constant). The leaf area per block was calculated by multiplying the leaf area per plant by total number of maize stands per block. Number of leaves and nodes were counted forthrightly until the maize tasseled and the measurements were also expressed as means of the selected plants. Average values of the measurements for the morphological parameters for 2013 and 2014 were recorded.

Table 2. Summary of field performance analysis of mean plant height (cm) of the maize plants 56 days after planting (DAP).

Spacing	14 DAP	28 DAP	42 DAP	56 DAP
80 x 20 cm	18.50	55.33	109.50	122.33
70 x 30 cm	18.83	59.00	124.83	168.83
60 x 40 cm	22.50	59.88	113.50	150.50
Mean	19.61	56.07	115.94	147.22
$LSD_{0.05}$	NS	NS	NS	4.26

Values represent means of 2013 and 2014 planting seasons' data.

Table 3. Summary of field performance analysis of mean stem girth (cm) of the maize plants 56 days after planting (DAP).

Spacing	14 DAP	28 DAP	42 DAP	56 DAP
80 cm x 20 cm	0.96	3.43	6.60	7.00
70 cm x 30 cm	1.50	4.41	7.11	7.71
60 cm x 40 cm	2.41	4.88	7.18	8.10
Mean	1.63	4.18	6.96	7.63
$LSD_{0.05}$	NS	NS	NS	NS

Values represent means of 2013 and 2014 planting seasons' data.

Table 4. Summary of field performance analysis of mean number of leaves of the maize plants 56 days after planting (DAP).

Spacing	14 DAP	28 DAP	42 DAP	56 DAP
80 cm x 20 cm	4	9	13	15
70 cm x 30 cm	5	10	14	17
60 cm x 40 cm	5	12	14	16
Mean	4.67	10.33	13.67	16.00
$LSD_{0.05}$	NS	NS	NS	NS

Values represent means of 2013 and 2014 planting seasons' data.

Yield data collection

Six plants were also randomly selected from each of the treatment blocks, and their cobs were left to dry on the field. They were later harvested dry, weighed and dehusked and the cob length and diameter measured using a measuring tape. The cob length and diameter of the undehusked and dehusked cobs were measured using a centimeter tape. The cob length was measured as the length between the two tips while the diameter was taken as the mean of the diameter of the two distal ends at the broadest portion of the cob. Values were taken and expressed as the means of the six selected cobs. Dry weights of cob + husk and cob alone were taken. The values were later expressed as a mean of the six selected cobs. The cobs were then shelled and 1000-grains from each of the treatments were oven-dried to a constant weight and moisture content of about 13%. The yield was measured in tons per hectare. However, the farmers were more interested in the harvest of dry weights than the oven-dry weights.

Method of data analysis

The data obtained were further subjected to statistical analysis using analysis of variance (ANOVA). The significant means were separated using Fishers least significant difference (FLSD) at 5% probability.

RESULTS

Results obtained from the study on comparative analysis of the three different spacing (80 x 20, 70 x 30 and 60 x 40 cm) and the effects on the morphological parameters of the maize plants in 2013 and 2014 are presented in Tables 2 to 6. The 70 x 30 cm spacing gave the highest values of plant height, number of leaves and number of nodes at 56 days after planting (Tables 2, 4 and 5). The 60 x 40 cm gave the highest values of the stem girth and leaf area at 56 DAP (Tables 3 and 6). There was a significant difference ($p < 0.05$) in the plant height among the different spacing at 56 DAP. The other morphological parameters considered showed no significant differences ($p > 0.05$) in the different spacing throughout the period of the study except the leaf area.

Table 7 shows the yield components of the maize plants at harvest. The 80 x 20 cm gave the highest 1000-grain weight (yield) (0.27 ton/ha) at harvest followed by 60 x 40 cm spacing (0.24 ton/kg) and 70 x 30 cm (0.21 ton/kg), respectively. The 80 x 20 cm also gave the highest cob weight (0.74 kg). The 60 x 40 cm gave the highest cob length and cob + husk weight. The mean cob length decreased with increased row spacing between plant from 14.01 to 16.15 and the lowest plant spacing (60 x 40 cm) gave the highest cob length, The different spacing showed no significant differences ($p > 0.05$) in the yield components.

Tables 8 and 9 show the summary of the analysis of variance (ANOVA) used. The analysis of result obtained for cob weight using f- ratio shows a calculated value of 1.3 and critical value of 5.14 at 5% level of significant. That obtained for 1000–grain weight using f- ratio gave a calculated value of 0.5 and a critical value of 5.14 at 5% level of significance.

DISCUSSION

Plant height determines the growth attained during the growing season. Plant height increased with the lower spacing densities on the field showing observable differences. The highest mean plant height of 168.83 cm and the lowest mean plant height of 122.33 cm at 56 DAP showed that spacing affected plant height significantly. It was observed that as the number of plants increased in a given area, the competition among the plants for nutrients and sunlight interception also increased (Reid, 2015; Sangarakka et al., 2004). Boomsma et al. (2009) found out that plant height declined with increase in plant population while Sangoi (2000) and Sangoi et al. (2001) observed that reducing plant space increased crop yield and performance and

Table 5. Summary of field performance analysis of mean number of nodes of the maize plants 56 days after planting (DAP).

Spacing	14 DAP	28 DAP	42 DAP	56 DAP
80 cm x 20 cm	3	8	13	14
70 cm x 30 cm	4	9	13	16
60 cm x 40 cm	4	11	13	15
Mean	3.67	9.33	13.00	15.00
$LSD_{0.05}$	NS	NS	NS	NS

Values represent means of 2013 and 2014 planting seasons' data.

Table 6. Summary of field performance analysis of mean leaf area (cm^2) of the maize plants 56 days after planting (DAP).

Spacing	14 DAP	28 DAP	42 DAP	56 DAP
80 cm x 20 cm	21.54	172.62	505.20	697.76
70 cm x 30 cm	19.65	227.25	628.44	793.95
60 cm x 40 cm	32.12	259.68	640.14	918.94
Mean	24.43	219.85	591.26	803.55
$LSD_{0.05}$	2.24	7.14	8.68	10.02

Values represent means of 2013 and 2014 planting seasons' data.

Table 7. Summary of total comparative yield analysis of maize at harvest.

Spacing	Cob length (cm)	Cob diameter (cm)	Cob + husk weight (kg)	Cob weight(kg)	1000-grain(t/ha)
80 x 20 cm	15.00	13.01	0.86	0.74	0.27
70 x 30 cm	14.01	13.48	0.78	0.57	0.21
60 x 40 cm	16.15	13.21	0.92	0.69	0.24
Mean	9.05	13.23	0.65	0.67	0.24
$LSD_{0.05}$	NS	NS	NS	NS	NS

Values represent means of 2013 and 2014 planting seasons' data.

Table 8. The analysis of variance (ANOVA) summary table for the comparative analysis of the mean of cob weight of maize.

Source of variance	Sum of square (ss)	Degree of freedoms (df)	Mean of square (ms)	f-ratio	f-critical
Between groups	5088.9	2	2544.45	1.3	5.14
Within group	13466.7	6	2244.45		
Total	18555.6	8			

such output was dependent on the interactions between management and environment. Stem girth determines the dimensional attainment of a plant during the growing period. Stem girth increased with lower plant densities as the average stem girths from the highest to the lowest dimensions were 8.1, 7.71 and 7.0 cm at 56 DAP. This coincides with the opinion of Maqboola et al. (2006) that wider spacing encouraged highest vegetative growth as seen with treatment 60 x 40 cm. Plant leaf area was affected significantly as observed between the highest and lowest populations. The highest leaf area of 918.94 cm^2 was produced by treatment 60 x 40 cm while treatment 80 x 20 cm produced the lowest leaf area of 697.76 cm^2. The leaf area reduced with closer plant density which confirmed that stand architecture alters growth and development patterns of maize (Baron et al., 2006; Raemaker, 2011). Unfortunately the treatment 60 x 40 cm with the highest leaf area as indicated in result,

Table 9. The analysis of variance (ANOVA) summary table for the comparative analysis of the mean of of 1000-grain weight (yield) of maize.

Sources of variance	Sum of square (ss)	Degree of freedoms (df)	Mean of square (ms)	f-ratio	f-critical
Between groups	0.0006	2	0.0003	0.5	5.14
Within group	0.004	6	0.0006		
Total	0.0046	8			

could not convert its vegetative mass to optimum grain yield. The number of leaves and nodes on the plant coincided with the increase in the plant height. The number of nodes in every plant represents the total number of leaves produced by an undecapped plant at any given time of growth as observed by Ikenganyia et al. (2015) who also noted that leaf number and leaf area were good measures of the photosynthetic capacity in cucumber (*Cucumis sativus*).

The mean cob length decreased with increased row spacing between plants from 16.15 to 14.01 as the lowest plant spacing (60 x 40cm) gave the highest cob length, showing that cob length decreased with increased plant population. This is in agreement with the findings of Enujeke (2013) that spacing has significant effect on cob length, also confirming the findings of Baloyi (2014) who indicated that maize planted on ridges have longer cobs than those planted on ordinary ground. There was a positive effect of spacing at harvest on the cob + husk weight The treatment 70 x 30 cm could not translate its plant height and number of leaves advantage to yield of production and this may not have been unconnected with the findings of Maqboola et al. (2006), Adeniyan (2014) and Anyanwu et al. (2003) that excessive growth during early stages of growth may result in severe competition for water between plants later in life, thereby, making the plant unable to produce at very critical stage. There was no significant difference among the weights obtained for the various treatments. Even though 80 x 20 cm seemed to have the least field performances as seen from the results, it stands significant in terms of the cob weight. Perhaps, this is due to the number of grains on each cob measured. The above observation is a confirmation of the studies carried out by Sharifi et al. (2009) which showed that plant population density increased maize dry matter yield and thus, maize grain responded to population density and spacing. The 1000-grain yield weight did not show mean significant difference in weights between the treatments.

Conclusion

Spacing significantly affected the performance of late maize production in Etche in terms of yield components. The 80 x 20 cm seemed to present a much viable agricultural and economic future for local farmers in Etche. However, further comparative analysis study on spacing of late maize cultivation in Etche is hereby suggested.

Conflict of Interests

The authors have not declared any conflict of interests.

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