GROWTH AND YIELD RESPONSE OF MAIZE TO VARYING PLANT DENSITIES IN IBADAN OYO STATE

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ABSTRACT

Maximizing maize yield could be achieved through varying Plant densities, hence the following row spacing's: 75cm x 40cm, 75cm x 50cm and 75cm x 60cm, were studied. A field experiment was conducted under rain-fed conditions in 2015 during the main cropping season at International Institute of Tropical Agricultural Ibadan, Oyo State, to determine their effect on the growth and yield of maize (*Zea may L.*). The design of the experiment was laid out in a randomized complete block design (RCBD) with three (3) replications. The statistical analysis was carried out using SPSS and the result obtained showed that plant density, growth and yield related traits of maize were significantly affected by different treatments at P<0.05. From the study, the maize plants were observed to have similar plant height and number of leaves throughout the period of measurement. Row spacing with wider intra row space (75cm x 60cm) increased the stem girth at 6 WAP and the leave area at 9 WAP compared to other row spacing. Maize grown in narrow spacing of 75cm x 40cm had higher dry cob weight which could have resulted in the higher grain yield observed with the same row spacing (0.688)

Keyword*: - Row Spacing, plant Density, Maize and Yield*

I. INTRODUCTION

Maize (***Zea mays L.***) is one of Africans dominant food crops, rich in vitamins A, C, and E, carbohydrates, and essential minerals as well as 9% protein. Maize (Zea mays L.) is the world's highest supplier of calorie with caloric supply of about 19.5%. It provides more calorie than rice (16.5%) and wheat (15.0%). Maize is one of the most important staple foods in the world today; maize, rice and wheat combine to supply more than 50% of global caloric intake [17]. It is one of the most important cereal crops cultivated in the Sub-Saharan Africa [6]. Maize is the most important staple food in Nigeria and it has grown to be local cash crop most especially in the southwestern part of Nigeria where at least 30% of the crop land has been devoted to small-scale maize production under various cropping systems [3]. In Nigeria, it is a high yielding crop grown commercially in a large or small-scale throughout the country. In view of its high demand for food grains and high yield per unit area, maize has been among the leading food grains selected to achieve food self-sufficiency in Africa.

Even though maize has multiple purposes and high yielding potential, the national average yield (1.67 $t \cdot ha^{-1}$) is low as compared to developed countries' average yield which is about 6.2 $t \cdot ha^{-1}$. To increase maize yield, row spacing approach is a better channel. This is because plant density is an efficient management tool for maximizing grain yield by increasing the capture of solar radiation within the canopy. Too close spacing interferes with normal plants development and increase competition resulting in yield reduction, while too wide spacing may result in excessive vegetative growth of plant and abundant weed population due to more feeding area available [15]. Therefore, use of optimum plant population per unit area without exceeding the economic threshold can increase the competitive ability of the plants in weed-infested field.

In addition to improving crop yields, reduced row spacing can also provide the crop with a competitive advantage over weeds. The low productivity of maize is attributed to many factors such as poor agronomic practices like inappropriate seed rate, row and plant spacing, poor soil fertility, drought, insects, diseases and weeds, farmer's limited access to fertilizers, and low access to seeds of improved maize varieties. Plant density is one of the factors that affect yield by influencing yield components such as the number of ears, the number of kernels per ear, and kernel mass. Moreover, grain yield of maize is more affected by variations in plant population than other members of the grass family because of its low tillering ability. Therefore, plant density and arrangement of plants in a unit area greatly determine resource utilization such as light, nutrients, and water; it affects the rate and extent of vegetative growth and development of crops particularly that of leaf area index, plant height, root length and density, yield and yield components, development of important diseases and pests, and the seed cost [11]. Because of this discrepancy, the establishment of required plant density is essential to get maximum yield since high plant density will deplete soil moisture and nutrients before the crops maturity, whereas low plant density will leave nutrients unutilized [13]. The majority of farmers are not aware much about information on crop management aspects, especially optimum row spacing, suitable variety and maintaining optimum plant population per hectare. In Nigeria, the national planting spacing recommendation for maize is 75cm x 50cm (26,666 plants/ha). This spacing has been used, without considering the numerous factors such as the existences of soil and climatic differences. Thus, effects of different spacing on maize yield must be investigated for practical purposes, as planting spacing is a major management variable used in crop yield per unit area and matching crop requirements to the environmental offer of resources.Reports from researches also indicate that yields of arable crops such as maize, cowpea, and soybean are increased through the use of appropriate plant population. Therefore, the objective of this study was to determine the effect of row spacing on growth and yield of maize hybrid (SUWAN 1).

II. METHODOLOGY

➢ ***Area of the Study***

The field experiment was conducted during 2015 season under rain fed conditions during the main cropping seasonat the International Institute of Tropical Agriculture (IITA) Ibadan, Oyo State, Nigeria located at latitude 7^0 25’0” N, longitude $3^0$39’4" and altitude 225 m above sea level. Agro-meteorological data of the site such as temperature, sunshine hour, average rainfall, and average relative humidity were taken from the month of January to August. The experiment was carried out in a humid tropical zone characterized by temperature ranging between 21 – 30^0C with a maximum temperature of 30.8^0C and Relative Humidity of 83%. The rain distribution of the area is bimodal describe the months of the season. The total amount of rainfall for the cropping season (April to October) in 2015 was 1142 mm with the mean maximum and minimum temperatures of 30.8˚C and 21.5˚C, respectively.The soil belongs to the order of Ultisol and the rainfall started appreciably in April and ended in October with a little break in August (August break) leaving November through March as a dry period.

➢ ***Sample Preparation***

The soil samples were taken using a sampling auger and air-dried at room temperature for 5 days and crushed into powder to pass through a 2 mm mesh sieve. The samples were analyzed to determine the physical and chemical properties of the soil. The sample analysis was done at IITA’s lab and the following physio-chemical properties of the site were taken such as textural class, clay, silt, sand, and pH (physical properties) and exchangeable cations: Ca, Mg, K, Na, Zn, Mn, Cu, Fe, ECEC, and exchangeable acidity.

➢ ***Experimental Design and Treatments***

The experiment was conducted using a factorial combination of one maize hybrid (SUWAN 1), one inter-row 75 cm and three intra-row 40, 50, and 60 cm spacingwith corresponding plant population of 33,333, 26,666 and 22,222 plant ha-1, respectively. The experiment was conducted using a randomized complete block design (RCBD) with three (3) replications. The experimental field was mechanically ploughed and harrowed using a tractor. Each plot was measured in 3 m x 4 m with spacing 0.5 m apart. Allay of 1 m were left between plots and block respectively. The total number of plots laid out in the entire experiment was 45. Maize seeds (hybrid) were obtained from the Institute (IITA), Ibadan. The maize seed was sown at the depth of 2 cm per hole and thinned down to 1 plant per stand after the emergence. Blanket application of compound fertilizer, nitrogen, phosphorus and potassium (NKP) 15:15:15 were applied four (4) weeks after planting at the rate of 400 kg/ha.

Table1: Physical and chemical analyses of the experimental site.

Parameters	**Values**
Sand (%)	66
Silt (%)	14
Clay (%)	20
Textural class	Sandy loam
PH	6.5
Exchangeable Cations	
Ca	6.2
Mg	1.18
K	1.42
Na	0.05
Exch.Acidity	0.00
ECEC	8.85
Zn (ppm)	49.13
Mn(ppm)	7.28
Cu (ppm)	6.10
Fe (ppm)	225.8

- ***Management of the Experiment***

After the land was well prepared, two seeds per hole were sown in May. All phosphorus fertilizer dose in the form of triple super phosphate (TSP) at the recommended rate of 100 kg·ha−1 (46 kg P_2O_5 ha−1) and half of recommended rate of N-fertilizer in the form of Urea 189 kg·ha−1 (87 kg N ha−1) were applied uniformly to all plots by band application method at the time of planting and the remaining half of N-fertilizer was applied as of 50 days from sowing. Thinning to a single plant per each hill was done when seedlings produced three to four leaves. All other agronomic practices were applied uniformly as recommended for the crop.

- ***Data Collection and Measurement***

Growth parameters of maize: Plant height (cm), number of leaves, leaf area, stem girth, Ear length, Days to 50% tasseling and Days to 50% silking were measured.

Yield parameters: fresh cob weight, dry cob weight, shelling percentage and grain yield (kg-ha^{-1}) were measured.

- ***Statistical Data Analysis***

All collected data were subjected to analysis of variance (ANOVA) by using GenStat statistical software. For significant treatment effects, the mean separation was made using the Least Significance Difference (LSD) test at 5% level of significance.

III. RESULTS

Effect of Row Spacing on the Growth Parameters

- ***Effects of Row Spacing on Plant Height and Number of Leaves of Maize Hybrid.***

The effects of row spacing on plant height of maize hybrid at IITA in the early wet season of 2015 are shown in Table 2. There were gradual increases in plant height of maize from the 3rd to the 9th week after sowing. The result obtained from this study showed that there were no significant (P < 0.05) differences in plant height and number of leaves in maize plant across the intra row spacing. This also showed that the maize plant produced similar number of leaves irrespective. The tallest plants (198.29 cm) were observed when maize was raised at 75cm x 60cm intra row spacing (22,222 plants ha-1) compared to the plant height (191.91 cm) that obtained at 75cm x 40cm planting spacing (33,333 plants ha-1). The minimum plant height (190.20 cm) was recorded from the treatment planted at 75cm x 50cm intra spacing (26,666 plants ha-1), but this was also statistically at par with plant height obtained under 75cm x 40 cm intra row spacing.

Treatment	Plant Height (cm)			No of Leaves		
	Weeks after planting					
Spacing	3	6	9	3	6	9

S1 75cm x 40cm	42.87a	97.56a	191.91a	4.76a	10.15a	13.18a
S2 75cm x 50cm	45.00a	94.75a	190.20a	4.67a	10.66a	13.88a
S3 75cm x 60cm	44.27a	102.29a	198.29a	4.64a	10.24a	13.88a
SED	1.31	3.16	4.25	0.168	0.282	0.682
LSD(0.05)	ns	ns	ns	ns	ns	ns

NB: S1: 75cm x 40cm, S2: 75cm x50cm, S3: 75cm x 60cm, LSD (5%) = Least significance difference at 5% level, standard error and NS=non-significant at 5% level.

- ***Effects of Row Spacing on Stem Girth and Leave Area of Maize Hybrid.***

The effects of spacing on stem and leave area of maize hybrid at IITA in the early wet season of 2015 are shown in (Table 3).Stem girth of maize hybrid investigated gradually increased from 3rd to 9th weeks after sowing. The result obtained showed that row spacing of the maize plants had significant effect ($P < 0.05$) on the stem girth at 6 WAP. The maize plant sown at 75cm x 60cm had the highest stem girth (11.85 cm) at 9th week compared to row spacing of 75cmx 40cm (7.58 cm) at 9thweek. However, it was not significantly ($P < 0.05$) different from the row spacing of 75cm x 50cm (7.85 cm). The leave area of the maize plants was significantly ($P < 0.05$) affected by the row spacing at 9 WAP only.Maize grown at row spacing of 75cm x 50cm had significantly ($P < 0.05$) reduced leave area (468.56 cm^2) at 6th and 9th week compared to a narrow intra row spacing of 75cm x 40cm (476.33 cm, 486.87cm) and wider intra row spacing 75cm x 60cm (512.59 cm^2) at 9th week.

Treatment	Stem Girth (cm)			Leave Area		
	Weeks after planting					
Spacing	3	6	9	3	6	9
S1 75cm x 40cm	3.18a	7.58b	11.85a	38.73a	476.33a	486.87ab
S2 75cm x 50cm	3.31a	7.85ab	13.12a	36.99a	456.87a	468.56b
S3 75cm x 60cm	3.17a	8.20a	12.51a	37.61a	469.96a	512.59a
SED	0.09	1.43	6.04	11.61	1475.2	7336.6
LSD	ns	ns	ns	ns	ns	ns

NB: S1: 75cm x 40cm, S2: 75cm x50cm, S3: 75cm x 60cm, LSD (5%) = Least significance difference at 5% level, standard error Deviation and NS=non-significant at 5% level.

- ***Effects of Row Spacing on the Developmental Parameters.***

The effects of spacing on tasseling and silking of maize hybrid at IITA in the early wet season of 2015 are shown in (Table 4).The effects of row spacing of the maize plants had significant effect ($P < 0.05$) on days to 50% tasseling. Maize grown in intra row spacing of 75cm x 60 cm and 75cm x 40cm had significant (P < 0.05) longer number of days to 50 % tasselling (60.87 and 65.67 days respectively) compared to maize grown in row spacing of 75cm x 50cm (59.47 days).The result obtained from this study showed that row spacing had no significant effect (P < 0.05) on the maize number of days to silking. The ear length of the maize plants were significantly (P < 0.05) similar in the three row spacing.

Treatment	Days to 50% tasseling	Days to 50% Silking	Ear Length
Spacing			
S1 75cm x 40cm	60.87a	63.67a	17.06a
S2 75cm x 50cm	59.47b	63.87a	18.31a
S3 75cm x 60cm	61.00a	63.6a	18.52a
SED	0.52	1.44	1.09
LSD	10.82ns	0.29ns	ns

NB: S1: 75cm x 40cm, S2: 75cm x50cm, S3: 75cm x 60cm, LSD (5%) = Least significance difference at 5% level, standard errorDivision and NS=non-significant at 5% level.

➢ ***Effects of Row Spacing on the Yield Components of the Maize Plant***

The effects of spacing on yield components of maize hybrid at IITA in the early wet season of 2015 are shown in (Table 5).The result obtained from the study showed that row spacing had no significant effect (P < 0.05) on the fresh cob weight of the maize, though higher fresh cob weight was observed in row spacing of 75cm x 60cm (2.09 g) (Table 5). Maize grown in narrow row spacing (75cm x 40cm) significantly (P < 0.05) had higher dry cob weight (1.83 g) compared to other row spacing used in this study. The row spacing had no significant effect (P < 0.05) on the cob length of the maize (Table 5). However, it was observed that maize grown in narrow row spacing 75cm x 40cm had the highest cob length (20.19cm) compare to the other row spacing.

Treatment	Fresh Cob Weight (g)	Dry Cob Weight(g)	Cob Length(cm)	Shellingpercentage (%)	Grain Yield(t/ha)
Spacing					
S1 75cm x 40cm	1.78a	1.83a	20.29a	58.8ab	0.688a
S2 75cm x 50cm	1.92a	0.28b	19.77a	54.9b	0.483a
S3 75cm x 60cm	2.09a	0.31b	19.74a	62.2a	0.414a
SED	0.36	13.54	0.98	3.82	0.033
LSD	ns	Ns	ns	ns	ns

NB: S1: 75cm x 40cm, S2: 75cm x50cm, S3: 75cm x 60cm, LSD (5%) = Least significance difference at 5% level, standard errorDivision and NS=non-significant at 5% level.

The row spacing had significant effect (P < 0.05) on the shelling percentage of the maize (Table 7). Maize grown with row spacing of 75cm x 60cm was significantly different from those grown with row spacing of 75cm x 50cm, though significantly had similar shelling percentage with 75cm x 40cm (58,8 and 54.9 % respectively). The row spacing had no significant effect (P < 0.05) on the grain yield of the maize (Table 7). However, it was observed that maize grown with row spacing of 75cm x40cm had the highest grain yield (0.688t/ha) followed by row spacing of 75cm x 50cm (0.483t/ha).

IV. DISCUSSION

Among cultural practices which affect the maize yield, row spacing is a one factor since it is ultimately related with plant density, root development, plant growth and fruiting. However, in most cases the optimum spacing is one which enables the plants to make the best use of conditions at their disposal.

From the study, the maize plants were observed to have similar plant height and number of leaves throughout the study period. Row spacing with wider intra row space (75cm x 60cm) increased the stem girth at 6 WAP and the leave area at 9 WAP compared to other row spacing used for this study. The reduced leaf area and stem girth observed may be due to the competition among the maize plants for space to allow the leaves to fully expand, thereby causing reduction in the amount of assimilates being produced by the leaves and stored in the maize stem. The result is in conformity with [1] and [4] that maize plant sown at spacing of 35cm -40cm were superior in stem girth over those sown at narrower or small spacing and that increased intra- row spacing resulting in larger leaf area possibly because there was a reduction in competition for space, sunlight and nutrient with the wider spaced plants. This may attribute a reduction in competition for space, sunlight, nutrient within the wider spaced plants, plants obtained more soil moisture than narrower spaced plants and other environmental factors. [1] and [10] suggested that increased intra-row spacing resulted in larger leaf area possibly because there was a reduction in competition for space, sunlight and nutrients within the wider spaced plants. However, row spacing with wider intra row spacing 75cm x 60cm had the tallest maize plant than the narrow spacing 75cm x 50cm. [12], [10], [14], and [8] also suggested that the increase in the plant height at wider row spacing is possibly because of reduction in competition for space, sunlight and nutrients. However, narrow spacing may be due to strong competition among the plants for space and light.

The development parameters presented in table 4 above described the tasselling and silking percentage of the maize plant. From the result obtained, it was observed that the wider intra row spacing 75cm x 60cm gave the highest tasselling percentage of (60) while narrow intra row spacing had the lowest percentage (59.47). This could be due to the fact that only one variety of maize was used and thereby having the same genetic constitution. The above resulted corroborated with the findings of [2]. [7], reported that tasseling period was highly weather dependent and this might be expected since light energy and temperature are near optimum in Eastern Mediterranean. The period of silking is a critical time for kernels formation after pollination. Any factor that affects silking and duration of silking can affect grain production directly. It was observed that the maize plants have similar silking percentage across the three intra row spacing studied.

On the yield components of the maize plant presented in the Table 5 above showed that row spacing had no effect on the fresh cob weight and length; however, it significantly influenced the dry cob weight and grain yield of the maize. Maize grown in narrow spacing of 75cm x 40cm had higher dry cob weight which could have resulted in the higher grain yield observed with the same row spacing (0.688 t/ha). This could be as a result of earlier canopy closure which reduced the weed fresh and dry weight as observed in this study, thereby, reducing competition with the maize plants allowing the crops to maximize the available growth resources efficiently. [16] and [5], report that the increased growth rates and earlier canopy closure of row spaced crops to quest for increased light interception as well as increased availability of soil moisture because of equidistance distribution of crop plants. Plant spacing is an important agronomic attribute since it is believed to have effects on light interception during which photosynthesis takes place which is the energy manufacturing medium using green parts of plant for optimum yield [9].

The cob weight and length are important determinant of maize yield. It were observed that the row spacing had no significant effect ($P < 0.05$) on the grain yield of the maize (Table 5). Accordingly, the highest grain yield ($0.688 t \cdot ha^{-1}$) was obtained at narrow intra row spacing 75 cm × 40 cm in 2015 cropping season, while the lowest grain yield ($0.414 t \cdot ha^{-1}$) was obtained at wider intra row spacing 75 cm × 50 cm (Table 5). The possible reason for the lowest grain yield at widest spacing might be due to the presence of less number of plants per unit. This indicated that low plant density per unit area that could get better available growth factors like moisture, nutrients, light, and space could not offset the grain yield obtained from high plant density per unit area. This is similar to the findings of [13] who reported, the highest grain yield (11.67

t·ha−1) was obtained in combination of 75 cm × 25 cm in 2016 cropping season, while the lowest grain yield (8.66 t·ha−1) was obtained at wider inter and widest intra row spacing combination (75 cm × 35 cm) in 2015 cropping season.

V. CONCLUSION

Among agronomic practices to increase crop yield, plant spacing require special attention. Wider row spacing (75cm x 60cm) enhanced the growth parameters of the maize, however, higher yield was observed in narrow row spacing (75cm x 40cm). Therefore, narrow intra-row spacing of 40cm increases maize yield under high yielding conditions. Narrow row spacing tolerates plant density stress and thereby, responds with increased yield.

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