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# RESPONSE OF EXTRA-EARLY MAIZE (*Zea mays* L.) TO VARYING INTRA-ROW SPACING AND HILL DENSITY

[a]Babaji, B.A., [a]Ibrahim, Y.B., [a]Mahadi, M.A., [b]Jaliya, M.M., [a]Yahaya, R. A., [a]Sharifai, A.I., [a]Mukhtar, A.A., [b]Sani, B.M., [b]Ibrahim, A., [a]Muhammad, A.A.
[a]Department of Agronomy, Ahmadu Bello University, Zaria, Nigeria.
[b]National Agricultural Extension Research and liaison Services, Ahmadu Bello University, Zaria, Nigeria.

**ABSTRACT**
Field experiment was conducted in 2004 and 2005 to study response of extra-early maize variety (95TZEE-$Y_1$) to three levels each of intra-row spacing (25, 50 and 75 cm) and stand density (1, 2, and 3 plants per hill) at Samaru, Nigeria. Randomized complete block design with three replicates was used. Most parameters tested were not significantly affected by intra-row spacing except plant height, number of leaves (at 6 WAS in 2005), de-husked cob and grain yields per hectare with values higher at 25cm. Stand density did not affect number of leaves but influenced plant height at 6 WAS of 2005 only with tallest plants at 3 plants per hill. Heavier cobs were produced at 1 plant per hill while cob and grain yield were highest at 2 – 3 plants per hill. The interaction of 25 cm and 2 or 3 plants per hill has the highest cob and gain yield.

**KEY WORDS:** intra-row spacing, stand density, extra-early maize.

## INTRODUCTION

Maize (*Zea mays* L.) is the third most important cereal in the world after rice and wheat. Temperature for growing maize is within the range of 10 and 30°C, while the rainfall requirement for the crop production is 600 – 1000mm. It requires well drained soil and medium texture with high water holding capacity and pH of 5.5 – 8.0. Northern Nigeria is the major maize producing area. Every part of the maize plant is useable for food, feed, bio fuel and other industrial products. Grain is the most important part of the maize and uses for food (Mani *et al.,* 2002 and 2006a & 2006b, Babaji *et al.,* 2007, Umar *et al.,* 2007). The production of the crop is influenced by many factors among which plant population and spacing play a very important role in enhancing its productivity (Aliyu, 2007, Babaji *et al.,* 2007, Umar *et al.,* 2007). Farmers in the Sudan savanna for which extra-early maize was bred for have the habit of growing their maize crop under inadequate plant population, hence, one of the reasons for low yields of crop in this area. The use of right stand density and spacing in addition to good land preparation has been observed to greatly enhance the productivity of maize crop (Mani *et al.,* 2002 and 2006a & 2006b, Iqtas and Acar, 2006, Valentinus and Tollenaar, 2006, Babaji *et al.,* 2007, Umar *et al.,* 2007, Onyango, 2009). However, the as result crop failure in the northern Guinea savanna due to dry spelt experiences in this area, farmers are being advice to delay planting and make also the use of extra-early maize as against the use of conventional late or medium maturing maize varieties(Mani *et al.,* 2002 and 2006a & 2006b). The objective of the study was therefore, determine response of extra-early maize variety to intra-row plant spacing and determine response of plant density per stand under the local weather condition of Samaru, Nigeria.

## MATERIALS AND METHODS

The experiments were conducted during the 2004 and 2005 rainy seasons at the research farm of Institute for Agricultural Research, Ahmadu Bello University, Samaru ($11^0$11'N, $07^0$ 38'E, 686m above the sea level). Prior to land preparation random samples of soils were taken at a depth of 30cm in each season and analysed for physico-chemical properties, the result of which indicated the soils to be loam with 0.02 – 0.03 % nitrogen, 5.29 – 6.34 ppm available phosphorus and pH of 4.7 – 5.10. Total rainfall received for each of the season was within the range of 1000 and 1100mm. Temperature was between 18 and 33 °C. Relative humidity during the period of experimentation was in the rage of 57 in October and 88 in August. The treatments consisted of factorial combinations of three levels each of intra-row spacing (25, 50, 75cm) and stand density (1, 2 and 3 plants/hill). Randomized complete block design was used with three replicates. The land was cleared, harrowed and made into ridges spaced at 75cm. Gross and net plot size were $13.5m^2$ and $4.5m^2$, respectively. Maize variety, Sammaz 12 was sourced from seed unit of the Institute for Agricultural Research, Samaru, Nigeria. It is an extra-early maturing variety that matures in 75 days, resistant to foliar diseases but susceptible to Striga and therefore suitable for low rainfall areas. The variety has white flint and is open pollinated. Planting was carried out on $9^{th}$ and $17^{th}$ July for 2004 and 2005 trials, respectively. The seeds in 2s, 3s and 4s were sown and later thinned to 1, 2 and 3, respectively.

Fertilizers were applied in two equal split doses by band placement at 1 (50:50:50 kg using 15:15:15 NPK/ha) and 3 (50kg N/ha using Urea, 46%N) WAS. Manual hoe weeding at 3, 6 and 9 WAS kept the plot weed free. Data collected include plant height and number of leaves (6 and 9 WAS), husked and de-husked cob weight per plant, number of seed rows per cob, de-husked cob yield per hectare, 100-grain weight and grain yield per hectare. The data collected were statistically analysed and the treatment means were separated using Duncan's Multiple Range Test, DMRT (Duncan, 1955).

**RESULTS AND DISCUSSION**

Tables 1 and 2 shows the response of maize height and leaf number to intra-row spacing and stand density at 6 and 9 WAS of 2004 and 2005 wet seasons. Both parameters significantly responded to intra-row spacing only at 6 WAS of the second season. It was observed that taller plants with more leaf number were produced at the closest spacing of 25cm. However, the leaf production from maize spaced at 25cm was statistically not different from those spaced at 50cm, likewise, the difference in leaf production between maize spaced at 50cm was not significantly different from those spaced at 75cm. Sowing 1 seed at 6 WAS of 2005 had resulted in taller plants only than those maize plants sown at 3 seeds. The interaction of spacing and stand density on plant height and number of leaves was not significant.

**TABLE 1:** Effects of intra-row spacing and stand density on plant height (cm) of maize at 6 and 9 WAS in Samaru during the 2005 rainy reason

| | Weeks After Sowing | | | |
|---|---|---|---|---|
| | 6 | | 9 | |
| Treatment | 2004 | 2005 | 2004 | 2005 |
| Intra-row Spacing (cm) | | | | |
| 25 | 57.5 | 129.6a | 112.9 | 214.6 |
| 50 | 56.6 | 119.2b | 108.2 | 208.2 |
| 75 | 54.7 | 111.6b | 104.7 | 198.3 |
| SE$\pm$ | 2.90 | 3.40 | 5.31 | 4.49 |
| Stand Density/hill | | | | |
| 1 | 53.2 | 113.1b | 103.9 | 207.4 |
| 2 | 55.7 | 120.8ab | 108.1 | 206.1 |
| 3 | 59.9 | 126.4a | 113.8 | 207.5 |
| SE$\pm$ | 2.90 | 3.40 | 5.31 | 4.49 |
| Interaction | | | | |
| S x D | NS | NS | NS | NS |

Means followed by the same letter(s) within a column and treatment set are not significantly different when using DMRT (P=0.05), NS= Not significant

**TABLE 2**: Effects of intra-row spacing and stand density on number of leaves of extra-early maize at 6 and 9 WAS in Samaru during the 2005 and 2006 rainy reasons

| | Weeks After Sowing | | | |
|---|---|---|---|---|
| | 6 | | 9 | |
| Treatment | 2004 | 2005 | 2004 | 2005 |
| Intra-row Spacing (cm) | | | | |
| 25 | 5.20 | 7.58a | 7.00 | 12.04 |
| 50 | 5.30 | 7.42ab | 7.00 | 11.85 |
| 75 | 5.10 | 6.92b | 7.00 | 11.63 |
| SE$\pm$ | 0.17 | 0.17 | 0.21 | 0.22 |
| Stand Density/hill | | | | |
| 1 | 5.2 | 7.23 | 7.00 | 12.04 |
| 2 | 5.2 | 7.36 | 7.00 | 11.52 |
| 3 | 5.1 | 7.33 | 7.00 | 11.96 |
| SE$\pm$ | 0.17 | 0.17 | 0.21 | 0.22 |
| Interaction | | | | |
| S x D | NS | NS | NS | NS |

Means followed by the same letter(s) within a column and treatment set are not significantly different when using DMRT (P=0.05), NS= Not significant

The result of this study has shown that most of the growth (plant height and number of leaves) and yield (weight per husked and de-husked cobs and 100-seed weight) parameters tested were not significantly influenced by the different intra-row spacing indicating that the fertilizer supplied to the crop was generally adequate to remove the negative effect of competition that might have arise as a result of narrower plant spacing. The taller plants with more leaves recorded when maize was spaced at 25 cm at 6 WAS of 2005 could be attributed to steep competition for light at closer spacing that might have resulted in an elongated plant with exposed leaves to sunlight. Narrow 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, Mani *et al.,* 2002 and 2006a & 2006b), resulting in less water being lost from the soil surface by evaporation thereby prolonging period for moisture and nutrients utilization (Sani and Oluwasemire, 2006, Sani *et al.,* 2006). The response of husked and de-husked weight per cob as influenced by intra-row spacing and stand density is presented in Table 3. Generally, it was observed that these two parameters were not significantly affected by intra-row spacing but stand density. Maintaining 1 plant per stand had resulted in heaviest cobs. The least cob weight was recorded when 3 plants/stand was maintained which in turn was statistically at par with that produced by maize sown at 2 plants/stand in 2004. Cob weight was significantly not affected by interaction of within row spacing and stands density.The effects of intra-row spacing and stand density on de-husked cob yield and number of rows/cob is shown on Table 4. The latter was significantly not affected by the two factors. Maize spaced at 25cm resulted in the highest cob yield. Increase in intra-row spacing to 50cm led to significant reduction in cob yield. The cob yield obtained at the widest intra-row spacing of 75cm was lower than for 50cm only in 2005. Maintaining 3 plants per stand had the highest cob yield that is significantly comparable only with that obtained by 2 plants per stand in 2005.

**TABLE 3**:Effects of intra-row spacing and stand density on weight per husked and de-husked cob (gm) of extra-early maize at harvest in Samaru during the 2005 and 2006 rainy reasons

| Treatment | Weight/ husked cob (gm) | | Weight/de-husked cob (gm) | |
|---|---|---|---|---|
| | 2004 | 2005 | 2004 | 2005 |
| Intra-row Spacing (cm) | | | | |
| 25 | 80.5 | 119.3 | 67.7 | 81.51 |
| 50 | 86.0 | 146.7 | 71.8 | 100.3 |
| 75 | 93.4 | 141.6 | 60.9 | 89.5 |
| SE± | 4.50 | 8.87 | 4.50 | 6.03 |
| Stand Density/hill | | | | |
| 1 | 93.3a | 177.1a | 78.8a | 111.6a |
| 2 | 74.0b | 132.9b | 61.1b | 92.0b |
| 3 | 72.6b | 97.5c | 60.6b | 68.0c |
| SE± | 4.50 | 8.87 | 4.50 | 6.03 |
| Interaction | | | | |
| S x D | NS | NS | NS | NS |

Means followed by the same letter(s) within a column and treatment set are not significantly different when using DMRT (P=0.05), NS= Not significant

**TABLE 4:** Effects of intra-row spacing and stand density on de-husked cob yield (t/ha) of extra-early maize at harvest in Samaru during the 2005 and 2006 rainy reasons

| Treatment | De-husked cob yield(t/ha) | |
|---|---|---|
| | 2004 | 2005 |
| Intra-row Spacing (cm) | | |
| 25 | 3.73a | 8.12a |
| 50 | 2.20b | 5.02b |
| 75 | 1.90b | 2.89c |
| SE± | 0.35 | 0.40 |
| Stand Density/hill | | |
| 1 | 2.10b | 3.55b |
| 2 | 2.30b | 6.02a |
| 3 | 3.40a | 6.47a |
| SE± | 0.35 | 0.40 |
| Interaction | | |
| S x D | ** | * |

Means followed by the same letter(s) within a column and treatment set are not significantly different when using DMRT (P=0.05), NS= Not significant, *=significant (P=0.05) **= highly significant (P=0.01)

The interaction of within row spacing and stand density only on de-husked cob yield per hectare was significant. The effects of intra-row spacing and stand density on de-husked cob yield and number of rows per cob is shown on Table 4. Only the number of rows per cob was significantly not affected by the two factors. Maize spaced at 25cm resulted in the highest cob yield per hectare. Increase in intra-row spacing to 50cm led to significant reduction in cob yield. The cob yield obtained at the widest intra-row spacing of 75cm was lower than for 50cm only in 2005. Maintaining 3 plants per stand had the highest cob yield that is significantly comparable only with that obtained by 2 plants per stand in 2005.

The interaction of intra-row spacing and stand density on de-husked cob yield in 2004 and 2005 is significant and is presented on Table 5. Combination of 25cm and 3 plants per stand had the highest cob yield that is comparable to all yields obtained at 25cm in association with other stand densities in 2004 and only 2 plants per stand in 2005. The least cob yield was recorded by the interactions of 50 or 75cm with either 1 or 2 plants per stand in 2004 and combination of 75cm with any of the stand density in 2005.In Table 6 100-grain weight did not significantly respond to either of the factors or their interactions. Each increase in intra-row spacing has resulted in corresponding significant decrease in maize grain yield. Increasing stand of maize from 1 – 2 plants had significantly improved maize grain yield. Further increase in stand density to 3 plants significantly enhanced yield only in 2004. De-husked cob and grain yield per hectare had recorded a significant response to different intra-row spacing used with values highest at 25 cm. The higher harvestable cobs arising from the used of closer spacing might have been the reason for the high cob yield obtained. This in turn might have led to higher threshed grain yield.

**TABLE 5:** Interaction of intra-row spacing and stand density on de-husked cob yield (t/ha) at Samaru during 2004 and 2005 wet seasons.

| Treatment | Stand density 1 | 2 | 3 |
|---|---|---|---|
| | | 2004 | |
| Intra-row spacing (cm) | | | |
| 25 | 3.20ab | 3.97ab | 4.04a |
| 50 | 1.69cd | 1.35d | 3.55ab |
| 75 | 1.42cd | 1.59cd | 2.70bc |
| SE± = 0.46 | | | |
| | | 2005 | |
| Intra-row spacing (cm) | | | |
| 25 | 4.72bc | 10.30a | 9.33a |
| 50 | 3.99c | 4.83bc | 6.25b |
| 75 | 1.94d | 2.93cd | 3.82cd |
| SE± = 0.69 | | | |

Means followed by the same letter(s) within a column and treatment set are not significantly different when using DMRT (P=0.05),

**TABLE 6:** Effects of intra-row spacing and stand density on 100-seed weight (gm) and grain yield (t/ha) of extra-early maize at harvest in Samaru during the 2005 and 2006 rainy reasons

| Treatment | 100-seed weight (gm) | | Grain yield (t/ha) | |
|---|---|---|---|---|
| | 2004 | 2005 | 2004 | 2005 |
| Intra-row Spacing (cm) | | | | |
| 25 | 22.0 | 20.63 | 2.9a | 6.68a |
| 50 | 22.0 | 21.11 | 1.6b | 4.14b |
| 75 | 19.4 | 20.68 | 1.0c | 2.39c |
| SE± | 0.93 | 0.85 | 0.34 | 0.39 |
| Stand Density/hill | | | | |
| 1 | 20.5 | 21.92 | 0.75c | 2.96b |
| 2 | 20.5 | 19.87 | 1.70b | 4.86a |
| 3 | 22.4 | 20.63 | 2.95a | 5.39a |
| SE± | 0.93 | 0.85 | 0.34 | 0.39 |
| Interaction | | | | |
| S x D | NS | NS | ** | * |

Means followed by the same letter(s) within a column and treatment set are not significantly different when using DMRT (P=0.05), NS= Not significant , *=significant(P=0.05) **= highly significant(P=0.01)

It further, explained that the use of narrower intra-row spacing of 25 cm is adequate enough not to cause any stress to the plant since the grain weight (100-seed weight) so produced at wider spacing was not significantly more than that from closer pacing. Similar findings were reported by Mani *et al.* (2006b), Iqtas and Acar (2006), Babaji *et al.* (2007) and Onyango (2009). Higher competition for light might have been the reason for production of taller plants at the highest stand density of 3 plants per hill at 6 WAS in 2005. However, the same parameter at most sampling periods and number of leaves and 100-seed weight at all sampling periods were not significantly affected by the used of different stand density probably due to presence of adequate plant nutrients from the fertilizer applied. Steep competition for light at higher stand density might have been the reason for the production of taller plants. Although the low competition for growth factors (nutrient, light, moisture and space) could have been the reason for heavier cobs produced at lowest stand density of 1 plant per hill, the large number of harvestable cobs at higher plant density of 2 – 3 per hill might have been the other reason for higher cob and grain yields (Mani *et al.,* 2002, Iqtas and Acar, 2006, Valentinus and Tollenaar, 2006, Babaji *et al.,* 2007, Umar *et al.,* 2007, Onyango, 2009).

**TABLE 7:** Interaction of intra-row spacing and stand density on maize grain yield (t/ha) at Samaru during 2004 and 2005 wet seasons

| Treatment | Stand density 1 | 2 | 3 |
|---|---|---|---|
| | | 2004 | |
| Intra-row spacing (cm) | | | |
| 25 | 1.17de | 2.87b | 4.63a |
| 50 | 0.59e | 1.59d | 2.51bc |
| 75 | 0.56e | 0.61e | 1.71c |
| SE± = 0.69 | | | |
| | | 2005 | |
| Intra-row spacing (cm) | | | |
| 25 | 3.89bc | 8.20a | 7.99a |
| 50 | 3.34bcd | 3.98bc | 5.11b |
| 75 | 1.68d | 2.41cd | 3.07cd |
| SE± = 0.62 | | | |

Means followed by the same letter(s) within a column and treatment set are not significantly different when using DMRT (P=0.05)

Table 7 shows the significant interaction of within row spacing and stand density on maize grain yield. The combination of 25cm and 2 plants per stand had the highest grain yield in each season that is significantly comparable with that at 3 plants per stand under similar intra-row spacing. 75cm + 1 plant per stand had the least grain yield that is statistically at par with, 75cm + 2 plants per stand, 50 cm + 1 plant per stand in both season, and 75cm + 3 plants per stand only in 2005.

The higher cob and grain yields so obtained at combinations of 25 cm and 2 or 3 plants per hill could also be due to fact that more cobs are harvested under this population (Mani *et al.,* 2002, Iqtas and Acar, 2006, Valentinus and Tollenaar, 2006, Onyango, 2009).Therefore from the result so obtained from this study it is therefore eminent that higher grain yield for the newly developed extra-early maize variety is possible at 25 cm intra-row spacing x 2 plants per hill as opposed to the recommended 25cm intra-row spacing x 1 plant per hill.

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