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GROWTH AND YIELD RESPONSES OF SOYA BEAN (*Glycine max L.*) TO VARYING SPACING IN JALINGO, TARABA STATE.

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ABSTRACT

A field experiment was carried out to study the effects of plant spacing on the growth and yield of soybeans (*Glycine max L.*), variety TGX 448-2E during 2016 cropping season at the Research farm of the Taraba State University, Jalingo. The experiment was laid out in a Randomized Complete Block Design (RCBD) having nine treatments replicated three times. Treatments included 5x30cm (T1), 5x45cm (T2), 5x60cm (T3), 10x30cm (T4), 10x45cm (T5), 10x60cm (T6), 15x30cm (T7), 15x45cm (T8) and 15x60cm (T9). Parameters monitored were plant height, number of leaves plant-1, number of days to 50% flowering, number of flowers plant-1, number of pods plant-1, number of seeds pod-1, number of seeds per plant-1 and total grain yield plot-1. Results of Analysis of Variance (ANOVA) of data collected revealed that plant height varied significantly ($p<0.05$) with tallest plants (41.5cm) obtained with 5x30cm spacing and lowest with 10x45cm spacing. Number of leaves plant-1 was highest (19.4) with 15x60cm and lowest with 5x30cm spacings accordingly. Number of seeds pod-1 was similar in all inductive spacings. Number of seeds plant-1 varied significantly ($p<0.05$) between the treatments with highest number of seeds obtained from the 15x30cm spacing. Total seed weight plot-1 was significantly ($p<0.05$) highest with 5x45cm and 15x60cm spacings. These results showed that the plant spacings 5x45cm and 15x60cm which gave the highest yield may be recommended for the location for best yields.

Keywords: *Soybean, Plant spacing, growth, yield, Jalingo.*

INTRODUCTION

Soybeans (*Glycine max L.*) have been cultivated in Asia civilization for thousands of years, and are one of the most important crops globally today. Commercially important products commonly made from soybeans include protein powders, textured vegetable protein, soybeans vegetable oil, sprouts, livestock feed, gluten-free flour, soymilk, soy cheese and curds and much more (FAOSTAT, 2016).

From 1914 to 2010, soybean production increased to 3, 000% from 2.92 to 90.80 million metric tons, while area harvested only increased by 1,200%, from 2.3 to 31.0 million ha. During this time the average yield rose to 139%; from 122.4 to 2925kg ha^{-1} (USDA, 2010).

According to the USDA (2016), soybean accounts for 3% of Bolivia's Gross Domestic Product, and employs 45,000 workers directly, while generating 65,000 more jobs indirectly. Nigeria may, therefore, take a cue from here as it considers agriculture as an alternative source of income generation.

Depending on the agronomic practices applied and the soil and weather conditions, yield per hectare of soybean may range between 1.8 and 2.3 metric tons.

Many farmers have been cultivating soybean but ending up with poor yields due to either too wide or too narrow spacing as the case may be. Though, the aim of any breeding program is to obtain high yields, farmers still harvest poor yields. Therefore, this research was carried out in order to come up with the best spacing to be adopted by the farmers in Jalingo for the best attainable yields since that is their target. Soybean (*Glycine max L.*)is a herbaceous annual plant in the family Fabaceae or Leguminoceae grown for its edible seeds. The plant is usually an erect bush with woody stems and alternately arranged leaves (Nafziger, 2015). The leaves possess three (3) individual leaflets which are oval or lance-like in shape, growing to a length of 3-10cm (1.2 - 4.0 in). It produces small white or purple flowers and curved seed pods which are 3-15cm (1.2 - 6 in) in length and can contain between 1 and 5 seeds. Seedsvary in colour including yellow, green, brown, black or a mottled combination. Soybean is an annual plant surviving only one growing season and can reach heights of 0.2 - 1.5m (0.7-1.4ft). During maturity, the pods turn brownish; the leaves yellowish which are later harvested (Nafziger, 2015).

Soybean varieties grown in Nigeria include TVX536-02D, TGX – 192c, TGX 306 – 036c and TGM 344. All these varieties were bred by International Institute of Tropical Agriculture (IITA), while Sam Soy I, Sam Soy II, and M351 were bred by Institute of Agricultural Research (IAR).

Soybean is planted in Nigeria from June to July; the seed rate depends solely on the purpose. The average planting distance between plantsis 25cm. Therefore, this study sought to analyse the effect of spacing below and above the average spacing and their effects on growth and yield parameters.

Plant density is one of the most tremendous factors that must be looked into and strictly maintained if reasonable plant yields are to be obtained (USDA 2012). Varieties differ in their ability to produce good yield with different rows, width and planting density. Lodging may be a problem with narrow rows, especially if the plant population density is too high (Ball *et al*., 2001).

According to IITA (2009), the current soybean spacing recommendation for Nigeria is 30 x 15cm (about 220,000 plants/ha). This, however, is a generalization as different locations have different climatic and soil conditions which may imply a modification of the given specification in order to obtain the best results.

Previously conducted studies have shownthat unique situations and environmental conditions can influence the yield responses of narrow rows in different ways. The varying impacts on narrow row responses make it difficult to predict yield gain in a given year (Pedersen and Lauer, 2003).

Abiotic and biotic stresses can mitigate the yield response of soybean to narrow spacing production. Moisture stress has been documented to reduce the yield benefits from narrow row spacing (Heitholt *et al*., 2005).

Plant density is an important agronomic factor that manipulates micro environment of the field and affects growth, development and yield formation of crops. Within certain limits, increase of plant population Density (PPD) decreases the growth and yield per plant but the reverse occurs for yield per unit area (Caliskan *et al*., 2007).

MATERIALS AND METHODS

Experimental site:The experiment was conducted at the Research Farm of the Faculty of Agriculture, Taraba State University Jalingo. The soil at the experimental site is sandy loam and well drained. Jalingo is located on Longitude 8.8929°N and Latitude 11.3771°E. It is 350 meters above mean sea level, with the annual temperature ranging from 28°C to 33°C.

Cropping history: The experimental site has been used over the years for the cultivation of different crop plants including maize, tomato, okra, melon etc.

Experimental Design:The experiment was laid out in

Randomized Complete Block Design (RCBD) having Nine (9) treatments and replicated three (3) times. The treatment were as follows: T1= 5cm x30cm, T2 = 5cm x 45cm, T3 = 5cm x 60cm, T4 = 10cm x 30cm, T5 = 10cm x 45cm, T6 = 10cm x 60cm, T7 = 15cm x 30cm,T8 = 15cm x 45cm, and T9 = 15cm x 60cm, where within and between the replicated blocks, the gross experimental area of 0.01ha (100m^2) was divided into three (3) with each block having an alley way left to facilitate easy movement during cultural operations.

Cultural Practices

Land preparation:The land was manually cleared on the 14 July, 2016.It was then made into beds of 3m x 3m in size, having a spacing of 0.5m between beds. Each block had three (3) plots giving a total of nine (9) plots and twenty seven (27) ridges.

Planting: The soybean variety TGX-1448-2E was manually drilled on the ridges on 23 July, 2016 and then covered with soil.

Thinning: The number of seed sowed per hole was two (2).Seedlingswere thinned down to one plant per stand two weeks after sowing (2WAS) to avoid competition for space and nutrient.

Pest control:The pest control was done at 3 weeks after planting with the use of pesticide (Cypermethrine) with 10% Es active ingredients. This chemical helped to protect the crop from the attack of insect pest.

Weed control:Weeding was done at intervals of two (2), four (4) and six (6) weeks after sowing (WAS). The surrounding was cleared for air circulation and to prevent rodents and other animals from destroying the crop. This was done at 12WAS.

Harvesting: The matured pods were harvested at 13WAS manually by hand pulling the stands from the ground when the pods are brown or tan in colour and the seeds rattle in the pod (Dennis, 2017). They were carefully tied and sundried for 3 days before threshing and winnowing was done based on the treatments.

Data Collection: Seed germination count was taken at 10 DAP to determine germination percentage. Parameters assessed included plant height, number of leaves per plant, number of days to 50% flowering, number of flowers per plant, number of pods per plant, plant height at harvest, number of seeds per plant and total grain yield per plot.

Plant height:Three randomly selected plant stands were measured from the ground level to the tip of the main stem using a measuring tape.

Number of leaves per plant: Three plants were randomly selected for each treatment. The entire fully opened leaves on the plant were counted.
Number of days to 50% flowering: This is the number of days at which half of the total number of plants per treatment had flowered.

Number of Flowers per plant: The numbers of flowers for individual plant stands were taken for three randomly selected plants for each treatment.
Number of pods per plant: Three plant stands were selected from each of the treatments and the number of pods was counted for each. The mean of the three was used.

Number of seeds per pod:Three pods were randomly sampled and the number of seeds counted after the pod had been split opened.

Number of seeds per plant: The entire seeds harvested from each stand for the representative treatments were counted to give number of seeds per plant.

Total grain yield per plot: The weights of the seeds from each plot were converted to the equivalent at 13% moisture content for better storage (Dennis, 2017). The ratio of the weight of grain in a plot to its percentage moisture content at harvest and multiplied by 13 gave the total grain yield at 13% moisture content as follows:

Grain yield at 13% moisture content = $\frac{a}{b} \times 13$

Where,

a = % moisture content at harvest

b = grain yield at (a) moisture content.

Statistical Analysis

The crop data collected were subjected to Analysis of Variance (ANOVA) to ascertain the significance of the treatment effect on various parameters tested, while LSD was used to separate the means.

RESULTS AND DISCUSSION

Plant height:

The effects of plant spacing on plant height at 2, 4 and 6 WAS is shown in Table 1. Plant height varied from 11.8 cm at 2WAS to 34.1 at 6WAS when the plants were subjected to 5 x 30 cm spacing, giving the highest plant height. Also, when they were subjected to 10 x 45 cm spacing, plant height increased steadily from 9.2 cm at 2WAS to 23.2 cm at 6WAS recording the lowest plant height for the nine (9) inductive spacings. Analysis of Variance (ANOVA) (Appendix 1) showed that there exists a significant ($p<0.05$) effect of plant spacing on plant height of soya beans.

Table 1. Effects of plant spacing on Plant height and Number of leaves per plant of Soya Beans at 2,4 and 6 WAS at Jalingo in 2016

Treatment (Spacing)	2WAS		4WAS		6WAS	
	PLH(cm)	NLPP	PLH(cm)	NLPP	PLH(cm)	NLPP
T1 (5 x 30cm)	11.8	7	17.8	15	34.1	27
T2 (5 x 45cm)	8.6	8	15.6	13	28.7	27
T3 (5 x 60cm)	9.8	7	15.6	12	26.0	25
T4 (10 x 30cm)	10.2	9	15.2	14	30.3	28
T5 (10 x 45cm)	9.2	7	14.8	12	23.2	22
T6 (10 x 60cm)	9.4	7	14.8	13	24.9	21
T7 (15 x 30cm)	10.0	9	19.4	15	30.7	34
T8 (15 x 45cm)	9.0	8	13.7	13	22.3	27
T9 (15 x 60cm)	9.8	9	15.9	14	26.8	28

Number of Leaves per plant:

The number of leaves per plant varied from 7 at 2WAS to 27 at 6WAS when the plants were subjected to 5 x 30cm spacing. The number of leaves also ranged from 9 at 2WAS to 28 at 6WAS with 10 x 30 cm spacing. However, with 15 x 30 cm spacing the number of leaves per plant increased from 9 at 2WAS to 34 at 6WAS to record the highest number of leaves per plant (Table 1). Analysis of Variance (ANOVA) (Appendix 4) showed that there exists a significant effect ($p<0.05$) of plant spacing on the number of leaves per plant of Soya beans.

Number of Flowers per Plant:

The effects of plant spacing on number of flowers per plant of soya beans are shown on Table 2. Subjecting the plants to 5 x 30 cm spacing resulted in 51 flowers per plant while 10 x 60 cm spacing resulted in 32 flowers per plant. On the contrary, a spacing of 15 x 30cm produced plants with the highest number of flowers (66). ANOVA results showed that significant differences ($p<0.05$) existed between the treatments in relation to number of flowers per plant in the soy plant (Appendix 4).

Number of pods per plant:

Table 2 showed that the mean number of pods per plant was 20 when the plant spacing was 5 x 30 cm. also, when the plants were subjected to 10 x 45 cm spacing, the number of pods per plant rose to 25. The plant spacing 15 x 60, however gave significantly ($p<0.05$) highest number of pods (49) per plant. ANOVA (Appendix 4) showed that there is significant spacing effect on the number of pods per plant in soya bean.

Number of seeds per pod:

The number of seeds per pod was similar across all inductive plant spacings (Table 2). ANOVA showed that there was no significant difference ($p<0.05$) in the number of seeds per pod across all the plant spacings applied to the soya bean plants (Appendix 4) as the mean number of seeds was three (3) in all treatments.

Number of Seeds per plant:

The mean number of seeds per plant for the different treatments is as shown in Table 2. A spacing of 5 x 60 cm produced a mean number of 25 seeds per plant while 10 x 30 cm spacing yielded a 50 seeds per plant. However, when the spacing was changed to 15 x 30 cm, the number of seeds per plant increased to 60, which is the highest compared to other plant spacings. ANOVA (Appendix 4) results showed that there was a significant difference ($p<0.05$) in the number of seeds per plant in soya beans when the spacing was varied. The results also showed a significant interaction between spacing and yield parameters of soya beans.

Table 2. Effects of plant spacing on the yield parameters of Soya beans in Jalingo in 2016

Spacing	NFPP	NPPP	NSPP	NSPPL	TSWPP (t ha-1)
T1 (5 x 30cm)	51	20	3	35	0.7
T2 (5 x 45cm)	37	36	3	41	0.9
T3 (5 x 60cm)	44	27	3	25	0.6
T4 (10 x 30cm)	55	41	3	50	0.5
T5 (10 x 45cm)	34	25	3	32	0.4
T6 (10 x 60cm)	32	31	3	52	0.7
T7 (15 x 30cm)	66	41	3	60	0.7
T8 (15 x 45cm)	35	27	3	41	0.4
T9 (15 x 60cm)	46	49	3	56	0.9

Key:

NFPP No of Flowers per Plant
NPPP No. of Pods per Plant
NSPP No of Seeds per Pod
NSPPl No. of Seeds per Plant
TSWPP Total Seed Weight per plot

Total Grain Yield per Plot:

The total grain yield per plot did not differ significantly (p>0.05) (Appendix 4). Total grain yield per plot was 0.7 t ha-1 for 5 x 30 cm, 10 x 60 cm and 15 x 30 cm spacings. This was not the case with 5 x 45 cm and 15 x 60 cm spacings which yielded 0.9 t ha-1 of grains. Linear regression analysis however showed that there was no significant different in total grain yield per plot.

The highest plant height observed with 5 x 30cm spacing revealed that close spacing between plant stands provided better light interception resulting to more photosynthetic activity that produced the luxuriant growth. This was in concord with Engli and Cornelius (2009) and Ball *et al.,* (2000) who reported that higher plant population facilitates maximum light interception that ultimately helps in adding to crop growth rate (CGR) of soya beans.

Caliscan *et al.,* (2007) had reported that increased plant population density decreases growth (plant height, number of leaves, stem girth, etc.). It was however, observed here that the closer spacing produced the tallest plants and the highest number of leaves.

The narrow row spacing in Soya bean gives higher yield than the wider row because of the greater light interception. Plant density affect yield in Soya beans by modulating leaves area and therefore light interception and canopy photosynthesis (Wells, 1999).

While increased plant populations appeared to increase yield (De Bruin and Pedersen, 2008c), many studies have also found an optimum seeding rate, beyond which yield will not increase (De Bruin and Pedersen, 2008c; Oplinger and Philbrook, 1999; Weber *et al.*, 1996). This study also showed that with the increased plant population using 5 x 45 cm spacing total grain weight per plot also increased.

The plant spacing 15×30 cm which produced the highest number of flowers in this study might have been due to closed space between the plant stands and Photosynthetically Active Radiation.

The highest number of pods per plant was obtained from a spacing of 15 × 60 cm which gavethe widest sowing distance which might have provided more air circulation and initiation of more nodes hence increased yield. Bullock *et al*., 1998 had reported that larger plant size was due to enhanced early growth hence creating additional "fertile" nodes with more filled pods thus increasing yield.

CONCLUSION

The optimum plant density to obtain highest yield may vary with the genotype and geographical location. In the USA, the optimum plant density varies from 30 to 50 plants m^{-2} (Grichar, 2007). In South Korea, (Kang *et al*., 1998) reported the highest yield at 33 to 53 plant m^{-2} while Cho and Kim, (2010) obtained highest yield at 66 plants m^{-2}.It was observed in this study that plant spacing (5×30 cm) had significant effect on growth and 15x30cm had significant effect on yield parameters of Soya beans. Although the performance of Soya beans may vary from year to year and location to location and from one variety to another, it may be concluded that the spacing of 5 × 45 cm and 15 x 60 cm which gave the highest yield should be adopted for implementation in this location.

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