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EFFECT OF THINNING TIME AND PLANT DENSITY ON GROWTH AND YIELD OF SORGHUM (*Sorghum bicolar L. Moench*) IN BAUCHI, BAUCHI STATE, NIGERIA

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ABSTRACT

A research was conducted at the Teaching and research farm of Bauchi state college of agriculture to investigate the effect of thinning time and plant density on the growth and yield of sorghum (Sorghum bicolor L. Moench). Bauchi is located in the Northern Guinea Savanna Zone of Nigeria between Latitude (10°25'N and

INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench) belongs to the family *Phocaea* an important annual cereal crop grown for both grain and palatable green forage for human and animal consumption respectively in many countries including Nigeria. Due to its peculiar traits it is adaptive to stressful environments and nutrient variability supply (FAO2012).The crop is grown throughout the arid and semi-arid tropical regions of the world. Nigeria is the third largest world producer of sorghum after the United States and India (FAO, 2015). It has a high calorie and nutritional value and it is therefore recommended for pregnant, lactating mothers, infants and the elderly (FAOSTAT,2012).. In order to grow strongly and develop well and give better yield, plants should not be crowded. Thinning is the removal of specific seedlings from a row in order to create more space between the remaining seedlings.

This provides room for proper gr owth and development better air circulation and efficient use of nutrients. The major constraints encountered in the production of sorghum by farmers who are mostly small holders includes; lack of knowledge of appropriate thinning time and optimum plant density, low investment in fertilizer, improved varieties and cost of labor(May *et al*, 2012) have so far been the major reasons for the decline in production and effective growth of sorghum. Similarly, close planting of crops always causes mutual shading among individuals and inevitably a depression in leaf photosynthesis. As the planting density increases, the total crop yield increases and reaches a maximum, at which point further increase in planting density results in reduced yield. It is, therefore, important to use appropriate planting density, keeping in mind the fact that the density that provides the highest yield and the density that

9°51'E). The research was conducted during the 2018 rainy season on the variety SK5912.The treatments consisted of three thinning times (2,4 and 6weeks after sowing) and four plant densities (1stand/hill or 53,333 plants/ha, 2 stands/hill or106,666 plants/ha, 3stands/hill or 159,999 plants/hill and 4plants /hill or 213,332 plants/ha) which were factorially combined, laid down in a randomized complete block design (RCBD) and replicated three times. Results showed that thinning early at two weeks after planting and 1plant/hill significantly (P≤ 0.01) yielded taller plants, maximum number of leaves , leaf area, stem girth, panicle weight panicle length, number of spikelet/spike, grain yield per hectare of sorghum than 4 and 6 weeks after planting. Plant density and thinning time of 1plant and two weeks after planting interacted significantly (P≤ 0.01) with the growth and yield of sorghum. It is therefore concluded that the adoption of thinning early at two weeks and the maintenance of 1 plant/ stand will give more grain yield in the study area.

Keywords: *Effect, thinning time, plant density, growth, yield, Sorghum (Sorghum bicolor L. Moench).*

provides the highest revenue should be considered The objectives of the Study was to determine the effect of thinning time on the growth and yield of sorghum , the effect of plant density on growth and yield of sorghum and to proffer recommendation to farmers the best thinning time and plant density for better crop production.

MATERIALS AND METHODS

The experiment was conducted at Teaching and Research Farm of the Bauchi State College of Agriculture (Latitude 10°25'Nand Longitude 9°51'E) located in the northern Guinea savannah, zone of Nigeria during 2018 rainy season.

The experimental material consisted of sorghum variety (SK-5912) which was obtained from seed multiplication unit Bauchi State Agricultural Development Programme (BSADP). The variety was released in 1970 by I.A.R Samaru, Zaria. It is a long-season variety (matures in 165-175 days) outstanding characteristics are yellow skin color, good for brewing, high yielding (1.8-3 t/ha).

The treatment consisted four (4) planting density (1, 2, 3 and 4 Stands/hole) and three (3) thinning times (2, 4, and 6 weeks after sowing). The treatments were factorially laid out in a randomized complete block design (RCBD) replicated three (3) times.

The experimental field was prepared using tractor mounted disc plough, the land was ploughed and harrowed to make a soil tilth ready for planting. Plot size of 3m×3m was used for the experiment and boarder row of 0.5m was left between plots while 1m was left out as a walk way between replicates or blocks.

Six (6) seeds per hole were sown at a spacing of 25cm X 75cm intra and inter row respectively.The compound fertilizer NPK 20: 10: 10: was applied as basal application at a rate of 30Nkg/ha, 30kg P_2O_5, and 30K_2O kg/ha at two weeks after sowing. However, urea fertilizer (46%N) was later applied as top dress for the remaining 30kgN at 6 WAS.

Manual weeding using small hoe was employed to control weed infestation at three (3) and seven (7) weeks after sowing, which ensured weed free plots.

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The crop was harvested by first cutting down the entire plant at maturity after 187 days after sowing. The panicles were removed using knife manually and left to dry under the sun for a week. The dried panicles were then threshed manually with stick and winnowed to remove the chaff.

Data Collection

Data were collected from10 randomly selected stands from middle rows of each plot which were tagged for observation. . Data was collected from ten randomly selected plants from each plot during the research for the following parameters; Plant Height (cm), Number of Leaves, Leaf Area (cm^2) stem girth (cm),panicle, 1000 grain weight (g) and Grain yield per plot (kg/ha) and Grain yield per hectare (kg/ha and were subjected to analysis of variance (ANOVA) to determine the significant difference between treatments and the mean performance of each treatment. However, the treatment means were separated using Duncan's Multiple Range Test (DMRT).

Results and Discussion

Plant Height (cm)

Table 1 shows the effect of thinning time and plant density on plant height of sorghum.Plant height was significantly ($P \leq 0.01$) influenced by thinning time and density. The tallest plants were obtained by thinning at two weeks after sowing and one plant per stand. The performance of thinning time at two (2) weeks after sowing could be an indication that the earlier the crops are being thinned the better for their vegetative growth. Furthermore, early thinning might have reduced excessive competition for resources of production (moisture, light and nutrients) between adjacent plants and increased photosynthesis.

Leaf Area (cm^2)

Effect of thinning time and plant density on leave Area is presented in table 2. Both thinning time and plant density significantly ($P \leq 0.01$) influenced leave area throughout the period of the study. Sorghum was observed to produce highest mean values when thinned at 2 weeks after

sowing (WAS) and one seedling per stand than all other plant densities used. However, interaction of thinning time and plant density didn't show any significance. The significant (P≤0.01) difference observed could be an indication that thinning early with lower plant density produce higher leaf area and increase photosynthetic rate and reduce competition. This was supported by earlier work of May,et.al (2012) who reported that less competition for growth requirements has a significant contribution on vegetative growth of plant.

Number of Leaves

Effect of thinning time and plant density on number of leaves presented in table 3 shows that number of leaves per plant was significantly (P≤0.01) influenced by thinning time only at 8 and 14 weeks after sowing. Thinning at one (1) week after sowing significantly produced higher number of leaves than other thinning time though at par with thinning at 6 weeks after sowing.Plant density significantly (P≤0.01) influenced number of leaves per plant of sorghum throughout the period of study. Sorghum thinned to 1seedling per stand produced higher number of leaves per plant than the other densities used. There was no significant interaction between thinning time and plant density.

The performance of plant density at 1 stand per hill could be an indication that lower density produce higher number of leaves due to less competition for growth resources. Similarly the present study corroborates with the work of Myers and Foale (1981) who reported that number of leaves of sorghum is a result of increase in plant height.

Stem Girth (cm)

Table 4 shows that both thinning time and plant density significantly (P≤0.01) influenced sorghum stem girth throughout the period of study. Thinning at 2 weeks after sowing produced thicker stems than other thinning time studied. Plant density of 1 seedling per stand also had significantly (P≤0.01) thicker stems than other plant densities. The result further revealed no significant interaction of thinning time and plant density. Thinning at 2 weeks after sowing and 53,333 plants per hectare produced thicker stem girth while late thinning and higher plant

densities decreased stem girth due to intense competition and poor seedling establishment. The present findings therefore is in conformity with the findings of Chaochen tang *et al.* (2017), who stated that increase in plant population, may result in the reduction in plant diameter and height, due to the competition for water, light and nutrients.

1000 Grain weight (g)

Table 6 shows effect of thinning time and plant density on 1000 grain weight of sorghum during 2018 rainy season in Bauchi. Thinning time had no significant (P≤0.05) effect on 1000 grain weight of sorghum. However, plant density had significant (P≤0.05) influenced on 1000 grain weight. The one (1) stand per hill produced the highest 1000 grain weight than all other plant densities studied. There was no significant interaction between thinning time and plant density. Thinning time and plant density exhibited a (significant (P≤0.05) positive effect on 1000 grain weight. Thinning at 2 weeks after sowing and 1 plant per stand produced higher 1000 grain weight; this is due to the capacity of sorghum to develop new reproductive structures in response to increase in available resources. The result is in agreement with the finding of Rahman and Hossain (2011) who reported that increase in plant density decrease yield components of plant.

Grain yield per plot

There was no significant effect of thinning time on grain yield per plot in table 6. Plant density had significant (P≤0.01) effect on grain yield per plot. The use of 1 stand per hillsignificantly (P≤001) produced highest number of grain yield per plot than other plant densities. There was no significant interaction between thinning time and plant density. Grain yield per plot was influenced by the evaluated thinning time and plant density. Thinning at 2 weeks after sowing and plant densityat 1 stand per hill produced higher grain yield per plot because decreased in plant density reduced crowding stress on plant. According to Rahman and Hossain (2011) who reported that crop may react to the pressure of a large population after competition starts through a decrease in fruit number and size and/or seed production.

Grain yield per hectare

Effect of thinning time and plant density on grain yield per hectare is presented in table 6. Both thinning time and plant density had significant (P≤0.01) effect on grain yield per hectare. Higher grain yield per hectare was obtained when thinning is done 2 weeks after sowing. Similarly, one (1) seedling per stand produce highest grain yield/hectare than all other treatments throughout the study. This study shows that with increasing plant density, grain yield per hectare decreased. Early thinning at 2 weeks after sowing and lower density of 1 stand per hill was positively correlated with higher grain yield per hectare. This result aligned with previous research findings of studies Thomas *et al.*, (1981) who reported increased plant density significantly decreased grain yield per hectare due to interplant competition.

Conclusion

The result of the study revealed that thinning time and plant density had influence on growth and yield of sorghum. Thinning as early as 2 weeks after sowing and maintenance of one or two plants per stand promote better plant establishment and grain yield of sorghum. .

Recommendations

Based on the result obtained, thinning sorghum at 2 weeks after sowing and plant density of 1 to 2 stands per hill can be recommended for sorghum farmers in the research area for more profitable crop production.

Table 1: Effect of Thinning Time and Plant Density onPlant Height (cm) of Sorghum (*Sorghum bicolor* L.)during 2018 Rainy Season in Bauchi, Bauchi State, Nigeria

Treatments	Weeks After sowing				
	8	10	12	14	16
Thinning time (TT) (weeks after sowing)					
2	55.49^{a}	79.51^{a}	93.93^{a}	103.06^{b}	123.68^{a}
4	56.88^{a}	74.33^{b}	89.33^{b}	105.47^{ab}	115.49^{b}

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6	54.02^{b}	72.91^{b}	88.05^{b}	106.46^{a}	118.34^{b}
LS	**	**	**	**	**
SE±	0.505	0.940	0.976	0.968	0.992
Plant density (PD) (Stand/hill)					
1	59.12^{a}	79.63^{a}	92.13^{a}	108.69	124.52^{a}
2	56.26^{b}	77.37^{ab}	91.956^{a}	106.20	121.10^{b}
3	54.68^{b}	74.80^{b}	89.82^{ab}	103.72	117.63^{c}
4	51.79^{c}	70.53^{c}	87.86^{b}	101.32	113.36^{d}
LS	**	**	**	**	**
SE±	0.583	1.085	1.270	1.049	1.145
Interaction TT x PD	NS	NS	NS	NS	NS

Means in the same column followed by the different letter(s) are significantly different using Duncan Multiple Range Test (DMRT)
LS= level of significant, NS = Not significant, ** = significant at 0.01.

Table 2: Effect of Thinning Time and Plant Density onLeave Area(cm) of Sorghum(*Sorghum bicolor* L.) during 2018 Rainy Season in Bauchi, Bauchi State, Nigeria

Treatments	**Weeks After sowing**				
	8	10	12	14	16
Thinning time (TT) (weeks after sowing) **2**	359.00^{a}	477.40^{a}	564.00^{a}	635.48^{a}	718.08^{a}
4	337.23^{b}	439.94^{ab}	522.76^{b}	581.38^{b}	677.02^{b}
6	318.83^{c}	432.58^{b}	512.93^{c}	581.38^{b}	674.74^{b}
LS	**	**	**	**	**
SE±	3.667	13.504	2.997	4.831	5.124
Plant density(PD) (Stand/hill)					
1	383.90^{a}	495.39^{a}	577.61^{a}	644.37^{a}	735.40^{a}
2	352.23^{b}	464.13^{ab}	545.59^{b}	613.60^{b}	698.11^{b}
3	324.19^{c}	435.75^{bc}	517.67^{c}	586.39^{c}	679.13^{c}

4	293.09^{d}	404.60^{c}	492.06^{d}	553.28^{d}	646.99^{d}
LS	**	**	**	**	**
SE±	4.234	15.593	3.860	5.579	5.917
Interaction TT x PD	NS	NS	NS	NS	NS

Means in the same column followed by the different letter(s) are significantly different using Duncan Multiple Range Test (DMRT)
LS= level of significant, NS = Not significant, ** = significant at 0.01.

Table 3: Effect of Thinning Time and Plant Density on Number ofLeaves(cm) of Sorghum (*Sorghum bicolor* L.) during 2018 Rainy Season in Bauchi, Bauchi State, Nigeria

Treatment	**Weeks After Sowing**				
	8	10	12	14	16
Thinning time (TT) (weeks after sowing)					
2	6.09^{a}	6.99	7.88	8.80^{a}	9.64
4	5.66^{b}	6.74	7.63	8.42^{b}	9.58
6	5.76^{ab}	6.66	7.73	8.81^{a}	9.53
L.S	**	NS	NS	*	NS
SE±	0.125	0.115	0.130	0.120	0.124
1					
2	6.41^{a}	7.33^{a}	8.26^{a}	9.24^{a}	10.09^{a}
3	6.01^{a}	7.03^{a}	7.88^{ab}	8.82^{b}	9.78^{ab}
4	5.58^{b}	6.64^{b}	7.66^{b}	8.51^{bc}	9.39^{bc}
L.S	5.33^{b}	6.16^{c}	7.2^{c}	8.12^{c}	9.08^{c}
SE±	**	**	**	**	**
Interaction TT x PD	0.145	0.133	0.150	0.135	0.143
	NS	NS	NS	NS	NS

Means in the same column followed by the different letter(s) are significantly different using Duncan Multiple Range Test (DMRT)
LS= level of significant, NS = Not significant, ** = significant at 0.01.

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Table 4: Effect of Thinning Time and Plant Density on Stem Girth (cm) of Sorghum (*Sorghum bicolor* L.) during 2018 Rainy Season in Bauchi, Bauchi State, Nigeria

Treatment	Weeks After Sowing				
	8	10	12	14	16
Thinning time (TT) (weeks after sowing)					
2	5.73[a]	6.80[a]	7.99[a]	8.89[a]	10.19[a]
4	5.34[b]	6.79[a]	7.73[b]	8.68[a]	9.48[b]
6	5.19[b]	6.33[b]	7.37[c]	8.29[b]	9.03[c]
LS	**	**	**	**	**
SE±	0.122	0.107	0.057	0.088	0.133
Plant density (PD) (Stand/hill)					
1	5.90[a]	7.12[a]	8.16[a]	9.08[a]	10.13[a]
2	5.59[ab]	6.80[ab]	7.89[b]	8.81[a]	9.86[a]
3	5.30[bc]	6.44[bc]	7.54[c]	8.47[b]	9.27[b]
4	4.98[c]	6.11[c]	7.20[d]	8.12[c]	9.01[b]
LS	**	**	**	**	**
SE±	0.141	0.124	0.066	0.101	0.154
Interaction TT x PD	NS	NS	NS	NS	NS

Means in the same column followed by the different letter(s) are significantly different using Duncan Multiple Range Test (DMRT)
LS= level of significant, NS = Not significant, ** = significant at 0.01.

Table 5: Effect of Thinning Time and Plant Density on yield components of sorghum.

Treatment	Panicle Weight (g)	Panicle Length (cm)	Number of Spikelet/Spikes	Number of Spike/Panicles	Number of Prop Root At Harvest/Plant	Number of Grains/Spikes
Thinning time (TT) (weeks after sowing)						
2	51.56[a]	26.42[a]	6.25[a]	29.42	6.08[a]	21.58
4	44.32[b]	23.83[b]	5.17[b]	28.80	3.42[b]	20.42
6	45.08[b]	22.83[b]	5.00[b]	27.41	2.25[b]	22.17
LS	**	**	**	NS	**	NS
SE±	1.030	0.419	6.215	1.352	0.451	1.956

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Plant density (PD) (Stand/hill)						
1	51.53a	27.56[a]	6.88[a]	32.89[a]	6.58[a]	25.33
2	48.16[ab]	25.33[b]	6.00[b]	30.77[ab]	4.67[b]	21.67
3	45.43[ab]	23.33[c]	5.00[c]	26.44[bc]	3.22[b]	20.22
4	42.82[c]	21.22[d]	4.00[d]	24.11[c]	1.22[c]	18.33
L.S	**	**	**	*	**	NS
SE±	1.189	0.484	0.248	1.561	0.521	2.26
Interaction TT x PD	NS	NS	NS	NS	NS	NS

Means in the same column followed by the different letter(s) are significantly different using Duncan Multiple Range Test (DMRT)
LS= level of significant, NS = Not significant, ** = significant at 0.01.

Table 6: Effect of Thinning Time and Plant Density on yield components of sorghum.

Treatments	1000 Grain Weight (G)	Threshing Percentage	Number of Grain/Panicles	Grain Yield/Plot	Grain Yield/Hectare
Thinning time (TT) (weeks after sowing)					
2	21.37	91.33[a]	2502.17	2031.58	2.27[a]
4	21.06	90.25[ab]	2523.33	1730.67	1.73[b]
6	20.75	88.00[b]	2491.17	2044.33	1.75[b]
LS	NS	**	NS	**	**
SE±	0.277	0.854	107.093	94.934	0.070
Plant density (PD) (stand/Hill)					
1	22.19[a]	93.22	2593.43	2274.89	2.18
2	21.06[b]	90.89	2557.40	2094.00	2.01
3	20.67[b]	89.00	2490.10	1842.33	1.81
4	20.33[b]	86.33	2381.20	1534.89	1.66
LS	*	**	NS	**	**
SE±	0.675	0.986	123.660	109.620	0.081
Interaction TT x PD	NS	NS	NS	NS	NS

Means in the same column followed by the different letters are significantly different using Duncan Multiple Range Test

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LS= level of significant, SE = Standard Error, NS = Not significant, ** = significant at 0.01.

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