



## EFFECTS OF NITROGEN AND SPACING ON GROWTH AND YIELD OF KENAF (*Hibiscus Cannabinus* L.) IN BAUCHI STATE, NIGERIA

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### ABSTRACT

Field experiment was carried out to determine the effects of nitrogen and intra-row spacing on the growth and yield of kenaf at Bauchi state college of Agriculture during the 2018 and 2019 rainy seasons. The treatments consisted of four nitrogen levels (0kg/ha, 56kg/ha, 112kg/ha and 168kg/ha) and three intra row spacing (10, 20 and 30). These were factorially combined to give twelve (12) treatment combinations and laid out in a randomized complete block design (RCBD) replicated three (3) times. Data were collected at bi-weekly interval on plant height, number of leaves, fresh and dry fiber yield. All data collected were subjected to analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) was used to separate the means. The result of the experiment revealed a significant ( $P \leq 0.01$ ) difference among the treatments used throughout the study period. The result indicated that, Application of nitrogen at the rate of 56 kg/ha significantly ( $P \leq 0.01$ ) produced taller plants than all other levels of nitrogen. On intra-row spacing the use 30cm had taller plants than all other treatments studied and were at par with 20cm at 6, 8, and 12 WAS. The result further revealed that, narrow-intra-row spacing (10cm  $\times$  50cm) resulted in a decrease in plant height at the beginning of the growing season, but had a significant ( $P \leq 0.00$ ) influence at 8 and 10 weeks after sowing. The result also revealed that, wider spacing (30  $\times$  50cm) increases plant height, stem girth, leaf area and consequently the stem and total dry fiber yield per plant. Based on the result of this study, application of nitrogen fertilizer at the rate of 56 kg/ha to kenaf spaced at 30 x 50 cm promote better growth and fiber yield in both the seasons under observation and can be adopted by farmers in the study area.

**Key words:** Kenaf, Nitrogen, Growth, Yield, Spacing

### INTRODUCTION

Kenaf is a multipurpose crop with various harvestable components such as leaves, stems and seeds. It is the third largest fiber crop of economic importance after jute and cotton, and produces high fiber yields with corresponding higher income per hectare as compared to most (United States Department of Agriculture; USDA. 1986). It has been used as an alternative to compensate for the gradual diminishing stocks of hard and soft woods (United States Department of Agriculture; USDA. 1986). The bark fibres are used for specialty papers, newsprint and multiple tissue paper grades (Bowyer, 1999). The paper made from kenaf is stronger, whiter, long lasting and more resistant to yellowing and has ink adherence better than that of wood paper (Liu, 2003). Even though Considerable information on kenaf agronomy and biomass productivity has been reported worldwide, it is often conflicting as to the responses of the crop to different agronomic practices and cultivation. The yield and composition of Kenaf plant components can be affected by many factors including cultivar, planting date, photosensitivity, length of growing season, plant maturity, plant population, row spacing and soil fertility (Webber *et al.*, 2002; Webber and Bledsoe, 2002a and b; Archontoulis *et al.*, 2005; Danalatos and Archontoulis, 2005; Hussain *et al.*, 2011a and b). Kenaf response to added



fertilizer depends on the initial soil nutrient levels, cropping history and other environmental and management factors (LeMalieuet *al.*, 1991). Plant height reacted positively to nitrogen at all stages of growth, although it was not significantly so at 96 DAP (Muchow & Wood, 1980; Kuchindaet *al.*, 2001). Generally, plant height and stem girth increased with wider rows and consequently the stem and total yields per plant also increased Abdul-Hamid *et al.*, (2009). This study was therefore carried out to determine the effect of nitrogen and inter-row spacing on the growth and yield of kenaf.

## **MATERIAL AND METHODS**

### **Experimental Site**

The experiment was conducted in Bauchi state of Nigeria, precisely at Bauchi State College of Agriculture Teaching and Research Farm, Bauchi located on latitude 10°17' N and longitude 90°49' E at an altitude of 690.2m above sea level. The annual rainfall for the area is about 1,809.48mm and a mean temperature of 36.50C with relative humidity ranging from 33.5% to 76.40%.

### **Experimental Materials**

Thekenaf variety used for the experiment was Guatemala (G-4), (*Hibiscus cannabinus*L.) obtained from the Plateau State Agricultural Development Programme (PSADP). Nitrogen fertilizer, camry digital weighing scale, measuring tape, meter stick, graduated ruler, and thread were used for the study.

### **Treatments and Experimental Design**

The treatments consisted of four (4) nitrogen rates (0, 56, 112 and 168kg/ha.) and three (3) intra-row spacing (10, 20 and 30cm). These were factorially combined to give a total of 12 treatment combinations and were laid out in a randomized complete block design (RCBD), replicated three times.

### **Cultivation Practices**

Kenaf cultivar Guatemala (G-4) was sown on the 25<sup>th</sup> June, in both years. Five seeds were sown per hole and germination took place six (6) days after sowing with 90% germination. The seedlings were thinned at two-leaf stage to two plants per stand two weeks after sowing. Nitrogen fertilizer (Urea) placement method was applied according to the treatments and the plots were kept weed free (United States Department of Agriculture; USDA. 1986) manually using small hoe and cutlass at 3 and 6 weeks after sowing. The plants were harvested on the 27<sup>th</sup> September in both years. The sample plants were tied in bundles and labeled.

### **Fiber Extraction**

The fibres were extracted manually after cutting the harvested stems from the base to the tip into two equal parts using a knife. The extracted fibers were sundried to determine the fiber yield.

### **Data Collection**

Data were collected from ten (10) randomly selected plants at bi-weekly interval starting from 4 weeks after sowing (WAS) to 12 weeks after sowing. The parameters assessed were plant height, number of leaves, fresh and dry fiber yield.

### **Data Analysis**

All data collected were subjected to Analysis of Variance (ANOVA) using Statistical Analysis System (SAS version 10.9.3) and means were separated using Duncan's Multiple Range Test (DMRT).



## RESULTS AND DISCUSSION

### Plant height (cm)

Table 1 and 2 showed the effect of nitrogen and spacing on plant height (cm) of kenaf during 2018 and 2019 rainy seasons. The results revealed a significant ( $P \leq 0.05$ ) difference on plant height among the various treatments used throughout the study period. The result further indicated that application of nitrogen at the rate of 56kg/ha produced significantly ( $P \leq 0.01$ ) taller plants followed by 112kg/ha, in both seasons. The control on the other hand produced the shortest plants compared to other nitrogen levels in 2018 and 2019 rainy seasons. Moreover, spacing of 30cm x 50cm was found to significantly ( $P \leq 0.05$ ) produced taller plants than the other spacing in both 2018 and 2019 rainy seasons. The interactive effects of nitrogen and spacing on plant height revealed that, the results were statistically the same for plant height in both 2018 and 2019 rainy seasons.

This positive response is in agreement with the findings of other researchers (Muchow&Wood, 1980: Kuchinda *et al.*, 2001). The increase in plant height with different nitrogen level may be related to the role of nitrogen on cell activity at the apical meristem. The tallest plant (157.31cm) for 2018 season at 12 weeks after sowing was higher than the peak value (127.52cm) of the 2019 season though statistically similar. The control plot with 0 kg/ha at 10 weeks after sowing measured an average height of 105.31cm in 2018 and 114.25cm in 2019. The average plant growth with no additional nitrogen (control) for this study revealed that sufficient water supplied could have mobilized nitrogen and other nutrients from the soil and made them available for the plant uptake. Furthermore, both positive and zero responses of kenaf plant height to nitrogen have been shown in literature (Muchow&Wood, 1980: Webber, 1996 & 1999: Kuchinda *et al.*, 2001).

No positive response was observed during the initial period of the study, this may be attributed to lack of competition for available resources such as radiation, soil moisture, and nutrients at the beginning of the growing season. However, as the plants grew, the intraspecific competition for light and other resources increased resulting in a decreased in plant height, although wider spacing tended to have a positive effect on plant height towards the end of the growing season as seen in 8 and 10 weeks after sowing. This result is in conformity with the findings of Danalatos, 2004 and Archontoulis, 2010. Indicating lack of competition for available resources such as radiation, soil moisture, and nutrient at the beginning of the growing season

**Table 1:** Effect of Nitrogen and Spacing on Plant Height of Kenaf during 2018 Rainy Season

Treatment	Weeks After Sowing				
	4	6	8	10	12
<b>Nitrogen (Kg/ha)</b>					
0	44.85 <sup>c</sup>	66.72	83.95 <sup>c</sup>	105.51 <sup>c</sup>	139.27 <sup>c</sup>
56	51.34 <sup>a</sup>	69.67	95.52 <sup>a</sup>	142.68 <sup>a</sup>	157.31 <sup>a</sup>
112	47.62 <sup>b</sup>	67.69	89.43 <sup>b</sup>	121.23 <sup>b</sup>	145.34 <sup>b</sup>
168	47.63 <sup>b</sup>	67.47	87.07 <sup>b</sup>	107.91 <sup>c</sup>	141.05 <sup>c</sup>
LS	**	NS	**	**	**
SE $\pm$	2.29	2.43	1.53	5.08	5.25
<b>Spacing (cm)</b>					
10	34.40 <sup>c</sup>	62.50 <sup>b</sup>	81.60 <sup>b</sup>	104.69	135.17 <sup>b</sup>
20	49.74 <sup>b</sup>	69.35 <sup>ab</sup>	85.81 <sup>ab</sup>	117.62	145.06 <sup>ab</sup>
30	59.03 <sup>a</sup>	71.97 <sup>a</sup>	88.17 <sup>a</sup>	112.42	152.49 <sup>a</sup>
LS	**	*	**	NS	**
SE $\pm$	2.03	2.15	1.36	5.08	4.66
<b>Interaction</b>					
N $\times$ S	NS	NS	NS	NS	NS

Means followed by the same letter (s) within the same column are not statistically different following DMRT, \* = Significant at 0.05, \*\* = Significant at 0.01, LS = Level of significance, NS = Not significant, SE = Standard error.

**Table 2:** Effect of Nitrogen and Spacing on Plant Height of Kenaf during 2019 Rainy Season

Treatment	Weeks After Sowing				
	4	6	8	10	12
<b>Nitrogen (Kg/ha)</b>					
0	51.07	68.12 <sup>b</sup>	82.83 <sup>b</sup>	114.25 <sup>c</sup>	122.98
56	61.45	73.34 <sup>a</sup>	100.36 <sup>a</sup>	130.62 <sup>a</sup>	127.52
112	57.21	72.96 <sup>a</sup>	99.60 <sup>a</sup>	122.15 <sup>b</sup>	125.27
168	55.60	70.95 <sup>a</sup>	96.02 <sup>ab</sup>	117.98 <sup>c</sup>	124.18
LS	NS	*	**	**	NS
SE $\pm$	3.23	2.30	2.98	3.11	3.16
<b>Spacing (cm)</b>					
10	48.88 <sup>b</sup>	70.30	92.67 <sup>b</sup>	111.81 <sup>b</sup>	115.73 <sup>c</sup>
20	59.08 <sup>ab</sup>	70.87	94.69 <sup>b</sup>	113.28 <sup>b</sup>	122.34 <sup>b</sup>
30	66.04 <sup>a</sup>	72.77	105.86 <sup>a</sup>	126.67 <sup>a</sup>	137.21 <sup>a</sup>
LS	*	NS	**	**	**
SE $\pm$	2.80	1.99	2.58	2.69	2.74
<b>Interaction</b>					
N $\times$ S	NS	NS	NS	NS	NS

Means followed by the same letter within the same column are not statistically different following DMRT, \* = Significant at 0.05, \*\* = Significant at 0.01, LS = Level of significance, NS = Not significant, SE = Standard error.

### Number of Leaves

The result of the effects of nitrogen and intra-row spacing on number of leaves of kenaf is presented in Table 3 and 4. The result revealed a significant ( $P < 0.01$ ) difference among the treatments throughout the study period. The result further indicated that, application of nitrogen



fertilizer at the rate of 112kg/ha produced higher number of leaves at 10WAS than other nitrogen levels. This is an indication that nitrogen fertilizer has influence on the number of leaves of kenaf. The result of this study is in conformity with the findings of Hussain *et al.* (2011) who reported an increase in number of leaves with increasing nitrogen level in kenaf. However, the decrease in the number of leaves at harvest (12WAS) might be due to the ageing of the plants and the increased contribution of the productive part. This is in agreement with the findings of Ayub *et al.* (2007) who reported a decrease in number of leaves in maize forage at harvest.

Spacing on the other hand, 30cm × 50cm produced the highest number of leaves throughout the study period. This is in line with the report of Abdul-Hamid *et al.* (2009) who reported a similar trend while conducting study on Kenaf.

**Table 3:** Effects of Nitrogen and Spacing on Number of Leaves during 2018 Rainy Season

Treatment	Weeks After Sowing				
	4	6	8	10	12
<b>Nitrogen (Kg/ha)</b>					
0	14.0	14.0 <sup>b</sup>	16.25 <sup>b</sup>	24.82 <sup>b</sup>	28.0
56	16.0	15.8 <sup>b</sup>	19.26 <sup>ab</sup>	29.83 <sup>ab</sup>	31.0
112	15.0	16.1 <sup>ab</sup>	19.05 <sup>ab</sup>	30.93 <sup>a</sup>	28.0
168	16.0	17.0 <sup>a</sup>	24.37 <sup>a</sup>	31.60 <sup>a</sup>	29.0
LS	NS	*	*	*	NS
SE±	0.61	0.52	0.57	1.25	1.09
<b>Spacing (cm)</b>					
10	13.47 <sup>b</sup>	15.11 <sup>b</sup>	17.68 <sup>b</sup>	21.87 <sup>c</sup>	27.0
20	5.25 <sup>a</sup>	16.18 <sup>ab</sup>	19.86 <sup>a</sup>	29.19 <sup>b</sup>	28.0
30	5.24 <sup>a</sup>	16.83 <sup>a</sup>	18.57 <sup>b</sup>	31.07 <sup>a</sup>	29.0
LS	*	*	*	**	NS
SE±	0.54	0.52	0.51	1.11	0.97
<b>Interaction</b>					
N × S	NS	NS	NS	NS	NS

Means followed by the same letter within the same column are not statistically different following DMRT, \* = Significant at 0.05, \*\* = Significant at 0.01, LS = Level of significance, NS = Not significant, SE = Standard error.



**Table 4:** Effects of Nitrogen and Spacing on Number of Leaves during 2019 Rainy Season

Treatment	Weeks After Sowing				
	4	6	8	10	12
<b>Nitrogen (Kg/ha)</b>					
0	17.00 <sup>c</sup>	17.94 <sup>b</sup>	27.0 <sup>b</sup>	34.82 <sup>b</sup>	40.70 <sup>c</sup>
56	24.28 <sup>a</sup>	26.13 <sup>a</sup>	35.16 <sup>a</sup>	47.15 <sup>a</sup>	54.39 <sup>a</sup>
112	21.02 <sup>ab</sup>	26.37 <sup>a</sup>	33.81 <sup>ab</sup>	46.47 <sup>a</sup>	52.04 <sup>a</sup>
168	19.38 <sup>b</sup>	18.05 <sup>b</sup>	30.70 <sup>ab</sup>	42.58 <sup>ab</sup>	46.70 <sup>b</sup>
LS	**	*	*	*	**
SE±	2.74	2.77	2.84	7.65	5.88
<b>Spacing (cm)</b>					
10	19.36	20.54 <sup>b</sup>	25.96 <sup>c</sup>	34.36 <sup>b</sup>	43.12 <sup>b</sup>
20	19.30	20.00 <sup>b</sup>	30.93 <sup>b</sup>	37.53 <sup>b</sup>	43.30 <sup>b</sup>
30	22.47	26.28 <sup>a</sup>	37.63 <sup>a</sup>	57.88 <sup>a</sup>	60.03 <sup>a</sup>
LS	NS	*	**	*	*
SE±	2.38	2.40	2.46	6.62	5.10
<b>Interaction</b>					
N × S	NS	NS	NS	NS	NS

Means followed by the same letter within the same column are not statistically different following DMRT, \* = Significant at 0.05, \*\* = Significant at 0.01, LS = Level of significance, NS = Not significant, SE = Standard error.

#### **Fresh Fiber weight (Kg/ha.)**

The result obtained from this study showed that, there is a significant ( $P \leq 0.01$ ) difference among the treatments in both the seasons under study. The result further indicated that, application of nitrogen fertilizer at the rate of 56kg/ha and 30 × 50cm spacing produced significantly ( $P \leq 0.01$ ) higher fresh fiber weigh than the other treatments throughout the period of study. Control on the other hand, produced the least fresh fiber yield compared to other nitrogen levels and spacing considered across seasons. The increase in wet fiber yield due to increase in nitrogen level indicated the importance of nitrogen fertilizer in Kenaf production. The result of this study lend support from previous study findings by Acreche *et al.*, 2005.

On the other hand, spacing significantly influenced fresh fiber with 30 × 50cm having higher yield than the two spacing. This might be attributed to reduced competition among plants in wider intra-row spacing. It is also a clear indication of the importance of spacing in improving the yield and yield components of kenaf. This is in agreement with the findings of Abdul-Hamid *et al.* (2009) who found a positive response of spacing on kenaf yield. The findings of this study contradict that of Danalators and Archontoulis (2005) who reported a negative response of kenaf yield to spacing.



**Table 5:** Effects of Nitrogen and Spacing on Wet Fiber Yield (kg/ha) of Kenaf during 2018 and Rainy Season

Treatments	Year	
	2018	2019
<b>Nitrogen (Kg/ha)</b>		
0	0.37 <sup>c</sup>	0.35 <sup>d</sup>
56	0.54 <sup>a</sup>	0.59 <sup>a</sup>
112	0.47 <sup>b</sup>	0.51 <sup>b</sup>
168	0.37 <sup>c</sup>	0.48 <sup>c</sup>
LS	**	**
SE±	0.05	0.04
<b>Spacing</b>		
10	0.43 <sup>b</sup>	0.41 <sup>c</sup>
20	0.37 <sup>c</sup>	0.49 <sup>b</sup>
30	0.51 <sup>a</sup>	0.57 <sup>a</sup>
LS	**	**
SE±	0.04	0.04
<b>Interaction</b>		
N × S	NS	NS

Means followed by the same letter within the same column are not statistically different following DMRT, \*\* = Significant at 0.01, LS = Level of significance, NS = Not significant, SE = Standard error.

### Dry Fiber Yield (Kg/ha)

Result of the effect of nitrogen and spacing on dry fiber yield of Kenaf is presented in Table 6. The result revealed a significant ( $P \leq 0.01$ ) difference among the treatments on dry fiber yield of kenaf harvest throughout the study period. The result further showed that, application of nitrogen fertilizer at the rate of 56kg/ha produced the highest dry fiber yield in both 2018 and 2019 rainy seasons. The increase in fiber yield observed in this study is an indication that nitrogen fertilizer has influence on dry fiber yield of kenaf. The result of this findings corroborate the report of Hossain *et al.* (2011) who reported an increase in dry fiber yield with increasing nitrogen level in kenaf. It was also observed that, there was a decrease in dry fiber yield with increased in the level of nitrogen above 56kg per hectare across the seasons. This is a clear indication that kenaf plant requires little or no nitrogen fertilizer in its production. This is in support of the findings of Baldwin and Graham, (2006) who also reported a decrease in dry fiber yield with increase in nitrogen level.

Intra row spacing on the other hand, dry fiber yield responded positively and significantly ( $P \leq 0.05$ ) to wider spacing with 30cm × 50cm spacing producing the highest dry fiber yield than other spacing in both 2018 and 2019 rainy season respectively. It is also a clear indication of the importance of spacing in improving the growth and yield of kenaf. The result of this study lend support from the findings of Abdul-Hamid *et al.* (2009) who reported a positive response of spacing on kenaf yield.



**Table 6:** Effect of Nitrogen and Spacing on Dry Fiber Yield (Kg/ha) of Kenaf during 2018 and 2019 Rainy Season

Treatments	Year	
	2018	2019
<b>Nitrogen (Kg/ha)</b>		
0	262.08 <sup>c</sup>	229.43 <sup>d</sup>
56	346.03 <sup>a</sup>	349.54 <sup>a</sup>
112	276.85 <sup>ab</sup>	281.50 <sup>c</sup>
168	292.59 <sup>b</sup>	301.88 <sup>b</sup>
LS	**	**
SE±	32.09	28.14
<b>Spacing</b>		
10	300.00 <sup>b</sup>	243.56 <sup>b</sup>
20	268.56 <sup>c</sup>	306.68 <sup>a</sup>
30	314.61 <sup>a</sup>	321.52 <sup>a</sup>
LS	**	**
SE±	27.79	30.00
<b>Interaction</b>		
N × S	NS	NS

Means followed by the same letter within the same column are not statistically different following DMRT, \*\* = Significant at 0.01, LS = Level of significance, NS = Not significant, SE = Standard error.

## CONCLUSION AND RECOMMENDATION

The results of the study revealed that, nitrogen, spacing improving dry fiber yield of kenaf. From the results of the study, It was clear that application of nitrogen fertilizer at the rate of 56kg/ha had a positive influence on the growth and yield of kenaf. The result also indicated that, wider spacing (30 × 50cm) is suitable for increase productivity of kenafas it tended to improve both growth and biomass characteristics of the stem. Therefore, growing kenaf at a spacing of 30cm × 50cm with the application of 56kg N/ha can be adopted by farmers in the study area.

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