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Effects of different nitrogen rates and seasonal variations on seed yield and yield related traits of kenaf (Hibiscus cannabinus L.) varieties

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Abstract
Field experiments were conducted during 2013 and 2014 rainy seasons at the Institute of Agricultural Research and Training, Obafemi Awolowo University, Moor Plantation, Ibadan to determine the effect of N-application rates on seed yield traits and seed yield of two kenaf varieties. The experiment was laid out in a randomized complete block design (RCBD). Kenaf seed of two varieties (Ex-Shika and A_2-60-282b) were planted in 2013 and 2014 with four rates of urea (0, 40, 80 and 120 kg/ha) applied in two splits at interval of 4 weeks. Data were collected from the two experimental rows and parameters measured include plant height, height of first capsule, number of capsules per plant, seed number per capsule, one thousand seed weight, seed yield per plant and seed yield per hectare. The results showed that seasonal variation was significant on all the agronomic and seed yield parameters measured. However, agronomic and seed yield traits were not significantly affected by kenaf genotypes and nitrogen fertilizer rates used. The highest plant height was obtained from the control rate (0 kg of nitrogen/ha). Varietal effect on all the traits measured was not statistically different. This research demonstrated that kenaf was relatively unresponsive to N application of 120 kg / ha and lower, and at high N-level there was a potential risk of decreasing plant height.

Keywords: Kenaf; Nitrogen rates; 1000 seed weight; Varietal effect; Seed yield

Introduction
Kenaf (*Hibiscus cannabinus* L.) is an annual crop of the Malvaceae family which is known for its economic and horticultural importance. Most researchers agree that the origin of kenaf is in Africa. It is adapted to southern United State and part of California. Kenaf is a short day annual herbaceous plant. It is cultivated for the soft bast fibre in its stem. It is closely related to cotton, okra and the hoolyhocks. Kenaf is one of the most important fibre crops in the world. It has been cultivated and used as cordage crop to produce twine, rope, gunny-bag and sackcloth for over six millennia (Dempsey, 1975).

Nitrogen is considered as one of the limiting factors in crop growth, development and finally economic yield (Glass, 2003; Parry *et al.*, 2005). Nitrogen helps plants grow quickly, while also increasing the production of seed and fruit, and bettering the quality of leaf and forage crops. Limited N, P and K supply decreases rates of cell division, cell expansion and cell permeability (Roggatz *et al.*,1999), photosynthesis, leaf production, plant growth (Gerik *et al.,* 1998) and yield (Zhao et al., 2007). Kenaf response to added fertilizer depends on the soil nutrient levels, cropping history, and other environmental and management factors (Danalatos and Archontonlis, 2010). Different concentrates of nitrogen (N) fertilizer did not result in any significant differences in plant growth, biomass and foliage production (Othman *et al.*, 2006). However, application of N with phosphorus (P) at the rate of 100 N: 200 P kg/ha showed significant positive effects on yield and growth of kenaf plants (Zainul, 2004). For optimum foliage, total biomass and fibre yield, N requirement can be as high as 112 kg/ha (FAO, 2002). However, seed production requires less fertile soils or less use of fertilizers (Webber and Blesdoe, 2002) as this could be of advantage to resource poor farmers in the tropics who cannot afford the use of fertilizer in recommended rates. Fiber production and quality were not affected by application of only N, whereas combined application of N and P showed small but non-significant effects (Daud, 2006). To grow kenaf, the response of plants to N, P and K fertilization are of considerable importance in agriculture. Data from kenaf trials in Greece (Danalatos and Archontralis, 2010) confirm that kenaf plant does not respond to N-application, and amount of 50 kg N/ha seem appropriate under various farming and environmental conditions. Kipriotis *et al.,* (2007) and Patane *et al.*, (2007) reported no effect of nitrogen application (range: 0-150 kg N/ha) on kenaf yield in different soils around Mediterranean region. In contrast, Bhangoo et al. (1986), Kuchindra et al.(2001) and Webber (1996) working at different soil-climatic conditions found a positive effect of nitrogen on kenaf yields, which were maximized with N-dressings in the range 86-224 kg N/ha. Kenaf has a wider range of adaptation to climatic conditions than other fibre crop grown for commercial use (Liu, 2003). The length of the growing season, the average day and night temperatures, and adequate soil moisture are considered the key factors affecting kenaf yields. The crop prefers area of rainfall of 500 mm - 600 mm over 4-5 months with wet and dry periods. For better fertilizer management, the study about the effect of different levels of N on kenaf seed yield is very crucial. This study was therefore undertaken to determine optimum rate of N-fertilizer for optimum seed production in kenaf.

Materials and Methods

Experimental design and planting

Certified seeds of two Kenaf varieties were collected from the Kenaf and Jute Improvement Programme of the Institute of Agricultural Research and Training (IAR&T), Obafemi Awolowo University, Moor Plantation, Ibadan. The two varieties used were Ex-Shika and A_2-60-282b. The experiment was conducted on the experimental field of the Institute in Ibadan during 2013 and 2014 growing seasons to study the effect of different rates of urea fertilizer on seed yield of kenaf. The city, Ibadan ($7^0$38' N, 3^0 84' E) is located in the semi-humid rainforest belt of South-western Nigeria. Planting was done on 27th June and 10th July 2013 and 2014, respectively. The land was prepared conventionally by ploughing and harrowing. The land prepared was divided into plots with each plot measuring 1.5 m by 3 m. These were arranged in randomized complete block design (RCBD) with inter and intra row spacing of 50 cm by 20 cm of two seeds/hill giving a total population of 200,000 plants/hectare. Pre-emergence herbicide, Pendimethalin (500 EC) was applied at the rate of 1.7 kg ai ha^{-1}, using a knapsack sprayer. Supplementary weeding was done 4 weeks after planting (WAP). Monocrotophos was applied at the concentration of 0.68 kg ha^{-1} active monocrotophos in 225 litres of water at 4 WAP and at 50 % flowering to protect plants from leaf beetle attack (Podagrica spp) and pud sucking insects, respectively. Nitrogen rates used for the experiment were 0 kg, 40 kg, 80 kg and 120 kg/ha, respectively. The nitrogen fertilizer (Urea) rates were applied in two splits of equal doses at four and eight weeks after planting. Other nutrient elements such as phosphorous and potassium were supplied using 50 kg/ha of P_2O_5 from Single Super Phosphate (SSP) and 50 kg/ha of K_2O from muriate of potash.

Data collection

Twenty kenaf plants were randomly sampled for data collection from the 2 middle rows of each plot. The sampled plants were harvested manually by cutting stems with cutlass on the month of November in 2013 and 2014, respectively. The height of the plant (cm) was determined from the above ground level using graduated meter rule.

The number of capsules per plant was counted to obtain the average values in each treatment. The seed yield from each plot was determined after the manual threshing and converted into kilogram/hectare. 1000 seeds were taken randomly from the threshed seeds for weight determination using a gravimeter scale model GF-2000. The data generated from the field experiments were subjected to analysis of variance (ANOVA) using general linear model procedures in statistical analysis system, SAS software version 8.1 (SAS institute, inc, 2002) to compute mean squares for each character. Mean separation was done using least significant differences (LSD) at 5% level of significant.

Results and discussion

The physical and chemical properties of the experimental sites are presented in Table 1 Also, the weather conditions for the two experimental years are presented in Table 2. The results showed that rainfall distribution during the period of planting differed markedly as reported by the rainfall data in parenthesis. Mean squares for agronomic and seed yield traits of 2 kenaf genotypes are presented in Table 3. Seasonal variation significantly ($p<0.05$-0.001) affected plant height (PLT), height of 1st capsule (HT1-C), number of capsule per plant (NC/P), seed number per capsule (SN/C), one thousand seed weight (1000SW), seed yield per plant (SYD/P) and seed yield per hectare (SYD/Ha). Treatment and varietal interaction effects were not significant on any of the traits measured. First order interaction among season, variety and treatment was also not significant for all the traits. All the agronomic and seed yield components, except for plant height and number of capsules / plant were greater in 2013 than 2014. Average plant height and number of capsule ranged from 345.19 cm in 2014 to 306.74 cm in 2013 and 48.10 in 2014 to 37.46 in 2013, respectively (Table 4). Plant height in 2014 was 38.44 cm taller with almost 8 more capsules / plant but with viewer seed number/ capsule of 5.24 as compared to 18.17 in 2013. However, height of 1st capsule, seed number/ capsule, 1000 SW, seed yield per plant and seed yield per hectare were highest in 2013 compared to their values in 2014. In both years, capsules were produced at a distance of more than 2 meters above the soil surface. This trait indicates that kenaf plant can serve dual purposes- planting for fibre at the same time for seed production. 1000 seed weight in 2013 was 80 % greater than in 2014. This contributed greatly to yield differences of 53.39 % in 2013 compared to 2014 as seed weight is an important determinant in final yield. The better yield performance in 2013 could also be ascribed

Table 1: Physico-chemical characteristics of the soil at the experimental site in 2013 and 2014 cropping seasons

Physico-chemical	2013 cropping season	2014 cropping season
Chemical properties		
pH(H2O)	6.80	6.49
Organic carbon kg-1	0.47	0.60
Total N g/kg-1	0.37	0.07
Available P(g kg-1)	13.54	13.12
Exchangeable bases (Me/100 g)		
K+	0.37	0.20
Ca2+	0.88	1.10
Mg	2.00	1.20
Na	0.47	0.30
CEC (%)	3.79	3.00
Base saturation	98	98
Physical properties		
Silt (%)	10	11
Sand (%)	88	87
Clay (%)	2	2
Textural class	Sandy soil	Sandy soil

Source: Central Laboratory of the Institute

Table 2: Seasonal variation during the 2013 and 2014 cropping seasons

Seasonal variables	Year 2013	Year 2014
Rainfall during season(mm)	1289.4 (753.4)	1003.1(594.4)
Mean day temperature (oc)	28.76	28.97
Mean night temperature (oc)	20.10	20.83
Relative Humidity (%)	84.40	81.78
Number of wet days during the Season	31	30

Rainfall during planting period in parenthesis to more rainfall during the planting period (Table 1). This corroborates the earlier findings of Olasoji *et al.,* (2014). They reported higher average number of capsule/plant, seed number per capsule, seed weight/plant and seed yield per hectare in 2010 as compared to the 2009.

Agronomic and seed yield traits of the varieties used in this experiment were not influenced by N- fertilization in the range of 0-120 kg/ha (Table 5). This agreed with the findings of Danalatos and Archontralis (2010). They confirmed that kenaf plant does not respond to different N-application, and amount of 50 kg N/ha seem appropriate under various farming and environmental conditions. This study therefore, shows that plant height tend to increase as nitrogen application rates increased (though not significantly different) up to 80 kg N/ha and at 120 kg N/ha, a reduction in plant height occured compared to the 80 kg N/ha. The non significant differences in plant height for all the treatments had also been reported by Rhoden *et al.,* (1993). In their investigation, they reported that increase in nitrogen did not produce any increase in plant height of roselle. Thus excess nitrogen application can be detrimental to seed yield as this will produce shorter kenaf plants with fewer capsules. Seed yield ranged from 1061.9 kg/ ha at 40 kg N/ha to 1370.4 kg /ha at 80 kg N/ ha. Although, seed yield

Table 3: Mean squares derived from analysis of variance for agronomic and seed yield traits of two varieties of Kenaf during 2013 and 2014 cropping seasons

Source of variation	DF	Plant Height (cm)	Height of 1st capsule (cm)	Number of capsule /plant	Seed number /capsule	1000 Seed Weight(g)	Seed Yield /Plant (g)	Seed Yield / Hectare(kg)
Season, S	1	17739.29***	2412.16*	1360.54*	343.47***	2940.32***	2006.52***	20065.1***
Treatment, T	3	392.31	509.93	137.55	5.55	19.75	22.74	22739.2
Variety, V	1	1.76	22.13	312.38	1.92	22.25	0.56	5605.2
S XT	3	380.44	627.19	381.10	28.79	27.88	36.84	36843.1
V X S	1	6.45	865.39	44.37	52.08	20.38	11.73	11734.5
VXT	3	269.78	1138.72	449.32	2.18	12.50	95.40	95403.6
V X S X T	3	560.47	331.30	196.87	48.07*	16.92	45.17	45171.3
Error	32	827	530.22	258.61	11.98	20.01	40.11	40105.6

*, **, *** significant at P<0.05, 0.01 and 0.0 01 respectively

Table 4: Mean values of agronomic and seed yield traits of two varieties of Kenaf during 2013 and 2014 cropping seasons

Season	Plant Height (cm)	Height of 1st capsule(cm)	Number of capsule /plant	Seed number capsule	1000 Seed Weight(g)	Seed Yield / Plant (g)	Seed Yield / Hectare (kg)
2013	306.75b	228.12a	37.46b	22.63a	35.09a	18.17a	1416.6a
2014	345.19a	213.94b	45.10a	17.28b	19.44	10.24b	923.5b

Means with the same letter in each column are not significantly different at P< 0.05

from 80 kg N/ha was the highest, it was not statistically different from those of other treatments. This finding is in agreement with the works of Webber and Bledsoe (2002). They recommended the use of less fertile soils or less fertilizer for kenaf seed production. Varietal effect was not statistically different due to the comparable values for agronomic and yield traits by the two varieties tested (Table 5). This research demonstrated that kenaf was relatively unresponsive to N application of 120 kg / ha and lower, and at high N- level there was a potential risk of decreasing plant height. It can be concluded that no effect of N fertilization was found in the range of 0-120 kg N/ha due to kenaf adaptability to marginal soils of the southwestern Nigeria. Cultivation of kenaf could therefore be recommended to resource poor farmers with little or no resources to expend on nitrogen fertilizer.

Table 5: Mean squares derived from analysis of variance for agronomic and yield traits of two varieties of Kenaf during 2013 and 2014 cropping seasons

Nitrogen (Kg/ha)	Plant Height (Cm)	Height of 1st capsulle(cm)	Number of capsule/Plant /	Seed number capsule	1000 Seed Weight	Seed Yield / plant	SeedYield / Hectare
0	325.22a	225.5a	41.98a	19.65a	28.35a	11.04a	1104.3a
40	329.17a	225.4a	38.52a	20.90a	26.96a	10.62a	061.9a
80	331.23a	221.6a	44.13a	19.31a	25.58a	13.70a	370.4a
120	318.25a	211.6a	46.49a	19.93a	28.16a	11.44a	1143.6a

Means with the same letter in each column are not significantly different at P< 0.05.

Table 6: Mean squares derived from analysis of variance for agronomic and yield traits of two varieties of Kenaf during 2013 and 2014 cropping seasons

Variety Yield	Plant Height (Cm)	Height of 1st capsule (cm)	Number of capsule/ Plant	Seed number /capsule	1000 Seed Weight	Seed Yield / plant	Seed / Hectare
Ex-Shika	326.16a	220.35a	40.23a	20.15a	27.91a	11.81a	1180.8a
A2-60-282b	325.76a	221.71a	45.33a	19.75a	26.61a	11.59a	1159.2a

Means with the same letter in each column are not significantly different at P< 0.05

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