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Effect of Organic Fertiliser on Growth, Fibre Yield and Nutrient uptake of Kenaf (*Hibiscuss cannabinus* L) in Southwest Nigeria.

Olanipekun S.O.
Institute of Agricultural Research and Training, Moor plantation, Ibadan, Nigeria
Corresponding author: Olanipekunsam@yahoo.com 08060372347

Abstract
Kenaf (*Hibiscus cannabinus* L.) production is constrained by cultural and agronomic practices which reduce its fibre and seed yield. Organic Fertilisers (OF) have proven effective in enhancing yield of some crops, however, information on use of OF to improve yield of kenaf is scanty. Therefore, growth performance, fibre yield and nutrient uptake of kenaf as influenced by different level of OF applied was investigated in 2016 at the Institute of Agricultural Research and Training, Ibadan, Nigeria. Five different rates of organic fertiliser equivalent to; 0, 70, 100, 130 and 160 kg N ha^{-1} were applied to kenaf plot following a randomly completed block design replicated three times. The tallest plants were obtained under 130 kg N/ha and shortest under control at 12 Weeks after sowing (WAS). Stem diameter (2.87 cm) was significantly larger the application of 160 kg N/ha and least (1.46 cm) under control. Higher core and bast (2.05 and 1.22 t/ha) were obtained under 160 and 130 kg N/ha respectively. Higher Nitrogen uptake (408.64 mg/plant) peaked under 160 kg N/ha, it was least under control. Organic fertiliser could favourably be used for the cultivation of kenaf as a substitute for synthetic fertiliser. The rate of application therefore should be based on the nutrient content of the organic fertiliser material to be used.

Key words: Bast fibre; Core fibre; Kenaf; Nitrogen uptake; Organic fertiliser

Introduction
Hibiscus cannabinus L commonly known as kenaf is a commercial annual crop planted in the hibiscus family (*Malvaceae*). It is indigenous to Africa (Mohd Hadi *et al*., 2013). It is used in the cordage and sacking industry as a substitute for jute. More recently, the interest in commercial cultivation of kenaf has been due to its elevated fibre content and short life cycle (Alexopoulou *et al.,* 2000; Manzanares *et al.*, 1996). It is 3 - 5 times more productive per unit area than pulpwood trees; producing pulp with quality equal or superior to that of many wood species (Francois *et al*., 1992). Although it is a tropical plant, kenaf cultivars are well adapted to a wide geographical and climatic range (Meints and Smith, 2003).

Organic fertiliser comprises waste materials of animals and plants which are potential sources of organic matter and plant nutrients (Ayoola and Makinde 2007). The high cost of mineral fertilisers in Nigeria and its scarcity justify a study into alternative plant nutrient sources such as organic fertilisers. Although organic fertilisers improve the growth and yield of crops, information on the use of organic fertiliser on the growth and fibre yield of kenaf in Nigeria is scanty. The objective of this research therefore is to examine the possibility of cultivating kenaf using organic fertiliser and to ascertain the appropriate level of organic fertiliser that optimises the growth and fibre yield of kenaf.

Materials and Methods
Experimental site and design
The experiment was conducted at the experimental farm of the Institute of

Agricultural Research and Training, located in Ibadan, Nigeria (07038'N, 03084'E 182M above sea level). The location is within rainforest savanna transition zone of Nigeria. The field was ploughed; harrowed and marked out into plots. The representative soil sample and sample from the organic fertiliser used were analyzed according to standard procedures (IITA, 1984).

Field experiment and cultural practices

Grade B Aleshinloye organic fertilisers at the rate equivalent to 0, 70, 100, 130 and 160 kg N/ha were applied following a randomised complete block designed (RCBD) with 3 replicates. It was thoroughly mixed with the soil and left for two weeks for the fertiliser to start mineralising before planting. Thereafter kenaf seeds (Ife-ken 400 variety) were sown at 50 cm x 20 cm on 31st May, 2016 and thinned to two plants per stand at two weeks after sowing (2WAS). Pre-emergence herbicide was applied after planting to suppress weed emergency. Thereafter supplementary weeding was done at 3 and 6 WAS while insect pests were controlled using Laraforce (Lamda-cyhalothrin 2.5% E.C) at the recommended rate of 1L ha^{-1} with a dilution factor of 2.5 ml/ lit.

Data collection

Five pre-tagged plants were randomly selected for data collection. Data collected include plant height which was measured with a tape rule from the soil surface to the tip of the plant and recorded in cm. Stem diameter was measured using a pair of vernier callipers at 10 cm above soil level and recorded in cm. Growth and dry matter biomass production was monitored by subsequent destructive samplings at intervals of two weeks from 4 to 12 weeks after sowing. At each sampling, 5 plants were harvested from the inner plot rows to avoid any border effect. The uprooted plants were separated into stems, leaves and roots and then oven-dried at 70^{o}C till constant weights were attained. Thereafter samples of each treatment from different plots were milled using a Glen Creston mill. The milled materials were analysed for nitrogen, phosphorus, potium, calcium and magnesium concentrations according to standard procedures (IITA, 1984).

Fiber yield determination

Plants within 1m^2 in each replicate were cut 10 cm above the ground at 10 WAP, defoliated and the stems were retted in water. After 14 days, the retted plants were removed from the water to separate the bast from the core and thoroughly washed with clean water, sundried to constant weight and fibre yield per hectare was determined.

Statistical analysis

All the data collected were subjected to analysis of variance (ANOVA) and means were separated using the Duncan's multiple range test (DMRT) at p = 0.05. The analysis was done using statistical analysis system (SAS).

Results and Discussion

The physio-chemical properties of the soil before cropping are shown in Table 1. Soil pH (6.09) was considered slightly alkaline. Values of total nitrogen (2.1 g/kg) and organic carbon (0.2 g/kg) were considered medium according to soil fertility maps of Nigeria. The available phosphorus (5.63 mg/kg) in the field was considered moderate. The exchangeable cations in the

Table 1: Physical and chemical properties of the soil used for field trial

Parameter	Values
pH (H_2O)	6.09
Total Nitrogen (g kg^{-1})	2.1
Organic Carbon (g kg^{-1})	0.2
Available P (mg kg^{-1})	5.63
Exchangeable cation (cmol kg^{-1})	
Na^+	2.87
Ca^{++}	2.52
Mg^{++}	0.17
K^+	0.43
H^+	0.10
ECEC	6.09
Particle size distribution (g kg^{-1})	
Sand	828
Silt	48
Clay	124
Textural class	Loamy Sand

Table 2: The chemical analysis of the organic fertilizer used for this experiment

Parameter	Value (%)
N	1.32
P	0.86
C	31.94
Ca	2.34
Mg	0.24
K	0.5
Micronutrient	(ppm)
Na	29.61
Mn	106.67
Fe	891.39
Cu	16.98
Zn	1.99

soil as well as effective cation exchange capacity were however low. The texture of the soils used is sandy. The organic fertiliser used which was from a commercially produced organic plant at Aleshinloye market shows appreciable level of various elements. The total nitrogen, available phosphorus and carbon content were 1.32 g/kg, 0.86 g/kg and 31.94 g/kg respectively. The exchangeable cations (Ca^{2+}, Mg^{2+} and K^+) were 2.34, 0.24 and 0.5 cmol/kg respectively with appreciable levels of micronutrients such as Na^+, Mn^+, Fe^{2+}, Cu^+ and Zn^+ present (Table 2).

Vegetative growth

The organic fertilizer (OF) significantly (P= 0.05) influenced plant height (PH). It was observed that plant height increased as the rate of organic fertilizer increased. Plants that received 160 kg N/ha were not significantly taller than those that received 130 kg N/ha at 4, 6 and 8 WAS (Table 3). However at 10 and 12 WAS, plants fertilised with 130 kg N/ha were significantly taller than those that received 160 kg N/ha. There was a progressive positive relationship between the stem diameter (SD) and rate of organic fertiliser applied. All the rates significantly increased stem diameter values above what was obtained under the control (Table 3). The largest stem diameter was observed in plants with the application of 160 kg N/ha throughout the period of the studies while the smallest was observed in the control. Number of leaves (NL) and leaf area (LA) responded to organic fertiliser (Table 4). The highest number of leaves and leaf area were obtained in plants under the application of 160 kg N/ha of organic fertiliser throughout the period of experiment.

Fibre yield and nutrient uptake

The highest core fibre (2.05 t/ha) was obtained in plants under the application of 160 kg N/ha (Table 5). It was similar to that obtained with application of 130 kg N/ha. Bast fibre yield obtained in plants under 130 kg N/ha did not differ significantly from that obtained in those under 160 kg N/ha. Both core and bast fibre yield increased with increase in fertiliser applied

Table 3: Effect of N rates of organic fertilizer on plant height and stem diameter of kenaf in Ibadan, Nigeria

Rate (kg N/ha)	Plant height (cm)					Stem diameter (cm)				
	Weeks After Sowing					Weeks After Sowing				
	4	6	8	10	12	4	6	8	10	12
0	42.39 ^{d}	66.98 ^{d}	101.93 ^{d}	116.55 ^{e}	144.39 ^{e}	0.57 ^{e}	1.01 ^{e}	1.12 ^{e}	1.38 ^{e}	1.46 ^{e}
70	60.20 ^{c}	84.10 ^{c}	126.18 ^{c}	158.60 ^{d}	170.63 ^{d}	0.69 ^{d}	1.16 ^{d}	1.46 ^{d}	1.82 ^{d}	2.00 ^{d}
100	65.98 ^{b}	92.58 ^{b}	157.88 ^{b}	166.78 ^{c}	175.40 ^{c}	0.74 ^{c}	1.31 ^{c}	1.65 ^{c}	1.99 ^{c}	2.21 ^{c}
130	81.78 ^{a}	119.65 ^{a}	196.25 ^{a}	219.48 ^{a}	237.72 ^{a}	0.76 ^{b}	1.39 ^{b}	1.87 ^{b}	2.01 ^{b}	2.41 ^{b}
160	81.92 ^{a}	121.00 ^{a}	193.35 ^{a}	208.20 ^{b}	227.84 ^{b}	1.05 ^{a}	1.61 ^{a}	1.98 ^{a}	2.51 ^{a}	2.87 ^{a}

Means within the column, followed by similar letter (s) are not significantly different at p = 0.5 according to DMRT.

Table 4: Effects of N rates of organic fertilizer on the number of leaves and leaf area of kenaf at Ibadan, Nigeria

Number of leaves					Leaf area (cm^2)				
4WAS	6WAS	8WAS	10WAS	12WAS	4WAS	6WAS	8WAS	10WAS	12WAS
12.95 ^{e}	30.12 ^{e}	37.2 ^{e}	43.35 ^{e}	51.08 ^{e}	2315.61^{d}	2388.13 ^{e}	3669.16 ^{d}	5445.72 ^{e}	7576.92 ^{e}
24.87 ^{d}	40.42 ^{d}	58.43 ^{d}	76.68 ^{d}	100.90 ^{d}	2638.09 ^{c}	2658.52 ^{d}	4167.24 ^{c}	5910.58 ^{d}	10263.11 ^{d}
32.20 ^{c}	49.40 ^{c}	72.61 ^{c}	87.39 ^{c}	118.35 ^{c}	2715.56 ^{c}	3060.42 ^{c}	4262.89 ^{c}	6280.86 ^{c}	10779.47 ^{c}
34.49 ^{b}	53.24 ^{b}	77.68 ^{b}	98.22 ^{b}	125.47 ^{b}	2999.46 ^{b}	3906.82 ^{b}	5316.04 ^{b}	7511.25 ^{b}	12786.18 ^{b}
38.70 ^{a}	57.95 ^{a}	90.71 ^{a}	108.85 ^{a}	135.84 ^{a}	3990.00 ^{a}	5257.65 ^{a}	7301.36 ^{a}	10361.20 ^{a}	14732.49 ^{a}

Means within the column, followed by similar letter (s) are not significantly different at p = 0.5 according to DMRT.

Table 5: Effect of N rates of organic fertilizer on the core and bast fibre yield of kenaf at Ibadan, Nigeria

N kg/ha	Core	Bast
	Fibre yield (t ha^{-1})	
0	0.54 ^{d}	0.34 ^{d}
70	1.70 ^{c}	0.81 ^{c}
100	1.83 ^{b}	0.98 ^{b}
130	1.99 ^{a}	1.37 ^{a}
160	2.05 ^{a}	1.22 ^{a}

Means within the column, followed by similar letter (s) are not significantly different at p = 0.5 according to DMRT.

with the least yield observed in plants in the control plot (Table 5).

Nitrogen uptake by plants that received 160 and 100 kg N/ha did not differ significantly (Table 6) but they were significantly higher than the values obtained from other application rates. Plants that received 130 kg N/ha had lower nitrogen uptake than those under 100 kg N/ha but higher than plants grown with 70 kg N/ha. Plants in the control plot had the least nitrogen uptake. Phosphorus uptake increased with increase in the rate of organic fertiliser applied with the least phosphorus uptake (9.27 mg/plant) observed in plants in the control plot and the highest (34.43 mg/plant) observed in plants under 160 kg N/ha. Potassium, sodium, calcium and magnesium uptake by plants that received 160, 130 and 100 kg N/ha did not differ significantly from one another but their values were significantly higher than those of plants that received 70 kg N/ha. The least value was obtained in plants in the control plot. Potassium and sodium uptake by plants that received 70 kg N/ha were not significantly higher than those obtained from plants in the control plot (131.23 and 119.25 mg/plant) respectively (Table 6).

Table 6: Effect of N rates of organic fertilizer on the nutrient concentration in plant tissue of kenaf at Ibadan, Nigeria

Rates (N kg/ha)	Nitrogen	phosphorus	Potassium	Sodium	Calcium	Magnesium
	⟶		mg/g plant dry matter		⟵	
0	162.64[d]	9.27[d]	131.23[b]	119.25[b]	500.03[c]	51.17[c]
70	265.86[c]	15.59[c]	190.91[b]	171.45[b]	709.66[b]	77.19[b]
100	358.46[a]	18.21[c]	299.31[a]	273.36[a]	915.43[a]	98.67[a]
130	325.43[b]	26.99[b]	305.79[a]	273.47[a]	935.49[a]	106.64[a]
160	408.64[a]	34.43[a]	300.56[a]	282.71[a]	940.86[a]	115.16[a]

Means within the column, followed by similar letter (s) are not significantly different at p = 0.5 according to DMRT

Discussion

The results of application of organic fertiliser up to 160 kg N/ha on plant height and basal diameter of the Ifeken 400 variety of kenaf plant corroborates that of Hossain *et al.* (2011). The authors reported that growth, yield and fibre morphology of kenaf on sandy soil was influenced by different rates of carbon. They found that applying carbon at higher rates had an adverse effect on some growth parameters. This result agrees with the findings of Hazandy *et al*. (2009) and it shows that the crop can be grown using organic fertiliser (Zheng *et al.*, 2003). The absence of difference in the effects of 160 and130 kg N/ha application rates in this study indicates that organic fertilizer to delivers 130 kg N/ha. This confirms the findings of Danalatos and Archontolis (2004; 2010). Nitrogen and phosphorus concentrations in kenaf plant tissue were increased with increase in rate of fertiliser applied. This nutrient uptake by the plant could be responsible for the significant increase in plant height and stem diameter recorded. Potassium, sodium, calcium and magnesium concentrations increased with increase in rate of fertiliser application. This is in agreement with the findings of Ahmed *et al.* (2008) who reported that nutrient uptake efficiency of crops could be enhanced by applying organic fertiliser.

Conclusion

At harvest, the tallest plants were from plots that received 130 kg N/ha while stem diameter was largest in plants that had 160 kg N/ha of the organic fertiliser. Core yield was highest in plants under 160 kg N/ha while plants under 130 kg N/ha had the highest bast yield. Nutrient uptake such as nitrogen, phosphorus and potassium were highest in plants under 160 kg N/ha but not significantly higher than the values obtained in plants under 130 kg N/ha. Application rate of 130 kg N/ha is recommended for kenaf fibre production in southwest Nigeria based on crop performance and nutrient uptake.

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