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An Assessment of Morphological Characteristics of Kenaf in Response to Some Organic Cultural Interventions

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ABSTRACT: Field trials were conducted during the rainy season of 2011 and 2012. The main objective of the study was to investigate the possibility of increasing the productivity of Kenaf under organic conditions. Organic manure (*Mucuna pruriens*, compost manure, and control), sowing distances (15 and 30cm) and number of seed per stand (2 and 4 plant per hill) were factorially combined (3×2×2) to obtain twelve factorial treatment combinations. The treatments were arranged in a split- plot design with the 3 fertility method as the main plots and the factorial combinations of number of plants per stand and spacing as the sub-plot treatments. Data was subjected to ANOVA. Means were separated using LSD at $p \geq 0.05$. Results obtained show that, spacing increased DMY, height at the first branch, plant height and stem width diameter of kenaf. Establishing 4 kenaf seedlings per stand also significantly ($p \geq 0.05$) increased DMY, height at the first branch, and plant height and stem width diameter of kenaf except in plant height where the establishment of 2 plants per stand produced taller plants. Compost manure proved superior to mucuna in its effect on all the yield parameters observed, while mucuna ranked second. It was suggested that compost manure apart from being richer in its nutrient composition, contains some useful microbes that are beneficial in soil nutrition. Compost and mucuna further augment soil organic matter and consequently, the water retaining capacity of the soil. It was recommended that compost manure combined with suitable agronomic practices like plant spacing and number of seeds per stand will enhance organic kenaf production.

Key words: Spacing, Plant population, Organic Manure, Fibre.

Introduction

Kenaf is considered a unique crop because of its usefulness in pulp, edible leaf vegetable, edible oil and fibre production. The high pulp yield according to Sticker *et al.,* (2001) makes the crop (kenaf) a good replacement for forest trees in paper production. Kenaf according to Balogun *et al.*, (2008) alleviates global warming because of its ability to absorb a large volume of CO_2, and produce up to 30 t/ha dry matter. All the component parts of a kenaf plant, that is, leaves, bast fibre and core are of industrial importance. The leaves are rich in protein (15 - 30%) and are used as animal feed; the bast fibre can be converted to pulp for newsprint, hydro-carbon free bags and ropes. The core can be used as animal beddings, soil amendments, and oil absorbents in chemical industries and in ethanol production.

Kenaf fibre is a biodegradable and environment-friendly raw material suitable for many applications, such as woven and non-woven fabrics, geotextiles and semi-rigid and laminated sheets for packaging and panelling. Kenaf stems are an excellent substitute for softwood as raw material for the pulp and paper industry. Prospects for increased kenaf fibre and pulp production are good in view of growing concerns about environmental pollution and dwindling forest resources. The foregoing makes kenaf a good component of organic farming and the fiber, a natural organic product.

In Nigeria, pulp and paper production capacities are low due to dependence on foreign inputs. Two of the three primary pulp and paper mills established in the 1960's to 1970's performed optimally till the 1980's. Later in 1985 and 1986, capacity utilization in Nigeria paper mill according to Balogun *et al*., (2008) reached 62.3% and 66.17% respectively. Also by 1988, the importation of newsprint had stopped. However, in 1996, the mills stopped production leading to complete dependence on importation of paper and paper products. This according to FAO (2000) resulted in the expenditure of an estimated amount up ₦500 billion (five hundred billion Naira) annually on importation of paper products. To ensure optimal pulp and paper capacities, there is a need to deliberately promote investment in small scale pulp and paper mills. This will be achievable through the encouragement of Kenaf production to complement and supplement other sources of fibre and pulp raw materials.

Lumbering for pulp wood contributes greatly to deforestation and consequent vices on general ecology/biodiversity and the climate. Enabor (1986) and Awe *et al*., (2012) initially estimated the rate of deforestation in Nigeria at about 286, 000 ha per annum. The mounting pressure on available forest resources for farming, housing, and other infrastructure development activities has also contributed immensely to desertification and deforestation (Petu-Ibikunle and Tenebe, 2012). The commercial agriculture in Nigeria poses more risk to the environment because of its exploitation and exploration nature. Conservation and sustainability is in most cases disregarded. Any agricultural production system that disregards organic practices is thus considered not to be environmentally friendly as reported by Akachuku, (1997) . Kenaf Production according to Aibueku (2016) is expected not to only provide a source of renewable source of raw material to the pulp and textile industry, but a check on deforestation/ felling of forest trees. Alexopoulou, *et al*.,(2000) and Enabor 2003) reported that in addition to the prospect in kenaf production, the hostile business environment created by the ban on synthetic packaging material has necessitated the adoption and use of fibre crops like Kenaf as a suitable alternative. FAO, (2003) likewise reported that, long fibre pulp production from *Sterculia setigera, Sterculia oblonga and Hibiscuss cannabinus* has become imperative to save foreign exchange.

The present study aimed at examining the effect of organic-cultural practices on the dimensional characteristics of Kenaf fibre/ and Plant height and the production of Kenaf under organic condition to enhance a minimum contamination/pollution to soil as well as minimise environmental degradation. The research was also designed to contribute to the existing knowledge of the use of kenaf for pulp and textile work which as of now is not yet popular in Nigeria.

Materials and Methods

Description of the experimental site:

Field trials were conducted in 2012 and 2013 in Ilorin situated at (8.5° North latitude, 4.55° East longitude), 290 meters above the sea level, with mean temperature of 26.3°C and Wind velocity of 2.4m/s North -West,

Soil samples and analysis:

The physical and chemical characteristic of the soil were taken before planting from within 15 cm depth in both years of the trial .The soil samples were air-dried and sieved through a 2.0 mm sieve in the laboratory. The following physicochemical properties of the soil were determined: texture by pipette method (Day, 1965), moisture content by gravimetric method (Day, 1965), total organic carbon by LECO carbon analyzer (model CR-412; LECO Corp., St. Joseph, Mich.), total N by Kjeldahl method (Bremner, 1960), extractable P by Bray and Kurtz (1945) no. 2 procedure. Potassium (K) in the solution, were determined using an auto analyzer (Quik Chem, Series 8000, Lachat Instruments

Inc., USA 2000-2009 procedure) and the Micronutrients (calcium, Mn), zinc and copper) were determined by atomic absorption spectrophotometer (Perkin-Elmer 5100 PC). using the double-acid method (Mehlich, 1953), pH in water at soil: water ratio of 1:5 and cation exchange capacity (CEC) by leaching with 1 M ammonium acetate.

Land Preparation

A parcel of farm land measuring 1 hectare on the Kwara State University (Nigeria) research and teaching farm was secured for the trial. The first main plots of the experimental field were cleared in the year 2010 and planted with *Mucuna pruriens* seeds sown at rate of 50 kg/ha between 15-22 of June both in 2012 and 2013 at plant spacing of 60 × 60 cm. The mature plants at flowering stage of 45 days were ploughed into the soil. The second main plot of the field was treated with compost manure at the rate of 20t/ha, and the third main plot of the experimental field was left (fallow) without any deliberate activity on it throughout the year 2010 cropping season.

Compost preparation

Kitchen waste, farm yard manure, poultry waste, fruits and vegetable from the market, waste from slaughter houses were deposited into the compost pit according to the procedure laid down by K.A.S.T (2007). Seeds were sown at 15cm and 30cm spacing, in factorial combinations with 2 and 4 plants per stand (to achieve 4 sub-plot treatments). Both the main and sub-plot treatments were arranged on the field in a randomised block design.

Experimental Treatments

Each of the (three) main-plot were respectively treated with specific types of manure argumentation (Compost manure and mucuna and a control).While the sub-plot factors were (i**)** spacing of 30 and 45 cm apart, and (ii**)** Number of seeds of 2, and 4 plants per stand. (The spacing and number of seed sown per hill was to effect a varying plant population). The two sub-plot factors were given a factorial combination to obtain (i) 4 plant stands at 30cm spacing (ii) 2 plants stand at 45cm spacing (iii) 4 plants stand spaced at 30cm (iv) 4 plants stand at 45cm spacing.

Field observation of Agronomic Data:

A sample of 15 plants was taken randomly from two central rows in each experimental unit to measure the following growth characters:

(i) Dry matter yield: **-** The oven plant samples were dried for 48 hours at 45° C to obtain a dry matter at 7% moisture content. The dried plant samples were weighed on a digital electronics weighing machine. Model: ASMCT PLUS model 3Kg x 0.1 gram digital scale balance.

(ii) Plant height (cm): - Samples were randomly selected from each treatment plots. This was done at the full flowering stage (45 days). The plants tallness was taken using a measuring tape placed at the beginning of the green portion of the stem close to the base of the plants to the flag leaf. The values obtained were averaged over fifteen plants.

(iii) Height at first Branching: **-** The number of branches on the main stem was counted directly from each stem and averaged of fifteen plants.

(iv) Leaf Area*:* Leaf area, (L.A) is a dimensionless quantity. It is the leaf area (upper side only) per unit area of land below, expressed as m^2 leaf area per m^2 ground area. Leaf area was determined using the punch method and crossed checked with the L×B method as both described by Watson, (1952).

(v) Plant Width/Stem diameter**:** Vanier calliper was used to measure the width 15 plant samples per treatment plot. The readings were taken at 3 regions of the stem (20, 40 and 60cm), and the average of the three values were taken. Data collected for 2012 and 2013 were subjected to combined Analysis of Variance (ANOVA) using statistix 8.1 soft ware package. Means that were significantly different from one another were separated using LSD at $P \geq 0.05$.

Results and Discussion

i) Physico-chemical properties of the soil: The average soil characteristics (Table 1) show Sand, silt and clay had percentages of 75.9, 12.65, and 11.45 respectively.

Table 1: Soil characteristics of the experimental sites

Soil Property	Experimental Site	
	2012	2013
Sand (%)	75.9	80.1
Clay (%)	12.65	12.1
Silt (%)	11.65	8.8
pH	5.7	5.5
CEC [coml.] (+) kg^{-1}]	9.66	9.5
Organic carbon (%)	0.45	0.4
N (g kg-1)	0.3	0.3
P (mg kg-1)	0.5	0.5
K (Cmol kg^{-1})	0.09	0.87
Ca (Cmol kg^{-1})	9.8	9.5
Mg (Cmol kg^{-1})	7.7	7.5
Mn (Cmol kg^{-1})	5.9	5.7
Cu (Cmol kg^{-1})	4.9	4.8
Zn (Cmol kg^{-1})	4.3	4.4

The analysis shows that, the soil was texturally classified as sandy loam. The pH of the soil was low {pH (H_2O) **5.7**} indicating a slightly acidic soil, The CEC (cmol kg^{-1}) 9.66, Organic carbon (%) 0.45,N (g kg-1) = 0.3, P (mgkg-1) = 0.05, K (cmol kg^{-1}) = 0.09, Ca (cmol kg^{-1}) = 9.8, Mg (cmol kg^{-1}) = 7.7, Mn (cmol kg^{-1}) = 5.9, Cu (cmol kg^{-1}) 4.9, Zn (cmol kg^{-1}) = 4.3. The CEC, Organic carbon (%), the Mn, Cu, and Zn are reduced/low; using organic matter (or compost) amendment will thus enhance the enrichment and enhancement of the fertility status of the soil. The soil pH can also influence plant growth by its effect on activity of beneficial microorganisms that ordinarily decompose soil organic. This might have prevented organic matter from breaking down, possibly resulting in an accumulation of organic matter and tie up of nutrients, particularly nitrogen, in the organic matter. It is expected that the sandy nature of the soil will effect a reduced leaching losses of NO_3-N as reported by Petu-Ibikunle and Tenebe (2012).

(ii) Plant Populations, Spacing and Manure on DMY (g/Plant): The number of plants established per stand (plant density) significantly ($P \geq 0.05$) increased the DMY of Kenaf (Table 2).

Table 2: The Sole Effect of Organic manure, Spacing and Number of Plants per hill on the Morphological Characteristics of Kenaf

	I	II	III	IV	V
Plant Spacing (cm)					
30	52.36b	72.77a	77.61b	1103.2b	11.44b
40	72.49a	72.51a	78.70a	1195.9a	12.50a
SE	**0.80**	**0.22**	**0.09**	**6.23**	**8.86-E03**
LSD P ≥ 0.05	**1.65**	**0.45**	**0.19**	**13.43**	**0.02**
Plants/Hill					
2 Plants	63.67a	72.71a	75.66b	1103.1b	11.93b
4 Plants	61.43b	72.58a	80.66a	1195.2a	12.00a
SE	**0.08**	**0.22**	**0.09**	**6.23**	**8.86-E03**
LSD P ≥ 0.05	**1.65**	**0.45**	**0.19**	**13.34**	**0.02**
Nutrient Source					
Mucuna	65.49b	72.56ab	89.26b	1165.5b	12.07b
Compost	73.59a	73.08a	94.20a	1249.1a	12.82a
Control	48.23c	72.29b	75.01c	1043.1c	11.01c
SE	**0.99**	**0.25**	**0.11**	**7.86**	**0.01**
LSD P ≥ 0.05	**2.03**	**0.55**	**0.24**	**16.34**	**0.02**

Means sharing the same alphabet are not significant different at LSD (P≥0.05). (i) DMY (g/Plant). (ii) Height at 1st branch (cm). (iii) Plant Height (cm). (iv) Leaf area (cm^2). (v) Plant width/diameter

A higher biomass yield of 63.67g was recorded from crops sown at 4 plants per stand, against 61.43g recorded from sowing Kenaf at 2 plants per stand. The dry matter yield of kenaf was significantly (P≥0.05) increased by the Soils fertility amendment. The highest DMY up to 72.49g was recorded from plot of crops spaced at 40cm apart. The lowest dry matter yield of 53.26g was recorded from 30cm spacing**.** The sources of soil fertility (manure) significantly (P≥0.05) increased the DMY of Kenaf. The lowest DMY of 48.3 g was recorded from the control, while the highest value (73.59g) was recorded from crops treated with compost manure. Crops treated with manure from Mucuna recorded a DMY of 65.67g to rank second to the yield from the yield from compost manure. The result of this experiment is consistent with the findings and result of Aniefiok *et al*., (2013) and Majahid & Gupta (2010) with the explanation that characteristics such as plant height, days to crop maturity and yield were strongly controlled by the weather, soil and the soils nutritional status, and crop management, such as plant spacing which directly influenced soil moisture extraction, light interception, humidity and wind movement via canopy coverage of the soil. Characters like plant height, branch development, fruit location and size, crop maturity and, ultimately the plant yield were thus consequently are subsequently influenced.

(iii) Effects of *Spacing, Plant Populations and Manure on Height of Kenaf at first Branching*: Spacing and number of plants established per stand did not significantly (p≥0.05) increased the height at which the first branches in Kenaf (Table 2). Some dead and weak plants were observed as a result of higher plant population (higher number of stand per hill) and closer spacing (higher plant population). The death of some crops and the weakness in the vigour of crops was explained as survivor of the fittest, leading to natural adjustment of plant population which according to according to Ball *et al*., (2008) may be responsible for this result via a compensation for environmental recourse (Light, moisture and nutrient), that was achievable by reducing the plant population to a more sustainable one.

Fertility augmentation significantly (p≥0.05) increased Kenaf plant height at the first branch (Table 2). The tallest plants with heights of 73.08 and 72.56cm were recorded from plots treated with compost and mucuna, while the shortest plants with 72.29cm were recorded from the control treatments.Increasing the number of plants per stand decreased number of branches per plant. These results are in agreement with the previous findings reported by many workers (El Naim and Ahmed, 2010; El Naim *et al*., 2010). The individual reports showed that an increased plant density reduced the number of branches per plant but not heights at which the first branch was recorded. Webber *and bledsoe*., (2002) reported further supported with a similar finding that that at low plant populations (i.e. higher spacing or lower number of plants per stand) the crop produces plants with multiple branches with a greater percentage of leaves, rather than the more desirable single-stalk plants.

(iv) Effect of Plant Populations, Spacing and Manure on Height: Plant spacing significantly ($p \geq 0.05$) increased Kenaf height (Table 2). Crops spaced at 40cm apart grew to the height of 78.7cm, while crops spaced at 30cm grew to a shorter height of 77.6cm. The number of plants per stand likewise significantly ($p \geq 0.05$) increased kenaf plant height to 80.66cm with 4plants per stand. Shorter plants that grew to the height of 75.66cm were recorded from crops sown at 2plants per stand. Organic sources of soil fertility augumentation (i.e. compost manure and mucuna) also significantly ($p \geq 0.05$) increased Kenaf plant height. The tallest plants with 94.2cm were recorded from plants treated with compost manure; crops treated with mucuna grew to the height 89.26cm while the shortest plants that grew to the height of 74.01cm were recorded from the control. This response is likely to have been influenced by the nitrogen contributed by the compost manure and Mucunas' nodulation.(Ball *et al*., 2000) and Mehmet (2008). Explanations were offered that N and plant density increased height and branching in soybean. The report by Streck et al., (2014) explained that cotton seedlings tend to grow taller in thick stands (closer spacing and higher number of plants sown per hill), and that this response is similar in other crops and weeds. A similar result was also reported by Rahnama and Bakhshandeh (2010) that an increase in plant spacing from 5 to 20 cm caused a decrease in stem height from 180.2 to 169.7 cm. Plant height at wider spacing were taller with the explanation that congestion at the lower canopy tends to make the plants stretch out and higher for photosynthetic active radiation (PAR).
These results are however, not consistent with the reports of Emmanuel et al., (2012), that nutrient supplied by Mucuna or compost appeared to be responsible for the delay in plant height, and Agbaje *et al*., (2011) report that plant height is not affected by intra row spacing. kenaf has the ability to reduce its population when the competition for space is intense. Plants population is thus adjusted via production of weak plants or natural death of some stands as a result of which plant population and spacing might have been adjusted.

(v) Effects of Plant Populations, Spacing and Manure on leaf Area: Spacing significantly ($p \geq 0.05$) increased the leaf area of Kenaf. The result in table 2 showed that sowing Kenaf at 40cm apart produced crops with LA of 1195.9 cm^2, while crops spaced 30cm apart produced 1103.2cm^2 leaf areas. Leaf area of Kenaf was also significantly ($p \geq 0.05$) increased by the number of seeds established per stand, sowing at 4 seeds per stand produced the highest leaf area.

Manure argumentation significantly ($p \geq 0.05$) increased the leaf area of Kenaf with compost application recording the highest leaf area 1249.1cm^2. Kenaf treated with mucuna ranked next to compost with leaf area value of 1165.5 cm^2, while the least leaf area of 1043.1 cm^2 was recorded from the control. The decreased in leaf area with the increasing plant density is a similar results with the work of El Naim & Jabereldar (2010) who reported that leaf area tends to decrease with increasing plant densities. Generally, increasing the plant population increases competition among plants for soil moisture, nutrient, light and carbon dioxide. Further explanation was offered that the low populated plants grew as isolated units for most of their early life and interfered less with each other than at higher densities.

El Naim *et al*., (2010) explained that plant density had a significant effect on most of the growth attributes measured. The result showed that sesame planted on mucuna fallowed land at wider spacing between plants significantly enhanced the growth of sesame.

All the growth parameters examined had over 10 % increase with the leaf length and breadth having the highest value of 17.91 and 17.65 % respectively under the mucuna fallowed land compared with the non-fallowed land. Increasing the spacing between sesame plants and consequently decreasing the plant population will be beneficial if the plant is grown for its vegetative part. Leaf area and shoot biomass of soybean were significantly affected by the row and plant to plant spacing. Geraldo (2011) presented a similar report that the leaf area index of canola under varying row spacing and plant density of sowing decreased with the increasing plant density. Similar results were obtained by El Naim & Jabereldar (2010) with a report that leaf area tends to decrease with increasing plant densities. Leaf length: breadth ratio and *leaf area* density showed an increasing trend with closer *spacing according to* Gopichand et al., (2006). Abubakar (2015) work further supported with the findings that Increased *leaf area* in onion was affected by Intra-row *Spacing* x rate of farmyard *manure* application and the work of Copchand (2006) is consistently agreed with the finding in the present study. Plant *spacing*, recorded significantly higher values of plant spread, *leaf area*, number of leaves, and average leaf weight. Streck *et al*., (2014) report is in contrast, leaf area of cassava decreased with an increase in plant population.

(vi) Effect of Plant Populations, Spacing and Manure Plant stem diameter: Plant spacing significantly ($p \geq 0.05$) increased the stem diameter of kenaf (Table 2). Plant spaced at 40cm produced the widest stem of 12.5 cm, while a smaller stem diameter of 11.44cm was recorded when crops were spaced at 30cm. Number of seedlings per stand (plant population) significantly ($p \geq 0.05$) increased the stem diameter of kenaf. A higher stem diameter of 12.00cm was recorded from kenaf established at 4plants per stand, while establishing crops at 2 plants per stand recorded a lower stem diameter of 11.93cm. Augmenting kenafs' soil nutritional status with manure significantly ($p \geq 0.05$) increased the stem diameter of kenaf. The widest stem diameter of 12.82cm was recorded from the application of compost manure, while the 12.00cm stem diameter recorded from mucuna augmented plots ranked second and the least stem diameter was recorded from the control. The low plant population (achieved from wider spacing and lower seedling number per stand) produced a wider stem diameter compared with the kenaf plants established high population. This observation may be attributed to the better soil moisture availability, decreased plant competition and increased light penetration through plant canopy at low plant population.

These results are in agreement with the previous findings reported by many workers (El Naim *et al*., 2010). Further explanation by Webber *and Bledsoe* (2002) and unveiled that basal stalk diameters may vary greatly within a given kenaf field, at satisfactory populations the average basal stalk diameters will be in the range of 1.9 to 3.8 cm.

Conclusion

The findings in the present studysuggest that the fertility requirement of a sandy loam Kenaf field can be effectively managed via and organic fertilizer management strategies. The organic matter amendment afforded from the use of compost and mucuna is observed to have been very useful by effecting an enhanced performance in kenaf on the sandy loam soil.

The superior performance recorded by compost may be linked to the nutrient composition of compost and the function of the individual constituents of compost. Compost adds humus and organic matter to the soil. In addition, compost contains a lot of free living and symbiotic species of bacteria and fungi, insects and worms that are very vital in conditioning the soil. Benefits thus derived from the soil thus include: improvement of soil properties like water holding capacity on the sandy soil, CEC, and soil reaction (i.e. neutralising the slightly acidic nature of the soil). Mucuna is a legume that fixes N_2, but may not be as rich as compost as a result of which the benefit derived from it may not be as enormous at that from compost.

A higher plant density (achieved from closer spacing and increased number of plants per stand) will ordinarily result to a heavy canopy cover of the soil. With that, moisture conservation and enhanced beneficial microbial activities was favoured at the root zone. Over populated kenaf field can self regulate the plant population by producing some weak and dead seedlings to permit an optimum plant population and the consequent crop performance.

A long length fibre as a result of the discouragement of branching at lower height and a robust basal diameter is desirable in fibre crop (kenaf) production. A closer spacing and increased number of plants per hill as observed in this experiment is considered appropriate to achieve the desirable fibre yield.

Pollutants, including nitrous oxide from fertilizers attacks atmospheric ozone**.** N containing fertilizers break down in the soil to emit nitrous oxide into the air. Decomposing animal dung likewise releases green house gases (specifically methane) when decomposing under natural field conditions. Composting the animal dung (meaning that the dung was not allowed on the fields to rot under uncontrolled condition), is a way of minimising the volume of green house gases emission. While the use of compost manure and mucuna as sources of soil nutrition had also averted a volume of nitrous oxide that would have contributed to the global warming.

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