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Preliminary Investigation of the Adaptation of Some Kenaf (*Hibiscus cannabinus* L.) Genotypes in the Coastal Plain Sand of Niger Delta

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Authors' contributions

This work was carried out in collaboration between all authors. Authors UEU and OJK designed the study, wrote the protocol, organized, analysed the plant and soil data. While author JGT managed the trial, data collection and literature searches with input from author UEU. Author OJK wrote the first draft with input from authors JGT and UEU. Author UEU prepared and managed the manuscript with input from author OJK. All authors read and approved the final manuscript.

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ABSTRACT

A field trial was conducted at the Faculty of Agriculture Research and Teaching Farm in Choba, Rivers State, Nigeria to determine the kenaf genotypes that are adapted to the area during the 2012 cropping season. The thirty genotypes were planted in a Randomized Complete Block Design (RCBD) with three replicates.
Results from this study showed that the genotypes differed significantly in terms of establishment and growth. The genotype NHC-39 had the tallest stands, NHC-14 had the highest number of established plants, NHC-14 was thickest in terms of stem girth, and NHC-25 had the maximum number of leaves, while NHC-16 had the highest leaf area per plant or foliar canopy. Evidence from the growth characteristics measured revealed that the following genotypes NHC14, NHC-16, NHC-

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25 and NHC-39 have the potential to survive and adapt to the Coastal Plain Sand area of the Niger Delta. The cultivation of these identified genotypes of kenaf is sustainable in the study area and is recommended as a part of the cropping system.

Keywords: Adaptation; genotype; kenaf; sandy soil.

1. INTRODUCTION

Kenaf (*Hibiscus cannabinus* L) is a warm season annual fiber crop closely related to cotton (*Gossypium hirsutum* L) and okra (*Abelmoschus esculentum*). It belongs to the family Malvacea. Kenaf can be successfully produced in large portion [1]. It is one of the world's most potential sources of fiber for the cotton industry. Recently, the interest in growing kenaf has increased throughout the world for its elevated fiber content [2]. Sixty years ago, kenaf was only entertained as a cordage crop and then more recently as only a pulp crop, but now has many diverse commercial applications for development [1].

The commercial use of kenaf continues to diversify from its historical role as a cordage crop (rope, twine and sackcloth) to various new applications including paper products, building materials, absorbent materials for livestock feed. Choices will continue to increase and involve issues ranging from basic agricultural production methods to marketing of kenaf products.

Intensive research on production of kenaf especially in the last decade has created a strong and diverse store house of knowledge, understanding and experience in kenaf production. This serves as a vast reservoir for critical, timely information for producers, processors and consumers.

Kenaf is composed of two distinct fibrous materials which includes the "bast" and "core". The outer fiber which is the bast comprises roughly 40% of the stalk's dry weight. The bast fibres are those most in demand in industrial market and offer the greatest added value to growers since they can be used in a variety of products such as paper, textiles bio composites materials and others [3]. The inner fiber is called the "core" and comprises of 60% of the stalk's dry weight. It can be used for a variety of products such as animal bedding, oil absorbent, etc. [3]. It has recently been suggested that Kenaf plant may help prevent global warming and help conserve forest resources [4]. Kenaf has received the greatest attention because of its greater adaptability and ease of handling than allied fiber crops. It is commercially cultivated in over 20 countries, more especially in India, China, Thailand and Vietnam, Russia, Mozambique, Iran, Taiwan, El Salvador, Guatemala, Dahomey, Ivory Coast and Nigeria, Latin America and some Asian countries[5]. However, China, India and Thailand account > 90 percent of global production [5].

In spite of these awareness and potentials of kenaf in other parts of the world, most developing countries are yet to understand the importance of the plant. Even with the ecological semblance of the study area to those in Asia where kenaf is grown, the crop is yet to be propagated and cultivated for its use. Kenaf is relatively a new plant in the south-south region of Nigeria especially in Port Harcourt, Rivers State, Nigeria. The potentials as an oil absorbent is what drives the interest in the current study. Rivers state is in the Niger Delta region where oil spillage and pollution have caused a lot of damage in the agro-ecosystem, hence growing plants with oil absorbent properties will form the bedrock for potential bio remediation of oil spillage. Kenaf may be grown on a wide range of soil types under varied climatic conditions and may not necessarily compete with food crops. In major kenaf growing areas, kenaf grows in a latitude range of 16°S to 41°N with a mean relative humidity range of 68-82% and the mean growing temperature during the season ranges from 22.6°C to 30.30°. During the growing season the mean rainfall per month ranges from 100-329 mm and 500-625 mm over a period of 5 – 6 months is essential for the successful production of kenaf fibre [6]. One of kenaf's advantages as a crop is it can be successfully grown in a wide range of soil types, from high organic peat soils to sandy desert soils [7]. Although kenaf grows better on well- drained fertile soils with a near-neutral pH, the crop can withstand late season flooding, low soil fertility and a wide range of soil pH values [7]. It has shown excellent tolerance to drought conditions. Different agronomic traits of kenaf genotypes evaluated in Africa revealed that genotypic characteristics and relationship between kenaf varieties is problematic [8]. They divided the various genotypes into three groups based on the selected morpho-agronomic characters: The early medium (first group), medium – late (second group) and late maturity

(third group). Other researchers divided kenaf germplasm into two main groups: the early maturing types and the late maturing types [9]. Maturity periods has been reported to be an indication of sensitivity of kenaf varieties to photoperiod and later maturing varieties are photo insensitive relative to early maturing genotypes when planted in the tropics [1]. According to [10] the genetic improvement of kenaf identification of genotypic potentiality for a specific location is very important. The cleistogamous nature of reproduction causes difficulties to generate new genetic variability through conventional breeding in kenaf family. The main objective of this study is to screen some kenaf accessions grown in other parts of Nigeria for adaptation to Port Harcourt. Other objectives include to determine the genotype that is more adapted in the study area and to assess the soil properties that will support the adaptation of kenaf in the study area.

2. MATERIALS AND METHODS

The research was conducted at the Faculty of Agriculture Teaching and Research Farm located on 04° 54' 538"N latitude and 006°55' 329'' E longitudes in Choba, Obio-Akpor Local Government Area of Rivers State, Nigeria during March – July 2012 cropping season. The study area was in the humid forest zone, with an annual rainfall of between 2000 mm and 4000 mm and an average temperature of 27℃ [11]. Climatic data for the area is presented in Table 1. The rainfall was lowest in the month of January and highest in the month of July, the values were between 97.2mm - 365mm during the growing season. The mean temperature and relative humidity during the growing season ranges between 22.1℃ - 29.3℃ and 82 - 92% (Table 1). The sunshine hours was between 2.3-5.2 hours (Table 1).

The kenaf (*Hibiscus cannabinus*) seeds of different genotypes were used for the trial. A total of 30 genotypes of kenaf were obtained from the Department of Crop and Environmental Biology, University of Ibadan. The experiment was laid out in a Randomized Complete Block Design (RCBD) with 30 treatments representing the 30 genotypes. The thirty genotypes used in this study were each planted at a row spacing of 25 cm x 50 cm in a plot size of 300 cm by 50 cm. Each genotype was replicated three times. Fertilizer was applied two times at 4 and 8 weeks after planting respectively at the rate of 120 kg/ha by banding using a compound fertilizer formulated as NPK: with 20% N, :10% P_20_5 and: 10% k_20. Data collected include; emergence count, days to flowering, plant height, stem girth at flowering, lamina leaf area, and stem dry weight (reported as stem yield because the economic value of kenaf lies with the stem). Emergence of each genotype was determined as a proportion of the total number of seeds planted [Emergence (%) = (No of x-genotype emerged/ Total no of x-genotype seeds planted) × 100]. Plant height and stem girth of each genotype was determined using meter rule and vernier caliper respectively. Leaf area was determined as lamina leaf area by measuring the lamina leaf length and the lamina width at the exact center of the lamina with a ruler. Stem dry weight or yield determination was based on the gross plot size (300 cm x 50 cm).

Composite soil samples were collected at the depth of 0-15 cm and 15-30 cm before planting. The soil samples were collected based on the slope of the area. Soil samples were collected at three points in each replicate and composited. The samples were air-dried and sieved through a 2 mm mesh sieve for laboratory determination of physical and chemical properties.

2.1 Laboratory Analysis

Soil pH was determined in 1:1 soil water ratio using a glass electrode pH meter according to [13]. Exchangeable cations (Ca, K, Mg and Na) were extracted with neutral normal ammonium acetate buffered at pH 7 according to [14] method. The cations were determined using the Atomic Absorption Spectrophotometer (AAS). Total organic carbon was determined by the dichromic acid digestion method of [15] as reported by [16]. Particle size analysis was determined using the hydrometer method. Available phosphorus was extracted by Bray No.1 P solution [17]. Exchangeable acidity was determined by KCl extraction and titration methods of [18].

2.2 Statistical Analysis

Data on collected on emergence, plant height, leaf number, leaf area, stem diameter(girth) and stem dry matter yield, were subjected to statistical analysis (ANOVA) using Statistical Analysis System statistical package (SAS) [19]. Mean comparisons were performed by Duncan's multiple range test (DMRT) and least significant difference (LSD) test at $P \leq 0.05$.as described by [20].

Table 1. Weather condition of the study area in 2012

Year	Months	Rainfall (mm)	Temperature ℃		Relative humidity (%)	Sunshine (hrs)
			Maximum	Minimum		
2012	March	97.2	34.6	24.0	82	4.8
2012	April	244.7	32.9	23.6	86	4.3
2012	May	194.9	32.4	23.1	86	5.2
2012	June	317.8	30.2	22.8	90	3.0
2012	July	365.0	29.3	23.0	92	2.3

Source: [12]

3. RESULTS AND DISCUSSION

The dominant soil order in the area is Ultisol [21]. The surface horizon of soils in Choba-Port Harcourt area are described as ochric while the subsurface is mainly argillic or agric. The soil has very low CEC (5 Cmol/kg by summation of cations) and base saturation of less than 50%. The soil is characterized by deep and perfectly well drained profiles are never saturated with water and have less than 0.9% organic carbon everywhere within the argillic horizon. The mean annual rainfall in the area is usually not less than 2.500 mm giving the soils an udic soil moisture regime. Mean annual temperatures are also high with minimal variation between the lowest and highest indicating an isohyperthermic soil temperature regime. Soil texture varied between loamy sand and sandy clay loam, and this textural class is characteristic of most soils in Southeastern region of Nigeria [22]. The percentage clay in the pedons decreased by more than 20% of the maximum within 1.5 m of the soil surface qualifying the soils as typic tropudults [21] and Dystric Nitosol [23].

The pH of the study area ranged from 5.40- 5.70, indicating that the soils are acidic, while the exchangeable cations had moderate ranges (Mg: 8.55 – 19.16 mg/kg); (K: 2.95 – 13.25 mg/kg) and (Ca: 5.80 – 19.88 mg/kg). The exchangeable acidity was in the range of 3.04-12.56 mg///kg (Table 2). The ranges of these nutrients are indicative that the soil was deficient in basic cations. Nevertheless, the performance of kenaf in the soil was satisfactory. This result confirmed [7] earlier finding that kenaf is a plant adaptable to a wide range of soil conditions and pH.

The organic carbon content of the study area was moderate, ranging between 0.117 – 0.839%. According to [24] the sufficiency level of TOC is 0.51 to 0.80% for most agricultural crops. The available phosphorus value of the soil ranged from 9.33 – 21.70 mg/kg. The phosphorus content in the surface soil layer was higher than subsurface soil. The status of available phosphorus in the soils will sustain kenaf cultivation as it is generally within the critical level for most crops.

Table 2. Ranges of pertinent physico-chemical properties of the soil

Parameters	Range
Silt (%)	19-20
Clay (%)	0.4-2
Sand (%)	80-92
pH	5.4 – 5.7
Total N. (%)	0.08 – 0.12
Avail. P (mg/kg)	9.33 – 21.70
TOC (%)	0.117 – 0.839
Mg (mg/kg)	8.55 – 19.16
K (mg/kg)	2.95 – 13.25
Ca (mg/kg)	5.80 – 19.88
Exch. acidity (mg/kg)	3.04—12.56

3.1 Growth Characteristics of Kenaf

The variation in emergence of the genotypes could be due to genotype specific characteristics in relation to their specific edaphic requirement (Table 3). NHC-14 was thickest in terms of their stem girth, followed by NHC-22 and NHC-400. The least genotypes in terms of stem girth were NHC-25, followed by NHC- 17 and NHC-51 (Table 3). The leaf characteristics observed with the genotypes have also confirmed the fact that they are the most important plant characteristics that will shape growth and adaptation of most plants in the study and any other location (Table 3). Genotypes differed significantly in terms of establishment and height. In terms of height, the genotype NHC-39 was the tallest, while the NHC-D1 400 was shortest (Table 3). Plant height, basal stem diameter and dry stem weight or yield (Fig. 1) has been reported as the major components of fiber yield and quality [25].

This is further confirmed by [26] who reported it that the height differences observed or exhibited by the genotypes may be due to environmental influences, these results agree with [27] who also reported the possibility of emergence and faster growth rate of one particular genotype in the

same location with others if the environmental conditions are favorable. The NHC-14 had the best stands in terms of germination, while the genotype NHC-D1400 had the lowest number of established plants.

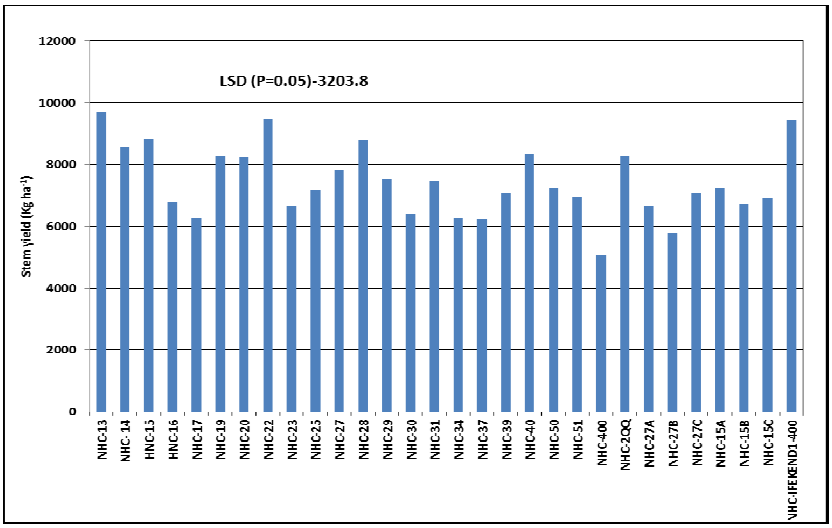

Fig. 1. Stem yield (Dry matter) of Kenaf genotypes

Table 3. Growth parameters of kenaf genotypes measured

Genotypes	Emergence 2 WAP (%)	Stem girth (cm)	Leaf no./ plant	Leaf area (cm^2)	Plant height (cm)
NHC-13	10.7^{ab}	3.4^{a}	80.5^{abcd}	16.4^{a}	111.9^{abc}
NHC- 14	11.3^{a}	3.6^{a}	94.4^{abcd}	17.2^{a}	75.9^{bcd}
NHC-15	9.0^{abcde}	2.9^{a}	66.4^{abcd}	13.9^{abc}	106.1^{abc}
NHC-16	9.0^{abcde}	0.0^{b}	54.9^{abcd}	5.9^{de}	80.7^{bcd}
NHC-17	8.7^{bcdef}	1.1^{ab}	37.3^{cd}	8.3^{bcde}	83.8^{bcd}
NHC-19	5.3^{hijkl}	3.1^{a}	94.3^{abcd}	15.4^{ab}	92.3^{abc}
NHC-20	10.7^{ab}	3.0^{a}	86.6^{abcd}	16.3^{a}	112.5^{abc}
NHC-22	7.0^{defghi}	3.5^{a}	88.1^{abcd}	14.9^{ab}	106.1^{abc}
NHC-23	6.3^{fghij}	1.3^{ab}	23.3^{d}	7.2^{cde}	77.3^{bcd}
NHC-25	8.7^{bcdef}	1.1^{ab}	125.3^{a}	15.3^{ab}	109.6^{abc}
NHC-27	7.0^{defghi}	3.3^{a}	93.1^{abcd}	15.4^{ab}	129.8^{ab}
NHC-28	8.7^{bcdef}	3.1^{a}	55.3^{abcd}	10.0^{abcde}	115.7^{abc}
NHC-29	8.3^{bcdefg}	2.1^{ab}	103.2^{abc}	16.4^{a}	112.3^{abc}
NHC-30	7.0^{defghi}	1.9^{ab}	58.2^{abcd}	11.7^{abcde}	83.2^{bcd}
NHC-31	9.3^{abcd}	2.3^{ab}	82.6^{abcd}	13.8^{abc}	119.3^{abc}
NHC-34	7.7^{cdefgh}	3.0^{a}	58.4^{abcd}	13.6^{abcd}	101.6^{abc}
NHC-37	5.0^{ijkl}	2.1^{ab}	45.6^{bcd}	10.8^{abcde}	22.3^{ef}
NHC-39	6.7^{efghi}	3.2^{ab}	102.5^{abc}	15.4^{ab}	147.0^{a}
NHC-40	6.7^{efghi}	1.2^{ab}	111.20^{ab}	16.1^{ab}	98.3^{abc}
NHC-50	0.0^{m}	0.0^{b}	54.67^{abcd}	5.6^{e}	0.0^{f}
NHC-51	4.0^{ghijk}	1.2^{ab}	97.5^{abc}	12.3^{abcde}	100.9^{abc}
NHC-400	6.0^{ghijk}	3.4^{ab}	84.0^{abcd}	12.2^{abcde}	61.1^{cde}
NHC-2QQ	3.7^{kl}	2.2^{ab}	82.3^{abcd}	14.3^{abc}	77.4^{bcd}
NHC-27A	9.0^{abcde}	3.3^{a}	80.7^{abcd}	15.7^{ab}	131.9^{ab}
NHC-27B	80^{cdefg}	3.3^{a}	80.6^{abcd}	3.3^{a}	122.3^{ab}
NHC-27C	6.0^{ghijk}	2.4^{ab}	58.3^{abcd}	13.4^{abc}	126.1^{ab}
NHC-15A	9.7^{abc}	3.7^{a}	92.7^{abcd}	16.8^{a}	131.5^{ab}
NHC-15B	9.7^{abc}	3.7^{a}	67.5^{abcd}	14.2^{abc}	127.4^{ab}
NHC-15C	9.7^{abc}	3.3^{a}	69.7^{abcd}	14.6^{abc}	98.0^{abc}
NHC-IFEKEND1-400	3.3^{l}	0.0^{b}	87.3^{abcd}	12.1^{abcde}	32.0^{def}
LSD(0.05)	**2.64**	**2.08**	**57.92**	**6.28**	**47.56**

Means of emergence, stem girth, leaf number, leaf area and plant height followed by the same numbers on the same column are not significantly different at 5% level of probability

4. CONCLUSION AND RECOMMENDATIONS

The trial revealed that out of the 30 genotypes that was used, the genotypes NHC 39, NHC14, NHC 25, NHC16 performed best compared to other genotypes that were used in this trial, some of which did not germinate at all. The study revealed that the environmental conditions and the soil properties of Choba in Obio/Akpu local government area of Rivers State, Nigeria were suitable for/ the adaptation of the kenaf. This is an indication that kenaf plant can actually survive and adapt to the upland areas of the humid forest ecology were the study was carried out.

It is recommended that this study be advanced in the following areas:

- Introduce seasonality in the study (carrying out the trial in two seasons)
- Look at specific micro environmental conditions that might shape the growth of these genotypes.
- Include more genotypes in subsequent study to determine the genotype that will grow in lowland areas which is the characteristic environmental condition of the study zone.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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