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Studies on seed yield potential of some selected kenaf (*Hibiscus cannabinus* L.) genotypes

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Kenaf seed yield depends on morpho-physiological traits between varieties, and the interaction between genotype and the environment. Studies were conducted in Ibadan, Ilora and Kisi stations of the Institute of Agricultural Research and Training (IAR&T), Obafemi Awolowo University, Moor Plantation, Ibadan, Oyo State, Nigeria during 2009 and 2010 cropping seasons to determine the influence of location and genotypes on seed yield potentials in 20 kenaf genotypes. The experiment was carried out using Randomized Complete Block Design (RCBD). Result shows that, kenaf plants had tallest average capsule height in Ilora in both years, while higher numbers of capsule/plant and seed number/capsule were recorded in Kishi. There were no significant differences among all the genotypes planted irrespective of the location on seed weight/plant, 100 seed weight and seed yield/ha. Average highest capsule height was recorded in 2009 across genotypes. However, average number of capsule/plant, seed number/capsule, seed weight/plant and seed yield/ha were higher in 2010. Local kenaf had highest number of capsules (55.04) with about the least seeds per capsule (9.45) and least weight of seed per plant (3.30 g). While BS-1 had the least capsule number (18.86) and highest seeds per capsule (15.74) was recorded in SF-549. AU-75 recorded the highest seed weight/plant. The 100 seed weight ranged from 3.37 to 2.19 g. Seed yield/ha across genotypes ranged from 660 kg/ha in Local line 36 to 1454.3 kg/ha in AU-75.

Key words: Kenaf, capsule height, capsule number, seed number, seed weight/capsule, 100 seed weight and seed yield/ha.

INTRODUCTION

Kenaf (*Hibiscus cannabinus* L.) 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; Charles, 2002). New applications of kenaf have been developed such as pulping and paper making, oil absorption, potting media, board making, filtration media and animal feed (Sellers and Reichert, 1999; Cheng,

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2001).

Kenaf is commercially cultivated in more than 20 countries, particularly in India, China, Thailand and Vietnam (FAO, 2003). The seeds are good source of low cholesterol vegetable oil and also for biodiesel production (Webber and Bledsoe, 1993). Kenaf has a high growth rate, reaching heights of 4-6 m in about 4-5 months and its yields of 6-10 tonnes of dry mass per acre each year, is generally 3-5 times greater than the yield for the southern pine tree (LeMahieu et al., 2003) which can take from 7-40 years to reach harvestable size. Kenaf has a wider range of adaptation to climatic conditions than other fiber crops grown for commercial use (Liu, 2003). The development of cultivars, which are adapted to a wide range of diversified environments, is the ultimate aim of plant breeders in a crop improvement program (Muhammad et al., 2003).

Genotype x Environment (GXE) interaction is an important issue to agronomists, who transfer a new variety from another environment. The adaptability of a variety over diverse environments is commonly evaluated by the degree of its interaction with different environments in which it is grown. A variety is considered to be more stable if it has a high mean yield but a low degree of fluctuation in yielding ability when planted over diverse environments (Purchase, 1997). Kenaf is now grown under different climatic conditions and a wide range of yield had been reported (Bhangoo et al., 1986). Literatures reported a seed yield in a range of 1-1.5 ton/ha in US and Mexico (Scott and Cook, 1995; Mullens, 1998). In Nigeria, seed yield reported are lower than 1 ton/ha.

However, the sustainable commercial production of kenaf depends on the availability of good seeds in enough quantity. Seed yield in kenaf is influenced by the population density or plant spacing and plant genotype (Mullens, 1998; Berti et al., 2013; Webber and Bledsoe, 2002).

Other factors like maturity ratings of cultivar, photosensitivity of varieties, latitudinal location soil fertility, cultural practices, rainfall in terms of distribution and intensity may significantly influence kenaf performance, seed quality and yield (Webber, 1996; Mullens, 1998, Webber and Bledsoe, 2002). Agbaje et al. (2011) also observed that time of planting and rainfall pattern had significant effect on higher seed weight and seed yield in 2007 as compared to 2006. The bulk of fats and oils, whether for human consumption or for industrial purpose is presently derived from plant sources.

Therefore, improvement has to be more on yield potentials of some selected plant species such as kenaf that has ability to produce unique desirable fats and oils. This study therefore seeks to determine the influence of geographical factors or elements on the seed yield. Hence, the suitability of different genotypes to these geographical locations will be determined for crop management recommendations in order to improve seed production.

MATERIALS AND METHODS

Location, experimental design, treatments and agronomic practices

The experiment was conducted in 2009 and 2010 cropping seasons at three different research stations of the Institute of Agricultural Research and Training, Moor Plantation, Ibadan, Nigeria. The research stations are; Ibadan (Transitional rainforest belt), Kisi (Guinea savannah) and Ilora (Derived savannah). Rainfall (mm) records were supplied from IAR&T meteorological unit during the experimental period for both years (Figure 1). Twenty (20) genotypes of kenaf were sourced from the Kenaf and Jute Improvement Programme of the Institute. The experimental design was randomized complete block design (RCBD) with three replicates. Each sub-plot was (3 × 5) m^2 in size. Planting was done on 17th July and 11th July in 2009 and 2010, respectively. Plots were ploughed and harrowed and a pre-emergence herbicide, Pendimethalin (500 EC) was applied at the rate of 1.7 kg ha^{-1}, using a Knapsack sprayer. Manual weeding was done 4 WAP and NPK fertilizer was applied 2 days after weeding at the rate of 80:30:30 in both years. Monoforce® (Monocrotophos) was applied at the concentration of 0.68 kg ha^{-1} active monocrotophos in 225 L of water at 5 WAP and at 50% flowering to protect plants from leaf beetle attack (*Podagrica* spp.) and pod sucking insects, respectively.

Agronomic data collection

Ten plants were tagged randomly within the inner rows at 4 WAP for the assessment of height (m), capsule number, seeds number per capsule and seed weight per capsule. The tagged plants were cut and separated from others at harvest. Harvesting of plant was done manually by cutting stems with cutlass in December, 2009 and 2010, respectively. The capsule height on the plant was determined from the above ground level to the first capsule from the base using graduated meter rule.

The number of capsules per plant was counted to obtain the mean values in each treatment. Seed number per capsule was determined by counting the number of seeds in 10 capsules and recording the average. This was also weighed to determine the seed weight per capsule.

One hundred seeds were taken randomly from the threshed seeds for weight determination using a gravimeter scale model GF-2000. The seed yield from each plot was determined after the manual threshing and converted into kilogram/hectare. The traits measured were analyzed for each year with SAS using General Linear Model (GLM) procedure and significant means were separated using Duncan's Multiple Range Test (DMRT) at 5% probability level.

RESULTS AND DISCUSSION

The mean squares due to location were highly significant ($p < 0.001$) on average height of the capsule, number of capsule/plant and seed number/ capsule (Table 1). Seasonal effect was also significant ($p < 0.001$) on average height of capsule, seed number/capsule, seed weight/plant and seed yield. Also, genotypic effect significantly ($p < 0.001$) affected number of capsule/plant and seed number per capsule. First order interaction of location x season was significant ($p < 0.05$-0.001) on all the parameters measured with the exception of 100 seed

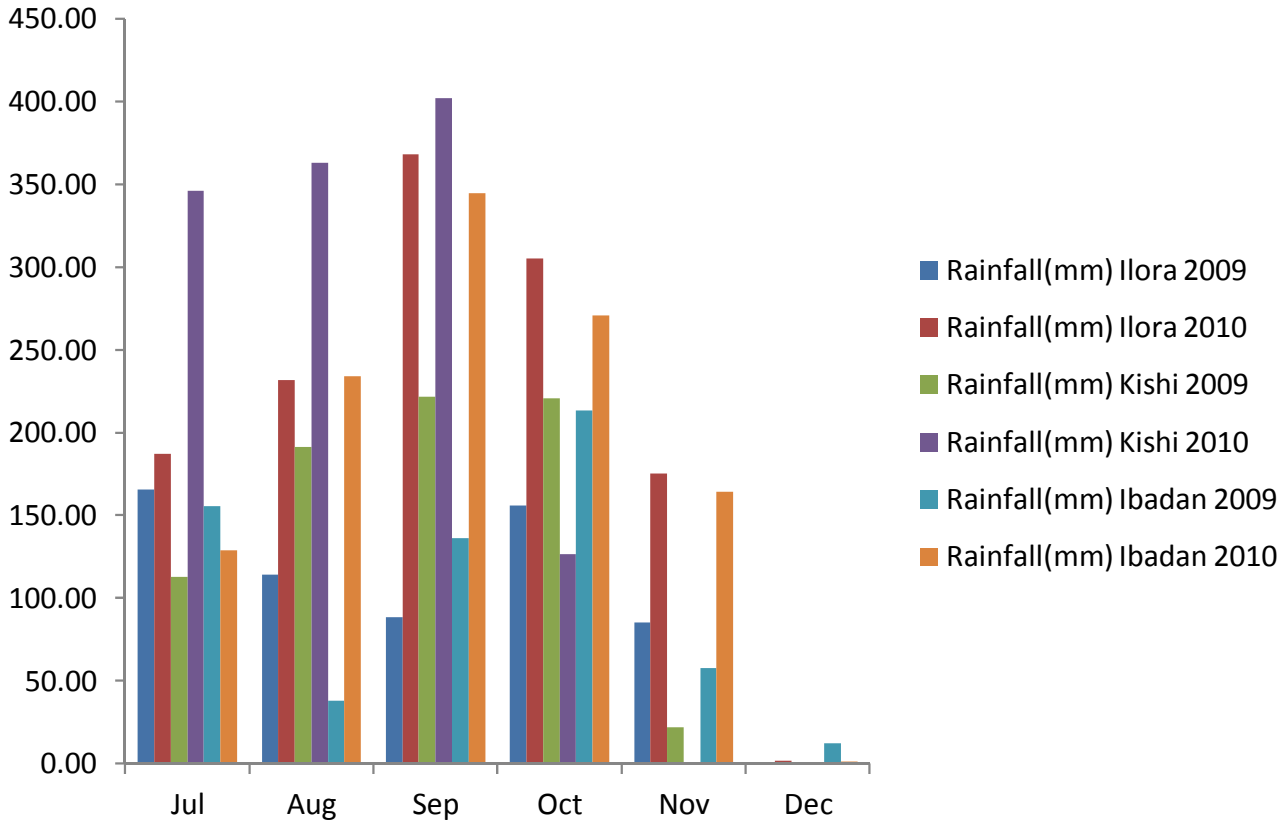

Figure 1. Rainfall distribution pattern at the experimental stations.

Table 1. Mean squares derived from combined analysis of variance for seed yield and yield components in 20 kenaf genotypes.

Source of Variation	DF	Capsule height (cm)	Capsule number/plant	Seed number /capsule	Seed weight/plant (g)	100seed weight (g)	Seed yield (Kg/ha)
Replicate	2	***	Ns	Ns	Ns	Ns	Ns
Location (L)	2	***	***	***	Ns	Ns	Ns
Year (Y)	1	***	Ns	***	***	Ns	***
Variety (V)	19	Ns	***	***	Ns	*	*
L X Y	2	***	***	***	*	Ns	*
L X V	38	*	Ns	Ns	Ns	Ns	Ns
Y X V	19	Ns	Ns	Ns	Ns	Ns	Ns
L ×Y ×V	19	Ns	Ns	Ns	Ns	Ns	Ns

*, ** and *** Significant at P< 0.05, 0.01 and 0.001 respectively. Ns, Not significant.

weight. Only one character, average height of capsule was significantly different ($p<0.001$) for the replication mean square. It means that environmental difference between locations existed in that character. Average height of the capsule ranged from 150.76 cm in Kishi to 175.25 cm in Ilora (Table 2). However, number of capsule/plant was highest in Kishi (29.78) and lowest in Ilora (20.34). In case of seed number / capsule, maximum seed number was recorded in Kishi, while minimum was noted in Ilora with values of 15.51 and 11.20, respectively. Average seed weight / plant, 100 seed weight and seed yield / hectare were not significantly affected by location. This may be due to the fact that had been reported by Dempsey (1975) that kenaf have a wider range of adaptation to environmental factors than other fibre plants cultivated for commercial use. Despite no statistical yield differences among the locations, seed weight/plant and 100 seed weight were

Table 2. Cumulative effect of location on seed yield and yield parameters in 20 kenaf genotypes.

Location	Capsule height (cm)	Capsule number/plant	Seed number/capsule	Seed weight/plant (g)	100 seed weight (g)	Seed yield (Kg/ha)
Kisi	150.76^{b}	29.78^{a}	15.51^{a}	6.45^{a}	2.33^{a}	1290.6^{a}
Ibadan	158.00^{b}	23.03^{b}	11.51^{b}	7.06^{a}	2.60^{a}	1411.7^{a}
Ilora	175.25^{a}	20.34^{c}	11.20^{b}	5.14^{a}	2.38^{a}	1067.3^{a}

Mean values within a column with the same letter are not significantly (P<0.05) different.

Table 3. Seasonal effect on seed yield and yield components in 20 kenaf genotypes.

Year	Capsule height (cm)	Capsule number/plant	Seed number/capsule	Seed weight/plant(g)	100seed weight (g)	Seed yield (Kg/ha)
2009	190.34^{a}	22.82^{a}	11.94^{b}	3.19^{b}	2.58^{a}	944.46^{b}
2010	126.87^{b}	26.71^{a}	13.65^{a}	10.19^{a}	2.46^{a}	1359.27^{a}

Mean values within a column with the same letter are not significantly (P<0.05) different.

Table 4. Effect of genotype on kenaf seed yield and yield components.

Variety	Capsule height (cm)	Capsule number/plant	Seed number/capsule	Seed weight/plant (g)	100seed weight (g)	Seed yield (Kg/ha)
2QC	158.91^{ab}	24.28^{b}	9.44^{d}	4.64^{ab}	2.37^{b}	928.8^{ab}
6QX	168.69^{ab}	21.56^{b}	12.72^{abcd}	6.24^{ab}	2.50^{b}	1247.9^{ab}
A-60-282	166.19^{ab}	21.67^{b}	13.09^{abc}	6.03^{ab}	2.51^{b}	1205.7^{ab}
A-60-284	175.0^{a}	24.39^{b}	14.71^{ab}	6.59^{ab}	2.56^{b}	1318.4^{ab}
AC-313	156.98^{ab}	19.52^{b}	13.98^{abc}	6.50^{ab}	2.42^{b}	1299.6^{ab}
AMC-108	162.85^{ab}	23.46^{b}	10.96^{cd}	7.24^{a}	2.47^{b}	1451.7^{a}
AU-75	171.66^{a}	25.38^{b}	13.41^{abc}	7.27^{a}	2.47^{b}	1454.3^{a}
BS-1	172^{a}	18.86^{b}	11.85^{bcd}	5.41^{ab}	2.31^{b}	1082.4^{ab}
Cuba 108	157.40^{ab}	22.59^{b}	14.25^{abc}	5.52^{ab}	2.56^{b}	1103.3^{ab}
Ex Funtua	165.85^{ab}	20.99^{b}	15.03^{ab}	5.10^{ab}	2.47^{b}	1019.7^{ab}
Ex Shika	168.41^{ab}	20.98^{b}	12.65^{abcd}	6.43^{ab}	2.44^{b}	1285.7^{ab}
G-45	165.69^{ab}	23.63^{b}	14.77^{ab}	5.79^{ab}	2.41^{b}	1155.2^{ab}
Ifeken 100	170.60^{a}	23.10^{b}	14.98^{ab}	7.10^{a}	2.36^{b}	1419.3^{a}
Ifeken 400	167.76^{ab}	23.90^{b}	14.30^{abc}	5.74^{ab}	2.19^{b}	1147.3^{ab}
Local Kenaf	146.63^{b}	55.04^{a}	9.45^{d}	3.30^{b}	3.07^{ab}	1361.6^{a}
Local line 36	167.02^{ab}	24.70^{b}	15.16^{ab}	6.81^{a}	2.28^{b}	660.0^{b}
S-72-78-10	167.20^{ab}	24.55^{b}	13.86^{abc}	6.73^{ab}	2.43^{b}	1345.5^{ab}
SF-549	158.53^{ab}	20,26^{b}	15.74^{a}	6.24^{ab}	3.67^{a}	1210.0^{ab}
Tainung 1	167.14^{ab}	22.57^{b}	14.17^{abc}	4.98^{ab}	2.35^{b}	996.7^{ab}
V_2 - 400	164.45^{ab}	26.06^{b}	12.72^{abcd}	6.35^{ab}	2.39^{b}	1269.7^{ab}

Mean values within a column with the same letter(s) are not significantly (P<0.05) different.

better in Ibadan and this contributed to higher yield (1411.7kg). Height of the first capsule produced in 2009 was higher as compare to the height of capsule in 2010 (Table 3). The implication of this is that in 2010 capsule formation on mother plant was more as compared to 2009. Average number of capsules/plant, seed number/capsule, seed weight/plant and seed yield/plant was higher in 2010 than in 2009. Differences in yield traits and seed yield between years were due to differences in rainfall from July through December each year. Rainfall for these months during 2009 and 2010 were 609.50, 786.40, 613.40 and 1269.40, 1237.80, 1143.40 mm in Ilora, Kishi and Ibadan, respectively. This result corroborates the findings of Webber (1996), Mullens (1998) and Webber and Bledsoe (2003). They reported that factors like maturity ratings of cultivar, photosensitivity of varieties, latitudinal location, soil fertility, cultural practices, rainfall in terms of distribution and intensity; may significantly influence kenaf performance, seed quality and yield. Table 4 shows that

Table 5. Influence of season and location on kenaf seed yield and yield components.

Location	Capsule height (cm)	Capsule number/plant	Seed number/capsule	Seed weight/plant (g)	100 seed weight (g)	Seed yield (Kg/ha)
2009						
Kishi	161.05	23.48	12.20	3.63	2.36	925.90
Ibadan	202.72	26.70	10.53	3.00	2.59	1020.90
Ilora	207.25	18.27	11.77	2.93	2.69	886.13
2010						
Kishi	140.47	26.07	13.82	9.28	2.30	1312.23
Ibadan	113.28	29.36	15.48	11.11	2.61	1502.57
Ilora	142.30	22.41	12.21	7.34	2.58	1212.25
F-Test	***	***	***	*	Ns	*

*, ** and *** Significant at P< 0.05, 0.01 and 0.001 respectively. Ns, Not significant.

average height of capsule ranged from 146.63 cm in local kenaf to 175.0 cm in A-60-284 with no statistical difference among the genotypes used. All the genotypes used with the exception of Local Kenaf could be planted for both seed and fibre production. Of all the genotypes used, Local kenaf produced 55.04 capsules/plant while BS-1 recorded 18.86 capsules/plant. Average seed number / capsule ranged from 15.74 in SF-549 to 9.44 in 2QC. Average seed weight/plant also ranged from 7.27 g in AU-75 to 3.30 g in Local kenaf. Both 100 seed weight and seed yield per hectare were statistically different among all the genotypes used. However, SF-549 recorded the highest hundred seed weight and lowest in Ifeken 400 with values of 3.67 g and 2.19 g, respectively. Genotypes AU-75 and Ifeken 100 recorded highest yield of 1454 and 1419 kg/ha, respectively. The least yield of 660 kg was recorded by Local kenaf. Four of the genotypes used recorded yield of less than 1 ton/ha. Average capsule height produced across the 3 locations in 2009 was higher than what was recorded in 2010 (Table 5). Both Ibadan and Kishi had kenaf with capsule height of more than 2 m above ground level. In 2010, average height of capsule was lower than 1.5 m in all the three location. There were 11.03, 9.90 and 22.66% increase in capsule number/plant in 2010 in Kishi, Ibadan and Ilora over 2009, respectively. There were increase in seed number/capsule and seed weight/plant in 2010 in all the three location as compared to what was recorded in 2009. Seed yield/ha of 41.83, 47.25 and 36.79% increase in 2010 over 2009 were recorded in Kishi, Ibadan and Ilora, respectively.

Conclusion

Sixteen (16) lines with high seed yield (> 1 ton/ha) and fibre yield potential were identified for the promising performance in Ibadan. These genotypes showed promising results as dual purpose kenaf lines; seed and fibre production, since the height at which capsules set were above 1.5 m from ground level. This will give necessary information in the development of combine harvester for kenaf for both seed and fibre production.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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