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Prospects of Kenaf as an Alternative Field Crop in Virginia[1]

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ABSTRACT

Kenaf (*Hibiscus cannabinus* L.), a warm-season annual plant, has shown potential as an alternate source of fiber in the United States. Although preliminary research has indicated feasibility of kenaf production in Virginia, production details are lacking. Field experiments were conducted during 1995 and 1996 to determine optimal row spacing and fertilizer needs, and to compare available kenaf cultivars. Although results indicated that differences in dry matter yields from four row spacings (30, 60, 90, and 120 cm) and four rates each of N, P, and K fertilizers (50, 100, 150, and 200 $kg \cdot ha^{-1}$) were not statistically different, the yields were adequate ranging from 8.8 to 16.0 $t \cdot ha^{-1}$ with an average yield of 12.5 $t \cdot ha^{-1}$. Dry matter yields for narrow-leaf cultivars proved superior to broad-leaf, and the overall results demonstrate that kenaf can be easily produced in Virginia.

INTRODUCTION

Kenaf (*Hibiscus cannabinus* L.), a relative of cotton (*Gossypium hirsutum* L.) and okra (*Abelmoschus esculentus* L.), is a warm-season annual plant that originated in northern Africa and has been used as a cordage crop for many years in India, Russia, and China (Dempsey, 1975). Kenaf research in the USA began during World War II to supply cordage material for the war effort (Wilson et al, 1965). During the 1950s and early 1960s, it was determined that kenaf was an excellent cellulose fiber source for a large range of paper products (newsprint, bond paper, corrugated liner board, etc.). It was also determined that pulping kenaf required less energy and chemical inputs for processing than standard wood sources (Nelson et al., 1962). More recent research and development work indicates that kenaf is also suitable for use in building materials (particle boards of various densities, thicknesses, with fire and insect resistance), absorbents, textiles, livestock feed, and fibers in new and recycled plastics (Webber and Bledsoe, 1993).

These observations indicate that kenaf could be potentially grown in Virginia to diversify cropping systems, to provide alternative materials for paper mills, and to meet varied industrial needs. Virginia State University's New Crops Program, established in 1991, initiated a kenaf research project in 1992. The objectives of this project were

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to conduct preliminary production research and to determine the feasibility of kenaf production in Virginia. Research conducted in Virginia during 1992-1994 indicated that kenaf has significant potential as an alternate crop in Virginia (Bhardwaj and Webber, 1994; Bhardwaj et al., 1995). However, information regarding desirable agronomic practices such as cultivar selection, fertility requirements, and plant densities, specifically for Virginia was not available. Therefore, experiments were conducted to identify: (1) high yielding varieties, (2) optimum levels of nitrogen, phosphorous, and potassium fertilizers, and (3) ideal row spacing.

MATERIALS AND METHODS

Three experiments were conducted during each of 1995 and 1996 at Randolph farm of Virginia State University, located in Ettrick, Virginia (37^0 14' N Latitude and 77^0 26' W Longitude) at an approximate elevation of 71 m. The soil type was an Abel sandy loam (fine loamy mixed thermic Aquatic Hapludult) soil that typically has a pH of 6.1 to 6.4.

In the first experiment, four inter-row spacings (30, 60, 90, and 120 cm) were evaluated with two kenaf cultivars: "Everglades 41" (A kenaf variety with broad leaves) and "Everglades-71" (A kenaf variety with narrow leaves). Three replications of a split-plot design with varieties in main plots and row spacings in sub-plots were planted on May 22, 1995, and May 20, 1996. Each plot consisted of three rows with a 60 cm spacing between sub-plots. These plots received 100 kg · ha^{-1} each of nitrogen (N), phosphorous (P), and potassium (K). In the second experiment, four rates (50, 100, 150, and 200 kg·ha^{-1}) each of N, P, and K, were evaluated with Everglades 41 variety in four replications of a split-plot design with N in main plots, P in sub-plots, and K in sub-sub-plots. Each plot consisted of three rows with inter-row spacing of 75 cm with one row left blank between the plots. These experiments were planted on May 23, 1995, and May 20, 1996. In the third experiment, 21 kenaf cultivars were planted on May 23, 1995, and May 21, 1996, in a randomized complete block design with three replications. Each plot consisted of three rows with inter-row spacing of 75 cm. These plots received 100 kg·ha^{-1} each of nitrogen (N), phosphorous (P), and potassium (K).

Approximately 100 seeds of each cultivar were planted in each 3 m long row. In each experiment, weeds were controlled with a pre-plant-incorporated application of 1.5 l· ha^{-1} of trifluralin herbicide. These experiments were not irrigated. Data were recorded for dry matter yield and plant height from samples harvested manually at the ground level after a hard freeze in early January had effectively killed the plants. During 1995, a 1-m sample was taken from the middle row of each plot in each experiment; and in 1996, a 2-m sample was harvested. After a two-month storage period, meant to stabilize the moisture content to a constant value and to dry the material, the harvested material was measured and the yield calculated in t·ha^{-1}. All data were analyzed using General Linear Models procedure of SAS (SAS, 1996).

RESULTS AND DISCUSSION

Row-Spacing: The differences in dry matter yield, averaged across two cultivars, for the four row spacings were not significant (Table 1). However, the closer spacing of 30 cm between rows showed a numerically higher yield of 11.1 t·ha^{-1}. The dry matter yields of Everglades 41 (8.2 t·ha^{-1}) and Everglades 71 (8.6 t·ha^{-1}) were also

TABLE 1. Effect of row-spacing on kenaf dry matter yield and plant height during 1995 and 1996 at Virginia.

Row Spacing	Dry Matter (t·ha^{-1})	Plant height (cm)
30 cm	11.1 a*	233.1 a*
60 cm	7.2 a	233.4 a
90 cm	7.2 a	231.3 a
120 cm	8.0 a	243.7 a
Mean	8.4	235.4

* Means across two cultivars (Everglades 41 and Everglades 71) and three replications each during two years. Means followed by similar letters are not different according to Least Significant Difference (5% level).

statistically similar (data not shown). The interactions between row spacing and cultivars for dry matter yield and plant height were not significant. The row spacing effects on plant height were also not significant. This research demonstrates kenaf's adaptability to varying plant densities. However, averaged across all row spacings, plants of Everglades 71 kenaf variety were taller (242 cm) than those of Everglades 41 kenaf variety (229 cm). No data were recorded on stalk diameter, however visual observations indicated that stalk diameter in closer row spacings was less than that of widely-spaced rows. Since a possibility of using kenaf as a forage crop exists, the closer row spacing may be desirable as it would reduce the woody component of kenaf harvested at green stage for feeding the livestock. However, the economics of kenaf seed would need to be considered. Kenaf, being a tropical plant, does not produce seed in the United States. Most kenaf seed is produced in Mexico or Carribean locations. Use of closer row spacing would entail more seed and would increase production costs.

Nutrient Needs: The dry matter yields and plant heights, following application of four rates (50, 100, 150, and 200 kg·ha^{-1}) each of N, P, and K, are presented in Table 2. The kenaf dry matter yield and plant height did not differ significantly in response to fertilizer rates. However, the highest dry matter yield of 11.4 t·ha^{-1} was obtained upon application of 50 kg·ha^{-1} N. The residual N content in the experimental area was approximately 14 kg·ha^{-1}, therefore, kenaf needs up to 64 kg·ha^{-1} N for optimal production. The response of kenaf to P and K applications was not significant. Previous observations (Rangappa et al., 2002) have indicated that soil at this experimental site, which is generally considered to be typical of most soils in the Southern Piedmont region in Virginia, contains approximately 54 to 77 mg·kg^{-1} P and 52 to 64 mg·kg^{-1} K. These levels, generally, provide adequate P and K for most crops, and positive responses to additional applications of these nutrients are not very common. These results indicate that the nutrient needs of kenaf are quite modest.

Varietal Evaluations: The mean dry matter yield from 21 kenaf varieties was 12.5 t·ha^{-1} (Table 3) which compares favorably with kenaf yields reported from other areas in the United States. The dry matter yields ranged from 8.8 to 16.0 t·ha^{-1}, respectively for GR 2563 and 78-18RS-10 kenaf varieties. The plant height varied from 229.7 to 288.6 cm, respectively for Tainung #1 and 78-18-GS-3 kenaf varieties. A significant positive correlation (+0.28, P=0.001) indicated that taller plants resulted in higher dry matter yields.

TABLE 2. Dry matter yield and plant height of kenaf following four rates each of N, P, and K fertilizers during 1995 and 1996 at Ettrick, Virginia.

Fertilizer	Dry Matter Yield ($t \cdot ha^{-1}$)			Plant Height (cm)		
Rate	N	P	K	N	P	K
50 $kg \cdot ha^{-1}$	11.4 a*	10.6 a	10.8 a	277.6 a	274.7 a	270.7 a
100 $kg \cdot ha^{-1}$	10.9 a	11.3 a	11.8 a	273.8 a	277.2 a	282.6 a
150 $kg \cdot ha^{-1}$	10.6 a	10.6 a	10.3 a	277.2 a	276.2 a	277.9 a
200 $kg \cdot ha^{-1}$	10.6 a	11.0 a	10.5 a	278.8 a	279.1 a	276.2 a
Mean	10.9	10.9	10.9	276.8	276.8	276.8

*Means followed by similar letters are not different according to Least Significant Difference (5% level). The interactions between N, P, and K were non-significant. The means of individual nutrients were obtained from averaging over all rates of other two nutrients i.e. the mean of N is averaged over all rates of P and K, the mean of P is averaged over all rates of N and K, and the mean of K is averaged over all rates of N and P.

TABLE 3. Dry matter yield and plant height of 21 kenaf cultivars when grown during 1995 and 1996 at Ettrick, Virginia.

Variety	Dry Matter Yield($t \cdot ha^{-1}$)	Plant Height (cm)	Leaf Shape
78-18RS-10*	16.0**	270.0*	Narrow
Everglades 71	14.3	266.3	Narrow
45-9	14.3	257.7	Narrow
SF 192	14.3	265.2	Narrow
15-2	14.3	278.5	Narrow
KK 60	14.1	280.3	Narrow
78-18GS-3	13.7	288.6	Narrow
Gautemala 51	13.5	267.0	Narrow
SF 459	13.1	259.2	Narrow
Tainung #1	13.0	279.3	Narrow
Gautemala 45	12.4	229.7	Broad
C 2032	12.4	247.2	Broad
Everglades 41	12.0	239.2	Broad
7N	12.0	253.8	Broad
Tainung #2	11.9	284.3	Narrow
Guatemala 4	11.7	258.0	Broad
C-108	10.9	245.8	Broad
Indian	10.6	229.8	Narrow
Cubano	10.5	274.8	Broad
Guatemala 48	9.1	270.0	Broad
GR 2563	8.8	241.8	Broad
Mean	12.5	261.3	-
LSD(.05)	3.4	31.2	-

* These are the names of kenaf varieties that are assigned by developers of these varieties.
** Means across two years and three replications per year. The year x cultivar interaction was non-significant.

Among the 21 kenaf varieties evaluated, 12 had narrow leaves and 9 had broad leaves (Table 3). A comparison of narrow-leaf shape group of kenaf varieties with broad-leaf shape group of kenaf varieties indicated that narrow-leaf group had a significantly (5% probability) higher yield and significantly taller plants (13.6 $t \cdot ha^{-1}$ and 268.8 cm, respectively) as compared to broad-leaf group (11.1 $t \cdot ha^{-1}$ and 251.1 cm, respectively). A problem with narrow leafed-cultivars is that the leaves superficially resemble those of marijuana (*Cannabis sativa* L.). There have been instances where narrow-leafed kenaf plants have been mistaken for marijuana plants. However, there are simple differences between kenaf and marijuana for identification purposes. The marijuana stalks are four-sided without thorns whereas kenaf stalks are generally round and have thorns. A marijuana leaf consists of seven or nine individual leaves joined at a common stem, whereas kenaf leaves are classified as compound leaves with seven lobes (Somers, 1991). We suggest that it may be desirable to grow broad-leafed cultivars at least until kenaf becomes a popular crop and potential confusion can be avoided.

CONCLUSIONS

The main goal of these research efforts was to evaluate the feasibility of kenaf production in Virginia. Results from two years of research indicate that under Virginia conditions, kenaf can be successfully planted at varying row spacings. The fertilizer needs of kenaf seem to be modest, approximately 64 $kg \cdot ha^{-1}$ of nitrogen may be adequate. The P and K content in most soils in Virginia is expected to be adequate for kenaf production. Our results also indicated that up to 16 $t\ ha^{-1}$ dry matter yield can be obtained from kenaf grown as an annual crop. These results indicate that kenaf can be easily produced in Virginia.

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