Kenaf: a new fiber crop for paper production

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A yield of 9.5 tons per acre was achieved in the Imperial Valley

Kenaf is an important source of fiber for the manufacture of bags, rugs, rope, and twine. Thought to have originated in Africa, kenaf is grown as a food crop in several African nations because of the high protein content of its leaves. The bark provides fibers for sewing and twine. Long, straight poles can be made from kenaf stalks and used for crop support.

A new use for kenaf (*Hibiscus cannabinis* L.) was tested in July 1987, when paper made from kenaf fiber was used to print 83,000 copies of the *Bakersfield Californian* newspaper. Reports indicate that the paper has excellent ink-retention characteristics and its high strength is well suited to new high-speed presses. The kenaf used in the Bakersfield test was grown in Texas, where much of the early work on the plant has been conducted.

Kenaf also appears to have good potential as a California crop. Dry-weight yields of 16 tons per acre at densities of 154,400 plants per acre have been reported in the San Joaquin Valley. The objective of the work reported here was to determine the yield potential of irrigated kenaf in California's arid Imperial Valley desert of the lower Colorado River basin.

Yield experiment

Field plots were laid out on the clay soil of the University of California Imperial Valley Agricultural Center near Holtville, where average annual rainfall is 3 inches per year. Irrigation water with a total dissolved solids content of 750 to 880 parts per million (ppm) was obtained from the Colorado River.

From 1983 to 1986, seven kenaf cultivars were planted during the last week of March or first week of April in a randomized block design with four replications of each cultivar. Seed was planted about an inch apart in two rows on a 40-inch bed and furrow-irrigated at a rate of 52 to 56 inches per year. Preplant fertilizer was applied at 100 pounds per acre nitrogen and 100 pounds per acre phosphorus. An additional 50 pounds per acre of nitrogen was applied in the furrow at five weeks and in mid-July. This amount of nitrogen was close to the optimum reported for the kenaf trial in the San Joaquin Valley.

Because emergence was highly variable, soil samples were taken from five paired locations in each of the replications in each variety. The samples were compared to determine if seedling emergence was related to salinity.

Harvest began the second week in November, when all stalks from the 20-foot plots were cut and weighed. The stalks and leaves of two plants per plot were dried in a forced air oven for a week to obtain dry-weight yield.

To test the effect of plant density on yield, seven kenaf lines were planted in late March 1986 on standard two-row, 40-inch beds 20 feet long. The plots were sprinkler-irrigated until seedlings were an inch high, and then furrow-irrigated. Plants were thinned to 2, 4, 8, and 16 inches between plants. There were four replications of each plant density in a randomized block design. The electrical conductivity at field capacity from the top foot of soil was 4.4 dS/m.

The same seven varieties had been planted in 1985 in a fine sand desert area and irrigated with groundwater containing 1,430 ppm total dissolved solids (TDS), including 750 ppm chloride. Seedlings were thinned to 4-inch spacings in rows 40 inches apart. These plots were irrigated through biwall tubing in an amount equal to class A pan evaporation. Yields were taken in early September and compared to a sample from the Agricultural Center plots.

Results

The electrical conductivity (EC) of the saturation extracts from the top inch of soil in the seed rows adjusted to field capacity was significantly higher where emergence was poor: the average EC where emergence was good was 29 dS/m compared with 44.7 dS/m from the poor areas. These results provide evidence that kenaf emergence was affected by salinity that accumulated in the seed row.

The range of dry weights is presented in table 1. Yield differences from year to year were not consistent. Only two cultivars ranked in the top three in all three years, E 41 and RS 10. These same two produced the highest yields in the high-density plots in the 1986 density trial. The two cultivars that showed the lowest yields, G 45 and C 2032, bloomed early in June and produced their first mature seed in October. The other five cultivars began to bloom in September and October, producing first mature seed in January. Statistical analysis showed no significant difference between years, but a highly significant difference between cultivars and a significant difference in the interaction between cultivars and years (analysis of variance with years as main plots and cultivars as subplots).

Stalk yields were highest at the greatest density, while leaf yields were highest at the lowest density (table 2). The high leaf load on the light densities was associated with extensive branching of the stalks that allowed leaves to develop lower in the canopy. The higher densities, on the other hand, produced only single unbranched stalks with leaves primarily at the top of the canopy. Since the highest density planting produced both the highest fiber yield and the greatest proportion of fiber in the plant tissue, this would be the best production practice.

The kenaf varieties grown in the desert with higher salinity irrigation water showed a substantial reduction in yield. Although

TABLE 1. Three-year average kenaf yield of seven cultivars in Imperial Valley

Kenaf cultivar	Dry weight*	
	Total	Stalk
	tons/acre	*tons/acre*
E 41	9.77 (± 1.19)	8.36 (± 1.02)
C 108	9.48 (± 1.63)	8.12 (± 1.40)
RS 10	9.51 (± 1.63)	8.02 (± 1.39)
Tainung	9.53 (± 2.04)	8.02 (± 1.72)
45-9X	8.99 (± 1.99)	7.62 (± 1.69)
C 2032	8.99 (± 2.19)	7.34 (± 1.79)
G 45	8.27 (± 0.52)	6.91 (± 0.44)

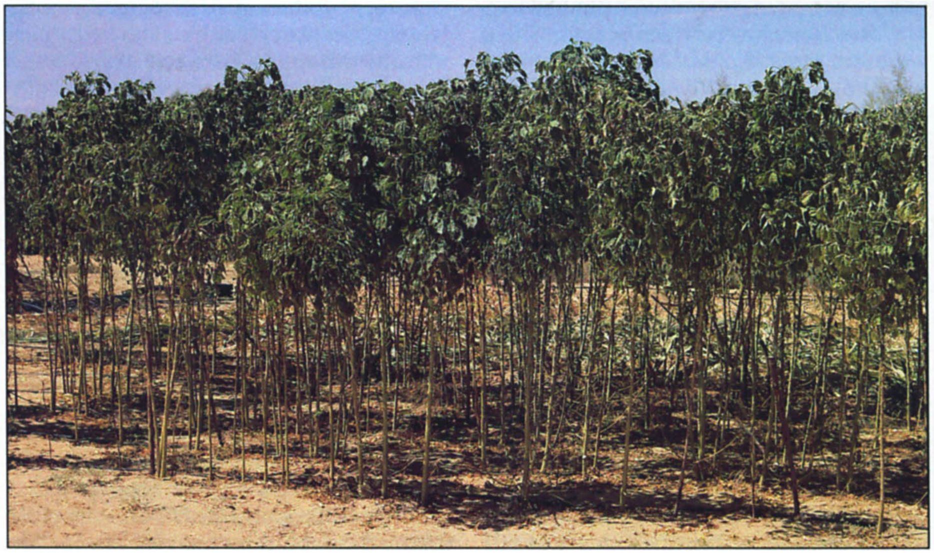
* Values in parenthesis indicate 95% confidence interval.

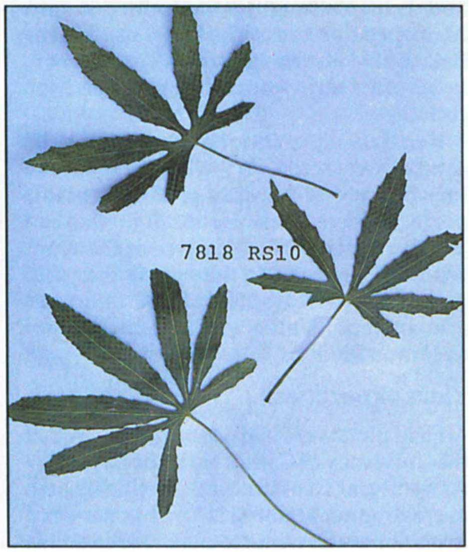
TABLE 2. Average yield summary of stalks, leaves, and their totals of seven cultivars, Imperial Valley, 1986

Plant density	Dry weight*		
	Total	Stalk	Leaf
1000/acre		*tons/acre*	
157	8.96 a	7.75 a	1.21 b
78.5	8.66 ab	7.43 a	1.23 b
39.3	8.13 bc	6.83 b	1.30 ab
19.6	7.55 c	6.08 c	1.47 a
LSD 5%	0.61	0.52	0.17

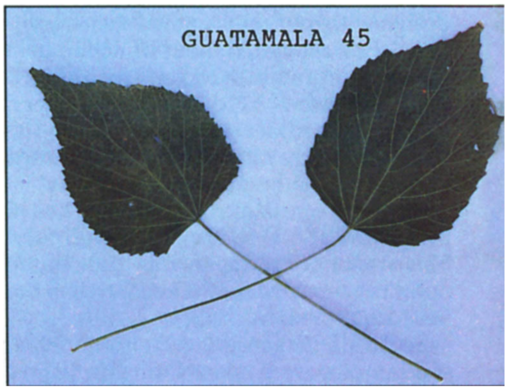
* Yields followed by the same letter are not significantly different.

Yields of kenaf fiber were greatest in high-density plantings (right). The fiber being held by lab assistant Marian Rubin is well suited for production of newsprint. In an Imperial Valley desert plot (below), rabbits ate the lower leaves off kenaf plants, which may grow to 16 feet tall in seven months.





The kenaf varieties evaluated in this test had palmate (divided) or entire leaves. Their high protein content makes the leaves a valued food in areas of Africa where kenaf is believed to have originated.



the space between rows in the desert was twice that at the Agricultural Center so that stands were 50 percent as high, the yield reduction was much greater than 50 percent. Yields in the desert ranged from only 11 percent (C 2032) to 20 percent (G-45) of the Agricultural Center yields. While the two areas had different soils, irrigation methods, and temperature regimes the comparison suggests that kenaf is at least moderately sensitive to saline irrigation water. This finding agrees with results obtained in greenhouse studies by A. Läuchli and P. Curtis, Department of Land, Air, and Water Resources, UC Davis.

Conclusions

Because stand was reduced by salt accumulation on seed beds and higher salinity water reduced yields, kenaf was considered to be at least moderately salt sensitive. In one trial, the best yields were obtained at a density of 157,000 plants per acre. The upper yield range is approximately 9.5 tons dry weight of stalks per acre and may improve with additional work on cultivation practices and genetic selection. Yields of this magnitude have encouraged the construction of a kenaf paper mill in southern Texas.

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