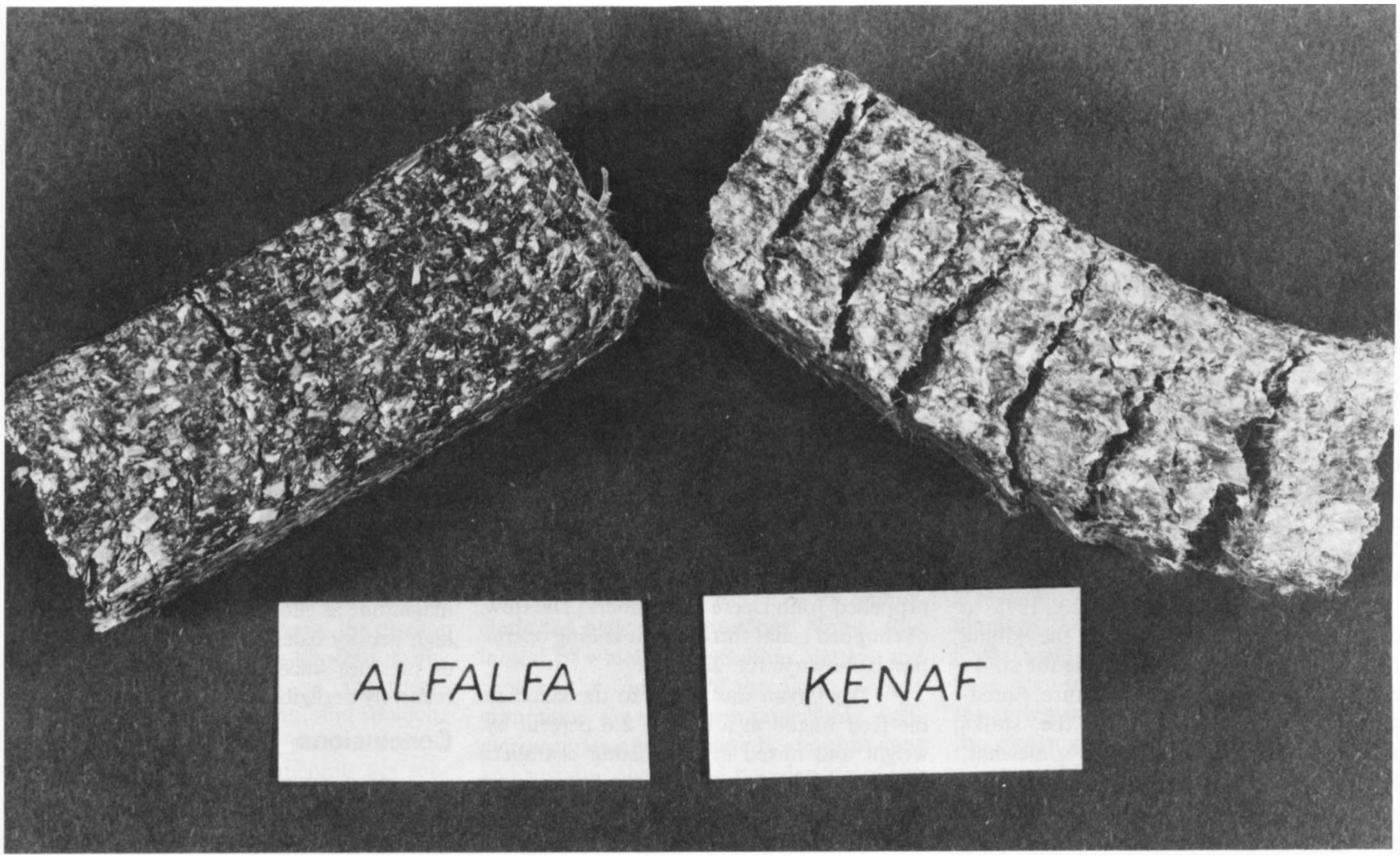

Fig. 1. Kenaf and alfalfa cubes, half actual size.

Cubing increases density of kenaf

Dennis J. DaVia ■ Marvin O. Bagby ■ Buren A. Wolf
Paulden F. Knowles ■ John R. Goss

The long bast-fiber bundles in the stem bark of kenaf (*Hibiscus cannabinus* L.) are used to make rope, twine, and cloth. Recently attention in the United States has focused on use of whole kenaf as a supplemental fiber source for the pulp and paper industry. Analyses of fiber characteristics indicate that kenaf fibers can be used alone or admixed with wood fibers to produce paper of commercially acceptable quality.

Certain characteristics of kenaf make it a promising fiber crop and source of papermaking pulp. Because kenaf is an annual plant, the capital and time necessary to produce a forest crop are not required. Kenaf can be quite productive in areas with an adequately long growing season where it will reach heights of 8 to 20 feet. When grown in thick stands, plants are erect with little or no branching, and basal stem diameters are relatively small (¼ to ¾ inch). At maturity the senescent leaves fall, simplifying collection of the stalks. These growth characteristics allow harvesting with currently available agricultural machinery.

Establishment of a kenaf-based pulp industry requires an economical and simple handling system; however, low density kenaf stalks require a relatively large amount of space for transportation and storage. Increased stalk density would lower transportation and storage costs and facilitate handling. This study evalutes the feasibility of using alfalfa-cubing methods to cube kenaf.

Plant material

To supply plant material for cubing, three acres of kenaf were grown at the U.C., Davis, Agronomy Farm in 1975. The crop was planted May 22, 1975, on 30-inch beds at a rate of about nine seeds per foot.

The crop was irrigated nine times during the growing season and reached 8 to 10 feet in height at maturity. The first killing frost occurred on December 15, 1975. On March 30, 1976, the average yield was estimated from samples to be 5.7 tons per acre with a moisture content of 10 to 12 percent.

Preliminary laboratory trial

Preliminary trials to determine the feasibility of cubing kenaf were performed using an individual-cube, laboratory machine. Cubing conditions (pressure, die temperature, and cubing time) in the laboratory were similar to those of a commercial cuber. Because it was successfully used in preliminary trials, Orzan was added as a binder at a rate of 2½ percent on a weight basis. The kenaf was hand-harvested and cut in ½- to 1½-inch lengths.

Attempts on November 20, 1975 to cube kenaf, harvested before the killing frost, failed, presumably because the stalks contained 70 to 80 percent moisture. Shredding rather than chopping the stalks alleviated the moisture problem somewhat, but produced a poorly formed cube.

The second laboratory cubing attempt was made on January 20, 1976, after several killing frosts. At this time moisture content of the stalks ranged between 10 and 20 percent. This cubing attempt successfully produced kenaf cubes with a mean bulk density of 28 pounds per cubic foot. Density values obtained by this laboratory method, however, were about 40 percent greater than values (19 pounds per cubic foot) found in a subsequent test using a commercial cuber. Whereas the individual-cube laboratory machine appears to adequately test for the ability of a substance to be cubed, density values obtained by this method do not always agree with those obtained in a commercial unit.

Large-scale field trial

Because laboratory experiments indicated cubing of kenaf was possible, a large-scale cubing attempt was undertaken with the remaining plant material. After overwintering, the kenaf was harvested May 26, 1976, at a moisture content ≤ 10 percent. Lodging of stalks in some areas of the field was quite severe.

A self-propelled New Holland ensilage chopper with a corn-pickup attachment was used to harvest the kenaf. No machine adaptations were required and the ensilage chopper appeared to have adequate capacity to harvest the kenaf stalks. The outer bast fibers of the bark were cut cleanly into ½- to 1-inch lengths and the core portion of the stem was shredded into pieces of similar length. Field losses caused by lodged stalks were estimated at 25 percent. The chopped kenaf was transported by truck to the stationary cuber, which was comprised of an electrically driven cubing unit from a self-propelled John Deere field cuber. (The flow of chopped kenaf through this cubing operation is shown in fig. 2.)

Dry Orzan was added to the kenaf in the feed wagon at a rate of 2.6 percent by weight and mixed in the mixing chamber. Water was added to activate the Orzan in an auger system which fed kenaf into the cuber. Cubes were elevated into a truck for delivery to a pulp mill.

The kenaf cubes were of good quality and similar to alfalfa cubes in size and shape (fig. 1). In contrast with chopped and bundled kenaf (5 and 6 pounds per cubic foot, respectively), this cubing process increased bulk density three to four times. The bulk density of these cubes was about 50 percent greater than most types of wood chips. Furthermore, cubing had no deleterious effects on fiber quality.

Because the most widely cubed plant material is alfalfa, comparison of kenaf with alfalfa cubing characteristics would indicate suitability of kenaf as a material for cubing. Alfalfa cubes were 6 pounds per cubic foot more dense than kenaf cubes, and were cubed at the rate of 5 to 6 tons per hour—four to five times faster than kenaf. Such factors as particle diameter and compressibility probably account for the lower density of kenaf cubes. Because long bast fibers frequently plugged the auger system, kenaf cubing was extremely slow. Conversion from an auger to a belt conveyer should significantly increase kenaf cubing rates to approximate those of alfalfa. Power supply modification of the experimental cuber would probably further increase cubing rates for commercial production.

Cubing compared quite favorably with other methods of increasing kenaf unit density. The cubing unit produced kenaf that was three to five times denser than that produced by a farm hay baler or low-pressure, high-density baler. Only a high-pressure, high-density baler using kenaf stalks harvested with a mower-conditioner produced unit density values of the same magnitude as cubing. Differences among the high density bales were primarily a function of pressure since pretreatment effects were relatively negligible.

Conclusions

After drying to a moisture content of 10 to 12 percent following a killing frost, kenaf can be harvested with a self-propelled ensilage chopper and cubed in a stationary cubing unit without major machine modification. Kenaf cubes produced by this method occupy only one-third the space required by chopped or bundled kenaf without loss in fiber quality. Cubing was more effective in increasing density than all other methods, except one, and the bulk handling characteristics of cubes are advantageous during transportation and storage.

Dennis DaVia is Staff Research Associate, Department of Agronomy and Range Science, U.C., Davis; Marvin Bagby is Research Leader, Northern Regional Research Center, Federal Research, Science and Education Administration, U.S.D.A., Peoria, Illinois; Buren Wolf is Laboratory Assistant, Department of Animal Science, U.C., Davis; Paulden Knowles is Professor of Agronomy, U.C., Davis; and John Goss is Professor of Agricultural Engineering, U.C., Davis.

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Fig. 2. Stationary cubing system used in the large-scale trial.