

Kenaf, an alternate fiber for the pulp and paper industries in developing and developed countries

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ABSTRACT: *Information on pulp and paper industry demands and the cost of kenaf production indicate that this fiber offers the environmental advantage of reducing dependence on the harvesting of plantation and natural forest resources.*

KEYWORDS: *Bast fibers, costs, developing countries, fibers, kenaf, Mississippi, nonwood fibers, nonwood plants, paper industry, production, pulp industry.*

The increasing demand for paper creates pressure on the global environment and opens the way for competitive alternatives to the well established wood fiber feedstocks. Kenaf is a fiber which has been the subject of much research, investigation, and commercial analysis in recent years. Earlier papers (1-3) describe the agricultural production, storage, and transportation of kenaf. These references also describe the separation of the bast (long-fiber) and woody core (short-fiber) components and the pulping and papermaking characteristics of these two constituents. Sufficient knowledge and experimental data are therefore available to indicate that the pulping of kenaf fiber is feasible.

The present paper will deal with the potential of the kenaf plant to improve the global environment by providing an alternative to the use of trees.

This objective requires the establishment of a kenaf-based pulp and paper industry in both developing and developed countries. Such an industry would have to be based on a proven and competitive fiber production, handling, and processing system. The paper will show that, because of the favorable impact on the economies of many developing and developed countries, kenaf is the nonwood fiber plant most appropriate for use in filling the gap in anticipated fiber requirements.

Future demand for pulp and paper products

To demonstrate the repercussion on the global environment of kenaf as an alternative fiber, it is necessary to examine probable future fiber demand and to calculate the requirements to fulfill these forecasts. Table I provides information on pulp production data

for 1989 and 1990 (4). The data is the sum of the pulp produced for the integrated paper manufacturing and market pulp operations. Other information forecasts annual expansion rates until 1995 of 3.90% per year for chemical pulp and 6.10% per year for mechanical pulp for world demand (5).

In order to simplify calculations, assume that these rates of expansion will pertain until the year 2010. Applying them to the pulp produced in 1990 will then provide an indication of future pulp and fiber requirements as shown in Table II. It is then possible to calculate the fiber requirement for the period to 2010 by applying the estimated average yields for a.d. chemical pulping of 50% and of mechanical pulping of 90%. Table III presents this data.

The impact of recycling is not considered in the data shown in Table III, however. When calculating the total fiber required for the period, therefore, the amount of available recycled secondary fiber must be considered. A probable estimate is that approximately 70% of the world's paper is made out of virgin fiber. By 2010, it is likely that this will be approximately 55%. Using a uniform, straight line increase for recycled secondary fiber until the year 2010 (6), Table IV shows the estimated global virgin fiber and land area requirements which will be required to meet the forecast for fiber quantities through 2010 as well as the impact which recycling has on the total long-term fiber requirement. The

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land area calculation in Table IV is based on an annual fiber yield of 1.36 kg/m² o.d. which represents a highly productive forestry operation (6). In colder climates, this yield would decrease and the time required to grow the fiber could be considerably extended. The age of harvestable forests would increase well above 10 years.

Only in the unlikely scenario that there is no expansion of demand beyond 1990 with no extra fiber or land requirements would the current supply be sufficient to maintain production at existing levels. Using 1990 as a base year for purposes of comparison, **Table V** indicates the additional fiber and land necessary for the expansion of demand beyond 1990. In this table, 1990 is the base year and other years are the value from Table IV minus the value for 1990.

Fiber requirements

Using other estimates (6–8), the total additional fiber which is known to be available to cover expansion until 2010 is approximately 65 million metric tons per year of o.d. fiber. Accordingly, the world will be running short of virgin fiber resources around the year 2000 as shown in Table V. After using the calculated excess capacity of 65 million metric tons per year, an additional 92 million metric tons per year will still be required by 2010.

The average age of forests to meet these requirements would be 10–15 years unless a major relocation of forest resources were to occur to the warmer climate zones. Approximately 10 million hectares of land per year would have to be planted now due to the long lead times required before harvesting.

Table IV indicates that 12.86 million hectares of land will produce the current fiber requirements. By 2010, this will almost double to 23.04 million hectares. Because forest plantations require a large amount of capital for long periods, it is unlikely that funds for long-term forestation projects would be available in the current pe-

I. Pulp production for 1989 and 1990, million metric tons

	Chemical pulp	Mechanical pulp	Other pulp	Total pulp
1989	120.83	35.31	7.47	163.61
1990	117.90	35.75	7.00	160.65

II. Estimated future global pulp requirements, million metric tons

	Chemical pulp	Mechanical pulp	Total pulp
1995	142.76	48.07	190.82
2000	172.85	64.63	237.48
2005	209.29	86.90	296.19
2010	253.41	116.84	370.25

III. Estimated future global fiber requirements, million metric tons a.d.

	Chemical fiber	Mechanical fiber	Total fiber
1995	285.51	53.41	338.92
2000	345.70	71.81	417.51
2005	418.58	96.55	515.13
2010	506.82	129.82	636.64

IV. Estimated future global virgin fiber and land area requirements

	Total of virgin fiber, %	Amount of virgin fiber, million metric tons a.d.	Land area required, million hectares
1990, base year	70.00	192.87	12.86
1995	66.25	224.53	14.97
2000	62.50	260.94	17.40
2005	58.75	302.64	20.18
2010	55.00	350.15	23.34

V. Estimated additional global virgin fiber and land area requirements based on 1990 usage

	Total of virgin fiber, %	Amount of virgin fiber, million metric tons a.d.	Land area required, million hectares
1995	66.25	31.67	2.11
2000	62.50	68.08	4.54
2005	58.75	109.77	7.32
2010	55.00	157.29	10.49

VI. Summary of kenaf fiber production costs

	United States	Australia	Thailand	India
References	(13)	(13)	(3, 15)	(16)
Yield, metric tons/hectare a.d.	13.36	16.06	10.13	10.13
Total cash costs ^a for farming input only, US\$/hectare	328	374	97	123
Return to land and management, harvesting, and transport, US\$/hectare	480	453	394	317
Total, US\$/hectare	809	828	491	439
Cost to purchaser delivered to plant, US\$/metric ton a.d.	61	52	48	43
Change in kenaf fiber costs using United States as base, %	0.0	14	20	28
Transportation distance, km	24	24	50	45
Cost of fiber required to make a.d. pulp ^b at mill gate, US\$/metric ton	121	103	97	87
^a US\$ = 1.32 AUD, 26 THB, 26 INR				
^b Two units of fiber assumed to produce one unit of pulp.				

riod of economic recession. Consequently, the world will face a shortage of fiber (9) and an increase in wood chip costs. This could lead to more pressure for the accelerated exploitation of existing mature forest resources.

Thus an increasing use of fast growing annual fibers would be the most probable commercially, practically, and environmentally acceptable alternative. There would be no long-term capital commitment in fiber production. The areas under cultivation could be increased or reduced on an annual basis subject to demand. Subject to climatic considerations, the annual fiber production per square meter would be higher, meaning that smaller areas of land would be required when compared with pulpwood production.

The analysis has indicated then that the forest resources required by the year 2010 will need to be almost doubled based on the present usage rate. This cannot be achieved without a major plantation program. Due to the lead time required, it is already too late to commence implementation using trees. Obviously, then, the introduction of the large scale utilization of annual, nonwood fibers such as kenaf in particular will be necessary to avoid a major world shortage of fiber for the pulp and paper industries. From an environmental point of view, the maintenance and indeed the expansion of global forests is an important objective which can only be achieved by providing an alternative nonwood fiber source.

Agricultural production of kenaf and fiber processing

It is quite clear that kenaf as an annual crop capable of producing both long and short fibers will be one of the key fibers, provided it can be processed into competitive products. As soon as a kenaf-based pulp industry is developed, an increasing amount of the existing forest resources will be saved from harvesting.

Kenaf growing and related research goes back many years in the United States and in other parts of the world. Most of the work in developed countries has been conducted by research or government organizations on relatively small plots of land. In this work, the agronomy and agricultural management practices were well established. Harvesting, handling, and storage technologies essential for commercial operations did not receive the same attention, however.

The combination of the necessary engineering technology with the already developed agricultural skills was the next stage of development. This has taken place mainly during the last 5-6 years.

For kenaf to be considered a competitive fiber, the agricultural production and the introduction of new technologies essential for the separation of the long- and short-fiber components must be proven in a continuously operating, commercial production unit. The first step in such a goal would be the establishment of agricultural operations. With financial assistance from the Tennessee Valley Authority (TVA), a feasibility study was conducted to evaluate the potential of a fiber separation facility. The study resulted in a commitment to build such a plant with completion sometime in 1992 in Mississippi. At present, this is the only commercial kenaf fiber processing facility of its kind operating in the world. The purpose of this installation is to demonstrate that the use of kenaf can be a suitable substitute for the conventional wood chip and woodyard operations in a pulp mill.

Not only did the study result in a commitment to build the plant, it also led to the formation of a farmers' cooperative as a source for assuring a competitive and continuous supply of kenaf fiber at all times. The 35 members participating in the initial formation of the cooperative planted approximately 815 hectares of land with kenaf seed in May and June 1991. This cooperative will be the sole provider of raw material to the fiber separation facility.

Pulping of the kenaf fiber

Data available from commercial and laboratory scale pulping of kenaf supports the conclusion that the pulping of the kenaf fiber should not present a barrier to the implementation of a commercial scale pulp mill operation in developed or developing countries (1, 2, 10-12). Laboratory trials have been conducted in Australia, Japan, and Canada on the chemical pulping of the separated long- and short-fiber components. The pulping of the whole stalk plant was developed on a commercial scale in a continuous chemical pulping operation in Thailand. In North America, mill scale trials were conducted on the chemical-thermomechanical pulping of the whole stalk kenaf. Extensive pulping experience with other nonwood fibers further indicates the technical feasibility of pulping kenaf fiber on a commercial scale.

Kenaf fiber growing costs

The cost of agricultural production for the kenaf fiber must be examined in developed and developing countries. The following is a comparison between kenaf production costs in the United States, Australia, India, and Thailand. In the analysis, there will be no attempt to compare the cost of wood chip and woodyard operations with the cost of processed kenaf fiber to a pulp mill. Rather the information provided will compare the kenaf fiber production costs in different countries deliv-

ered to the site of the pulp mill or processing plant.

Kenaf fiber is stored by farmers after being harvested and compacted in the field. Delivery of the fiber is coordinated with the requirements of the mill and the cost of storage is included in delivery costs in this paper. In developed countries, the harvested kenaf crop is delivered to the processing plant in square bales or large modules and the condition of the fiber is a.d. to approximately 10% moisture content. In developing countries, the whole stem kenaf is tied together into bundles and transported to the mill in a.d. condition. The kenaf fiber may be processed by the pulp and paper industries as whole stem or separated into the long- and short-fiber components.

Table VI shows data for kenaf fiber production costs for Australia, India, and Thailand compared to the values for the United States. The yields and input costs shown in this table for growing kenaf offer farmers commercially acceptable returns compared to alternate crops. The difference between the highest and the lowest delivered fiber cost is just under 30%. This range is quite small when considering the differences in the developed and developing countries between the technologies and methods used for production, processing, and distribution.

Kenaf as an alternate crop

In many developing countries, there are significant amounts of agricultural residue being processed as fiber for the pulp industry: bagasse, rice straw, straw, etc. The fluctuations of supply, quality, and price—as well as the location of the producing areas—limit the large scale use of these fibers as long-term alternatives for the pulping of forest products.

The utilization of high-yielding kenaf varieties can compete in cost, quality (2), and availability on a large scale, as shown in Table VI, provided suitable climatic conditions exist and

large enough land areas are available. Kenaf is both an alternative and a complementary crop for soybeans and cotton in the southern United States. In Australia, it can replace wheat, rice, and—to a certain extent—sugar cane, depending on the location of producing areas. In Thailand, it is a very attractive alternative to cassava and plantation eucalyptus. There is likewise an advantage in India where the jute industry is suffering from the problems of overproduction and a shrinking demand with the concomitant downward trend of prices.

There is no shortage of land for kenaf production in India, Thailand, and in most of the countries in Asia. These areas rely heavily on the importation of long-fiber pulps for which they have to find foreign currency. Land is available in southern and central Europe (13) where the countries are seeking alternative industrial crops to the heavily subsidized, conventional agricultural products.

Very large areas are available for kenaf production in the southern United States and Australia with opportunities in South America and to a lesser extent in Africa.

Due to its potentially favorable impact on the economies of many developing and developed countries, kenaf is the nonwood fiber plant which is most likely to be used to fill the anticipated gap in fiber requirements. Furthermore, it is correct to assume that, once a large-scale fiber production business has been operating for a period of time, the productivity of the operation will increase quite significantly. The historical evidence supporting this statement (14) was collected over a period of 60 years for crops like soybeans, cotton, and rice. The data indicates a yield increase in the order of 200% over this period for each of these crops.

Apart from the normal learning experience which is required, the improvement in productivity is due to the development of new technologies and cultivars, all of which have occurred during this period.

In a competitive economy, such improvements will lead to a decrease in price in the long term. These improvements of productivity and related reduction in fiber costs are more likely to take place in the open economies of the developed countries. Therefore the cost of kenaf production as illustrated in Table VI should be improving in favor of the developed countries over the long term unless the developing countries elect to use similar or comparable capital intensive technologies in the future.

A commonly held view today among the pulp industry experts of developed countries is that the production of nonwood fibers is not viable or competitive in their economic environment. The same industries, on the other hand, are prepared to accept a heavy long-term reliance on wood fibers due to a perceived lack of alternatives in the face of increasing shortages and an anticipated higher price structure (9). Based on the information above, however, it may be concluded that nonwood fibers and kenaf in particular will have an important role to play in the future to meet the fiber requirements of both developing and developed countries.

Environmental considerations

From an environmental point of view, the public has demonstrated an eagerness to buy products having a favorable environmental impact. Recent demand and ready acceptance of nonbleached paper products in markets traditionally placing a premium on brightness demonstrates this. The labeling of recycled paper products attracts a sufficient marketing advantage with a segment of the public to justify the extra cost, promotion, and effort required.

It is therefore reasonable to assume that it would be possible to develop a competitive range of paper products based on kenaf and that these products would appeal to a large segment of the population in all countries. Worldwide the purchasing public is

becoming increasingly conscious and environmentally aware of the need to preserve forests. Therefore it is very likely that kenaf will soon be recognized as an alternative fiber source to the increasing utilization of forest resources.

Conclusion

If there is no increase in the demand for paper and paper products after 1990, no additional fiber sources or growing lands will be necessary since the current fiber supply is sufficient to maintain production at existing levels. As shown in Table IV, however, the 12.86 million hectares of land needed to produce the current fiber requirements in 1990 will almost double to 23.04 million hectares in 2010. It should be possible to develop a competitive range of paper products based on kenaf. These products should appeal to a large segment of the population of all countries where there is a desire to preserve forests for environmental reasons.

The harvests from the plantings of the farmers' cooperative on 815 hectares in Mississippi—which will be used in the newly built commercial kenaf production, fiber separation, and processing plant—will be the first step in the world effort to utilize kenaf in the pulp and paper industries. ■

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The author thanks the Tennessee Valley Authority, the Mississippi Agricultural and Forestry Experimental Station, the Mississippi Delta Fiber Cooperative, and the American Paper Institute for their support.

Received for review Jan. 14, 1992.

Accepted April 29, 1992.

Presented at the China TAPI 1992 International Nonwood Fiber Pulping and Papermaking Conference.