Review of kenaf as potential source of pulp

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SUMMARY

Bamboo forms a major portion (above 80%) of the fibre source for paper making in our country. However, sharp declines in its supply have prompted a closer look to the possibilities of increasing the use of non-conventional materials for pulp and paper production. The demand for forest based and agriculture based materials is likely to exceed supply in near future.

Kenaf is one such fibre source having the best prospects for commercial development in our country. Detailed pulping and agronomic research programmes are essential to establish the suitability of kenaf as potential source of pulp.

The paper out-lines the pulping and agronomic research programmes conducted in the U.S.A., Australia and other countries. Brief details are also given of commercial developments arcund the world into the utilisation of kenaf for pulping,

Kenaf bast fibres are relatively long (2.6 mm) where-as the core materials contains very short (0.6 mm) fibres. But recent developments on wole kenaf use have shown promising results. Yield of 4 to 10 tons of dry material per acre have been obtained annually.

The use of kenaf on increasing scale is recommended to attain the target of 4.6 million tons of production in our country by the turn of the century.

Bamboo forms a major Portion (above 80%) of the fiber source for paper making in our country whereas wood is the principal raw material (above 90%) for the production of paper pulp around the world.

However, sharp declines in the supplies of bamboo and hardwoods in our country have prompted a closer look to the possibilities of increasing the use of non-conventional materials for pulp and paper production.

All of us know that depleting forest resources have created panic in the minds of paper manufacturers and most of the units are frantically trying hard to meet the demand for uninterrupted fiber supply as the demand for forest based and agriculture based materials is likely to exceed supply in the near future.

In 1976, the world consumed 154 million metric tons of paper and paper board products and produced 122 million metric tons of pulp. These consumption and production statistics are 11% greater than for 1975 recession year and are similar to record heights of 1974.

About 93% of the world's fibre used in the manufacture of paper and board is derived from forests. The other 7% comes from bagasse, bamboo cereal straws, leaves and other fibrous annual plants.

The increased demand for fiber will need to be met by one or more of several potential supply sources : (a) increased harvest of the world timber supply (b) improved production of timber (c) increased yield by better control of pests and catastrophies, (d) increased utilisation of forest waste, (e) increased utilisation of waste paper or (f) increased utilisation of non-wood fibrous plants.

The use of waste and new fiber will have profound impact on the properties of raw materials available from the forest. Perhaps the greatest potential for increasing world fiber supply rests with the

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p oduction of non-wood plants. The advantages of annual plant include :

1) annual re'urn on investment,
2) improved planning through short term forecasting, and
3) greater flexibility in land use.

Aside from bamboo, much of the fibrous non-wood raw material in world usage accumulates as residue from harvesting and processing of agricultural crops for their primary food and feed components.

It has now become highly essential to assess the prospects of cultivating annual plants specifically for pulp production. Kenaf (Hibiscus cannabinus and Hibiscus safdariffa) is one such fibre source having the best prospects for commercial development in our country. Detailed pulping and agronomic research programme are essential to establish the suitability of kenaf as potential source of pulp.

Considerable amo nt of work is already reported in literature (see references) and special conferences were held in USA, Australia and elsewhere to review the prospective crops like kenaf.

Kenaf is an herbaceous annual plant with a straight unbranched stem that can attain a height of 6 meters and produce dry stem yields upto 20-30 tons per hectare.

The paper outlines the pulping and agronomic research programme conducted in the USA and other countries. Brief details (Ref. No 2) are also given of commercial developments around the world into the utilisation of kenaf for pulping.

The term kenaf is used here to cover the two allied species of Hibiscus cannabinus and H. Sobdariffa. The latter species is widely grown in Thailand where it is referred to as kenaf but the correct common name is rosselle.

The history of the usage of kenaf for pulp production goes back at least as far as last century with a mention by Watt (Ref. No. 3) in 1809.

In his dictionary of the Economic Plants of India, Watt mentions that the fibre of kenaf (H. Cannabinus), at that time known as The Deccan Hemp, was used in Bengal for the same purpose as jute, including the production of pulp. He sites tests with 39 gsm paper in which the paper made out of kenaf fibre was superior in strength to the paper made from Bank of England note pulp.

Biswas (Ref. No. 4), referring to H. Cannabinus states, "In Dacca, East Bengal, the plant forms the chief material in manufacture of paper." This is the earliest reference available on the use of whole plant of kenaf for pulping and paper making.

Lathrop and Nelson (Ref. No. 5) provide the earliest detailed data on the composition of a number of leaf and bast fibers, including kenaf, their requirements for pulping and characteristics of the pu p: In the pulping study of non-woody plants s arted in 1956. in USA (Ref. No. 6), a member of Malvaceae family, was selected as having the best potential for the production of pulp and an intensive pulping and agronomic research programme was initiated.

This large programme had been undertaken in Florida, Cuba, Guatemala and El Salvador and had produced a number of high yielding cultivars and considerable information on the agronomic requirements for growing the crop for fibre.

Kenaf which can be harvested yearly compared to the 15 to 20 years required to grow alpine tree, is considered to be nine times more profitable than wood and much easier to cultivate. American newspaper editors keen on cutting production costs, have sponsored several studies on the potential economic benefits of this plant.

A private company in Maryland has concluded that kenaf not only would lower newspaper production costs and creating jobs in the agriculture sector, but it would stimulate the chemical, transport and other related industries.

These initial studies have prompted throughout the world to call for further indepth research. The International Federation of Newspaper Editors, which met in Oslo, Norway, last May, called for expanding kenaf production and developing new technology to exploit all the advantages offered by the plant.

The federation also recommended establishing contracts with agricultural associations, publishing houses and other national and international organisations that would contribute to the development of the plant.

Newspaper editors intend to lobby at the December meetings in Paris of the International Programme for the Development of Communications (IPDC), for funds to support further research into kenaf development in the Third World.

AGRONOMIC STUDIES WITH KENAF :

The plant kingdom provides a reservoir of 2,50,000 to 3,00,000 known plant species. Fewer than 0.1% are commercially exploited in the world. From this plant resources annually renewable fiber for pulp and paper could be identified. The studies (Ref. No. 7) revealed some promising species belonging to Malvaceae (Mallow), Gramineae (Grass) and Leguminosae (legume) families. The laboratory studies on sulphate pulping revealed that the species of greatest potential were of the genera Hibiscus, Crotalaria, Sorghum, Cannabis, Gynerium, Lygeum, and Sinarundinaria.

Native to East Central Africa, kenaf is herbaceous annual with straight slender stems often reaching heights of 5-6 meters or more and is largely unbranched in dense stands. Basal diameters may exceed 5 cm. Late maturing varieties require short days for floral initiation. The seeds weigh about 25 g/1000. H. Cannabinus is grown in Central America and South east Asia, however, the term kenaf frequently implies Hibiscus sabdariffa or roselle which is grown much more extensively in our country. Of the two, kenaf (H.+Cannabinus) is much more productive than roselle (H. Sabdariffa).

Under a variety of local names kenaf has been cultivated in many parts of the world as a source of bast fibers.

The crop is fast growing and is capable of producing upto 15 ADMT per hectare in 3 to 5 months.

STUDIES IN USA

The research programmes on kenaf have started more than two decades ago in US. Experimental plots of kenaf have been grown throughout the United States (Ref. No. 8).

In recent years, the US Agronomic research programme on kenaf has been largely centred at the United States Department of Agriculture (USDA) Research Centre, Beltsville, Maryland. The studies have covered the differential response of cultivars to the fungal disease *Botrytis Cinerea* and the effects of different population densities and sowing dates on growth and yields. Some work was also done to assess the effectiveness of a number of herbicides in controlling weeds in kenaf. Studies conducted in Georgia and Maryland showed that trifluralin at 2.8 kg/ha was effective where the weeds were primarily grasses.

Stem yields in Georgia have been as high as 27 metric tons per hectare; in Texas, 34 metric tons per hectare and in Florida, 45 metric tons per hectare (REF. NO. 9, 10).

The bast fibers, similar to jute fiber, constitute about 20% of the stalk's dry weight. For pulping, the interior woody portion of the stalk should also be incorporated for best economy.

The selection and breeding programme with kenaf and rosselle is continuing at Savannah, Georgia. The main selection criteria are, vigor, non-branching habit, entire leaves and green stems. Several lines of roselle appear very promising.

STUDIES IN AUSTRALIA

In the early 1950's, trials were conducted with kenaf and other fibre crops at South Johnstone in the wet tropics of North Queensland (REF. No. 11) and at Grafton in New South Wales in response to shortage of vegetable fibres on the world market. The pulping studies with kenaf in USA lead to a number of trial sowing in Australia. In the late 1960's APM Ltd. conducted trials near Coffs Harbour in New South Wales and S. E. Queensland as part of a study investigating alternate sources of long fibred pulp.

The first detailed agronomic studies in Australia to establish the cultural requirements of kenaf when grown for pulp production were commenced at the Ord Irrigation Area in 1972.

The studies at Ord indicated that, with irrigation, kenaf could be grown year—round for pulp production at a cost competitive with wood (REF. No. 12).

Harvesting trials with kenaf have been conducted at several locations in Queensland. The trials clearly established that standard sugarcane harvesters would satisfactorily harvest kenaf (REF. No. 13).

STUDIES IN OTHER COUNTRIES

In the traditional kenaf growing countries like India, Bangladesh and Thailand, there is extensive body of information on the cultural requirements of kenaf grown for fibre. While much of this is still relevant when the crop is grown for pulping, there have been few published studies on the specific cultural requirements for this form of utilisation. Sholton (REF. No. 14) has closely examined cultural practices in N. E. Thailand and suggested procedures for gathering, bundling, drying, trimming and transporting whole kenaf stems for pulping. All kenaf in N.E. Thailand is grown by small-holder subsistance farmers and all operations are done manually.

The North East Agriculture Centre in Thailand has conducted some plant population, row spacing and cutting trials to establish optimum requirements of kenaf crops grown for paper pulp.

PULPING STUDIES WITH KENAF

A technical seareh on kenaf will reveal more than 1000 references of which almost 200, all in the period 1950 to 1976, were on kenaf for paper pulp.

Kenaf is a dicotyledon having about 40% bark and 60% core. The bark has much longer fibres, 2 6 mm on average, compared to 0.6 mm for the core and cantains more cellulose and less lignin than core (REF. No. 15).

For these reasons bark gives higher yields with less alkali use when pulped, and the resultant pulps

had much higher tearing strength (REF. No. 16).

KRAFT AND SODA PULPING

Although sulfate pulping has been investigated more thoroughly, soda and neutral sulfite have also been studied (REF. No. 16, 17, 18 & 19).

Data on sulfate and soda pulping indicate that, in contrast to the long recognized superiority of sulfate or kraft wood pulps over wood soda pulps, strength characteristics of kenaf soda pulp were equal to those of their respective sulfate pulps (REF. No. 16).

Comparable yields of kenaf pulp are obtained by the two processes. However, drainage of kenaf soda pulps is slightly better than that of the kenaf sulfate pulps. Kenaf and wood pulps combine with synergistic effects (REF. No. 20).

NSSC PULPING

Sodium and ammonia based NSSC pulping gives higher yields with lower alkali use than chemical pulping (REF. No. 15). The paper making properties of NSSC bark pulps are comparable with those for the chemical pulps whilst those of the core pulps are lower in tearing strength but higher in bonding strength. The pulp drainage rates are superior to the rates of the chemical pulps. Kenaf pulps give a range of acceptable blends.

EXPLOSION PULPING

Using sodium hydroxide as the pulping reagent, the explosion process had a similar alkali demand to conventional batch cooking when pulping both kenaf wood and kenaf bark (REF. NO. 21).

However the explosion process was faster and pulp of Kappa number 30 could be prepared in cycle times of 20-35 min. as against 2.75 h. by the conventional method.

CHEMIMECHANICAL AND CHEMITHERMO-MECHANICAL PULPING OF KENAF

Long fibered pulps of high tearing strength can be made from the bark fraction by mechanical or chemimechanical refining. The high yield pulping processes like RMP, TMP, CMP and CTMP have been tried with kenaf (REF. No. 22).

SEPARATED BARK AND CORE

Being a dicotyledonous plant, kenaf contains two principal types of fibers. The stem consists of 2 parts bark, which contains the bast fibers, and 3 parts core. Relative to the core, the bark contains more cellulose and correspondingly less pentosan and lignin (REF. No. 23). Core fibres have a lower ratio of cell wall thickness to cell diameter than bark fibers (REF. No. 24) and this contributes to their characteristic flexibility (REF. No. 25).

Properties of these fibers suggest a range of potential uses. Bark pulp provides porous high-strength sheets, and core pulp yields smooth dense sheets (REF. No. 26).

KENAF PULP BLEACHING

The CEH, CdEHD processes were tried. The four stage process provided bleached pulps at nearly 90% brightness (REF. No. 21) Some bleaching studies have been done using CE and CdE sequence (REF. No. 27, 28).

RAW METARIAL PROCESSING AND CLEANING

Green secculant or low moisture, field dried kenaf stems can be processed to high quality chemical pulps. However, it has generally been recommended that leaf top of the green plant be removed before pulping. Removal of juices and solubles from green stalks reduces chemical requirements during pulping and subsequent bleaching without loss of strength. Kenaf juice contains sugars, mainly fructose and glucose, and nonprotein nitrogen. The juice would be a promising nutrient for fermentation media.

The feasibility of dejuicing the green plant before pulping would depend on the economics of juice solids, pulping chemicals, and transportation.

HARVESTING AND HANDLING

Equipment especially designed to harvest kenaf is not available; however, it has been harvested with commercially available equipment. Sickle-bar mowers have been used without difficulty and mower-conditioners render material amenable to farm type pick-up balers. Whole stalks can be harvested and bundled with binders designed for corn or other tall plants. For special uses requiring separation of bark and core, decorticating equipment might also have application in kenaf processing. Since kenaf has a relatively low density of 16 lb/cu ft and a bulk density chopped of 5.5 lb/cu ft, it might be desirable to increase the density for economy in handling.

STORAGE

To ensure the mill of a continuing supply of raw material, the timing of seeding should be consistant with scheduled demands of the mill.

Storage is necessary in areas where multiple cropping is not feasible. One form of storage would

be to extend the harvest time (REF. No. 29). Unlike most annual crop, kenaf can be harvested for several months, begining with green kenaf at 120 days after planting and continuing several weeks or even months.

COMMERCIAL DEVELOPMENTS

The Phoenix Pulp and Paper Company has started a bleached kenaf market pulp mill at Bang Pa-in, Thailand for production of 70,000 tons of whole kenaf pulp annually. The Company has established its own demonstration farms and extension services to assist farmers to increase their production of kenaf.

If problems in growth, collection, storage and processing economically are overcome, then kenaf can be one of principal non-conventional raw material available for commercial exploitation around the world.

CONCLUSION

In conclusion, it is hoped that with this review of the research work, that has been carried out in many parts of the world, a better understanding has been obtained on the problems and possibilities of kenaf for paper pulp.

It appears that there is sufficient research information on hand on the pulping of kenaf. Therefore, the time has now come to take the practical step of setting up additional raw fiber preparation system equipment that would require fiberizing bagasse or straw pulp mill of modern design so that appreciable quantities of pulp could be made available for papermaking runs and trials for market acceptability. In addition, parallel technical and economic investigations in depth should be made to evaluate kenaf whole stalk and its woody core fraction for newsprint and reconstituted panel—board so that commercial developments in these areas of manufacture can go forward as well.

ACKNOWLEDGEMENT :

The author is grateful to Shri N. S. Sadawarte, Jt. Managing Director, The Central Pulp Mills Ltd. and President, IPPTA for his kind guidance in the preparation of this paper.

He is also grateful to Dr. P. M. Parkhe, Managing Director, Paper and Pulp Conversions Ltd. and Managing Trustee, Parkhe Research Institute for permission to publish the article.

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