1998
TAPPI
PROCEEDINGS

NORTH AMERICAN NONWOOD FIBER SYMPOSIUM

February 17-18,1998
Atlanta, Georgia

COSPONSORED BY:

USDA BIOBASED PRODUCTS COORDINATION COUNCIL

TYPES AND AMOUNTS OF NONWOOD FIBERS AVAILABLE IN THE U.S.

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ABSTRACT

Three potential sources of nonwood fibers for paper production are considered: crop residues from point source processing centers, food crop residues, and crops grown for their fiber alone. Use of any of these fiber sources will depend on cost, availability, and suitability. Very approximate estimates of the quantity for each of these sources are presented along with data on cellulose and lignin content and fiber length and width.

INTRODUCTION

There is a greater awareness of the need for paper in an expanding world population and increasing affluence. It took all of recorded history for the world population to reach 1 billion by 1830. In 1930, just one hundred years later, world population had doubled to 2 billion. At the present rate of population growth we now add 1 billion people every eleven years.

The traditional source of fiber for paper in the U.S. has been wood and this will continue to be the major source. Wood has a higher density than annual plants so there will be more bulk when using nonwood agricultural crop fiber. There are also concerns about the seasonality of annual crops which requires considerations of harvesting, separating, drying, storing, cleaning, handling, and shipping. In the present system of using wood storage costs can be reduced by letting the tree stand alive until needed. With any annual crop, harvesting must be done at a certain time and storage/drying/cleaning/separating will be required. This will almost certainly increase costs of using nonwood resources over wood depending on land and labor costs, however, in those countries where there is little or no wood resource left or where restrictions are in place to restrict the use of wood alternate sources of fiber are needed if there is to be a paper industry in those counties.

Nonwood, agro-based fibers have been utilized for thousands of years for paper. Hemp and ramie fiber were reportedly used as early as 105 A.D. in China to make paper (Young 1997). The use of straw for production of paper was established well before the advent of wood-based papers. Collectively, society learned very early the great advantages of using agro-based resources that were widely distributed, locally available, multi functional, strong easy to work, and renewable. In more recent times, the use of nonwood agro-based fibers for paper has increased dramatically and a considerable amount of literature has been published on these applications.

While the use of nonwood fiber for paper is very limited in the U.S. (less than 1% of total capacity), counties such as China, India, Pakistan, Peru, Thailand Venezuela, Greece, Egypt, Cuba, Iraq, and Vietnam mainly or exclusively use nonwood fiber for paper (Young 1997). Worldwide, about 10% of all paper produced comes from nonwood sources.

This conference is evidence of a renewed interest in the use of non-wood, agro-based resources for paper. This resouce includes point source waste residues, agricultural crop residues, and a wide variety of plants that are now or could be grow for fiber production.

FIBER SUPPLY

In any commercial development, there must be a long term guaranteed supply of resources. In order to insure a continuous fiber supply, management of the agricultural producing land should be under a proactive system of land management whose goal is both Sustainable agiculture and the

promotion of healthy ecosystems. Ecosystem management is not a euphemism for preservation, which might imply benign neglect. Sustainable agriculture denotes a balance between conservation and utilization of agricultural lands to serve both social and economic needs, from local, national and global vantage points. Sustainable agriculture does not represent exploitation but rather is aimed toward meeting all the needs of the present generation without compromising the ability of future generations to meet their needs. It encompasses, in the present case, a continuous production of fiber, considerations of multi-land use, and conservation of the total ecosystem (Rowell 1997).

There are a wide variety of nonwood, agro-based fibers to consider for paper production (Institute for Local Self-Reliance 1997, Atchison 1994, USDA, Agricultural Statistists 1993, USDA, Economic Research Semite 1997, White and Cook 1997). All of them should be considered to take advantage of cost, availability, and suitability. Unless one particular fiber has some advantage in the market it will be replaced with whatever resource has the market advantage. Three potential sources of nonwood fibers will be considered in this paper. The most cost effective sources on nonwood fibers would come from crop residues from point source processing centers. These represent resources such as rice hulls, sunflower seed hulls, cotton linters, sugar cane bagasse, rind residues from juice and fruit plants and stalk residues from food processing plants. The second most cost effective source of nonwood fibers would be food crop residues which are presently,

Table 1 - Inventory of U.S. non-wood fibers

Fiber Source	Potential Quantity (dry tons)		
	ILSR[1]	Atchison[2]	USDA, Ag Stat[3]
Stalks			
Corn	245,400,000	150,000,000	300,800,000
Wheat	112,700,000	76,000,000	78,900,000
Barley	20,800,000	7,000,000	12,000,000
Sorghum	13,500,000	28,000,000	33,700,000
Oat	10,700,000	5,000,000	6,000,000
Rice	7,400,000	3,000,000	7,500,000
Cotton	5,100,000	4,600,000	7,100,000
Flax (seed)	4,500,000	500,000	700,000
Rye	1,500,000	400,000	400,000
Grass (seed)	1,200,000	1,100,000	900,000
Soybean		7,730,000	
Sugar cane bagasse	4,900,000	4,400,000	3,000,000
Husks from grain mills	20,000,000[1]		
Corn cobs	1,350,000[1]		
Kenaf	13,800[4]		
Peanut and other hulls	3,200,000[1]		
Cotton linters		500,000	500,000
Cotton lint		3,500,000	3,500,000
Citrus rinds	10,000,000[5]		

[1] Institute for Local Self-Reliance 1997.

[2] Atchison 1994.

[3] USDA, Agricultural Statistists 1993 and USDA, Economic Research Service 1997

[4] Kugler 1997 (based on 9,860 acres of kenaf using an estimate of 1.4 tons of bast fiber per acre).

[5] Based on an estimate that half the green weight of each citrus fruit is dry residue.

for the most part, left on the land for soil improvement. Finally, there are potentials to grow crops for their fiber alone. Utilization of these fiber sources will be based on cost, availability, and suitability.

There are many estimates on the availability of nonwood fiber for the production of paper. Table 1 shows the inventory of some of the larger sources of nonwood fiber that could be utilized for paper. The data for this table was extracted from several sources using estimates and extrapolations for some of the numbers. For this reason, the data should only be considered to be a very rough estimate of potential U.S. nonwood fiber resources. It can be noticed in Table 1 that differing estimates of available residues exist. No one source of inventory exists and the data is scattered in a wide variety of sources. An effort must be made to collect this data in one reliable source.

There are many other sources not listed in Table 1 that are potentially available for paper production but no inventory data could be collected. These include bean and pea stocks, tobacco stalks, hay, weeds, beet pulps, grasses, and fiber from municipal waste.

Kenaf is the only plant listed in Table 1 that is grown exclusively for its fiber. There are many other potential plants that could be grown for fiber if it was cost effective (Berger 1969, Dempsey 1975, Catling and Grayson 1982). Kenaf, flax, and hemp fiber are used today for specialty papers. Some common fibers grown round the world could be grown in the U.S. Table 2 shows some of the climatic requirements for some of the common plants that could be grown for fiber. Most of these plants are or could be grown in the U.S.

Table 2. Climatic requirements for some common agro-based fibers

Common Name	Optimum Temperature (°C)	Minimum Moisture[1] (mm)	Optimum Soil pH	Growing Cycle (days)	Fiber Yield (kg/hectare)
Flax	10-20	150	5.5-7.0	85-120	1100
Hemp	13-22	125	7.0-7.4	130-180	1225
Ramie	20-30	140	5.4-6.4	45-60	550
Jute	18-33	250	6.6-7.0	120-150	2200
Kenaf	22-30	120	6.0-6.8	150-180	1700
Roselle	25-30	150	5.2-6.4	150-180	2600
Urena	21-27	160	about 7	120-180	2200
Sunn Hemp	18-33	---	---	90-120	3610
Sisal	25-30	120	about 7	continuous[2]	3360
Cotton	21-25	175	5.2-7.0	180-200	790
Abaca	25-29	200	5.2-6.4	continuous[3]	3000
Kapok	---	120	5.2-6.4	---	---

[1]Water required during the growing season, [2]12-15 year plant life cycle, [3]7-8 year plant life cycle.

For most of the plants listed in Table 2, only the past fiber is used for products. In all cases, this represents a very small percentage of the total plant mass. Table 3 shows the percent of plant mass that is contained in leaves and bast fiber. If the total dry weight of each plant were used to produce fiber, the yield would be much higher but the fiber may not be suitable for paper production.

Table 3. Percent of plant mass in leaves and isolated bast or tow fiber

Common Name	Percent of total dry mass in: Leaves	Fiber (tow or bast)
	%	
Flax	---	4-8
Hemp	12.5	4-5
Ramie	7.2	3-4
Jute	3.9	5-7
Kenaf	3.3	4-5
Roselle	3.6	4-5
Urena	8.7	5-6
Sunn Hemp	4.0	3-4
Sisal	97	3
Cotton	20	10-11
Abaca	–	3-4

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Table 4 shows the chemical imposition and fiber dimensions of many different types of plant fibers (Esau 1977, Iivessalo-Pfaffli 1995, Han and Rowell 1997). This type of data is critical in order to determine if a given fiber is suitable for paper production. While this type of data exists in the literature for some types of nonwood fibers, the data is incomplete. There needs to be a concerted effort to expand the data base to include all potential fiber sources.

Table 4. Dimensions and chemical composition of some common agro-fibers[1]

Type of Fiber	Cellulose (%)	Lignin (%)	Fiber Dimension (mm) Mean Length	Mean Width
Cotton	85-90	0.7-1.6	25	0.02
Seed Flax	43-47	21-23	30	0.02
Hemp	57-77	9-13	20	0.022
Abaca	56-63	7-9	6.0	0.024
Coniferous wood	40-45	26-34	4.1	0.025
Sisal	47-62	7-9	3.3	0.02
Bamboo	26-43	21-31	2.7	0.014
Kenaf	44-57	15-19	2.6	0.02
Jute	45-63	21-26	2.5	0.02
Esparto	33-38	17-19	1.9	0.013
Papyrus	38-44	16-19	1.8	0.012
Sugar cane bagasse	32-37	18-26	1.7	0.02
Cereal straw	31-45	16-19	1.5	0.023
Corn straw	32-35	16-27	1.5	0.018
Wheat straw	33-39	16-23	1.4	0.015
Rice Straw	28-36	12-16	1.4	0.008
Esparto	42-54	17-19	1.2	0.013
Deciduous wood	38-49	23-30	1.2	0.03
Coir	35-62	30-45	0.7	0.02

[1] Listed by increasing mean fiber length

CONCLUSIONS

There are many potential sources of nonwood fiber that can be used for paper production. Accurate inventory on crop residues from point source processing centers, food crop residues, and crops grown for their fiber alone are, at best, scattrered, and at worst, not available. A single source of accurate inventory is needed. Estimates of this inventory indicate that there are millions of tons of nonwood fibers potentially available. There is still incomplete information on availability, suitability, sustainability, storage, and cost. Markets will not be fully realized for nonwood fiber sources until this type of data is collected, analyzed, and applied.

ACKNOWLEDGMENTS

The authors thank several people for their help in supplying data and projections for this paper. These include Michelle Carstensen, (Institute for Local Self-Reliance), Dan Kugler, (USDA, CSREES), Frank Werber (USDA, ARS, retired), and Frank Riccio, Jr. (Danforth International).

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