Fibre Dimension Studies of Some Hardwood and Grass Species of Bangladesh

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There are more than 500 tropical hardwood species and a number of grass and bamboo species in Bangladesh. Only a handful of these are, at present, used for the manufacture of pulp, paper, fibreboard and rayon. Sundri and gewa of the Sunderbans and a number of hardwood species of the Chittagong area are used for the manufacture of paper and fibre boards. Rice straw and bagasse are also used for the same purpose. Besides, some bamboo species of the Chittagong Hill Tracts and three grass species of Sylhet district are, at present, used for the manufacture of pulp and rayon. Most of the other minor hardwood and grass species have practically no industrial use.

In this study, 20 minor hardwood species and 20 grass species of Bangladesh have been taken up with a view to determine their suitability for the manufacture of pulp. Runkel ratio, flexibility co-efficient and relative fibre length have been found out from the fibre length, fibre diameter, cell-wall thickness and lumen diameter of the fibres. From those data the tensile strength, tearing resistance and general suitability of the fibres for the manufacture of pulp and paper could be estimated. From the Runkel ratio obtained, it can be predicted that most of the species under study will be suitable for the manufacture of quality paper. Only Kannari and Jaikkagola among the wood species, daloo and lata bans from the bamboo species and nal, ikra and khagra among the grass species are likely to yield moderate quality pulp.

বাংলাদেশে পাঁচ শতাধিক গ্রীষ্ম মণ্ডলীয় বৃক্ষপ্রজাতি ছাড়াও বেশ কিছুসংখ্যক ঘাস ও বাঁশের প্রজাতি আছে। মণ্ড, কাগজ, তন্তু-তক্তি ও রেয়ন উৎপাদনে বর্তমানে এইগুলির সামান্য অংশই ব্যবহাত হয়। কাগজ ও তন্তু-তক্তি নির্মানে সুন্দরবনের সুন্দরী ও গেওয়া এবং চট্টগ্রাম অঞ্চলের কিছুসংখ্যক শক্তজাতের কাঠ ব্যবহার করা হয়। খড় ও আঁখের ছিব্ড়াও এই উদ্দেশ্যে ব্যবহার করা হয়। বর্তমানে মণ্ড এবং রেয়ন উৎপাদনে পার্বত্য চট্টগ্রামের

কয়েকটি বাঁশের প্রজাতি এবং সিলেট জেলার তিনরকমের ঘাস ব্যবহৃত হয়। বাকী অধিকাংশ শক্তজাতের কাঠ বা ঘাসের, বলিতে গেলে, শিল্পক্ষেত্রে কোন ব্যবহারই নাই।

মণ্ড উৎপাদনে ২০ জাতের ঘাস ও ২০ জাতের শক্ত কাঠের উপযোগীতা এই সমীক্ষায় নিরীক্ষণ করা হইয়াছে। ইহাদের আঁশের দৈর্ঘ্য, ব্যাস ও কোষ প্রাচীরের বেধের উপর ভিত্তি করিয়া রাংকেল অনুপাত, নম্যতাংক ও আপেক্ষিক তন্ত দৈর্ঘ্য নির্ণয় করা হইয়াছে। এই সমস্ত উপাত্ত হইতে কাগজ ও মণ্ড নির্মানে আঁশের টানন শক্তি, ছেদনরোধ ও সাধারণ উপযোগীতা মূল্যায়ন করা হইয়াছে। প্রাপ্ত রাংকেল অনুপাত হইতে সিদ্ধান্ত গ্রহণ করা যায় যে বক্ষ্যমাণ প্রজাতির অধিকাংশই উৎকৃষ্ট কাগজ নির্মানে উপযোগী হইবে। শুধুমাত্র কন্নারী ও জইক্কাগোল কাঠ, ডলু ও লতাবাঁশ এবং ইকরা, খাগড়া ও নল ঘাস হইতে মধ্যমমানের মণ্ড প্রস্তুত করা যাইতে পারে।

INTRODUCTION

There are more than 500 tropical hardwood species and a number of grass and bamboo species in Bangladesh. Only one bamboo species from the Chittagong region is, at present, used in the Karnaphuli Rayon Complex. A few more bamboo species are proposed to be used as raw material in the Sylhet Pulp Mill. Three grass species are also to be used in the same mill (1). These grasses are used as fuel-wood by the villagers. Some of the bamboo species find use in low-cost housing and handicraft industries. Only a few selected hardwood species are utilized industrially. The remaining wood, bamboo and grass species remain scattered throughout the Chittagong, Chittagong Hill Tracts and Sylhet districts of Bangladesh in varying quantities. Most of the species cannot even be used as fuel wood because of inaccessibility and high cost of felling and transportation. These are allowed to remain in the forests as cull timber or to rot after clear felling.

Karnaphuli Paper Mills in Chittagong Hill Tracts were originally designed to use Muli bamboo (*Molacanna bambusoides* Trin.) as its cellulosic raw material. Muli flowers gregariously over vast tracts of land and dies thereafter. The life-cycle is 45 years. Natural regeneration from seeds takes place periodically but it is obtained chiefly from rhizomes (2). When most of this species died after flowering, the mill was obliged to use hardwood species in lieu of bamboo. Later, a rayon complex was established on the same premises to manufacture rayon and cellophane from bamboo pulp. It has now become imperative to look for new sources and to study the morphological characteristics of the potential grass, bamboo and minor wood species for the manufacture of pulp, paper and allied products.

In this study, twenty minor hardwood species and twenty grass species have been taken for the analysis of fibre with a view to determine their suitability for use in the pulp, paper, board and other fibre products industries. The wood species grow mostly in the Chittagong and Chittagong Hill Tracts districts whereas nal (*Phragmites karka* Trin.), khagra (*Saccharum spontaneum* Linn.) and ekrah (*Erianthus ravannae* Beakle.) grow in Sylhet district. Other 17 grass species grow in the Chittagong, Chittagong Hill Tracts and Sylhet districts. The woody species grow gregariously in the forest to a height of 40-70 feet and from 1-4 feet in diameter at breast height. Most of these are fairly straight boled, but there are some crooked species as well. In general, the bark is smooth, and constitutes approximately 3-5 percent of wood by volume. Variations are found in a few species like champhata (*Sappium baccatum* Roxb.) which have barks with longitudinal ridges and furrows constituting about 10 percent of wood by volume. The density of these wood species vary from 40-70 lbs. /cubic feet in the green condition. Ekrah, khagra and nal are reeds growing in the marshy lands to a height of 15 feet or so.

Bamboo species vary greatly in diameter. Some do not exceed more than one inch in diameter whereas some attain a diameter of six inches. These grow to a height of 30-80 feet.

MATERIALS AND METHODS

Several cords of each of the hardwood species were collected from the Chittagong forests in green condition. These were chipped to the size of 1 inch x1/2 inch x 1/8 inch. Specimens were collected from the chips by way of random selection. Bamboos and grasses were collected from the Sylhet forests and specimens were taken after chipping. The wood and grass chips were macerated in a 1 : 3 mixture of a 10% solution of chromic and nitric acids. Temporary slides were made from the macerated fibres after throughly washing them with water. Cell-wall thickness and lumen diameters were taken by means of an eye-piece microscope. Cell-wall thickness was calculated as half the value of fibre diameter less lumen diameter, (F.D—L.D.) /2. Lumen diameter was taken by direct readings. Average of 100 readings was taken for each of the above measurements.

Table 1. Fibre dimensions of twenty hardwood species

Sl. No.	Local name	Botanical name	Family	Fibre length			Fibre diameter (mm)
				Max. (mm)	Min. (mm)	Average (mm)	
1.	Itchri	*Anogeissus acuminata*, Wall.	*Combretaceae*	1.638	1.092	1.369	0.024
2.	Amra	*Spondias pinnata*, Kurz.	*Anacardiaceae*	1.638	1.092	1.403	0.034
3.	Barta	*Artocarpus lakoocha*, Roxb.	*Moraceae*	1.274	0.546	0.762	0.026
4.	Champhata	*Sappium Baccatum*, Roxb.	*Euphorbiaceae*	1.438	0.546	1.035	0.030
5.	Gut-gutiya	*Bursera Serrata*, Colebr.	*Melliaceae*	1.638	0.819	1.255	0.023
6.	Chakua koroi	*Albizzia chinensis*, Merr.	*Leguminoseae*	1.456	0.546	1.010	0.025
7.	Kuramara	*Pithecolobium augulatum*, Benth.	*Leguminoseae*	1.456	0.546	0.951	0.030
8.	Jagga Dumur	*Ficus glomerata*, Roxb.	*Moraceae*	1.638	0.910	1.279	0.031
9.	Dharmara	*Stereospermum persenatum*, Chatt.	*Bignoniaceae*	1.456	0.764	1.994	0.021
10.	Kannari	*Gardenia c^{o}ronaria*, Ham.	*Rubiaceae*	1.547	0.965	1.318	0.025
11.	Jaikkagola	(Unidentified)	—	1.638	0.673	1.289	0.025
12.	Minjri	*Cassia siamea*, Lamk	*Leguminoseae*	1.128	0.546	0.770	0.021
13.	Mandar	*Erythrina indica*, Lamk.	*Leguminoseae*	1.547	0.728	1.106	0.032
14.	Pitali	*Trewia nudiflora*, Linn.	—	1.310	1.190	1.250	0.027
15.	Gurba	*Ilex godajam*, Colebr.	*Verbenaceae*	0.238	0.152	0.196	0.030
16.	Jalpai	*Elaeocarpus robustas*, Bl.	*Elaeocarpaceae*	1.492	0.874	1.901	0.020
17.	Udal	*Sterculia villosa*, Roxb.	*Sterculiaceae*	1.638	1.092	1.325	0.030
18.	Hargeza	*Dillenia pentagyna*, Roxb.	*Dilleniaceae*	0.217	0.152	0.183	0.038
19.	Hansak	*Xanthophyllum Flavescens*, Roxb.	*Polygalaceae*	0.184	0.076	0.147	0.029
20.	Assarh	*Grewia microcos*, Linn.	*Tilliaceae*	1.419	0.910	1.169	0.022

Table 3. Fibre dimension of twenty grass species

Sl. No.	Local name	Species. Botanical name	Family	Fibre length			Fibre diameter (mm)
				Max. (mm)	Min. (mm)	Average (mm)	
1.	Muli	*Melocanna bambusoides*, Trin.	*Gramineae.*	3.845	1.624	2.798	0.0401
2.	Mitinga Bans	*Bambusa tulda*, Roxb.		3.940	1.732	2.569	0.0306
3.	Hill Barua (Sal.)	*Bambusa balcooa*, Roxb.	,,	3.637	1.018	2.211	0.0237
4.	Bariala Bans	*Bambusa vulgaris*, Schrad.	,,	3.961	1.580	2.853	0.0261
5.	Bakal	*Bambusa pallida*, Munro.	,,	3.356	0.909	2.377	0.0256
6.	Kali Bans	*Bambusa auriculata*, Kurg.	,,	3.183	1.234	2.266	0.0265
7.	Burma Bans	*Thyrsostachys oliveri*	,,	3.139	0.974	2.473	0.0234
8.	Orah Bans	*Dendrocalamus longispathus*, Kurz.	,,	3.616	0.801	2.407	0.0315
9.	Tara Bans	*Melocanna bambusoides*, Trin.	,,	4.974	1.147	2.623	0.0304
10.	Parua	*Bambusa polymorpha*, Munro.	,,	4.221	1.104	2.761	0.0304
11.	Khang/Rupai	*Dendrocalmus longipathus*, Kurz.	,,	3.897	0.866	2.391	0.0248
12.	Daloo Bans	*Teinestachyum dullcoa*, Gamble.	,,	4.936	0.931	2.654	0.0241
13.	Bethua Bans	*Bambusa polymorpha*, Munro	,,	3.733	1.451	2.396	0.0231
14.	Pocha (Turi)	*Dendrocalamus hamiltonii*, Nees.	,,	4.265	0.909	2.660	0.0228
15.	Lata Bans	*Melocalamus compactiflorus*, Benth.	,,	4.915	1.299	2.817	0.0238
16.	Jai Bans (Jaibura)	*Bamboes balcooa*, Roxb.	,,	3.616	0.974	2.394	0.0228
17.	Budung Bans	*Dendrocalamus giganteus*, Munro	,,	3.745	1.212	2.534	0.0262
18.	Nal	*Phragmites karka*, Trin.	,,	—	—	2.464	0.0161
19.	Khagra	*Saccharum spontaneum*, Linn.	,,	—	—	2.612	0.0161
20.	Ekrah	*Erianthus ravannae*, Beakle.	,,	—	—	2.214	0.0144

In paper, the properties generally sought are good tear, burst, tensile and folding endurance values. These strength properties of paper, board and other fibre products depend to a great extent on the length of the fibres, as the bonding is effected by the fibres themselves rather than by external agents. So, the fibre-lengths is of importance to the manufacturers of these products. It has been seen that some pulps have very good tensile strength but lack in other properties. Similarly, some pulps may have good folding endurance values but may lack the remaining ones. To evalute the suitability of the species under study for making pulp products, different physical properties (Runkel ratio, Flexibility co-officient and Relative fibre length) have been determined by following standard procedures (6).

Runkel ratio, which is obtained by dividing twice the cell-wall thichness by lumen diameter, (2*C. W. T.*) / (*L. D.*) classifies the fibres into groups. The first group, which has a ratio less than unity should be quite good for use in paper-making, the second group which has a ratio approximately equal to unity should yield moderate quality pulp and the third group having a ratio more than unity is deemed to be poor in paper-making qualities(3). In this study it has been found that kannari (*Gardenia coronaria* Ham.) and jaikka gola (unidentified) among the wood species and daloo bans (*Teinestachyum dullcoa* Gamble.), late bans (*Melocalamus compactiflorus* Benth.), nal, ekrah and khagra among the grass species fall in the third group. Minjri (*Cassia siamea* Lamk.) and mandar *Erythrina indica* Lamk.) among the wood species and turi jai bans (*Bamboosa balcoea* Roxb.) and budung bans (*Dendrocalamus gigantius* Munro.) fall in the second catogory. The rest fall in the first catogory (Table 2).

Table 2. Relationship between fibre dimension and strength properties of Minor hardwood species

Sl. No.	Species (Local name)	Lumen diameter (F. D.-2C.W.T.) (mm)	Cell-wall thickness (F.D.-L.D.)/2 (mm)	Runkel ratio 2C.W.T/L.D.	Flexibility Ce-efficiant (L.D./F.D.)	Relative fibre length (F.L./F.D.)	Remarks.
1.	Itchri	0.016	0.0039	0.487	0.666	57.04	Good tear.
2.	Amra	0.024	0.0049	0.009	0.705	41.27	Good tensile
3.	Barta	0.017	0.0044	0.518	0.653	37.00	Good tensile
4.	Champhata	0.020	0.0045	0.490	0.666	34.50	Good tensile
5.	Gutgutiya	0.016	0.0035	0.437	0.695	54.56	Good tear
6.	Chakua koroi	0.019	0.0035	0.368	0.760	40.40	Good tensile
7.	Kuramara	0.020	0.0051	0.510	0.666	31.70	Good tensile
8.	Jagga Dumur	0.022	0.0048	0.436	0.709	41.25	Good tensile
9.	Dharmara	0.013	0.0042	0.646	0.619	52.09	Good tear
10.	Kannari	0.008	0.0085	2.125	0.320	52.72	Good tear
11.	Jaikka Gola	0.009	0.0080	1.777	0.360	51.56	Good tear
12.	Minjri	0.011	0.0052	0.945	0.523	36.66	Good tear
13.	Mandar	0.018	0.0072	0.880	0.563	34.56	Good tear
14.	Pitali	0.020	0.0036	0.360	0.741	—	Good tear
15.	Gurba	0.021	0.0053	0.505	0.700	06.53	Good tensile
16.	Jalpai	0.012	0.0039	0.650	0.600	54.55	Good tear
17.	Udal	0.018	0.0059	0.655	0.600	44.17	Good tear
18.	Hargeza	0.024	0.0068	0.566	0.631	04.82	Good tear
19.	Hansak	0.019	0.0051	0.537	0.655	05.07	Good tear
20.	Assarh	0.014	0.0041	0.585	0.636	53.13	Good tear

Table 4. Relationship between fibre dimension and strength properties of grasses

Sl. No.	Species.	Lumen diameter (F.D.-2 C.W.T.) (mm)	Cell-wall thickness F.D.-L.D./2 (mm)	Runkel ratio 2 C.W.T/L.D.	Flexibility Co-efficient (L.D./F.D.)	Relative fibre length (F.L./F.D.)
1.	Muli	0.0271	0.0065	0.4809	0.6758	69.79
2.	Mitinga Bans	0.0211	0.0047	0.4413	0.6895	83.95
3.	Hill Barua	0.0173	0.0032	0.3706	0.7299	97.55
4.	Bariala Bans	0.0201	0.0031	0.03043	0.7701	109.30
5.	Bakal	0.0186	0.0035	0.3811	0.7265	92.85
6.	Kali Bans	0.0189	0.0038	0.4000	0.7132	85.51
7.	Burma Bans	0.0160	0.0036	0.4533	0.6837	105.68
8.	Orah Bans	0.0206	0.0054	0.5262	0.6539	76.41
9.	Tara Bans	0.0203	0.0050	0.4943	0.6677	86.28
10.	Parua	0.0154	0.0053	0.6891	0.5945	106.60
11.	Khang (Rupai)	0.0152	0.0048	0.6319	0.6129	96.41
12.	Daloo Bans	0.0096	0.0072	1.49	0.3983	110.12
13.	Bethua Bans	0.0130	0.0509	0.781	0.5629	103.72
14.	Pocha (turi)	0.0114	0.0572	1.007	0.5000	116.60
15.	Lata Bans	0.0992	0.0692	1.395	0.4168	118.36
16.	Jai Bans	0.0122	0.0523	0.8577	0.5350	105.00
17.	Budung Bans	0.0185	0.0385	0.9044	0.7061	96.71
18.	Nal	0.0036	0.0057	3.167	0.25	153.7
19.	Khagra	0.0046	0.0058	2.527	0.2826	162.4
20.	Ekra	0.0044	0.0054	2.454	0.3034	169.9

Flexibility co-efficient obtained by dividing lumen diameter by fibre diameter, (*L. D.*) / *F. D.*) predicts that the higher the ratio, the better the tensile strength. Accordingly, it is found that amra (*Spondias pinnata*, Kurz.), chakua horoi (*Albizzia chinnensis* Merr.), Jagga dumur (*Ficus glomerata* Roxb.), pitali (*Trewia nudiflora* Linn.) and gurba (*Ilex godajam* Colour.) among the wood species have better tensile properties than others. In general, the bamboos yield paper with slightly better tensile strength than the wood species under study. Nal, khagra and ekra are, however, exceptions.

Relative fibre length, the ratio of fibre length and fibre diameter (*F. L.*) / (*F.D.*), is a measure of the slenderness of the fibres. The thinner the fibre, compared to the length, better the tearing resistance. These pulps, which give higher relative fibre length, should have better tearing resistance values. The wood species have been found to be yielding pulps having poor tearing resistance values. However, itchri (*Annegeissus acuminata* Wall.), gutgutiya (*Bursera serrata* Colebr.) dharmara (*Stereosprmum persenatum* Chatt.), kannari, jaikka jola, jalpai (*Elaeocarpus robusta* Bl.) and assar (*Grewia paniculata* Linn.) have been found to have comparatively better tear values among the wood species.

Nal, khagra and ekra are definitely better in this respect than all other species under study and in general the grasses promise to yield pulps having better tearing resistance values amony the wood species (5).

REFERENCES

1. Hossain, S. M., Razzaque, M. A. and Das, P. 1971. Chemical pulping of Sylhet grasses. Forest Research Institute Bull No. 5 (Pulp & Paper Series) pp. 1-7.
2. Rahman, S. A. 1973. Silviculture and Economics of Natural Bamboo Forests of Sylhet, Bano Biggyan Patrika 5 (1) : 11—27.
3. Runkel, R. 1952. TAPPI 35(4) : 174.
4. Runkel, R. O. H. 1949. Papier 3 ; (476-490.)
5. F A O. 1965. Ragio Industrielle dela cellulose celeniale, Pulp & Paper properties in Latin America. pp. 378-38.
6. Das, D. K. 1965. Fibre dimensions of Sylhet grasses, Science & Industry, 3 (4) : 314-320

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