Pulp And Paper Making Properties in 15 Clones of *Casuarina Equisetifolia*

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ABSTRACT:-- The dependence of the paper and paperboard industries on the forests is being increased significantly to meet the demands of wood raw material. In the paper industries, bamboos are the most popular forest wood for paper production. However, as bamboo wood is not available in sufficient, many paper mills have started using other forest woods for rayon and pulp production like eucalyptus, ***Casuarina, Leucaena, Acacia*** *etc. Casuarina wood has excellent multipurpose qualities to replace eucalyptus in paper industry.*

The present paper details the utility of Casuarina wood in paper and rayon industry. To find out the suitability of clonal material, 15 out of 55 clones of ***Casuarina equisetifolia*** *were analyzed for related traits. Of 15 analyzed clones, 5 clones were found promising for paper manufacturing. Total paper yield, from the pulp of these clones, was more than 50 per cent.*

INTRODUCTION

Ever increasing population has been depending on forests to meet their food, fodder, fuelwood, fibres, and many other basic needs since generations. The dependence on forests further increased in the beginning of the 19th century with the technological advances in plywood, paper, pulp, veneer and fibre, and since then wood has become an important industrial raw material (Hegde, 1993). Chadha et al. (1992) reported that 27.50 million m^3 wood is required annually for industrial purposes; of which, packaging alone consumed 6.80 million m^3 and little less, 6.57 million m^3, wood by paper and pulp industry. At present, only 12 million m^3 wood is available in the country against 27.50 million m^3 required, which leaves a gap of 15.50 million m^3 wood. Further, in India, the paper consumption is estimated to be around 3 kg per capita against Asian average of 18 kg and International average of 200 kg (Anonymous, 1994). With the growing population, emphasis on literacy through campaigns and liberalization of economic polices, per capita wood consumption would increase in forthcoming years resulting in increased demand of wood based raw material.

The most popular tree species which are in demand by paper industry are bamboos and eucalypts. There are many other species found suitable for pulp and paper production and are also having good potential under farm and agro-forestry systems. They are mostly Casuarina equisetifolia,

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Acacia auriculiformis, Leucaena leucocephala, Gmelina arborea, poplars and number of tropical pines (Hegde, 1993). Paper and paperboard industries can utilize wide varieties of hard woods in combination with bamboos, and thus bamboo utilisation can be brought down dramatically. For instance, Nepa Paper Mills, Madhya Pradesh, which uses bamboos and Boswellia sarrata in the ratio of 70 : 30, has reported that they can utilise 100 per cent Leucaena leucocephala (Hegde, 1988). The South India Viscose Limited, Coimbatore, uses Eucalyptus grandis wood for the production of viscose fibre which is used for textile industry. In fact, many rayon grade pulp mills of India have started using eucalypts and casuarinas for rayon pulp (Hegde, 1993) besides bamboos. Thus, it is necessary to select fast growing high yielding species of casuarinas and eucalypts, and further improve the quality of planting stock. Large valume of literature is available in eucalyptus improvement (Verma, 1994). With regard to casuarinas, however, lot of work needs to be done for production quality planting material.

Casuarinas contribute to considerable area of plantation forests, both in tropics and subtropics. The native of Australia was introduced to Indian subcontinent during 1860, by the Forest Departments. It forms a group of 96 species of which three species, Casuarina equisetifolia, Casuarina stricta and Casuarina suberosa, were introduced at the same time in the Nilgiris of the then Madras Presidency. However, Casuarina equisetifolia only was found to be the most suitable species for large scale plantation. Casuarina equisetifolia is planted in more than 50,000 hectares in India and harvested in 5 to 10 years rotation (Rawat, 1989). It fetches good prices in the market and fine charcoal is made from its wood. Today, it is believed that it has a tremendous ability to replace eucalyptus in field, laboratory and industry, due to its excellent multipurpose qualities. The demand for casuarina wood for paper and pulp production is also increasing dramatically (Hegde, 1993).

MATERIAL AND METHODS

The wood analysis was carried out for 15 Candidate Trees (CTs), which have been established in the clone bank of Casuarina equisetifolia at the Institute of Forest Genetics and Tree Breeding, Coimbatore, to find out suitable clones for paper and pulp making (Ashok Kumar, 1995). Samples for wood analysis were taken from 100 cm above the ground level. The wood analysis was carried out at the Paper and Pulp Research Institute, Jaykaypur (Orissa).

1. Physical Characteristics

Wood density: Wood density was determined as per Technical Association for Paper and Pulp Industries, New York (TAPPI) method number 258 Om-85. This method describes the measurement of the basic density of pulp wood in the form of disks by taking the cross section of logs. Volume was determined by the amount of water displaced by the test specimen of wood.

Fibre morphology: The fibrous elements of the CTs which are commonly encountered in paper making were identified on the basis of their morphology. Fibre length (mm) and diameter (micron) were measured microscopically. The unbleached pulp was partially delignified with an acidified sodium chlorite solution at 60^{0}C for 5 minutes. Then the pulp was washed with distilled water. A small portion of the pulp was thoroughly dispensed and was taken for slide preparation. The prepared slides were examined for the measurements, microscopically.

2. Proximate chemical analysis

Wood logs were chipped and the chips were grounded to a fine particle size in Wiley grinder. The grounded material was passed through 40 mesh screen. Then the screen material was taken for proximate chemical analysis. The analysis was carried out according to TAPPI standard method (TAPPI, 1954).

Ash: Ash was determined according to TAPPI method number T211 : Om-85. In this method, ash was determined by keeping wood dust in an electric Muffle furnace at temperature of 575^{0}C till complete burning. Complete ignition was indicated by the absence of black particles.

$$\text{Ash (per cent)} = \frac{\text{weight of the ash (gm)}}{\text{weight of moisture free test specimen (gm)}} \times 100$$

Alcohol-Benzene extractive: A-B extractive describes the procedures for determining the amount of solvent and non-volatile material in wood, A-B extractive was determined according to TAPPI method number T204 : Om-88. A-B extractive was calculated with following formula.

$$\text{A-B extractive (per cent)} = \frac{\text{Oven dry weight of extract (gm)}}{\text{Oven dry weight of wood (gm)}} \times 100$$

Lignin: Lignin was determined according to TAPPI method number 222 : Om-88, a procedure for determining the acid-insoluble lignin in wood (TAPPI, 1943). Lignin was calculated with following formula.

$$\text{Lignin (per cent)} = \frac{\text{Oven dry weight of lignin (gm)}}{\text{Oven dry weight of test specimen (gm)}} \times 100$$

Holocellulose: Holocellulose was determined according to acid chlorite method (TAPPI, 1954) and the following formula was used to calculate the holocellulose.

$$\text{Holocellulose (per cent)} = \frac{\text{Oven dry wt. of holocellulose (gm)}}{\text{Oven dry weight of the wood (gm)}} \times 100$$

3. Pulping

The kraft pulping process was adopted for pulping. In this process, the chemical used was white liquor which was containing NaOH and Na_2S. The wood chips were cooked in a 15 litre capacity laboratory rotary digester. Following conditions were maintained during cooking.

Active alkali (Na_2S)	17 per cent
Sulphidity	18 per cent
Wood liquor ratio	1 : 2.7
Cooking temperature	165°C
Time for cooking	90 to 120 minutes
H factor	1380

Pulp yield: Screened yield was determined on oven dry basis.

$$\text{Yield (per cent)} = \frac{\text{Oven dry weight of screened pulp}}{\text{Oven dry weigth of wood chips}} \times 100$$

Fibre strength factor: Fibre strength is the important parameter which determines the quality of pulp being produced. Evaluation of hand sheets was done using the Trouble shooter, which provides a measure of the strength of the constituent fibres and also allows rapid characterization of basic pulp quality. Fibre strength factor (F.S. factor) was determined by pulmac trouble shooter (Model-TS 100) by re-wetting the strips. From the readings, F.S. factor is calculated as follows.

$$\text{F.S. Factor} = \frac{\text{Mean wet zero span value} \times \text{Std } (60 g/m^2) \text{ basis wt.}}{\text{Actual average basis weight}}$$

RESULTS AND DISCUSSION

Wood analysis for fifteen CTs was carried out to understand the utility of Casuarina equisetifolia in paper and rayon industry. The results for physical properties, proximate chemical analysis and pulping analysis are presented in Table 1 to 3, respectively. It is known that casuarinas can be used as raw material in paper and rayon indusry (Hegde, 1993). Kandeel et at. (1982) reported that casuarinas yield more pulp with higher tear strength compared to Eucalyptus camaldulensis. Guha and Karira (1981) reported that Casuarina equisetifolia produced kraft pulp similar in strength properties to Eucalyptus grandis and Eucalyptus citriodora and found its suitability in paper industry. Maheswari et al. (1979) suggested that long fibre pulps like bamboos can be blended with casuarina in view of inadequate availability of bamboos.

Table-1

Physical and morphological analysis for wood samples in 15 CTs of Casuarina equisetifolia.

S. no.	Clone number	Wood density ($kg.m^3$)	Fiber length (mm)	Fiber diameter (micron)
1.	CHCE890201	633.00	0.93	14.40
2.	CHCE890401	689.00	0.94	14.40
3.	CHCE890903	671.00	0.96	14.90
4.	CHCE890905	705.00	0.94	13.50
5.	CHCE891003	585.00	1.07	15.20
6.	CHCE892003	596.00	0.95	14.10
7.	CHCE892602	651.00	0.97	14.80
8.	CECE892604	616.00	0.96	14.60
9.	CHCE893003	615.00	0.94	10.84
10.	CHCE893004	594.00	0.96	11.47
11.	CPCE890108	737.00	0.97	13.60
12.	CPCE890110	764.00	1.01	14.50
13.	CPCE890301	787.00	0.90	14.80
14.	CPCE891802	723.00	0.96	16.70
15.	CPCE893702	693.00	0.86	8.95
AVERAGE		670.60	0.95	13.78
S.E.		16.07	0.01	0.49

Table-2

Peroximate chemical analysis for the wood samples in 15 CTs of *Casuarina equisetifolia.*

S. no.	Clone number	Ash (%)	A-B extr. (%)	Lignin (%)	Cellulose (%)	C/L Ratio
1.	CHCE890201	0.57	2.22	23.67	67.00	2.83
2.	CHCE890401	0.64	1.73	26.93	72.60	2.70
3.	CHCE890903	0.92	1.38	22.95	73.90	3.22
4.	CHCE890905	0.92	2.22	23.30	75.17	3.23
5	CHCE891003	0.59	1.86	23.73	72.44	3.05
6.	CHCE892003	0.97	1.09	23.64	68.10	2.88
7.	CHCE892602	0.62	1.52	26.24	74.05	2.82
8.	CECE892604	0.66	1.08	24.70	73.00	2.96
9.	CHCE893003	1.26	1.94	24.24	69.20	2.85
10.	CHCE893004	0.87	1.92	23.82	73.30	3.08
11.	CPCE890108	0.78	1.52	23.09	71.01	3.08
12.	CPCE890110	2.48	1.77	23.34	74.50	3.19
13.	CPCE890301	0.68	2.71	27.03	70.30	2.60
14.	CPCE891802	0.67	1.47	24.03	71.23	2.96
15.	CPCE893702	0.52	2.32	23.06	71.00	3.08
AVERAGE		0.88	1.78	24.25	71.79	2.97
S.E.		0.12	0.11	0.34	0.60	0.05

Table-3

Pulping analysis for wood samples in 15 CTs of *Casuarina equisetifolia.*

S. no.	Clone number	Kappa number	F.S. factor	Screen Yield (%)	Total Yield (%)	Rejects (%)
1.	CHCE890201	14.85	31.00	50.12	50.22	0.30
2.	CHCE890401	14.70	32.80	45.00	45.10	0.10
3.	CHCE890903	17.56	25.20	45.77	47.16	1.39
4.	CHCE890905	15.95	32.76	50.66	51.66	0.90
5.	CHCE891003	18.50	34.28	48.22	49.08	0.86
6.	CHCE892003	15.38	27.29	47.86	48.99	1.13
7.	CHCE892602	15.97	30.70	47.99	48.23	0.24
8.	CECE892604	16.70	31.00	50.80	51.81	1.01
9.	CHCE893003	17.56	32.66	45.26	46.21	0.95
10.	CHCE893004	16.67	25.42	51.19	51.95	0.76
11.	CPCE890108	16.91	28.00	48.77	51.13	2.36
12.	CPCE890110	21.00	24.38	43.19	46.19	3.00
13.	CPCE890301	18.58	22.57	49.10	51.50	2.40
14.	CPCE891802	17.64	28.15	47.39	49.19	1.80
15.	CPCE893702	17.30	25.27	50.33	51.63	1.30
AVERAGE		17.02	28.77	48.11	49.34	1.23
S.E.		0.40	0.92	0.60	0.58	0.21

It is well documented that quality of wood affects the quantity and quality of pulp production. The quality of wood within the species varies to a considerable extent depending upon the genetic characteristics, growth pattern and environment in which it is grown (Patel, 1994). Selection of specific clones for specific end use requirements such as paper or rayon is important to meet their increasing demand. At Aracruz Florestal, Brazil, 5000 plus trees of eucalypts were selected from 36,000 hectare population. These trees were than tested for specific gravity and yield of bleached pulp. About 625 plus trees met the required standards. These trees were further screened and finally 25 trees were selected. These trees are propagated clonally for large scale plantations. Zobel (1993) reported that using these clones pulp yield (m^{-3}) was improved by 23 per cent and the total product. [illegible] pulp $ha^{-1}yr^{-1}$ was improved by 135 per cent.

In the present study, 15 wood samples were randomly selected from 55 cloned trees (Ashok Kumar, 1995). Basic density of wood samples was found to be higher compared to eucalypts. The presented results are in conformity with the findings of PAPRI (1994). Higher wood density, without heartwood, leads to higher productivity of digester in the paper manufacturing as more weight of wood can be accommodated in given volume of digester. However, very high wood density leads to lesser penetration of cooking liquor and thereby lesser pulpability. In the present study, clones CPCE 890108, CPCE 890110 and CPCE 890301 were found to have high basic density (Table 1). Clone CPCE 890110 contained maximum ash i.e. 2.48 per cent. The fibre length and fibre diameter for all the wood sample tested was found in the normal range of the hard woods for paper production (Table 1). The results presented are in the conformity with Guha and Madan (1963). They reported an average fibre length of 1.08 mm with 11 micron diameter for Casuarina equisetifolia pulp.

The pulpability of wood also depends on A-B extractive and lignin content. If the quantity of lignin and A-B extract is more, the pulp yield comes down. However, factors like nature of carbohydrates also influence the pulpability. From the presented results, it was concluded that clones CHCE 890201, CHCE 890905, CHCE 892604, CPCE 890108 and CPCE 893702 are the promising clones for paper manufacturing (Table 3). Total paper yield, from the pulp of these clones, was more than 50 per cent (Table 3). However, clone with more than 47 per cent paper yield can always be considered in the factory for paper production purposes (Patel, 1994). Clones CPCE 890110, which had highest ash content with low screen yield and F.S. factor may not be a proper clone for paper production, however, may be propagated for pole and scaffolding purposes.

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