Wood and Paper Properties of Poplar Clones

Goyal Savita, Singh S.P., Chauhan Luxmi and Rai A.K.

Cellulose and Paper Division, Forest Research Institute, P.O. New Forest
Dehradun-248 006

ABSTRACT

Three clones of Populus deltoides G-3, S7C3 and 112910 of six years old plantation were evaluated for specific gravity, fibre morphology, proximate chemical analysis, pulping and papermaking characteristics. It was observed that the clone 112910 gave higher pulp yield, smaller rigidity index and higher L/T ratio with better pulp properties as compared to other two clones i.e. G-3 and S7C3.

INTRODUCTION

Pulp and paper industry in India is more than a century old. In the beginning the industry enjoyed the vast fibre resources available for the manufacture of paper, particularly bamboo and then afterwards started using agricultural residues like bagasse, rice straw and wheat straw apart from other alternative fibre resources. But the scenario has changed now. Paper mills are facing acute shortage of fibre supply from forest and the industry will need to develop strategies to ensure sustainable fibre supply. Forest plantation of fast growing species like poplar are threfore gaining increasing attention from the pulp and paper industry as a strategy. Poplar as a pulp and papermaking fibre source is well recognised(1-7) and thus various clones fo poplar, as a fast growing species, were planted on large scale as well as on experimental basis in punjab, Haryana, Uttar Pradesh and Uttranchal.

Wood quality of trees grown in these plantation of poplar clones is primary concern of scientists and technologists. The present paper would provide information on the proximate chemical analysis, fibre morphology, pulping and papermaking characteristics of three clones of poplars of six years old plantations.

EXPERIMENTAL:

Raw Material Preparation

Six years old trees of three poplar clones G-3, S7C3 and 112910 were obtained from Chandian Farm Wimco seedlings Ltd, Rudrapur (Uttranchal). The trees were felled and billets were prepared at different levels of tree height i.e. at breast height, 25%, 50% and 75% of total tree height. Out of these billets, 6 cm thick wood discs were cut for studies on anatomical properties and rest of the billets were used for chipping. The chips of all the three clones, separately, were prepared manually, air dried and stored in polythene bags for further studies. Before pulping the moisture content of the chips were determined and 200g wood chips on oven dry basis were taken for pulping experiments in case of all the three clones.

Determination of Specific Gravity & Fiber Characteristics

From each disc, a 4 cm. wide strip was removed from pith to periphery at the widest radii. The strip was demarcated for each ring and samples were cut. A radial half of each sample was taken for determination of specific gravity and the other half was mercerized using 30% nitric acid with a pinch of potassium chlorate as per method described elsewhere(8) for determining the fibre characteristics. Specific gravity was determined by oven-dry weight/green volume method.

Fibre characteristics viz. fibre length, fibre diameter and lumen diameter were determined for each sample ring. Mean values were determined and wall thickness, L/T ratio, where L is fibre length and T is wall thickness were calculated and recorded in Table-1.

Proximate Chemical Analysis

Extractive content of each wood was determined by extracting wood meal (passing through a 40 mesh screen but retained on 60 mesh screen) with alcohol-benzene solution in a ratio 1:2 (v/v) in a Soxhlet apparatus for 24 hours.

Other chemical analysis were performed on extractive free wood dust. Klason lignin was determined according to TAPPI test method (T222 Om-88). Holocellulose content was determined by using acid chlorite method(9). Pentosan was determined

TABLE-1
Specific Gravity and Fibre Characteristics of Poplars

Clone No.	Wood sp. gravity	Fibre length μ	Fibre diameter μ	Lumen diameter μ	Wall thickness μ	L/T	$(T/D)^3 \times 10^{-4}$
S7C3	0.441	1031	23.4	14.6	4.39	234.55	66.02
G-3	0.383	1023	23.4	15.0	4.00	255.75	49.91
112910	0.405	1096	24.8	17.2	3.8	288.42	35.96

TABLE-2
Proximate Chemical Analysis of Poplars

Clone No.	Alcohol-Benzene solubility (%)	Lignin (%)	(Pentosan) (%)	Holocellulose (%)	Ash Content (%)
S7C3	1.55	22	15.25	74.72	0.61
G3	2.08	24	13.05	73.98	0.63
112910	1.79	23	14.56	74.25	0.81

according to TAPPI test method (T 223-OS-78). Ash content of all the three clones was also determined as per standard method.

Pulping

The wood chips of *P. deltoids* G-3, S7C3 and 112910 clones were delignified separately using Kraft process in a "hatto" air heated digester, equipped with six autoclaves of 2.5 liters capacity.

Pulping Conditions

Raw Material 200 g chips (O.D. basis)
Total active alkali as Na_2O : 16%
Sulphidity : 25%
Material to liquor ratio : 1:3

Cooking schedule

From room temp. to 165°C : 90 minutes
At 165°C : 90 minutes

After the cooking cycle was over, the pulp was thoroughly washed till free from the black liquor. The pulps were evaluated for the screened pulp yield and Kappa number (using TAPPI test method T-235-0S-76).

Analysis of Pulps

All the pulp samples were beaten separately in a Lampen mill under standard conditions to 250±25 ml CSF. Hand sheets of 60 ± 2 g/m² were prepared as per ISO standard (R-187). The physical strength properties of handsheets were determined according to ISO standard (DP 5269).

RESULTS AND DISCUSSION:

Wood Properties:

Specific Gravity: The data recorded in Table-1 showed that clone G-3 had lowest specific gravity (0.383) and clone S7C3 had highest sp. gravity (0.441) and sp. gravity of clone 112910 fell in between i.e. 0.405.

Fibre Morphology: Table-1 reveals the results on fibre morphology. The average fibre length varies from 1023 to 1096 μ for all the three clones. The wall thickness of fibres of all the clones varies from 3.8 to 4.39 μ. The fibre diameter of clone S7C3 and G-3 is same i.e. 23.4 μ and for clone 112910, it is 24.8 μ. The lumen diameter of clone S7C3 and G-3 is comparable (14.6-15.0 μ) but it is higher (17.2 μ) in case of clone 112910.

The values of L/T ratio for S7C3 and G-3 are comparable 234.55-255.75) whereas for the clone 112910 it is higher (288.42).

The cell wall thickness is a valuable indicator of fibre quality but it is inadequate for completely characterising the fibre quality since fibres having similar wall thickness can have very different coarseness or vice versa.

Conformability or collapsibility of fibre is an important factor determining fibre bonding potential. The collapsibility depends on wall thickness and diameter. Collapse pressure of a thin wall cylinder

TABLE-3
Unbleached Kraft Pulp Yield and Kappa No. of Poplar Pulps

Clone No.	Screened Yield (%)	Rejects (%)	Kappa No.
112910	57.16	1.05	22.00
S7C3	55.21	0.95	21.00
G-3	51.13	1.00	20.00

(10)where it is proportional to (T/D^3). T is the wall thickness of the cylinder and D is the external diameter. We have used this term here to express the rigidity of fibres, arbitrarily. Table-1 shows that clone S7C3 has the greatest rigidity index (66.02) and clone 112910, the lowest value (35.96). The differences in rigidity index may indicate the interfibre bonding potential of fibre.

Chemical Composition

Table-2 reveals that the alcohol-benzene solubility of all three clones varies from 1.55%-2.08% and all the three clones had similar lignin content between 22%-24%. The holocellulose content in the clone S7C3 and 112910 is 74.25% and 74.72% and in the clone G-3, it is 73.98%. The pentosan content is maximum, 15.25% in clone S7C3 and minimum, 13.05% in G-3 and in clone 112910 fell in between and is 14.56%. The ash content in the clones is comparable and is 0.61%-0.81% Table-2.

TABLE-4
Strength Properties of Unbleached Pulp from Poplars

Clone No.	Tensile index (Nm/g)	Tear index index (mNm/g)	Burst index ($kPam^2/g$)	Porosity (Gurley) (100 ml/S)
112910	78.89	6.44	4.08	25
S7C3	72.43	6.26	3.85	41
G-3	75.21	6.12	4.10	34

Pulp Yield

It could be seen from the data recorded in Table-3 that the pulp yield obtained was highest in case of clone 112910 (57-16%) with kappa number 22.0. The clone G-3 gave the lowest pulp yield (51.13%) having kappa number 20.0. The pulp yield and Kappa number for clone S7C3 fell in between and are 55.21% and 21.0, respectively.

Pulp Properties

Tensile strength: The clone S7C3 had the greatest rigidity index as indicated in the Table-1 and gave the poorest tensile index, 72.43 N.m/g. The poplar clone 112910 having lowest rigidity index gave highest tensile index 78.89 Nm/g. The tensile index of G-3 is at 75.21 Nm/g. (Table 4).

Burst index: The data given in Table-4 reveals that all the clones exhibited similar burst index. However clone S7C3 gave lowest burst index and was 3.85 $kPam^2/g$.

Tear index: All the clones showed almost same tear index and varied from 6.12-6.44 mNm^2/g.

Porosity: Gurley Porosity of the paper sheets of all the three clones was comparable and varied from 25-41 seconds/100 ml.

CONCLUSION:

The clone 112910 gives higher pulp yield and shows smaller rigidity index, higher L/T ratio and better pulp properties, followed by clone G-3 and S7C3 which gives less pulp yield and poor pulp properties as compared to other two clones.

REFERENCES:

1. Singh, M.M., G.M. Mathur, K.K. Kalra and B.G. Karira. Ind. For. 107 (11) : 725-733 (1981).
2. Rai, A.K. and Ilam Chand J. Timb. Dev. Assoc (India) 34 (4) : 18-24 (1988).
3. Rai, A.K. and Ilam Chand J. Ind. Acad. Wood Sci. 19 (2) : 45-49 (1988).
4. Rai, A.K., K.K. Sharma and Y.K. Sharma Ind. For., 117 (3) : 213-224 (1991).
5. Shukla, N.K., A.K. Khanduri and Mohan Lal Van Vigyan 28 (1-2) : 26-33 (1990).
6. Rai, A.K., Ilam Chand and Rajesh Garhia Ind. For 121 (12) : 1151-1154 (1995).
7. Rai, A.K.,S.S. Bhandari and S.V. Singh Ippta 12 (1) : 39-46 (2000).
8. Singh, M.M., S.K. Purkayastha, P.P. Bhola and A.K. Gupta Ind. For., 103 (9) : 641-650 (1977).
9. Wise, L.E., M. Murphy and A.A. D' Addieco. Paper Trade Jour, Tappi Section 122 (2) : 11-19 (1946).
10. Law, K.N., Sylvie Rioux and Jacques. L. Valade. Tappi. 83 (5) : 1-6 (2000).