Agriculture Update
Volume **12** | TECHSEAR-8 | 2017 | 2252-2256
Visit us : ***www.researchjournal.co.in***

RESEARCH ARTICLE :

Pulping and strength properties of Bamboo genetic resources at various age gradations

■ **R. THIRUNIRAI SELVAN, K.T. PARTHIBAN AND B. PALANIKUMARAN**

ARTICLE CHRONICLE :
Received :
20.07.2017;
Accepted :
16.08.2017

SUMMARY : Seven bamboo species *viz.*, *Bambusa bambos, Dendrocalamus strictus, Bambusa vulgaris var. vulgaris, Bambusa vulgaris var. striata, Bambusa balcooa, Bambusa tulda, Bambusa polymorpha* with five age gradations were taken for the study. The pulping and strength properties were analysed for Bamboo genetic resources with all age gradations. With regards to pulping properties, five-year-old *Bambusa balcooa* has recorded higher pulp content (50.06 %) with optimal kappa number (18.50). The strength properties of five age gradations revealed that the superiority of five-year-old *Bambusa balcooa* in terms of tensile index (78.34 NM g^{-1}), burst index (24.87 mNm^2 g^{-1}) and tear index (7.54 KPa m^2 g^{-1}) of unbleached pulp. Considering all the parameters into account, the five-year-old *Bambusa balcooa* species proved superior in terms of pulp yield, kappa number and strength properties and hence, this study recommends five-year rotation for pulpwood plantation of *Bambusa balcooa*.

KEY WORDS:
Bamboo genetic resources, Pulp yield, Kappa number, Tensile index, Burst index, Tear index

How to cite this article : Selvan, R. Thirunirai, Parthiban, K.T. and Palanikumaran, B. (2017). Pulping and strength properties of Bamboo genetic resources at various age gradations. *Agric. Update*, **12** (TECHSEAR-8) : 2252-2256.

Author for correspondence :

R. THIRUNIRAI SELVAN
Forest College and Research Institute, Tamil Nadu Agricultural University, METTUPALAYAM (T.N.) INDIA
Email : selvanforester @gmail.com

See end of the article for authors' affiliations

BACKGROUND AND OBJECTIVES

Bamboo, a versatile group of woody grasses belonging to the subfamily Bambusoideae of the family Poaceae containing more than 1250 species coming under 75 genera were seen unevenly distributed in the various parts of the humid tropical, subtropical and temperate regions of the world. India has an abundant bamboo resource. There are about 24 genera and 138 species. Among these, three genera are exotic and the others are indigenous. India possesses 25 per cent of the species found in the world and 43 per cent of species found in Asia and has rich species diversity and world's largest reserves of bamboos after china (Negi and Naithani, 1994). Bamboo grows extensively in the Western Ghats and in the North eastern States. There are about 1, 39,577 km^2 of bamboo forests in India (15.67% of total forest cover), which yield about 4.5 million tons of bamboo per annum (FSI, 2011). Out of the 138 species found in India, only the following 13 species are used commercially in various states *viz.*, *Bambusa arundinacea, B. balcooa, B. polymorpha, B. tulda, B. vulgaris, B. Nutans, Dendrocalamus brandisii, D. hamiltonii, D. strictus, Melocanna*

baccifera, Ochlandra scriptoria, O. ebracteata and *O. Travancorica* (Haque 1984).

Bamboo has not only gained importance as raw material in cottage industries but is also used in large scale industries as pulp and paper (Maheswari and Satpathy, 1990). About 30 per cent paper mills spread over the country meet about 60 per cent of their fibrous raw material requirement from bamboo. As indicated above, industrial demand for paper is rising but bamboo reserve is dwindling fast. Against this backdrop, the study was conducted to identify the high pulp yielding bamboo genetic resource with optimal age gradation.

RESOURCES AND METHODS

Pulping properties :

Four hundred gram of OD chips were cooked by kraft process in an electrically heated glycol bath series digester consisting of six bombs each 2.5 lit. Capacity under the following constant pulping conditions.

Parameters		Conditions
Chemical added as Na_2O (%)	:	17
Bath Ratio	:	1:2.8
TAA in white liquor (gpl)	:	85
Cooking temperature (°C)	:	170
Cooking time (min.)	:	90
H - Factor	:	1600

At the end of the cooking, the bombs were removed from the digester and cooled by immersing in water. Bombs were opened and spent pulping liquor was filtered off on double fold nylon cloth. The pulps were washed until the filtrate became colourless. The washed pulps were screened on a flat screen (slot 0.3 mm). The dryness of the pulp was determined and thus, the pulp yield was calculated on the basis of dryness of pulp. Kappa number of each pulp was determined as per the TAPPI method.

Strength properties of unbleached pulp :

The dried sheets were air dried and were again conditioned at 27 ± 1ºC and 65 per cent ± 2 RH for four hours before testing. The tensile strength, bursting strength, tensile energy absorption and elongation of paper sheets were measured according to TAPPI standard.

Statistical analysis :

The estimates of mean, variance and standard error were worked out using the method described by Panse and Sukhatme (1978). The significance test was carried out by referring to the standard 'F' table of Snedecor (1961).

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads :

Pulping properties :

Among various Bamboo species the age gradations of *Bambusa vulgaris* var. *vulgaris* showed the lowest unbleached pulp yield ranged between 42.54 per cent (One-year-old) and 46.18 per cent (Five-year-old). Other age gradations *viz.*, four, three and two years old recorded the pulp yields of 43.68, 44.14 and 45.08 per cent, respectively. Maximum unbleached pup yield was observed in age gradations of *Bambusa balcooa viz.*, one (45.26 %), two (46.63 %), three (48.10 %), four (49.39 %) and five-year-old (50.06 %). Followed by, the age gradations of *Dendrocalamus strictus* recorded high unbleached pulp yield than the grand mean. These values show that unbleached pulp yield was increasing with an increase in age (Table 1).

The kappa number is an indicative of lignin content of pulp and gives an idea of bleaching demand in manufacturing process. Within the different age

Table 1 : Comparison of pulping properties for different bamboo species at different age gradations

Species	Pulp yield					Kappa number				
	1	2	3	4	5	1	2	3	4	5
Bambusa vulgaris var. *vulgaris*	42.56	43.64	45.57	46.04	47.44	14.20	15.80	16.70	17.20	18.90
Bambusa vulgaris var. *striata*	42.54	43.68	44.14	45.08	46.18	15.70	16.40	17.20	18.60	19.30
Bambusa balcooa	45.26	46.63	48.10	49.39	50.06	15.20	15.80	16.90	17.40	18.50
Bambusa tulda	42.85	43.69	44.20	45.10	46.27	12.45	13.60	13.70	15.20	16.40
Bambusa polymorpha	42.97	43.78	45.67	46.56	47.57	18.72	20.48	22.16	23.27	24.00
Dendrocalamus strictus	46.38	47.07	47.93	49.01	49.78	19.75	21.42	23.16	24.58	25.40
Bambusa bambos	45.82	46.09	46.75	47.04	47.84	19.40	20.50	21.10	21.90	23.80

gradations of various bamboo species one-year-old bamboo species has the minimum kappa number. In one-year bamboo species minimum kappa number was found in *Bambusa tulda* (12.45) and maximum in *Dendrocalamus strictus* (21.42) at 18.0 per cent of chemical charge. The other age gradations of *Bambusa tulda viz.,* two (13.60), three (13.70), four (15.20), five-year-old (16.40) also showed minimum kappa number. It is also revealed that kappa number is increasing with an increase in age (Table 1).

Strength properties of unbleached :

The tensile index of refined unbleached pulp was found maximum in five years old *Bamboo* species ranges between 72.18 Nm g^{-1} (*Bambusa tulda*) and 78.34 Nm g^{-1} (*Bambusa balcooa*). The maximum tensile index was found in the age gradations of *Bambusa balcooa viz.,* one (72.78 Nm g^{-1}), two (74.29 Nm g^{-1}), three (75.84 Nm g^{-1}) and four-year-old (76.27 Nm g^{-1}) among the various bamboo species. Followed by the age gradations of *Bambusa vulgaris* var. *striata* shows higher tensile index. The lowest tensile index was observed in the age gradations of *Bambusa tulda viz.,* one (63.47 Nm g^{-1}), two (65.49 Nm g^{-1}), three (68.24 Nm g^{-1}) and four-year-old (70.84 Nm g^{-1}). This result shows higher tensile index in the five-year-old gradation of *Bambusa balcooa* and tensile index is increasing with an increase in age (Table 2).

Maximum Tear index was recorded in the five-year age gradation of *Bambusa balcooa* (24.87 mNm^2 g^{-1}) and the minimum was recorded in the *Bambusa tulda* (15.86 mNm^2 g^{-1}. The age gradations of *Bambusa balcooa viz.,* one (23.57 mNm^2 g^{-1}), two (23.84 mNm^2 g^{-1}), three (24.08 mNm^2 g^{-1}) and four-year-old (24.59 mNm^2 g^{-1}) shows higher tear index comparing all the other age gradations of various *Bamboo* species. Followed by the age gradations of *Bambusa vulgaris* var. *striata* has the highest tear index among various *Bamboo* species. The lowest value was recorded in the age gradations of *Bambusa tulda viz.,* one (13.76 mNm^2 g^{-1}), two (14.67 mNm^2 g^{-1}), three (14.92 mNm^2 g^{-1}), four (15.47 mNm^2 g^{-1}) and five-year-old (15.86 mNm^2 g^{-1}). It revealed that five-year-old age gradation shows higher tear index than the other age gradations and among various bamboo species *Bambusa balcooa* shows higher tear index and it is increasing with an increase in age (Table 2).

In regard to burst index five year age gradation of *Bambusa balcooa :*

(7.54 KPa m^2 g^{-1}) shows maximum burst index and minimum was recorded in the age gradation of five year in *Bambusa tulda* (6.56 KPa m^2 g^{-1}). Among various *Bamboo* species the age gradations of *Bambusa balcooa viz.,* one (6.82 KPa m^2 g^{-1}), two (6.94 KPa m^2 g^{-1}), three (7.01 KPa m^2 g^{-1}) and four-year-old (7.24 KPa m^2 g^{-1}) shows higher burst index followed by the age gradations of *Dendrocalamus strictus* shows higher value. The lowest burst index was recorded in the age gradations of *Bambusa tulda viz.,* one (6.32 KPa m^2 g^{-1}), two (6.39 KPa m^2 g^{-1}), three (6.46 KPa m^2 g^{-1}), four (6.41 KPa m^2 g^{-1}) and five-year-old (6.56 KPa m^2 g^{-1}). These results shows that burst index is increasing with an increase age and five-year age gradations of *Bambusa balcooa* shows higher burst index (Table 2)

Pulping properties :

Unbleached pulp yield ranged between 50.06 (*Bambusa balcooa*) and 46.27 per cent (*Bambusa tulda*) in the five-year age gradation. Among all the age

Table 2 : Strength properties (300 ml CSF) of bamboo species at different age gradations

Species	Tensile index (NM/g)					Tear index (mNm^2/g)					Burst index (KPa m^2/g)				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Bambusa vulgaris var. *vulgaris*	66.48	68.41	70.86	71.38	73.18	20.40	20.60	21.10	21.30	21.60	6.24	6.38	6.42	6.48	6.59
Bambusa vulgaris var. *striata*	72.49	74.23	75.62	76.21	78.18	23.48	23.82	23.99	24.43	24.82	6.46	6.57	6.62	6.68	7.04
Bambusa balcooa	72.78	74.29	75.84	76.27	78.34	23.57	23.84	24.08	24.59	24.87	6.82	6.94	7.01	7.24	7.54
Bambusa tulda	63.47	65.49	68.24	70.84	72.18	13.76	14.67	14.92	15.47	15.86	6.32	6.39	6.46	6.41	6.56
Bambusa polymorpha	64.75	67.81	69.48	71.28	73.81	23.24	23.57	23.72	23.97	24.13	6.27	6.41	6.48	6.52	6.64
Dendrocalamus strictus	68.24	70.84	72.48	75.84	76.87	23.26	23.38	23.62	23.87	23.91	6.61	6.76	6.86	6.91	7.14
Bambusa bambos	68.47	70.46	73.28	75.54	77.94	20.84	21.21	21.57	21.97	22.31	6.67	6.86	6.98	7.18	7.29

gradations, five-year-old sample showed maximum pulp yield. The age gradations of *Bambusa balcooa* recorded lowest kappa number among various bamboo species (Fig. 1 and 2). Similar results were reported in *Anthocephalus cadamba* at different age gradations (Lal, 2010) which lend support to the current study.

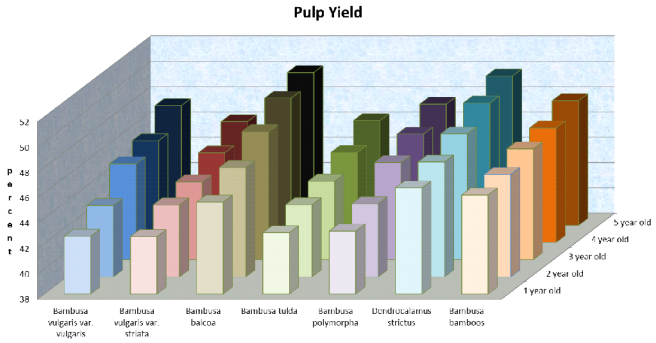

Fig. 1 : Pulp yield of various Bamboo species at different age gradations

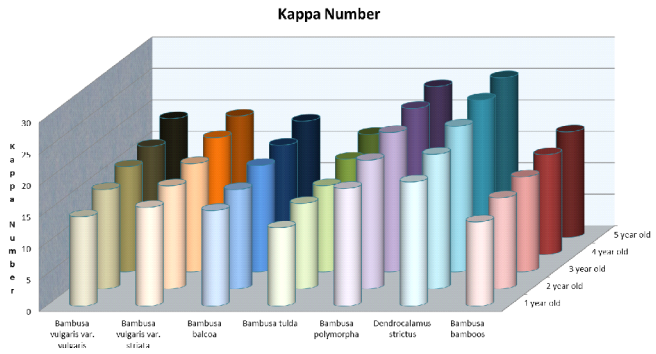

Fig. 2 : Kappa number of various Bamboo species at different age gradations

Strength properties of unbleached pulp :

The strength properties of any manufactured paper in terms of tear, burst and tensile factors are very important for paper quality (Anonymous, 1982). In the present study, the strength properties of all species were investigated for bleached pulp. The strength properties indicated that the burst and tear index were maximum in the five age gradation of *Bambusa balcooa viz.*, tensile index (78.34 NM g^{-1}), tear index (24.87 mNm^2 g^{-1}) and burst index (7.54 KPa m^2 g^{-1}) and minimum was recorded in the five year age gradation of *Bambus tulda* (Fig. 3, 4 and 5). In the one-year age gradation, strength properties of unbleached pulp were very low. Strength properties were increased with an increase in age. This reveals that five-year age gradation supports bamboo species for quality pulp and paper production. Within the five-year age gradations *Bambusa balcooa* showed superior pulping and strength properties followed by *Bambusa vulgaris* var. *striata* and *Dendrocalamus stictus*. Similar results were earlier reported in tensile and burst indices of paper obtained from one-year-old *Leucaena leucocephala* (Lopez *et al.*, 2008), which supports the findings of current results. The pulp and paper property are highly dependent on fibre morphology and sheet forming processes (Pavilainen, 1993 and Seth *et al.*, 1997).

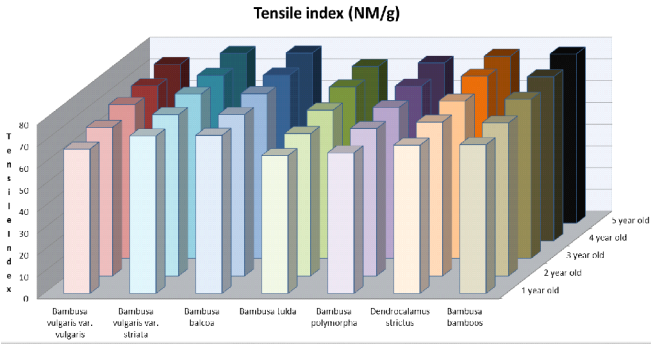

Fig. 3 : Tensile index of various Bamboo species at different age gradations

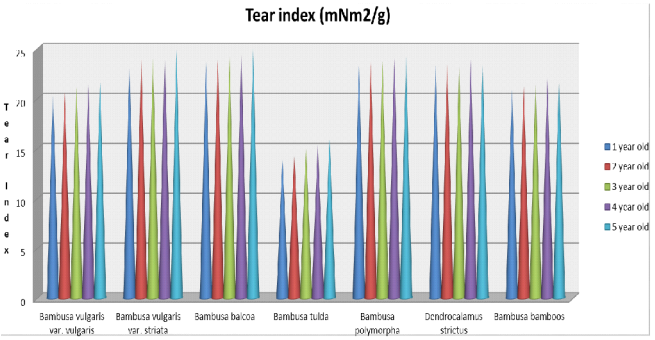

Fig. 4 : Tear index of various Bamboo species at different age gradations

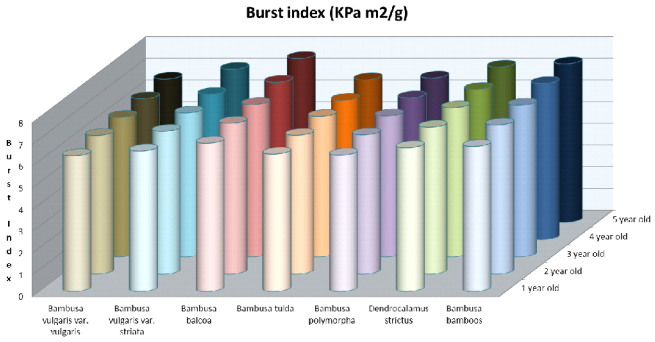

Fig. 5 : Burst index of various Bamboo species at different age gradations

Conclusion :

Pulping experiments were carried out for 20 kappa for each age gradations. Among the various bamboo species, *Bambusa balcooa* recorded highest pulp yield and lowest kappa number. The unbleached pulp yield for all the age gradations were found between 45.26 and 50.06 per cent. The kappa number was found to be satisfactory with minimum chemical charge. The maximum pulp yield was recorded in five-year-old sample. Similarly, kappa number was found low in one-year-old samples of different species. Among all the age gradation of *Bambusa balcooa* investigated, five-year-old sample recorded superior tensile, burst and tear strength properties (78.34 Nm g^{-1}, 7.54 kpa. m^2 g^{-1} and 24.87 mN. m^2 g^{-1}), thus, most suited for pulping. It is concluded that five-year age gradation of *Bambusa balcooa* showed higher pulping character and strength properties followed by *Bambusa vulgaris var. vulgaris*.

Authors' affiliations :

K.T. PARTHIBAN AND B. PALANIKUMARAN, Forest College and Research Institute, Tamil Nadu Agricultural University, METTUPALAYAM (T.N.) INDIA

REFERENCES

Anonymous (1982). Advances in pulp and paper research in India. Indian Council of Forestry Research and Education, Dehradun, UTTARAKHAND (INDIA).

FSI (2011). State of Forest Report 2011. Ministry of Environment and Forests, Forest Survey of India, Dehradun, UTTARAKHAND (INDIA).

Haque, M.S. (1984). Bamboo -the tree grass. *Science Reporter*, **21**(9): 474-476.

Lal, P. (2010). Clonal forestry in India. *Indian Forester*, 136(1): 17-37.

Lopez, F., Garcia, M.M., Yanez, R., Tapias, R., Fernandez, M. and Diaz, M.J. (2008). *Leucaena* species valoration for biomass and paper production in 1 and 2 year harvest. *Bioresource Technol.*, **99** : 4846-4853.

Maheswari, S. and Satpathy, K.C. (1990). The efficient utilization of bamboo for pulp and paper marketing. In: Bamboos: current research [Rao, I.V.R., Gnanharan, R. and Shastry, C.B. (Eds.)]. Kerala Forest Research Institute, India and IDRC, Canada.

Negi, S.S. and H.B. Naithani. 1994. A Handbook of Indian bamboos. Dehradun, UTTARAKHAND (INDIA).

Panse, V.G. and P.V. Sukhatme (1978). *Statistical methods for agricultural workers*. ICAR Publication, NEW DELHI, INDIA.

Pavilainen, L. (1993). Conformability, flexibility and collapsibility of sulphate wood fibers. *Paperi Puu*, **75**(9-10) : 689-703.

Seth, R.S., Jang, H.F., Chan, B.K. and Wu, C.B. (1997). Transverse dimensions of wood pulp fibres and their implications for end use. The fundamentals of papermaking materials. 11th Fundamental Research Symposium, Cambridge, Vol. I. Pira International, Surrey, UK. pp. 473-503.

Smook, G. (1992). Handbook for pulp and paper technologists. Angus Wilde Publications, VANCOUVER, BC.

Snedecor, G. (1961). *Statistical methods*. Ed. 5. Iowa State Univ. Press, Ames. Iowa. p. 534.