Growth and Pulping Characteristics of Subabul and Eucalyptus at 3, 5 and 7 years

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***ABSTRACT:** Growth and pulping characteristics of eucalyptus tereticornis and leuceana leucocephala from the experimental plantation, are presented. The proximate analysis, pulping and bleaching properties after 3, 5 and 7 years have been compared. Suitability of both eucalyptus and subabul on 5-7 years rotation, has been conceived.*

Introduction:

Eucalyptus and subabul are the two fast growing trees with resource potentiality for both greening of earth and raw material for pulp and paper industries. Extensive studies (2-7) have been carried out on these two plants either to evaluate the high growth pattern or to establish superior pulping properties over exotic plants of the country.

Subabul was reported to be quite suitable for newsprint through soda pulping where plantation in short rotation (8 years) was suggested (11). The majority of works carried out in Australia on eucalyptus (8, 9) in this direction was for trees > 10 years. Attempts have, however, been initiated to find out suitable species for pulping at short rotation all over the world (9,10).

The species studied here are: Eucalyptus tereticornis and Leucaena leucocephala, planted in an experimental plantation of 26 acres. The soil and climate of Koraput district in Orissa are very typical and therefore the present work will be quite useful for plantation programme in the tribal region where greening of earth is of utmost importance of socio-economical reasones(1).

Experimental plantation:

The region is at altitudeof ~800 ft above sea level, having annual rain-fall of ~1500 mm. The site is at close proximity of the Institute in an area of 26 acres on both sides of the route. The soil is slightly acidic with pH of ~ 6.5.

Seedlings were planted at spacings of 2m X 2m in August, 1984. Initially, BHC treatment (10g) was made to avoid termite attack.

The log woods, collected from experimental plantation, were manually debarked and then chipping was carried out in mill chipper. The acceptable chips (-32, + 3 mm) were taken for experimental study. For proximate chemical analysis, chips were powdered in laboratory Wiley grinder and - 40 mesh fraction was taken for analysis.

Fig. 1: View of experimental plantation of Eucalyptus

Results and Discussion:

Growth and yield measured af·er 3, 5 and 7 years are shown in Table 1.

After three years, eucalyptus and subabul have (5.2 m and 5.3 m) practically same height but the average diameter of subabul exceeded by 5 cm from eucalyptus. After 5 years, the heights were found to be varying, 8.1 and 6.8 m respectively for eucalyptus and subabul with diameter of 29.9 and 35.2 cm. The yield of subabul is almost double of

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Table -1

GROWTH ATTRIBUTES AND YIELD OF EUCALYPTUS AND SUBABUL

Particulars		Eucalyptus			Subabul		
		3 years	5 years	7 years	3 years	5 years	7 years
1. Average Height,	m	5.2	8.1	9.6	5.3	6.8	7.92
2. Average dbh,	cm	20.0	29.9	37.4	24.8	35.2	36.12
3. Yield, (OD basis) without bark	t/ acre	-	7.8	12.5	-	14.5	21.8

Table-2

PROXIMATE CHEMICAL ANALYSIS

Particulars	Unit	Eucalyptus			Subabul		
		3 years	5 years	7 years	3 years	5 years	7 years
Cold water solubility,	%	5.6	3.3		5.9	5.0	
Hot water solubility,	%	6.65	3.5		8.6	5.5	
1% NaOH solubility,	%	18.0	15.1	18.1	18.3	16.5	19.3
Alcohol-Benzene solubility,	%	5.6	1.7	2.34	4.5	2.9	2.2
Klason lignin,	%	24.8	21.2	25.2	23.8	23.2	24.1
Bole-cellulose,	%	68.4	70.6	69.1	70.2	72.0	70.5
Pentosans,	%	14.4	15.3	16.7	18.0	16.8	17.5
Ash,	%	0.4	0.63	0.75	0.8	1.05	1.3

eucalyptus which is quite significant. However, it was observed that mortality rate is high with subabul at the initial period due to termite attack.

The priximate chemical analysis of eucalyptus and subabul after 3,5 and 7 years are shown in Table 2. It can be seen in general that subabul and eucalyptus both having 5 years age, have same or better chemical characteristics than at 7 years and better than 3 years old plant. The solubility in 1% NaOH is 18 , 15.1 and 18.1% for 3,5 and 7 years old eucalyptus respectively which are 18.3, 16.5 and 19.3% for subabul. Thus, the 5 years old tree has lesser amount of NaOH solubility than 3 and 7 years, and consequently the degradation of hemi-cellulose during cooking will be least for 5 years old tree. The A-B extractives for 3 years old eucalyptus is 5.6% while for subabul it is 4.5% which are much lower in 5 and 7 years old trees. It appears that the fatty acids, resins and other unsaponifiable materials are maximum when the trees are young. No clear cut formation of heart wood could be observed for both even at 5 years age. The heart wood formation is reported to start after 5 years in case of eucalyptus (12).

The acid insoluble lignin in case of eucalyptus is lowest at the age of 5 years (21.2%) against 24.8 and 25.2% for 3 and 7 years. The NaOH serves for dissolution of lignin, A-B extractives and other organic compounds and therefore higher the solubility value, lower is the yield. Lignin A-B extractives and alkali solubles amount to 48.4% for eucalyptus at 3 years of age against 38% at 5 years and 45% at 7 years. It would indicate pulp yield to be lowest at 3 years and highest at 5 years.

On the other hand, subabul shows fairly same chemical compositions at 3,5 and 7 years, excepting A-B extractives. Lignin, A-B extractive and 1% NaOH solubility for subabul at 3,5 and 7 years are 46.6 and 45.6% respectively. One tends to presume from these results that subabul can be used profitably at lower ages compared to eucalyptus. The holocellulose content remains unchanged from 68-70% while the amount of pentosan slightly increases in case of eucalyptus with age but decreases in case of subabul. The ash content on the other hand increases with age for both the plants. However, the values are not significant.

The chip classification data for six samples are shown in Table 3. It is important to mantion that the coarser fraction decreases with increase of age as much as 10% both in subabul and eucalyptus.

The pulping characteristics of the samples are shown in Table 4. Active alkali dose employed is 15%. The screened unbleached pulp yield is 45-48% for eucalyptus and 47-

Table -3

CHIPS CLASSIFICATION

Screen size, mm	Eucalyptus			Subabul		
	3 years	5 years	7 years	3 years	5 years	7 years
- 32, + 25,	15.7	13.6	5.7	19.7	10.5	9.5
- 25, + 22,	10.1	10.1	7.2	10.6	10.7	10.0
- 22, + 19,	9.6	12.2	10.8	10.5	11.6	11.0
- 19, + 16,	9.8	15.0	17.7	10.6	17.5	17.2
- 16, + 13,	10.7	14.2	19.7	8.7	17.2	17.9
- 13, + 6,	15.8	23.8	31.6	11.7	24.7	26.5
- 6, + 3,	6.7	2.6	4.5	1.9	2.4	2.9

Table -4

PULPING CHARACTERISTICS

Particulars	Unit	Eucalyptus			Subabul		
		3 years	5 years	7 years	3 years	5 years	7 years
Active Alkali as Na_2O,	%	15.0	15.0	15.0	15.0	15.0	15.0
Screened pulp yield,	%	45.0	48.27	48.39	47.2	51.25	52.20
Rejects,	%	3.2	1.1	1.2	1.3	1.6	1.2
Total unbleached yield,	%	48.2	49.37	49.59	48.5	52.85	53.40
Kappa no.	-	27.0	22.0	22.8	26.0	23.0	20.7
Residual active alkali,	gpl	7.0	6.2	7.44	13.9	8.7	8.06
H' factor,	-	1380	1380	1380	1380	1380	1380

Constant Cooking Conditions:

1. Sulphidity of white liquor, % - 19 $\pm$ 1
2. Bath Ratio, - 1 : 2.7
3. Cooking Schedule :
   50°C to 165°C - 2.0 hrs
   At 165°C - 2.0 hrs.

Table -5
BLEACHING CHARACTERISTICS

Particulars	Unit	Eucalyptus 3 years	Eucalyptus 5 years	Eucalyptus 7 years	Subabul 3 years	Subabul 5 years	Subabul 7 years
1. Kappa no.	-	27.0	22.0	22.8	26.0	23.0	20.7
2. Chlorination:							
a) Cl_2 - added	%	5.5	4.0	5.0	5.0	4.0	4.5
b) Cl_2 - consumed	%	5.5	3.93	4.5	5.0	3.93	4.2
c) Final pH	-	1.8	1.7	1.8	1.8	1.7	1.9
3. Alkali extraction:							
a) NaOH added	%	1.4	1.5	1.8	1.8	1.5	1.8
b) Final pH	-	9.5	10.0	9.8	10.5	10.8	10.0
4. Hypo-stage:							
a) Hypo (available chlorine) added	%	3.25	3.25	2.5	3.0	3.25	2.0
b) Buffer added,	%	0.8	0.8	0.4	0.6	0.8	0.4
c) Final pH	-	8.3	8.1	8.2	9.2	8.0	8.5
d) Cl_2 (as available) Consumed	%	2.7	2.4	2.39	2.8	2.86	1.99
5. Brightness	% El	78.5	82.0	80.7	79.8	80.8	78.6
6. Viscosity (0.SMCED)	Cp	6.5	5.9	5.2	6.2	8.3	7.4

Constant conditions:	Chlorination	Alkali extraction	Hypo-stage
1. Temperature, °C	Ambient	55	40
2. Retention time, hrs	0.75	1.5	2.5
3. Consistency, %	3.0	10	10

52% for subabul; the reject value being 1-3% . The total unbleached field obtained is 48-49% for eucalyptus and 48-53% with subabull. Similar yield values have been reported from eucalyptus at Tamilnadu (8). The kappa no values are 21 and 23 for 5 and 7 years old trees and the residual active alkali values for eucalyptus are 6-7 gpl while it is 8-14 gpl in subabul. Thus subabul can be better than eucalyptus as far as pulp yield is concerned. The cooking conditions adopted are shown in Table 4.

Table 5 summarises the bleaching characteristics of both the plants for the 3 age groups. The amount of Cl_2 consumed is more or less same for 5 and 7 years old eucalyptus and subabul (brightness value of 80% El). However, the total chlorine consumption is quite high in 3 years old plant (8%). The viscosity values of subabul are marginally higher than eucalyptus. The bleaching conditions adopted are given in Table 5.

The Bauer Mc-nett fibre classification data from + 16 to + 100 mesh sizes are presented in Table 6. The fibre fraction of - 16, +30 in subabul is much higher then eucalyptus. The fibre percentage of - 30, + 50 fractions are more or less same while the finer fractions are comparatively lower in subabul than in eucalyptus.

The fibre dimensions, determined by optical microscopy are tabulated in Table 6. The maximum fibre length is 1.1-1.3 mm in eucalyptus while it is 1.8-1.3 mm in case of subabul. Thus 5 years old subabul has higher fibre length than the 7 years old plant. The minimum fibre length values for both subabul and eucalyptus are 0.5-0.31 mm.

The physical strength properties of bleached pulp at different freeness levels have been determined (Table 7). The bulk values for 5 years eucalyptus is 1.21, while for 7 years it is 1.4 Cm^3/g at 40^0 SR; the corresponding values being 1.25 and 1.31 Cm^3/g for subabul. The burst factors at 40^0SR at 5 years old tree are exceptionally higher than trees of both 3 and 7 years old. Burst factor of 5 years old eucalyptus is 52 while it is 43 for 3 years and 38 for 7 years old eucalyptus; the corresponding values for subabul being

Table -6

BAUER McNETT FIBRE CLASSIFICATION

Mesh Size, No.	Fibres retained %											
	Eucalyptus						Subabul					
	3 years		5 years		7 years		3 years		5 years		7 years	
	Initial (16°SR)	40°SR	Initial (18°SR)	40°SR	Initial (18°SR)	40°SR	Initial (17°SR)	40°SR	Initial (16°SR)	40°SR	Initial (17°SR)	40°SR
+ 16,	2.3	0.5	0.75	0.38	0.5	0.2	3.7	1.0	4.42	0.34	3.1	0.9
- 16, + 30,	17.2	4.3	1.7	1.77	3.4	4.0	34.0	12.8	25.66	12.48	21.4	14.2
- 30, + 50,	24.0	·19.5	56.42	52.54	42.7	31.4	29.7	26.3	47.08	44.80	49.8	41.3
- 50, + 100,	21.5	36.7	22.69	20.30	32.3	35.8	22.4	28.7	10.60	13.68	9.7	14.9
- 100,	35.0	39.0	18.44	25.01	21.1	28.6	10.2	31.2	12.24	28.7	16.0	28.7

FIBRE DIMENSIONS

Particulars	Eucalyptus			Subabul		
	3 years	5 years	7 years	3 years	5 years	7 years
Fibre length , mm:						
Minimum	-	1.15	1.30	-	1.79	1.31
Maximum	-	0.5	0.31	-	0.5	0.32
Average	0.85	0.77	0.82	1.03	1.09	0.79
Fibre diameter, micron	-	-	14.06	-	-	12.0

Table -7

PHYSICAL STRENGTH PROPERTIES OF BLEACHED PULP AT DIFFERENT °SR

Particulars	Unit	Eucalyptus							Subabul						
		3 years		5 years			7 years		3 years		5 years			7 years	
		40°SR	18°SR	30°SR	40°SR	18°SR	30°SR	40°SR	40°SR	16°SR	30°SR	40°SR	17°SR	30°SR	40°SR
Bulk,	cc/g	1.25	1.46	1.31	1.21	1.86	1.55	1.40	1.27	1.39	1.3	1.25	1.86	1.52	1.31
Burst factor,	-	43.0	43.0	49.3	52.0	19.2	33.1	38.6	35.7	43.0	47.7	49.5	18.2	34	43.1
Tear factor,	-	37.0	47.0	45.0	45.0	40.0	47.2	37.5	40.0	61.0	56	46	36.5	35.7	34.8
Breaking length,	m	5852	5765	6440	7050	3330	5005	5860	5450	6070	6556	6896	3635	5400	6555
Double fold,	no.	39	11	15	23	5	11	12	31	39	52	76	5	11	12
Zero span breaking length,	m		11690				9715				12320			10040	

50, 36 and 43. These observations are in favour of the supremacy of 5 years old tree over 3 and 7 years.

The tear factors of 5 years old tree are significantly higher than 3 and 7 years plant; for eucalyptus these are 45, 37 and 37.5, while for subabul the values are 46, 40 and 35 for 5,3 and 7 years respectively. The breaking length values are also in the same order at 40°SR; namely 7050, 5850 and 5860 m for eucalyptus and 6896, 6070, 6555 m for subabul of 5,3 and 7 years trees. The double fold values for 5 years old trees are better than the 7 years old trees in both eucalyptus and subabul.

Conclusion:

Both eucalyptus and subabul are promising for short rotation and high pulp qualities. Trees at 5 years can be considered appropriate for rotation. Trees at 3 years possess higher amount of lignin and A-B extractive with higher percentage of big size chips than 5 and 7 years. Subabul produces pulp with 2.4% higher yield than eucalyptus of same age.

Subabul is more promising than eucalyptus in many respects.

Acknowledgement

The authors express gratefulness to the Management of Pulp and Paper Research Institute, Jaykaypur for giving permission to publish this paper. The authors are indebted to Shri S.C. Jain, President, M/s. Straw Products Ltd., for providing land and assisting in plantation of the trees.

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