Comparison of Pulping studies of Eucalyptus from Hybrid Seed Routed Wood vis-a- vis Clonal Wood.

S.N.Singh, K.N.Mishra, R.C.Joshi, G.G.Bhargava, Deepak Khare, M.C.Pande and N.K.Thusu

Orient Paper Mills Amlai District: Shahdol (M.P)

Eucalyptus Hybrid plantations planted in Amlai through seed route have achieved MAI of 6-12Cu.m/ Ha/year. Another route through clonal plantation was investigated to increase the raw material productivity and faster growth. In this regard 65 candidate plus trees from Shahdol. Dindori and Mandla districts of M.P were selected out of which 61 clones were tested and 5 were ultimately selected for multiplication. The selected clones have MAI of more than 30.Cu.m/ha/year.

Amlai and Dindori Eucalyptus Hybrid clonal plantations of 5 years of age were evaluated for pulping characteristics and comparison was made with seed routed Eucalyptus hybrid plants of seven years of age of Amlai region.

INTRODUCTION

The availability of forest-based raw material is becoming scarce in India due to depletion of forest cover under increased biotic pressure. Every year around 2 million hectare of forest cover is lost owing to over exploitation of natural resources for tremendous increase in demand of food, fuel, fibre, fodder, shelter, communication and industry. Already 130 million hectare area has become degraded out of total land area of 329 million hectare (1). India,s geographical area of 329 million hectare is only 2.5% of world's land area whereas it is supporting over 15% of total human population and around 16.0% world's cattle population(2). Present pace of depletion is alarming and may threaten human life eventually.

Average productivity of forests in India is 1.37cu, m/ ha/year against world average of 2.1 cu. m /ha/year. Restoration of green cover and substantial improvement in land productivity on sustainable basis is the need of the hour. As per FAO (3.4) the demand of wood by 2010 will be as follows

The green revolution in India has made the country self -sufficient and self -dependent to meet the food grains requirement of the second most populous country of the world. It is equally important for the survival of human being to safeguard precious green cover and to utilize it judiciously on a sustainable basis. One way to achieve this objective is to conserve the resources and to increase productivity per unit area of land by raising plantations of fast growing genetically superior clonal varieties. High tech clonal plantations are necessary to meet the increasing requirement of wood in the country besides maintaining ecological balance and to alleviate tremendous biotic pressure on forestland.

Worldwide attempts are going on (5-12) for increasing wood yield with technologies of faster growth coupled with shorter rotation, mostly with Eucalyptus. Silvicultural applications have also been made (13,14) and pulping and bleaching studies have been reported from 2 to 10 year age of trees. Majority of works carried out in Australia on Eucalyptus are on trees of higher than 10 years of age. Eucalyptus species have been planted around the world on a massive scale with area expected to be around 10 million hectares by the year 2000 (15). Apart from Eucalyptus camaldulensis, E. Grandis has been planted more widely than other species in the coastal area (16). Many positive responses in tree growth to fertilizers have been reported in Australia and other countries (17). In Australia and South Africa E. Grandis is regarded as the most

important hard wood pulp species (18,19) whereas in Brazil it is dominated by E. Grandis and E. Hybrid pulp wood species (20).

Seed routed Eucalyptus plantation at Amlai

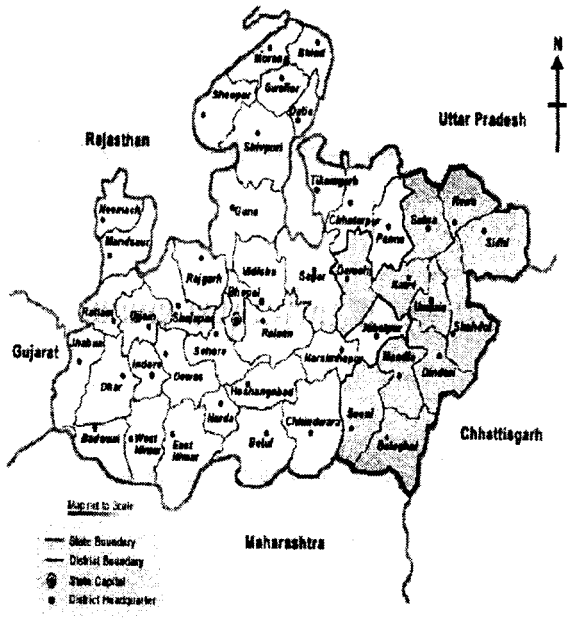
Particular	million tonnes
Fuel wood & Charcoal	344
Industrial round wood	37
Sawn timber	33
Paper & Board	5.7
Wood based Panels	1.3

In Amlai region rain fed Eucalyptus Hybrid plantations through seed route have been traditionally raised since 1967. Soil in the plantation area has been sandy loam with slightly acidic conditions. Soil depth varies between 1 to 3 meters overlaying a continuous belt of hard rock. The Eucalyptus Hybrid seedlings were planted at an espacement of 2.0m x 2.0 m. The mean tree height, diameter at breast height and mean of annual increment per hectare/year after seven years of planting at Amlai region are given in table.1. Height and DBH measurement were recorded once in a year before commencement of spring growth.

It was observed that seed routed plantations of Eucalyptus were not meeting the growth standards expected from fast growing species in the semi-arid region of Madhya Pradesh, in which the mills have been promoting tree planting under Farm-Forestry Programme. It was also observed that quality of seeds has been deteriorating as it happens due to inbreeding in successive generations. The diverse quality of seeds also resulted in very high variation in their crops. The variation resulted in the Mean Annual Increment variation between 6 to 12 cu.m/ Ha/Year.

ORIENT Clonal Eucalyptus Plantation at Amlai and Dindori area

Clonal technology leads to gain in productiviy and quality of produce from plantations. This technique involves selection of "Candidate plus trees" (CPTS) from existing plantations based on desired characters. CPTS with a minimum MAI of 30 cu.m/year/hactare were identified). Under regulated environmental conditions coppice cuttings of selected CPTS were rooted and field-tested for selection of genetically superior fast growing. disease resistant clones having straight bole and canopy of one third of total height. Special emphasis was given to plus trees from semi arid conditions in the catchment area of Orient Paper Mills. Total 65 plus trees were identified (thirty five from Amarkantak, Dindori and Mandla region and 30 each from Shahdol and Amlai area). The geographical location of the area is shown in the map of M.P.



Madhya Pradesh

From the selected 65 Candidate plus trees from Shahdol,

Table-1

Eucalyptus Hybrid, age years	Mean tree height (m)	Mean tree D.BA (m)	Avg vol O.B(m^3)	M.A.I m^3/Ha/yr
7.0	8.0	0.09	0.02	7.14

Table- 2

Proximate Chemical analysis of Amlai Eucalyptus hybrid(s), Amlai and Dindori Eucalyptus Hybrid (c).

Particular	Amlai Eucalyptus Hybrid	Eucalyptus clones	
		Amlai	Dindori
Ash, %	0.8	1.0	1.1
Cold water Solubility, %	6.05	4.05	5.07
Hot water Solubility, %	4.16	4.34	5.86
1 % NaOH Solubility, %	17.7	18.30	18.70
Alcohol/Benzene Solubility, %	1.20	1.87	1.57
Holo cellulose, %	67.5	68.8	68.0
lignin, %	28.50	27.34	27.62
Pentosans, %	13.0	14.2	14.6

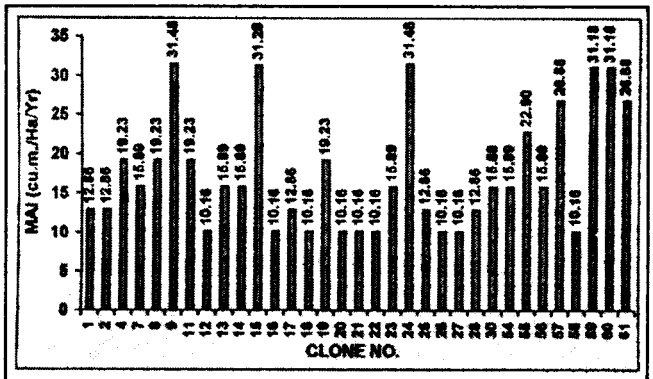
Dindori and Mandla districts, the coppice cuttings were rooted at the vegetative propagation Unit and saplings were developed. These clones were tested at the mills under unirrigated conditions for field performance in Randomised Block Design and Growth data were collected and analyzed. 61 clones have been tested so far and 5 have been selected for further multiplication.

It may be noted that mills catchment area is semi arid where plantations achieve a low productivity of 6 to 12 cu.m/year/hectare. With planting of ORIENT clones it is expected to achieve MAI of about 30 Cu.mt/ha/year as these saplings shall be genetically superior and similar in phenotypic character. Clonal plantations will improve productivity of the same land with optimum utilization. This will result in the benefit to farmers in getting higher returns from the same piece of land. Thus Mill's availability of raw material is expected to increase in coming years from the same land mass and will help in conservation of natural forest resources. Secondly a farmer can get identical returns from clonal plantations in comparison to seed routed plantations, within much shorter span of time.

Comparison of pulping Characteristics of Seed routed and Clonal Eucalyptus Plantations

Eucalyptus hybrid seed routed plantations were grown in Amlai region and Eucalyptus hybrid clones were developed in Amlai and Dindori region. Seed routed Eucalyptus plantation of seven years age and Clonal plantation of five years of age were also evaluated for determining pulping characteristics.

Table: MAI of Clones Tested at Amlai



Note: Survival Percent 75, Average crop height for all clone is 15.00 m, Plus Trees selected from Amlai for clone no. 1 to 30, Plus Trees selected from Dindori Area for clone no. 54 to 61

Planting year -July1996, Data measurement year - Dec.2001.

Proximate chemical analysis of Eucalyptus Hybrid(s) and Eucalyptus(c) chips dust (-40, +60 mesh) was carried out employing Tappi Standard methods. The results ate tabulated in Table.2. It may be seen that Alcohol/Benzene solubility, Holocellulose and Pentosan contents in Amlai and Dindori Eucalyptus (c) are higher than Amlai Eucalyptus Hybrid (s). Comparison of Proximate analysis of Eucalyptus Hybrid(s) and Eucalyptus Hybrid(c) are projected in Fig.1

Amlai Eucalyptus hybrid(s), Amlai and Dindori Eucalyptus(c) wood screened chips (-29.0, +3.0 m.m) chips 8S per mill requirement were digested with 15.0% alkali under identical cooking conditions. The

Table-3

Kraft Cooking of Amlai Eucalyptus hybrid(s), Amlai & Dindori Eucalyptus Hybrid (c).

Particular	Amlai Eucalyptus Hybrid	Eucalyptus clones. Amlai	Dindori
Chips taken on O.D. basis (kgs)	2.0	2.0	2.0
Alkali used as Na_2O, %	15.0	15.0	15.0
Sulphidity, %	18.19	19.5	19.5
Bath ratio.	1:3	1:3	1:3
Cooking Cycle:			
i) Up to 135°C, mnts	120	120	120
ii) 135 to 165°C, mnts	60	60	60
iii) At 165°C, mnts	60	60	60
iv) Total cooking time (hrs)	4.0	4.0	4.0
Unbleached pulp yield, % (on O. D. chips)	45.62	46.07	46.19
Rejects, % (on O. D. chips)	0.76	0.58	1.22
K. No. (25ml.) of pulp.	16.7	17.0	17.1
Kappa. No. of pulp.	24.7	26.7	26.4
Black Liquor Analysis:			
i) °TW at 60°C	25.5	25.0	24.5
ii) R .A.A, g/l	18.60	18.60	19.30
iii) Inorganic, %	30.2	29.54	30.01
iv) Organic, %	69.8	70.46	69.99
v) Silica, % (Acid insoluble)	0.40	0.42	0.42

unbleached pulp yield in Eucalyptus clone wood was observed to be higher by about 0.5% than Amlai Eucalyptus(s) (Table.3) may be because of lower Lignin and higher holocellulose content. Amlai Eucalyptus Hybrid(s), Amlai & Deindori Eucalyptus (c) were easily converted into bleachable grade of pulp.

Fibre dimensional studies of Amlai Eucalyptus (s), Amlai and Dindori Eucalyptus(c) pulps were also carried under a Projectina Projection microscope. The Eucalyptus clonal pulps have higher slenderness ratio than Amlai Eucalyptus hybrid (s) bleached pulps (Table.4). Comparison of Fibre dimensions of Eucalyptus bleached pulps is highlighted in Fig.2

Unbleached Eucalyptus(s) and clonal unbleached pulps were beaten to 30° S.R freeness in a P.F.I mill and standard sheets were evaluated for physical strength properties. It may be observed that Amlai and Dindori eucalyptus clone unbleached pulps have better strength properties than Amlai hybrid(s) pulp (Table.5).

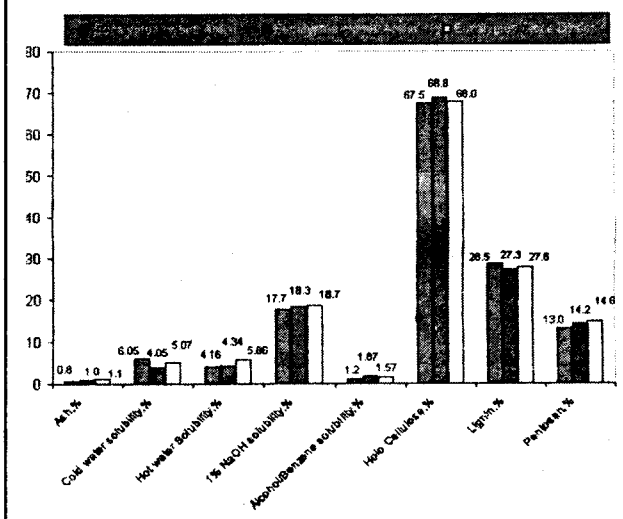


Fig. 1 Comparison of proximate Chemical analysis of Eucalyptus (Seed routed) and Eucalyptus (clones)

Bleaching studies were also conducted on Amlai Eucalyptus(s) and Amlai & Dindori Eucalyptus (c) pulps under C-Ep-H-D sequence for pulp brightness

Table-4

Fibre dimensions of Amlai Eucalyptus hybrid(s), Amlai & Dindori Eucalyptus Hybrid (c) pulps.

Particulars	Amlai Eucalyptus Hybrid	Eucalyptus clones Amlai	Dindori
Fibre Length. (m.m.)			
Min.	0.80	0.90	0.70
Max.	2.00	2.00	2.30
Avg.	1.30	1.34	1.32
Fibre Diameter. (m.m.)			
Min.	0.005	0.005	0.005
Max.	0.03	0.03	0.035
Avg.	0.016	0.016	0.016
Slenderness Ratio.			
L/D	81.25:1	83.75:1	82.5:1

Table-5

Physical Strength Properties of Amlai unbleached pulps from Eucalyptus hybrid(s), Amlai & Dindori Eucalyptus Hybrid (c).

Particulars	Amlai Eucalyptus Hybrid	Eucalyptus clones Amlai	Dindori
Number of beating revolution in P.F.I. mill rpm.	6000	4500	4525
Final freeness °SR of pulp.	31	29	31
Bulk c.c. /gram	1.39	1.41	1.40
Tensile Index. N.m /g	67.13	68.93	67.76
Burst Index. K Pa. m^2/ g	5.32	5.60	5.47
Tear Index. mN. m^2/ g	7.50	8.10	7.69
Double fold.	480	550	502
Strength Index,	2234	2350	2280

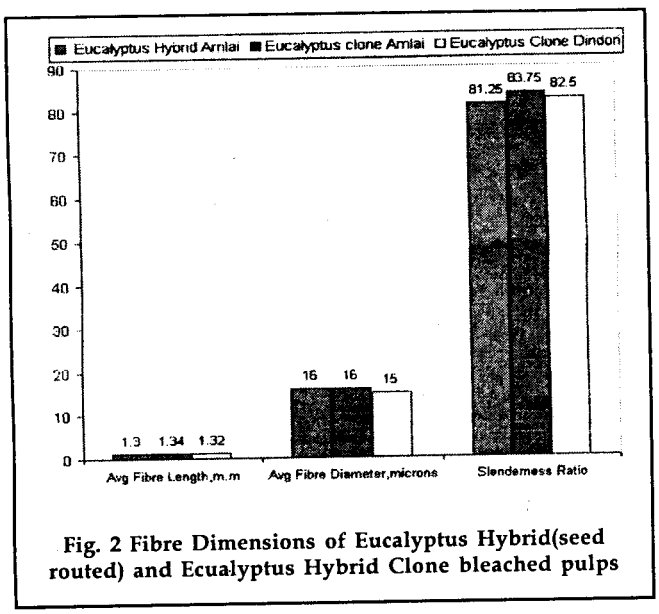


Fig. 2 Fibre Dimensions of Eucalyptus Hybrid(seed routed) and Ecualyptus Hybrid Clone bleached pulps

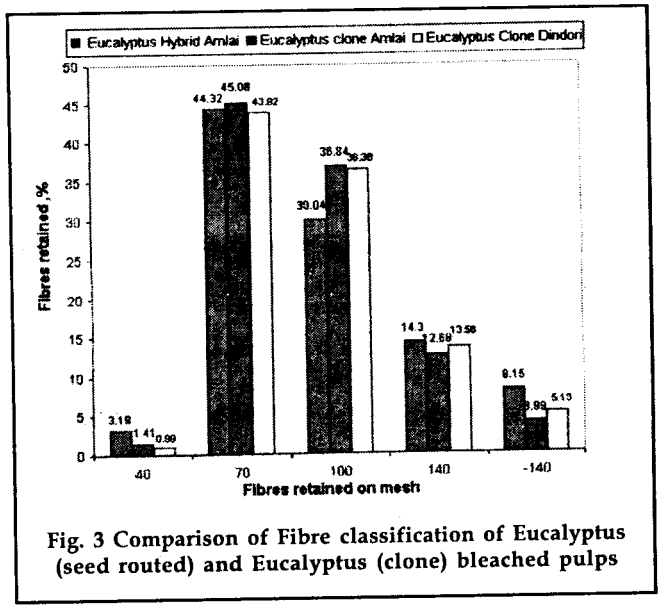


Fig. 3 Comparison of Fibre classification of Eucalyptus (seed routed) and Eucalyptus (clone) bleached pulps

Table-6

Bleaching of Amlai Eucalyptus hybrid (5), Amlai & Dindori Eucalyptus Hybrid (c) wood pulps under C-Ep-H-D sequence.

Particular	Amlai Eucalyptus	Eucalyptus Clone Amlai	Dindori
Chlorination Stage.			
i) Cl_2 applied / consumed, %	4.50/4.44	4.50/4.47	4.80/4.48
ii) End pH.	1.8	1.6	1.6
iii) Consistency %	3.0	3.0	3.0
iv) Temp.°C	Ambient	Ambient	Ambient
v) Time,mts.	60	60	60
Alkali Extraction Stage.			
i) Caustic applied, %	1.3	1.3	1.3
ii) H_2O_2 applied, %	0.4	0.4	0.4
iii) End.pH	10.8	10.4	10.4
iii) Consistency %	10.0	10.0	10.0
iv) Temp. °C	65±1	65±1	65±1
v) Time,mts.	60	60	60
Hypo Chlorite Stage.			
i) Hypo applied /consumed, %	2.80/2.22	2.50/2.27	2.50/2.27
ii) Sulphamic Acid, %	0.1	0.1	0.1
iii) Buffer added, %	0.5	0.6	0.6
iv) End pH	7.8	7.8	7.7
Iii) Consistency %	10.0	10.0	10.0
iv) Temp. °C	40±1	40±1	40±1
v) Time,mts	120	120	120
Chlorine dioxide Stage.			
i) ClO_2 applied / consumed, %	0.60/0.59	0.60/0.48	0.60/0.48
ii) End pH	4.25	4.80	4.60
iii) Consistency %	10.0	10.0	10.0
iv) Temp. °C	70±1	70±1	70±1
v) Time,mts	120	120	120
Final Results.			
i) Total Cl_2 applied / consumed, %	7.30/6.60	7.00/6.74	7.00/6.75
ii) Pulp Brightness, % P.V.	87.5	87.0	87.0
iii) Bleached pulp yield. %	39.8	41.04	40.50
iv) Pulp Viscosity, (0.5%C.E.D.Cps)	7.6	8.1	7.9
v) P.C. No.	1.89	1.80	1.90

87±1% P.V. Total chlorine consumption in Eucalyptus pulps (s) and (c) was found to be nearly the same to achieve the same target brightness 87±% P.V. While bleached pulp yield (41.04%) of Amlai Eucalyptus (c) was higher than Dindori(c) (40.5%) and Amlai Eucalyptus(s) (39.8%). Similar trend was obesrved for bleached pulp viscosity (Table 6).

Fibre classification of bleached pulps was carried out in a Bauer Mcnett Classifier. Fibre retention percentage on 40 mesh was observed to be higher in Amlai

Table-7

Fibre Classification of bleached pulps from Amlai Eucalyptus Hybrid (s), Amlai & Dindori Eucalyptus Hybrid (c).

Mesh Size	Amlai Eucalyptus Hybrid	Eucalyptus clones	
		Amlai	Dindori
+40	3.19	1.41	0.99
-40+70	44.32	45.08	43.92
- 70+ 100	30.04	36.84	36.38
- 100 + 140	14.30	12.68	13.58
-140	8.15	3.99	5.13
Total	100.00	100.00	100.00

Table- 8

Physical strength properties of bleached pulps from Amlai Eucalyptus hybrid (s), Amlai & Dindori Eucalyptus Hybrid (c).

Particulars	Amlai Eucalyptus Hybrid	Eucalyptus clones	
		Amlai	Dindori
Number of beating revolutions in a P.F.I mill.	4600	5200	4750
Final freeness °SR of pulp.	29.0	29.0	29.0
Bulk, c.c/gram	1.35	1.37	1.36
Tensile Index. N.m/g	64.05	65.88	65.55
Burst Index. K Pa.m^2 / g	4.64	5.02	4.73
Tear Index. m N.m^2 / g	7.20	7.40	7.3
Double fold.	253	279	270
Strength Index.	2030	2116	2060

Eucalyptus(c) bleached pulp than Dindori(c) and Amlai Eucalyptus(s) bleached pulps. Fines passing through 140 mesh was lower in Amlai Eucalyptus(c) bleached pulp than Dindori(c) and Amlai(s) bleached pulps (Table. 7). Comparison of Fibre classification of Eucalyptus bleached pulps is projected in Fig.3

All the three bleached pulps were beaten to 30° S.R freeness and evaluated for physical strength properties (Table.8). It may be seen that Amlai Eucalyptus (c) bleached pulp had higher pulp strength properties than Dindori Eucalyptus(c) and Amlai Eucalyptus (s) bleached pulps. Comparison of strength properties of Eucalyptus(s) and Eucalyptus(c) bleached pulp strength properties is highlighted in Fig.4

CONCLUSION

The clonal plantation is the ultimate solution to meet the growing demand of woody materials for the sustainable development of Indian paper Industry besides helping in restoration of environmental degradation. Clonal plantations reduce the requirement of land mass required to produce the same quality of

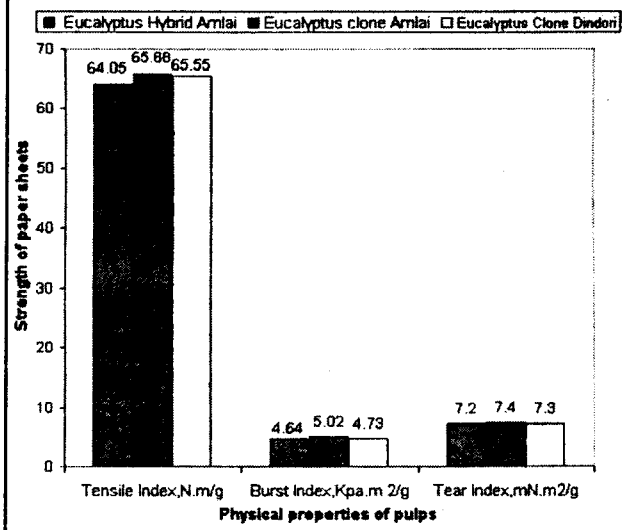


Fig. 4 Comparison of Physical strength Properties of Eucalyptus (seed routed) and Eucalyptus (clone) bleached pulps

pulpable wood as compared to seed routed plantations. Clonal plantations of Eucalyptus hybrid are 2 to 3 times faster in growth than seed routed Eucalyptus hybrid plantations in Amlai region. Clonal plantation wood also gives higher bleached pulp yield and better strength properties than seed routed Eucalyptus hybrid plants even though Clonal Eucalyptus plantations grown in different region differ in pulp yield and its quality. It is, therefore, essential to carefully choose appropriate clones for each geo-climatic region to get optimum pulp wood yield as well as pulps with better fibre characteristics

REFERENCES

1. Rao S.N. IPPTA Con. Issue, p. 35. December 1998.
2. Rao S.N.IPPTA J.14. (4) 13, 2002.
3. Anon. Inaugural Address of Shri Babagouda Patil, Union Minister of State for Rural Areas and Employment Seminar on promotion of Agro- forestry in Non forest wastelands under Investment promotional scheme. New Delhi (1999).
4. Anon. Report of the Expert committee of Review of a forestation policies and Rehabilitation of waste lands-Ministry of Environment and Forests. Govt of India New Delhi.
5. Patel M. & Sridhar .P, IPPTA J. , 6 (3); 77 (1994)
6. Farrington A, Hansen, N.W.& Nelson, P.F, APPITA, J. 30 (4); 313,1977.
7. Cromer. R.N and Hansen. N.W, APPITA. J. 26(3); 187 (1972).
8. Barker, R.G, TAPPI, J. 57(8); 107 (1974).
9. Einspahr, D.W, TAPPI, J. 59 (II); 63 (1976).
10. Jett, J.B and Zobel, B.J, TAPPI, J. 58 (1); 92 (1975).
11. Steinbeck, K. and Gleaton, E.N, Pulp and Paper Canada, 48 (13); 96, (1979)
12. Barassi, J & Welford. J. APPITA, J. 48 (2); 118 (1995).
13. Dash. B. & Patel, M.IPPTA. J. Con. Issue, 69(1994)
14. Veena, V. Sahu, A.K & Patel M. IPPTA, J. 4(1); 21 (1992).
15. Turn bull, J.W-IUFRO Symposium, Intensive forestry; **The role of Eucalyptus** (Ed. A.P.G, schonau); Durban, South Africa, pp 2-27(1991).
16. Boland, D.G, Brooker, M.I.H, Chippendale, G.M. Hall. N. Hyland. B.P.M. Johnston, R.D.J, Kleinig, D.A. and Turner, G.D.-Forest Trees of Australia, 4th Edn. Nelson- CSI RO, Melbourne,(1984).
17. Robin. N. Cromer, V.Balodis, David Cameron, Carl. P.Garland, Stan Rance & Paul Ryon APPITA. J. 51(1), p.45, (1998).
18. du Plooy, A.B.J. The relationship between wood & pulp properties of E. grandis (Hill Ex - Maiden) grown in South Africa- APPITA, 33(4); 257(1980).
19. Graz, F.P. & Von Gadow. K-Forecasting of Eucalyptus Grandis Resource in South Africa. SA. Institute of Forestry Symposium, "Management of Eucalyptus Grandis in South Africa", Stellenbosch.(1990).
20. de F .gely ,A.R and Parson, M. J.-Forest product trade-the supply challenge from plantations in New Zealand, Chile and Brazil. National Agriculture and Resource Outlook Conference," Commodity Markets and Resource Management", Canberra (1997)