Development of Captive Tropical Pine Pulp-Wood Plantations on Degraded Forest Lands in Karnataka

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ABSTRACT:-- Paper Industry in India uses Bamboo and Soft wood (conifers) as long fibre and mixed hardwood as short fibre raw material for paper making. There is considerable shortfall in the available forest raw material, especially long fibre. The shortfall for long fibre can be met through raising tropical pine plantations.

The Mysore Paper Mills Limited, Bhadravathi in Karnataka is raising Tropical Pine plantations from 1981 to cover 6700 Ha. on eastern aspects of Western-ghats with edaphic and climatic conditions congenial for raising Tropical Pine. Plantations are going to yield long-fibre wood on a sustained basis from 2003 AD. Promising species and provenances are identified for the sites. Nursery and plantation development techniques have been standardised. Growth data of plantations are encouraging and indicate an MAI of 13.7 M^3/Ha. a potential yield of 94 debarked Air Dried Tonnes (ADT) per hectare at the rotation period of 12 years. The Pine wood pulp consists mainly of long fibre fractions, contributing to higher strength properties.

INTRODUCTION

The growing industrialisation of India and the planned rise in the living standards of the people are certain to result in considerable increase in the requirement of forest produce, particularly for purposes such as for the manufacture of pulp and paper (Sridhran, 1982). Although, the per capita consumption of paper in our country is very low (around 2-3 kg.) compared to developed countries like USA where per capita consumption of paper is around 289 kg. Keeping in view the present rate of population growth and assuming a per capita consumption of paper at 4.5 kg. by 2000 AD, the demand for paper would be around 45 lakh tonnes.

A comparative position of the requirement of the forest raw-materials and their estimated availability by 2000 AD are as follows:-

Sl. No.	Kind of Forest raw-material	Requirement (lakh tonnes)	Potential availability (lakh tonnes)	Short fall (lakh tonnes)
1.	Bamboo	35.46	30.30	5.16
2.	Hard-woods	82.04	47.81	34.23
3.	Soft-woods	23.90	3.16	20.74

(Source: National Commission on Agriculture (NCA), 1976)

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Presently, most of the paper mills in India use bamboo and soft-woods (Conifers) as long fibre raw-materials and mixed hard-woods as short fibre raw-materials. There is already a yawning gap between requirement and availability of pulpwood particularly long fibre material. The availability of bamboo has been decreasing at an alarming rate in recent times. Further, the situation is aggravated by considerable demand for domestic consumption of bamboo which is known as "Poor man's timber".

INTRODUCTION OF TROPICAL PINES IN INDIA

Raising of bamboo plantations to meet the long fibre raw material demand of paper industry has not been much of a success because bamboo needs longer time for establishment and requires continuous protection throughout its rotation. Hence, it may be very difficult for the pulp-wood industries to establish economically viable bamboo plantations on denuded forest lands. Besides, complete dependence on bamboo for long fibre can be disastrous, as bamboo flowers unpredictably and gregariously. The only alternative to obtain long fibred material on sustained basis is to go in for Tropical Pines which can be grown in similar areas and are expected to give much higher yield as compared to bamboo. The Tropical Pines are fast growing with fantastic adaptability to varying agro-climatic conditions.

Around 1906, several exotic Pines were introduced in South India (2160-2400m altitude) and **Pinus radiata** was found to be the best among several species tried (Kaul, 1982). Introudction of Pines continued and during 1958, trials of exotic pines started on a systematic basis in different parts of the country with a hope that some suitable seed source, within a wide range of naturally distributed genetic variation can be identified for each locality. The results of the trials indicated that **Pinus caribaea** var. **hondurensis** seems to be the best species at low altitudes and **Pinus patula** appears to be suitable for high altitudes i.e., 1200m and above (Ghosh, 1977). Pinus pseudostrobus, **Pinus kesiya & Pinus oocarpa** also have considerable scope for afforestation. In Karnataka Tropical Pine introductory trials are very limited and as such very little data are available to interpret the results. The NCA has estimated that 30 million hectares of forest land can be brought under intesive management for Production Forestry. The area available for conifers out of it is roughly 8.4 million hectares which are more than sufficient to meet the long fibre raw material requirement of paper industry. In Karnataka about 0.5 million hectares are found suitable for Tropical Pine plantaion development.

Experience of Mysore Paper Mills (MPM) Ltd., Bhadravathi in raising captive Pulp-wood Plantations.

FOREST RAW MATERIAL DEMAND

The Mysore Paper Mills Ltd., has an installed capacity to manufcture 75000 tonnes per annum (tpa) of newsprint and 37000 tpa. of cultural paper but the actual production is 90000 tpa of newsprint and 30000 tpa of cultural paper. The total annual forest raw material requirement of MPM is 2,40,000 Air Dry Tonnes (ADT) , of which the long fibre wood requirement is 57,600 ADT and short fibre requirement is 1,82,400 ADT.

At present MPM is dependent on Acacia and Eucalyptus wood for short fibre and is dependant on bamboos for long fibre. The availability of bamboos from natural source has now become critical and hence MPM started planting bamboos admixed with Acacia in pulpwood plantations, but bamboos have failed to establish successfully. Therefore MPM tried to introduce Tropical Pines, which serve as an alternative source of long fibre wood material, in a portion of 30,000 ha. of degraded forest land leased to MPM by Govt. of Karnataka.

ESTABLISHMENT OF TROPICAL PINE PLANTATIONS

The degraded forest lands leased to MPM comprise some areas on eastern aspect of western ghats with edaphic and climatic conditions congenial for raising Tropical Pine plantations. The MPM started raising Tropical Pine plantations on an experimental scale from 1981 and onwards which established successfully. Now, it has planned to establish about 6700 ha of Pine plantations with **Pinus caribaea** var **Hondurensis** to meet the long fibre raw material requirement of MPM on a sustained basis from 2003 A.D.

LOCALITY FACTORS OF PLANTATION SITES

The locality factors of the sites where Tropical Pine plantations are raised are given in Table-1.

Table-1

Locality factors of plantation sites

Factors	Thirthahalli (Araga)	Hosanagar	Sagar (Talguppa)
Altitute	620 MSL	600 MSL	592 MSL
Latitude	13° 44' N	14° 10' N	14° 13' N
Longitude	75° 12' E	74° 50' E	74° 55' E
Mean annual rainfall	2606 mm.	2550 mm.	2765 mm.
Soil	Red sandy & Lateratic	Deep red loam & Lateratic	Red Sandy & Lateratic
pH	6.0	5.8	5.7

RESEARCH ACTIVITIES

Extensive silvicultural research has been carried-out in the project sites in Tropical Pines in order to provide scientific base for the successful establishment of the pulp-wood plantations with Tropical Pines. Research carried-out is grouped into:

a. Nursery Research

Trials are laid-out to find out optimum time of sowing and polythene bag size for raising healthy seedlings of **Pinus caribaea** var. **honurensis** for plantation development. Polythene bags of three sizes viz., 3" X 7", 4" X 6" and 5" X 8" and 4 dates of sowing in the mother beds viz., November, December, January and February are tested in the trials. The results of the trials have indicated that a nursery period of about 5 months and a polythene bag of size 4" X 6" are optimum to obtain a planting stock of height 25-30 cm, with fairly good number of active root tips, less root coiling and better collar diameter.

b. Species and Provenance Research

Species and provenance trials (for promising species only) are laid-out in systematic designs and the data on growth parameters are collected regularly. The data pertaining to different trials are presented in table 2, 3 and 4. Species trials indicated that **Pinus caribaea** var. **hondurensis** is the most promising and suitable species for our locality. **Pinus caribaea** var. **hondurensis** is well adapted to our site conditions with dark green and dense foliage, good vigour and promising growth. The trees are producing both male and female flowers in synchronised way which is a good sign that the species is growing in the correct environmental zone (Burley and Barnes, 1989). **Pinus tecunumanii** is the next best species with slightly pale green and sparse foliage, good vigour and satisfactory growth. Perhaps, it might be growing in a hotter climate and probably less fertile soils than where it occurs naturally (Burley and Barnes, 1989).

Pinus kesiya is slow growing than **Pinus caribaea** var. **hondurensis** and **Pinus tecunumanii** but looks healthy. It is grown under considerably higher temperature than it does in the areas of it's

Table-2

Mean plant height (M) and mean DBH (Cm) assessed at different ages for different Tropical Pine species tried at Kalammanagudi during 1987.

Species		1988	1989	1990	1991	1992	1993	1994	1995	MAI
P. oocarpa	Ht.	1.71	3.52	5.27	6.96	8.44	10.51	11.26	11.88	1.48
	DBH.	--	--	6.74	9.50	11.72	13.27	14.79	15.57	1.94
P.Kesiya	Ht.	1.07	2.36	4.14	6.17	7.60	9.67	10.88	11.30	1.42
(9256)	DBH.	--	--	5.27	8.24	10.61	12.04	12.74	14.38	1.79
P.kesiya	Ht.	1.07	2.64	4.68	6.67	8.09	10.40	11.09	11.87	1.48
(cafma B C)	DBH.	--	--	5.92	8.05	11.31	12.49	13.96	15.27	1.90
P.caribaea	Ht.	1.74	3.28	5.51	7.71	9.35	12.13	12.95	13.48	1.68
var. hond. (13 H)	DBH.	--	--	8.38	11.68	14.77	16.87	18.74	20.33	2.54
P.caribaea	Ht.	1.51	3.21	5.33	7.41	9.15	11.72	12.69	13.95	1.74
var. hond. (4 H)	DBH.	--	--	8.21	11.48	14.70	16.79	18.60	20.50	2.56

Table-3

Mean Plant Height (M) and Mean DBH (Cm) assessed at different ages for the provenances of Pinus caribaea var. hondurensis tried at Varakodu during 1988.

Sl.No.	Provenance		1989	1990	1991	1992	1993	1994	1995	MAI
1.	Mt. Pine Ridge	Ht.	0.71	2.07	3.96	5.27	7.65	9.26	10.35	1.48
	(Belize)	DBH.	--	--	--	9.30	11.30	13.10	14.50	2.10
2.	Tierra Blanca	Ht.	0.73	2.23	4.17	5.57	7.77	9.64	10.77	1.54
	(Hond)	DBH.	--	--	--	10.10	11.80	14.30	15.90	2.30
3.	San Antonio	Ht.	0.77	2.19	4.13	5.69	7.23	9.24	10.34	1.48
	Decortes (Hond)	DBH.	--	--	--	9.80	11.30	13.20	14.70	2.10
4.	Guanaja	Ht.	0.85	2.32	4.22	5.62	7.18	8.83	9.87	1.41
	(Hond)	DBH.	--	--	--	9.60	11.10	12.70	13.90	2.00
5.	Brus Laguna	Ht.	0.79	2.32	4.36	5.96	7.80	9.67	10.75	1.54
	(Hond)	DBH.	--	--	--	9.90	11.60	13.30	14.70	2.10
6.	Los Limones	Ht.	0.72	2.18	4.10	5.58	7.40	8.81	9.63	1.38
	(Hond)	DBH.	--	--	--	9.50	11.70	13.30	14.70	2.10
7.	La Brea	Ht.	0.96	2.56	4.44	6.16	7.88	9.77	11.20	1.63
	(Hond)	DBH.	--	--	--	10.60	11.80	13.40	15.30	2.20
8.	Agalteca	Ht.	0.66	198	3.82	5.50	7.17	9.01	10.69	1.52
	(Hond)	DBH.	--	--	--	9.60	11.20	13.20	14.80	2.10
9.	Yojoa	Ht.	0.81	217	3.97	5.57	7.45	9.15	10.00	1.43
	(Hond)	DBH.	--	--	--	9.70	11.20	13.20	14.30	2.00
10.	Culmi	Ht.	0.61	180	3.57	5.15	6.88	8.92	9.92	1.41
	(Hond)	DBH.	--	--	--	8.70	10.60	12.80	14.90	2.10
11.	Poptum Peten	Ht.	0.60	175	3.67	5.42	7.18	8.90	10.00	1.43
	(Gautemala)	DBH.	--	--	--	9.60	10.40	12.20	13.60	1.90

Table-4

Mean Plant Height (M) and Mean DBH (Cm) recorded at different ages for the provenances of Pinus tecunumanii tried at Varakodu during 1988.

Sl.No.	Provenance		1989	1990	1991	1992	1993	1994	1995	MAI
1.	San Raefel	Ht.	0.79	2.26	4.03	5.53	7.35	7.82	10.74	1.53
	Ridge (Belize)	DBH.	--	--	5.10	7.80	10.20	12.50	14.50	2.10
2.	San Esteban	Ht.	0.55	1.51	2.98	4.47	5.99	7.44	8.83	1.26
	(Hond)	DBH.	--	--	3.50	6.00	8.10	10.40	12.00	1.70
3.	Ojo De Agua	Ht.	0.78	2.21	3.83	4.73	6.74	8.17	9.60	1.37
	(Hond)	DBH.	--	--	4.90	6.90	9.40	11.30	13.60	1.90
4.	Villa Santa	Ht.	0.91	2.48	4.17	5.73	7.32	9.11	9.83	1.40
	(Hond)	DBH.	--	--	5.30	8.10	10.30	13.10	14.40	2.10
5.	Gualaco	Ht.	0.87	2.33	3.96	5.33	7.24	8.71	10.26	1.46
	(Hond)	DBH.	--	--	4.70	7.20	9.90	12.60	14.30	2.00
6.	La Sampredana	Ht.	0.64	1.84	3.29	4.47	5.83	6.38	8.57	1.22
	(Hond)	DBH.	--	--	3.80	6.10	8.40	10.30	12.00	1.70

natural occurrence (Burley and Barnes, 1989) **Pinus oocarpa** is also growing well but not tried extensively.

Fourteen provenances of **Pinus caribaea** var. **hondurensis** from Honduras, Gautemala, Belize, Queensland (Australia) and six provenances of **Pinus tecunumanii** from Honduras and Belize are tested to identify most suitable seed source for our locality. The data collected indicated that 4 H and 13 H provenances from Queensland, Mountain Pine Ridge provenance from Belize, La Brea, Brus Laguna, Los Limones, Tierra Blanca and Culmi provenance from Honduras in **Pinus caribaea** var. **hondurensis** and San Raefel del Norte provenance from Nicaragua, Villa Santa, Gulaco and Ojo De Agua provenance from Honduras in **Pinus tecunumanii** are suited for the locality. **Pinus caribaea** var. **Hondurensis** seed sources from Queensland are being used for raising captive pulp-wood plantations because of their uniform and higher rate of growth.

c. Silvicultural and Managerial Research

A trial is laid to determine the spacing that gives maximum production of desirable size pulp-wood in the shortest time in **Pinus tecunumanii.** The treatments included 1m x 1m (10,000 stems/ha.), 2m x 2m (2,500 stems/ha.), 2.5m x 2.5m (1,600 stems/ha.), 3m x 3m (1111 stems/ha.), 3.5m x 3.5m (816 stems/ha.), 4m x 4m (625 stems/ha.) and 5m x 5m (400 stems/ha.) spacings. The interim results at the end of 7th year indicated that a stocking of between 1,600 stems/ha. (2.5m X 2.5m) and 2,500 stems/ha. (2m X 2m) may be ideal for maximum pulp-wood production with desirable size i.e. 5 cm. and 20 cm. diameter (over bark). However, the spacing trials need to be continued through the rotation to confirm the observed trend.

NURSERY AND PLANTATION TECHNIQUES

Pinus caribaea var. **Hondurensis** seed sources from Queensland are being used for plantation development because of their uniform and higher growth rate in our locality. The seeds are sown in raised sand beds during January and germinated seedlings assembling matchsticks are pricked-out and transplanted into 4" X 8" polythene bags. Potting mixture contained sand, red earth and forest top soil in 1:1:1 ratio with a pinch of Diammonium Phosphate granules in the middle of the bag and a spoonful of mycorrhiza soil. The seedlings are maintained in the nursery by regular weeding, watering and shifting till planting in the main field with the onset of South-west monsoon i.e., during June. In the field, preplanting operations consisted clearfelling the rankgrowth and burning the same on heaping, followed by line ripping by D-50 or D-80 bulldozer at an espacement of 2.5 m to 3 m between lines. The seedlings are planted with the onset of monsoon to give a planting density of 1,800 plants per Ha. NPK 15:15:15 is applied at the rate of 60 gms. per plant in two equal doses and 45 gm. of Rock Phosphate per plant during first year only. Fertilizer application has given a boost for quick establishment of planted seedlings in the main field. After care operations include scraping and hoeing one metre around plants, digging of soil 1 m. wide all along trenches and two weedings in first year. During second and third year, two weedings and one digging in each year are carried-out. Fire protection and watch and ward at the rate of 1 labour for every 40 Ha. are given till harvest as protection measures against biotic interference.

PESTS AND DISEASES

Pests and diseases have not caused any problem so far. Damping-off of seedlings is noticed in the nursery and this is controlled by providing proper drainage and controlled watering. Yellowing of leaves has been noticed in the nursery and this is controlled by application of micronutrients. In the field yellow spots are noticed on leaves of weak plants during monsoon season but so far it is not a serious problem. Damage due to termite has been noticed after the end of monsoon on small scale upto 2 years. Pine shoot moth has not been noticed so far in any of our Pine plantations.

PRODUCTIVITY OF PLANTATIONS

Growth rate of trees in plantations is continuously monitored by recurrent measurement of trees in sample plots called Permanent Sample Plots (Adlard, 1990). The sample plots are circular in shape with 11.3 M radius (0.04 ha.). The diameter at 1.3 M above ground level (DBH) and total tree

height are measured in sample plots at an interval of 6 months. The data processing is computerised using Permanent Plot Records (PPR) program specially developed by Mr. PG Adlard for growth monitoring of MPM plantations. Using DBH and tree height data the program derives other relevent growth parameters.

Altogether, 34 Permanent Sample Plots are laid-out in 33 Tropical Pine plantations spread over entire Tropical Pine growing area with variations in climatic and edaphic factors. Table-5 shows the growth pattern of Tropical Pine plantations as recorded in Permanent Sample Plots.

The growth data are encouraging and indicate a potential yield of 94 debarked ADT per hectare at time of harvest after 12 years. However, the rate of growth of Pines is varying with plantation locations. This might be partly due to the fact of using seeds imported from Honduras, Gautemal, Belize etc., where seeds are collected from natural stands. The

Table-5

Growth of Tropical Pine plantations

Plantation	Planting year	Species	Age. (years)	Plants per Ha.	DBH (Cm)	Ht. (M)
Neratoor	1983	P.c	12.08	800	18.3	12.5
Behalli	1985	P.c	9.92	1050	20.50	17.70
Agilubagilu	1985	P.c	10.00	1225	18.30	13.30
Brahmadevaragadde	1985	P.c	10.00	1200	16.00	12.50
Gorgodu II	1985	P.t	10.25	975	17.60	15.20
Kalasavalli	1986	P.c	9.25	1350	17.30	13.30
Nilasagallu	1986	P.c	9.25	1300	16.20	14.90
Alagerimandri	1986	P.c	9.33	875	10.90	7.10
Kusugundi	1986	P.c	8.33	1125	16.50	13.80
Halandur	1986	P.c	9.08	1350	13.60	10.50
Shankarapura	1986	P.c	9.50	1750	15.00	12.00
Varamballi	1986	P.t	9.33	1275	13.70	12.00
Mandaka	1987	P.c	9.08	1725	13.30	11.00
Halandoor	1988	P.c	7.33	1425	13.40	11.10
Ganimakki	1988	P.c	7.33	1425	16.10	13.00
Mythali	1988	P.c	7.17	1275	15.90	12.40
Jala bydur III	1988	P.c	7.33	1250	11.30	7.80
Hegatoor	1988	P.c	7.33	1525	11.90	8.30
Hosakote V	1988	P.c	7.33	1100	11.10	7.30
Hosakote IV	1988	P.c	7.33	1500	9.90	7.10
Jala bydur II	1988	P.c	7.33	1025	9.70	7.60
Tadagalale	1988	P.c	7.33	1025	10.40	10.70
Jala II	1988	P.c	7.33	1525	13.20	11.20
Amrutha	1988	P.c	7.08	1675	11.80	9.70
Kargal	1988	P.c	6.92	1450	14.70	8.80
Masagalli	1988	P.t	7.33	1425	13.70	11.60
Badenagari A	1988	P.t	7.33	1175	10.90	8.60
Badenagari B	1988	P.t	7.33	1225	11.90	9.10
Jala III	1988	P.t	7.33	1250	13.70	10.60

P.C = Pinus caribaea var hondurensis. P.t. = Pinus tecunumanii.

growth data recorded in MPM plantations when compared with the data collected elsewhere in India reveal that growth is better in MPM plantations, probably due to line ripping with buldozer and intensive after care operations coupled with good protection. Growth pattern of MPM plantations represented by mean annual increment (MAI) and current annual increment (CAI) for volume is graphically represented in Chart-1. It can be seen that CAI and MAI curves meet at the age of 19 years which is the rotation age for maximum volume production. In MPM the rotation is tentatively fixed as 12 years instead of 19 years considering pulpwood size and not volume. The logs for pulpwood have typical size limits of 5 Cm. to 20 Cm. diameter, and bigger size logs need splitting. The annual diameter (DBH) increment in MPM plantations as indicated at present age is about 1.5 Cm. to 2 Cm., and at this rate the trees will be thicker than the required pulpwood size and need uneconomical splitting operation at the age of 19 years while maximum production of desirable pulpwood is obtained at the age of 12 years. In addition to the size of logs the big size trees at 19 years age will be having more resin which is not desired for pulping.

PHYTOMASS DISTRIBUTION OF PLANTATIONS

One of the Tropical Pine plantations is converted to seed stand in which number of stems per ha. is reduced from 1111 plants per ha. at the time of planting to a final stocking of 135 stems per ha. by a series of thinnings. At the time of thinnings some trees were felled for Destructive Sampling to estimate distribution of phytomass to leaf , small branches, bark and pulp wood portion of the trees. Table-6 shows the proportion of different parts of tree recorded by destructive sampling.

It may be seen that utilizable wood increased from 60% at 10th year to 64% at 12th year while the proportion of branches less than 3cm diameter has reduced from 10.6% at 10th year to 9.1% at 12th year, and that of leaves reduced silghtly from 15.9% at 10th year to 15.3%at 12th year, indicating more utilizable wood production with increase in age.

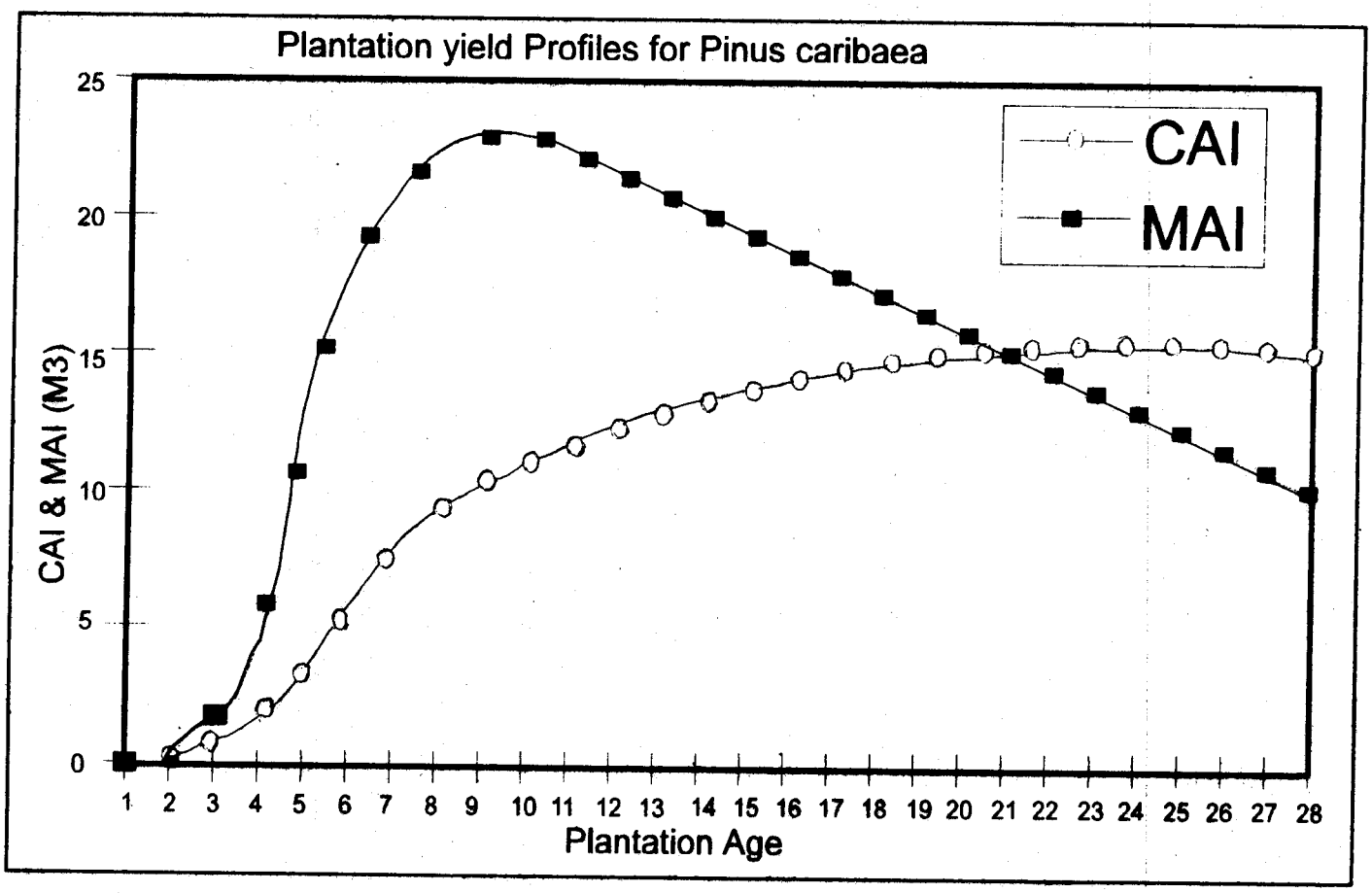

Table-6

Distribution of phytomass of Pinus caribaea var. Hondurensis Poptun peten, Guatemala (Kgs/tree)

Trait measured on Green Wt. basis (Kg.)	10 year old tree	12 year old tree
Utilizable wood (UB) (Dia. 3 cm and above)	89.38 (60.36%–)	106.30 (64.31%–)
Branches (Dia. less than 3 cm)	18.37 (10.64%)	15.10 (9.10%)
Leaves	22.78 (15.99%)	25.40 (15.36%)
Bark	15.30 (13.01%)	18.48 (11.18%)
Total Bio-mass	145.80	165.28
Volume OB (M^3)	0.1317	0.1638
Volume UB (M^3)	0.094	0.110
Bark - Volume (%)	34.89	32.84
Form factor	0.59	0.53

The volume (OB and UB) has increased from 10th year to 12th year while the precent bark volume has reduced from 10th year to 12th year. The bark thickness at DBH level and green weight of peeled bark measured on 10 and 12 year old trees reveal that brak thickness has increased from 2.76cm. at 10th year to 3.01cm. at 12th year and green weight of peeled bark has incresed from 15.3 kg. at 10th year to 18.4 kg. at 12th year while the precentage of bark volume has reduced from 34.89% at 10th year to 32.84% at 12th year. This observation falls in line with that of Gibson, (1982), who has observed that as trees increase in diameter bark thickness also increases but the relative percentage of total bark volume falls.

PULPING CHARACTERISTICS OF TROPICAL PINES

The trees thinned in the plantations converted to seed stand are sent to the factory to analyse pulping characteristics. The test results are given in Table-7 and compared with that of Bamboos and **Pinus patula** (kodaikanal).

The fibre size classification indicates that the pulp consists mainly of long fibre fractions, contributing to higher strength properties. The pulp yield is less in **Pinus caribaea** var. **hondurensis** and **Pinus patula** as compared to bamboos.The test results indicate that alkali requirement for **Pinus caribaea** and **Pinus patula** is about 5% more as compared to bamboos.

CONCLUSION

There is an urgent need to develop captive Pulp-wood Plantations on suitable degraded lands with Tropical Pines in India to bridge the yawning gap between the requirement and the availability of long fibre material for Paper Industry. **Pinus caribaea** var. **Hondurensis**, with the Queensland seed sources from clonal and seed orchards holds the promise as a potential species for plantation development because of its better adaptibility, higher productivity and good pulping qualities.

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Table-7

Pulp evaluation results of Pinus caribaea var. hondurensis, Pinus patula and Bamboos.

Sl. No.	Parameters		P. caribaea (12 Years)	P. patula (16 Years)	Bamboos
1.	Bulk Density	(Kg./m^3)	231.0	195.0	199.0
2.	Basic Density	(Kg./m^3)	480.0	410.0	630.0
3.	Lignin content	(%)	27.4	29.7	28.3
4.	Pulp yield	(%)	44.7	44.5	47.8
5.	Fibre size classification				
	a. Retained on 30 mesh	(%)	83.3	82.3	53.6
	b. Retained on 50 mesh	(%)	7.4	7.8	15.8
	c. Retained on 100 mesh	(%)	3.5	3.0	5.7
	d. Retained on 200 mesh	(%)	1.2	1.2	7.0
	e. Passed through 200 mesh	(%)	4.6	5.7	17.9

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