Acacia Auriculiformis – A Potential Pulp-Wood Species for Industrial Plantations in India

Kariyappa G.S., Mohamed Amanulla B.K., Nagaraj S. & Devaiah P.K.

*ABSTRACT:-- Paper industry in India mainly depends on forest based raw-material for paper manufacturing. The selection of species for pulp-wood plantation development has to satisfy a variety of requirements. **Acacia auriculiformis** has shown tremendous potentiality as pulp-wood species. The Nitrogen fixing capacity of this species and its better nutrient re-cycling made this species a value-based and eco-friendly.*

*Intensive Silvicultural Research carried-out in this species has resulted in identification of best seed sources viz. Balamukh, Springvale and Morehead River and improved silvicultural systems which are in operation for plantation development. Recurrent measurements of growth of **Acacia auriculiformis** have indicated a Mean Annual Increment of 16 M^3 at the **end** of 8th year. The Mean Annual Increment and the Current Annual Increment meet slightly beyond the age of 8th year and a rotation of 8 years is fixed. On an average a total productivity of 128 M^3 or 80 ADT (Air Dried Tonnes) is expected from Acacia pulp-wood plantations raised with local seed source. It is expected that with the introduction of best seed sources in plantation development, the productivity of Acacia could be enhanced further and it will be higher atleast by 20%. Phytomass distribution and pulping characteristics studies were conducted. The Acacia pulp is found suitable for manufacture of wide range of paper production.*

INTRODUCTION

The basic raw material source for the paper production in India is wood based even to-day, though the use of non-conventional agro-based and the recycled paper is in vogue in other parts of the world. Once abundantly available forest based raw-material has now become scarce. The import of pulp-wood is not only cost prohibitive but cannot be relied on availabilty intime. Further, non conventional raw materials for paper, paper borad & newsprint production do not offer permanent viable solution because of their seasonal availability and competing alternate uses (G.S. Kariyappa, 1995). This has led to the search for other tree species as viable alternate sources of pulpwood.

The demand for paper & paper board in India is estimated to be 3.4 million tonnes and that of newspaper would be 1.03 million tonnes by 2000 AD. Consequently, the demand for forest based raw-material has increased many-fold and the existing raw-material scenerio led to the development of Captive plantations with fast growing pulp-wood species viz., Eucalyptus and Acacia.

Mysore Paper Mills Limited, Bhadravathi
Office of the Director (Forests),
Old Mamcos Building, Kote Road,
SHIMOGA- 577 202 (Karnataka)

CHOICE OF SPECIES

The selection of species for pulp-wood plantation development is a multistage process which has to satisfy a variety of requirements such as

i. Raw-material requirement of the industry
ii. Characteristics of the available land for plantation development
iii. Pulp-wood productivity
iv. The government policy

In most of the developing countries, Eucalyptus formed the principal species in pulp-wood plantations. The Eucalyptus because of it's adaptability to wide range of geo-climatic conditions and high productivity on degraded lands has greater acceptability as plantation species all over the tropical world. But, in India controversy crept-in against the Eucalyptus on environmental grounds. Hence, Karnataka state government prohibited growing of Eucalyptus in high rainfall zone i.e. more than 1125 mm. (Shyam Sundar, 1986). Thus, **Acacia auriculiformis** is chosen as an alternative to Eucalyptus in the MPM captive plantation development programme.

Reports of suitability of **Acacia auriculiformis** for newsprint and paper production are evident. Nampraser, P, (1982) reported that Chemi-Thermo-chemical pulp of **Acacia auriculiformis** is found suitable for news-print production. Logan, A.F., (1987) also indicated that **Acacia auriculiformis** and **Acacia mangium** have shown similar pulping qualities to that of **Eucalyptus deglupta, Eucalyptus** regnans and Gmelina arborea.

Experience of Mysore Paper Mills (MPM) Limited, Bhadravati in raising Captive pulp-wood plantations

MPM Limited, Bhadravathi situated in Karnataka was established in the year 1936. At present it has a installed capacity to produce 37,000 MT. of cultural paper and 75,000 MT. of news-print. However, the present level of production is 30,000 MT. of cultural paper and 90,000 MT. of news-print and MPM has plans to expand the production capacity further. The total forest based raw material required by MPM annually is 1,82,400 ADT (Air Dried Tonne) short fibre (Eucalyptus/ Acacia/ Casuarina) and 57,600 ADT long fibre (Bamboo). The wood supply from the plantations raised by forest dept. and KFDC could not fulfill the requirement of MPM for paper and news-print production due to the pressure on the dept. for the supply of wood to other social commitments. With this background state govt. conceded 30,000 Ha. of degraded forest lands to MPM on long lease of 40 years for Captive pulp-wood plantation development to meet its increased forest raw-material requirement on sustained basis. The conceded areas are classified into:

i. Wet-zone (Zone-A) areas along the eastern flank of Western-ghats with a mean annual rainfal of 1000 mm. and above. These areas are situated at an average lead of 100 Kms. from the factory. About 40% of the areas in this zone are located in difficult terrain and are grass - lands. But afforestation is possible by mechanized method. Soils are medium to deep, well drained, red loam and lateritic. These areas are found suitable to grow Acacia, casuarina and Tropical Pine Plantations. Areas are available in scattered blocks of size varying from 30 Ha. to 100 Ha.

ii. Dry-zone (Zone-B) areas further east where mean annual rainfall is less than 1000 mm. These areas are situated at an average lead of 40 Kms. away from the factory.

Acacia auriculiformis is planted as a principal species in Wet-zone and the locality factors of sites where **Acacia auriculiformis** is grown are given in the Table-1.

Table-1

Locality factors of plantation sites where Acacia auriculiformis is grown.

Factors	Thirthahalli	Sagar	Hosanagar
Altitude	620 m	592 m	600 m
Latitude	13° 44' N	14° 13' N	14° 10' N
Longitude	75° 12' E	74° 12' E	74° 59' E
Rainfall (Avg. 10 Yrs)	2606 mm.	2765 mm.	2550 mm.
No. of rainy days	110	109	105
Soil	Red sandy loam and lateritic	Red sandy loam and lateritic	Deep red & lateritic
pH	6.0	5.7	5.8

CAPTIVE PULP-WOOD PLANTATIONS

MPM took-up its ambitious captive plantation development programme on degraded forest lands with Acacia, Casuarina and Eucalyptus as short fibre source and Tropical Pines as long fibre source. The plantation development programme has been carefully drawn taking into consideration the pulp-wood requirement of the Mill and suitability of the land for plantation development. The details of the species-wise area envisaged in the plantation programme are as follows.

Sl. No.	Kind of species	Targetted area (Ha.)	Actual area (Ha.) as on 31.03.96
1.	Acacia auriculiformis	15573 (52%)	13211.95
2.	Eucalyptus	7155 (24%)	10290.04
3.	Pinus caribaea var Hondurensis	6715 (22%)	4424.45
4.	Research plots	557 (2%)	557.00
	Total	30000	28483.44

FOREST RESEARCH ACTIVITIES

Forest Research Division took up extensive Silvicultural Research encompassing species and provenance trials, Nursery trials, Silvicultural and Managerial trials and Clonal Forestry to provide sound technical guidance to the plantation programme.

I. Nursery Research

Trials were laid-out in the project sites in Acacia to find out the optimum nursery period and polythene bag size for raising healthy planting stock. The polythene bags of three sizes viz., 3" x 7", 4" x 6" and 5" x 8" and 4 dates of sowing in the nursery were tried. The data indicated that a nursery period of about 4.5 months and a polythene bag of size 4" x 6" are found optimum to obtain a healthy planting stock of height 30-35 Cm. with fairly good number of active root tips, less root coiling and better collar diameter. However, keeping in view the degraded plantation site conditions, a polythene bag of size 4" x 8" is being used for captive plantation development. Pruning of roots which are coming out of the polythene bags in the nursery on need basis helps in reduction of mortality of seedlings in the main field by preventing possible root coiling.

II. Species and Provenance Research

Under this programme several Acacia species and provenances known to produce quality pulp-wood have been screened for their suitability, adaptability and pulp-wood productivity under prevailing geo-climatic conditions.

Out of 18 species of Acacia tried, the research trials indicated that **Acacia mangium** is found promising and posses better stem form than **Acacia auriculiformis.** However, it is more-wind prone because of its dense crown and susceptible to pests and diseases and has lower wood density compared to **Acacia auriculiformis.** The tree form of **Acacia crassicarpa** is poor and it is susceptible to the pests and diseases though it has higher wood density and higher pulp yield compared to **Acacia auriculiformis.** Unlike the above two species, **Acacia auriculiformis** is very versatile and comes up well in wide range of rainfall (1500 mm to 3000 mm) and site conditions. It is found that **Acacia auriculiformis** comes up satisfactorily on shallow and poor soils and less rainfall areas compared to **Acacia mangium** and **Acacia crassicarpa** which require deep and fertile soils and high rainfall. **Acacia auriculiformis** has also shown remarkable resistance to pests and diseases. The rate of growth of the above three species is given in the table-2.

Table-2

Average Growth rate of Acacia species in 3 different experimental sites.

Age / Species	(- - IV year - -) Ht. (M.)	DBH (Cm.)	(- - VI year - -) Ht. (M.)	DBH (Cm.)	(- - VIII year - -) Ht. (M.)	DBH (Cm.)
A. auriculiformis (Local seed source)	8.71	7.10	11.91	9.82	13.79	11.70
A. mangium	7.94	7.77	11.12	10.45	13.66	12.32
A. crassicarpa	7.89	7.25	10.74	9.57	12.68	11.50
A. aulocarpa	5.23	3.80	7.29	6.76	9.19	7.36
A. polystachya	4.39	3.25	6.57	4.83	8.56	6.33

The provenance trials in **Acacia auriculiformis** showed that Balamukh, Morehead river, Bensbach from Papua-New Guinea (PNG) and Springvale and Morehead river from Queensland (QLD), Australia are performing better than the local seed source. On an average, 15% higher height increment and 30% higher diameter increment is recorded in the above promising provenances in comparison with the local seed source at the end of 8th year in three different trial sites. It is expected that if captive pulp-wood plantations are established with the above promising seed sources, the productivity would be increased atleast by about 25-30% with 8 years rotation. The Mean Annual Increment (MAI) of these seed sources varies from 21 M^3 to 35 M^3 whereas the MAI of local ed source varies from 16 M^3 to 20 M^3 with 8 years rotation. Besides, the above seed sources posses better stem form and less multiple stems compared local seed source. Hence, the above promising provenances have greater potentiality for use as pulp-wood and timber. The details of growth rate of promising provenances tested in our sites are given in Table-3.

Plantation development with promising provenances is being taken-up to enhance the plantation productivity further in project sites.

III. Silvicultural and Managerial Research.

It is widely recognised that rapid establishment and control of competing vegetation are fundamental requirements of raising successful plantations. Spacing, thinning and fertilizer dosage trials have been established and these trials have started yielding valuable data. These trials need to be continued for some more years to confirm the observed trend. With the data on hand following recommendations are made.

1. A planting density of 2300 plants/Ha. is recommended for operational scale plantings keeping in view the size of the pulp-wood required by the mill.

Table-3

Average Growth rate of various provenances in Acacia auriculiformis in comparison with local seed source at different ages in trial plots.

Sl. No.	Provenance	Locality	Age (years)	DBH (Cm)	Ht. (M)	(% increase) DBH	HT.
1.	Balamukh, PNG	B. gadde	8	12.41	13.33	26.63	10.35
2.	Springvale, QLD	B. gadde	8	11.74	13.57	19.80	12.33
3.	Oenpelli, NT	B. gadde	8	10.13	12.64	3.36	4.63
4.	Local seed source	B. gadde	8	9.80	12.08	--	--
1.	Balamukh, PNG	A. bagilu	8	13.09	13.95	32.90	14.43
2.	Springvale, QLD	A. bagilu	8	13.23	14.21	34.31	16.60
3.	Oenpelli, NT	A. bagilu	8	11.70	13.90	41.11	14.02
4.	Local seed source	A. bagilu	8	9.85	12.19	--	--
1.	Balamukh, PNG	Kanase	8	13.57	18.07	26.82	15.83
2.	Springvale, QLD	Kanase	8	12.73	17.49	19.00	12.10
3.	Oenpelli, NT	Kanase	8	12.13	17.61	13.40	12.88
4.	Local seed source	Kanase	8	10.70	15.60	--	--
1.	Springvale, QLD	Halawani	6	10.87	11.60	38.10	23.40
2.	Balamukh, PNG	Halawani	6	10.32	11.10	31.13	18.08
3.	Morehead R., QLD	Halawani	6	11.40	11.70	44.85	24.46
4.	Bensbach W PNG	Halawani	6	10.28	10.60	30.62	12.76
5.	Local seed source	Halawani	6	7.87	9.40	--	--
1.	Springvale, QLD	Heddur	4	8.46	9.23	28.76	19.09
2.	Balamukh, PNG	Heddur	4	8.62	9.29	31.20	19.87
3.	Morehead R. Morehead PNG	Heddur	4	8.55	9.09	30.13	17.29
4.	Morehead river, QLD	Heddur	4	9.13	9.63	38.96	24.25
5.	East Alligator, NT	Heddur	4	7.13	8.39	11.26	8.25
6.	Local seed source	Heddur	4	6.57	7.75	--	--

2. Planting as early as possible with the onset of monsoon i.e. within 3-4 weeks of onset of monsoon gives better survival and quick establishment which results in higher initial rate of growth.
3. Application of in-organic complete fertilizer i.e., NPK 15 : 15 : 15 at 60 gms. per plant in two equal doses during first year has helped in quick establishment and higher initial growth.
4. Need based pruning is essential to have a access to the plants for execution of various after-care operations and to maintain the health of the stand.

TREE IMPROVEMENT ACTIVITIES

Wide genetic base in Acacia is available in MPM trial plots. MPM has initiated tree improvement activities in Acacia recently to increase the plantation productivity further on degraded forest lands. The activities envisaged under tree improvement are as follows and they are in different stages of implementation.

1. Introduction of best suited provenances of **Acacia auriculiformis** to the plantation sites viz. Balamukh, Morehead river, Morehead, Springvale, Morehead river which have shown higher productivity and better stem form than the local seed source.
2. The half-sib progenies selected from the phenotypically elite trees from the above provenances are used for the development of single/multi family breeding seed orchards for genetic gains.
3. Establishment of Seed stands, seedling seed orchards and clonal seed orchards with the genetically superior materials.
4. Tree breeding programme involving inter-specific hybridisation between promising seed sources of **Acacia auriculiformis X Acacia mangium**. In MPM trial plots, natural hybrids (supposedly between **Acacia auriculiformis X Acacia mangium**) have been identified and these hybrids posses 2-3 times more growth compared to either parent. The pulping analysis of 5 year old hybrid has indicated the suitability of these hybrids for paper production. Hence, further studies like establishment of clonal screening plot and clonal bank through cloning of hybrids is under-way.

NURSERY AND PLANTATION DEVELOPMENT TECHNIQUES

Nursery techniques have been developed and are in operation. Seedlings from the mother bed are pricked-out into the polythene bags when the emerged seedlings are in button stage. About 8-10 days are required to attain button stage after sowing seeds in the mother bed. The polythene bag of size 4" x 8" is filled-in with a soil media of red earth, sand and forest top soil in the proportion of 1:1:1. A nursery period of 4.5 months produces a healthy planting stock of height 30-35 Cm.

After clear felling and burning the unwanted jungle growth, line ripping to a depth of 40-45 cm. is done through a bulldozer at an espacement of 2.5-3 m. After weathering, the soil is refilled before the onset of monsoon, With the onset of monsoon soil is scooped at 1.75 m. apart in the ripped line and the seedlings are planted by carefully removing the polythene bags without disturbing the ball of earth. 30 gms. of Gafsophos is given as a basal dose at the time of planting. After care operations consisted application of 60 gms. of NPK per seedling, two weedings, scraping and hoeing and digging during first year and two weedings and one digging each during second and third year. Fire tracing works and watch and ward are given to protect the plantations against biotic interference particularly fire occurrence and cattle damage till harvest.

PRODUCTIVITY OF ACACIA AURICULIFORMIS PLANTATIONS

In order to monitor the growth potential of Acacia under different geo-climatic conditions, a systematic inventory of captive plantations is done. Radial temporary and permanent sample plots with a fixed area of 0.02 ha. are laidout. Altogether, 55 Permanent Sample Plots are laid-out. The regular bi-annual measurement of diameter and height is done which helps to predict the productivity of the plantations with a reasonable degree of accuracy. However, the yield estimation in Acacia is very complex and difficult in view of multiple stems. These multiple stems vary significantly in their rate of growth. The data processing is computerised using Permanent Plot Records (PPR) specially developed by Mr. PG Adlard for growth monitoring of MPM Plantations. Using Diameter At Breast Height (DBH) and

total tree Height the program derives other relevant growth functions like basal area, CAI, MAI etc. An analysis of growth data indicated that Current Annual Increment (CAI) increases steadily upto end of 6th year and there-after it decreases sharply. The Mean Annual Increment (MAI) increases steadily right from the first year and reaches it's peak during 9th year and there-after it decreases steadily. The CAI and MAI meet slightly beyond the age of 8th year and a MAI of 16 M^3 (Over Bark) is estimated at the end of 8th year (See Chart-2). The yield profiles developed indicate a rotation of 8 years in order to obtain maximum pulp-wood (80 ADT per Ha.). Growth details of Acacia are given in table-4.

PHYTOMASS DISTRIBUTION AND NUTRIENT RE-CYCLING IN ACACIA

At the rotation age of 8 years, Destructive sampling was carried out to determine the phytomass distribution in **Acacia auriculiformis.** Destructive Sampling carried-out on 56 Acacia trees of age 8 years had indicated that the distribution of phytomass as follows on dry weight basis.

	Kgs/tree	Percentage
1. Utilisable debarked pulp-wood (Upto 5 Cm. Over Bark at thin end)	36.50	70%
2. Lops and Tops (Less than 5 Cm. Over Bark)	6.77	13%
3. Bark	5.92	11%
4. Leaves	2.70	6%
Total	52.13	

The nutrient re-cycling is very important aspect in plantation development with short rotation tree species such as Eucalyptus and Acacia as it has profound influence on fertility status of degraded lands. The litter studies carried-out in 6 years old **Acacia auriculiformis** stand indicated that about 4 MT. of litter is added to the soil per hectare. The leaf forms the major component of litter. Foliar analysis of 5 to 6 years old Acacia stand indicates that the content of Nitrogen is 1.84%, Phosphorus 0.05% and Potassium 0.39%. Thus, **Acacia auriculiformis** adds 73.8 Kgs. of available Nitrogen, 2.192 Kgs. of available Phosphorus and 15.76 Kgs. of available Potash annually to the soil which improves the fertility of the site to a considerable extent.

PULPING CHARACTERISTICS OF ACACIA

Studies on pulping characteristics in Acacia are carried-out and results show that the pulp obtained from Acacia is found suitable for manufacture of wide range of paper. The Strength properties of Acacia pulp are much higher compared to Eucalyptus. The pulp yield of Acacia is higher by about 2% compared to Eucalyptus. Fibre length and diameter of Acacia are slightly higher compared to Eucalyptus. The Un-bleached pulp brightness of Acacia is about 8-9% higher indicating less requirement of chemical for bleaching compared to Eucalyptus. The results of the pulping analysis of

Table-4

Growth rate of Acacia auriculiformis in MPM plantations raised with local seed source

Sl. No.	Location	Age (years)	No. plants (per Ha)	Avg. Ht. (M)	Abg. DBH (Cm)	MAI (M3)
1.	Kallugudda '85	7.83	1500	15.10	17.90	15.80
2.	Behalli '85	7.83	1500	17.40	10.70	15.80
3.	Ambuthirtha '85	7.92	1900	14.30	11.20	16.10
4.	Humcha '85	7.92	2550	14.50	9.80	18.60
5.	Humcha '85	6.83	2000	12.90	10.10	15.60
6.	Hosakoppa '86	6.92	1900	13.60	9.40	15.60
7.	Kogadu '86	6.92	2300	14.20	14.30	19.00
8.	Kalasavalli '86	6.92	1800	12.80	10.50	16.90
9.	Balagar '86	6.42	2150	13.00	9.70	16.10
10.	Tyarandoor '86	6.83	1850	12.20	10.00	15.90
11.	Mandaka '86	6.83	2250	13.30	11.30	18.80
12.	Muthala '87	8.25	1350	15.80	10.50	19.90
13.	Madenoor '87	8.25	2500	13.70	10.30	20.50
14.	Malalimath '87	8.00	2450	11.80	9.50	19.40
15.	Billodi II '87	8.00	2100	12.60	9.00	21.70
16.	Jamballi '87	8.00	2250	12.70	11.00	19.30
17.	Kamachi '87	8.00	2350	12.20	10.90	19.60

Acacia are indicated in Table-5 in comparison with Eucalyptus.

Table-5

Pulping characteristics of Acacia auriculiformis and Eucalyptus hybrid at the age of 8 years.

Sl. No.	Parameters	Test results Acacia	Eucalyptus
1.	Fibre length (mm)	0.70	0.50
2.	Fibre diameter (microns)	18.50	11.00
3.	Fibre fractions of Un-bleached pulp		
	Retained on 30 mesh, %	9.80	3.55
	Retained on 50 mesh, %	39.25	16.05
	Retained on 100 mesh, %	23.40	37.60
	Retained on 200 mesh, %	15.55	27.05
	Passed through 200 mesh, %	12.00	15.75
4.	Strength properties of Un-bleached pulp at 200 CSF		
	Burst Factor	21.70	12.05
	Breaking Length, metres	4250.00	2650.00
	Tear Factor	41.45	25.40
	Double Folds	13.50	--
5.	Pulp yield (on BD Chips)		
	Gross yield, %	84.55	82.75
	Screened Rejects, %	0.85	0.55
	Un-bleached, Screened pulp, %	83.70	82.20
	Bleached pulp, %	81.50	79.90
6.	Specific gravity of logs	0.61	0.68
7.	Basic density of the accepted size chips (i.e., 38 mm + 3 mm) on b.d. basis Kg/M3.	600.00	645.00

CONCLUSION

With the increase in population coupled with increase in literacy rate and technological advancement, the demand for paper and pulp has increased many fold. The acute shortage of forest based raw-material has crippled the paper industry in India. Extensive forest research activities in MPM have led to the identification of Acacia auriculiformis as a potential pulp-wood species. The degraded barren lands are successfully re-vegetated and productivity of these lands has been enhanced with effective land-use management.

Acacia auriculiformis by virtue of it's Nitrogen fixing character, effective nutrient recycling, higher rate of growth on degraded lands and better pulping qualities has wider acceptance in captive pulp-wood plantation development.

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