EUCALYPTUS CULTIVATION
IN
MADHYA PRADESH

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INTRODUCTION

The population of the towns and the herds of the countryside alike consume the forests directly or indirectly at an unprecedented pace; the gulf between supplies and requirements is too wide to bridge by a rational exploitation of the indigenous forests, or even by reforestation with local species, as these, although adapted to the environment, are too slow in growth.

In many parts of Madhya Pradesh, as also in other parts of the country, the pressing problem is the quick production of high-quality timber, as of fuelwood and small timber for local use.

Foresters were in search of promising tree species, capable of rapid growth and high yields, able to survive under very varied conditions and useful for special products and special purposes, including protection of soil and water resources. One of the most attractive and interesting of such tree groups is the genus Eucalyptus, now widely planted in every continent of the globe. Plantation trials of Eucalyptus in India have clearly demonstrated their capability of establishing in almost all the soil types and climatic conditions. Eucalyptus on account of its inherent eco-adjustments, is most suited for degraded sites, mine overburdens, deep ravines, hard latosols and loose sandy soils, and many other refractory sites, where the environmental degradation has reached such a stage that only a fast-growing and colonizing species such as Eucalyptus, Neem, Sissoo, Babul can restore the site productivity.

Having impressed with the wide range of adaptability and fast growth a strike is gradually building among the farmers to plant Eucalyptus on the banks of their agricultural lands and even in the agricultural land as a commercial proposition.

Eucalyptus planted on agricultural fields bunds contribute to the farmer's income; its economy is more gained when agricultural crops fail on account of natural calamities. Eucalyptus plantation thus act as an insurance against crop failures; its economics has already proved attractive with the farmers of Gujarat, Karnataka, Haryana, Maharashtra etc. This is gradually now catching up with the farmers of Madhya Pradesh too.

In Madhya Pradesh, though small scale experimental plantations of some Eucalyptus species had started as early as 1955-66 yet large scale commercial plantations of Eucalyptus (mainly Eucalyptus tereticornis commonly known as 'Mysoor Gum') was started in 1956. The objective of Eucalyptus plantations was to provide raw material to the existing paper industries or which were planned to come up in the State.

For this purpose, three Plantation Divisions, at Bhopal, Shahdol and Bastar were created to raise large scale industrial plantations of Eucalyptus and other important fast growing pulpwood species. This programme continued till 1974 and about 45,000 hectares of area was planted with Eucalyptus during this period (1966-74). The total area under Eucalyptus in the State at the end of 1960 stood at 63,376 hectares.

In recent years, large scale plantations of Eucalyptus have been raised in degraded forests, road-sides, canal banks, community lands, premises of public institutions, schools and colleges. Under the social forestry programme the World Bank, USAID and SIDC in several States have financed projects which have included Eucalyptus plantations on community waste lands and field bunds etc. Eucalyptus has also become popular among farmers, especially in States like Gujarat, Karnataka, Maharashtra, U.P.

and Haryana. With the introduction of Social Forestry Programme in Madhya Pradesh too, the farmers are coming up with more and more demand for Eucalyptus seedlings.

In Madhya Pradesh the area under various types of forests is about 15 million hectares. According to an estimate half of these forests are not producing enough and can thus be categorized as degraded forest areas in need of urgent measures, including plantations to restore their productivity. Besides this, the State possesses large extent of areas as waste lands in the form of extensive and deep ravine lands in the northern region, vast stretches of Bhaia lands (hard latosols) in the eastern region and degraded revenue waste lands everywhere. According to the latest land records, a total area of about 7 million hectares is available as revenue wastelands. The State being one of the richest States in natural resources, has large deposits of minerals (coal, lime-stone, bauxite, dolomite, soap-stone, diamonds, iron-ore, manganese-ore, copper-ore etc). The exploitation of this rich mineral wealth, which incidentally is hidden beneath equally rich sal, teak and mixed, miscellaneous forests, leaves behind a trail of total devastation of forests and vegetation with consequent ecological upsurge and environmental hazards. Recolamition of such mine overburdens is an uphill task. The extent of such mine overburden is estimated to be about 0.20 million hectares. Experimental plantations have been raised on these sites in past 5-6 years by State Forest Research Institute, Jabalpur. Of various species, both exotic and indigenous, Eucalyptus camaldulensis and E. tereticornis in terms of growth and biomass production have been found as most successful and superior to all other species.

In an effort to halt the present pace of destruction leading to environmental degradation the Prime Minister, in 1984, outlined programme of development of wastelands for production of fuelwood and fodder over an area of 5 million hectares every year. This policy announcement envisaged involving non-governmental organizations for fulfillment of this stupendous task. Implementation of this massive afforestation programme through Governmental agencies alone would require a huge sum of money and other infrastructure for undertaking this programme. Participation of voluntary organizations in the development of wastelands, and motivation of farmers to take up tree cultivation on marginal agricultural lands on field bunds as well as on a part of their farmlands would go a long way in fulfilling the above programme. For such a programme Eucalyptus, Su-tappal, Babul, Neem, Sissoo, Bamboo, Sissoo, Annie etc are the best tree species capable of growing at different sites, requiring less after-planting care. These species can provide better monetary returns especially to those farmers who practice agriculture in proxy.
HISTORY AND MORPHOLOGY OF EUCALYPTUS

The story of the eucalypts, a group of evergreen trees and shrubs, began in 1770 when Joseph Banks, a botanist, and Daniel Carl Solander, his assistant, collected the first specimen known to science (*Eucalyptus gunnii*). On the shores of Botany Bay on the east coast of Australia, during Captain James Cook's first voyage to the Pacific Ocean. It was not until 1789 that the first description of a *Eucalyptus* species was published and the name *Eucalyptus* proposed by Charles Louis L'Héritier de Brutelle, a French botanist. L'Héritier derived the name *Eucalyptus* from the two Greek words, meaning 'well' and 'calyx', i.e., 'covering', in reference to the lid or operculum which seals the flower until it is thrown off during the process of opening. The possession of this operculum is the characteristic feature which so readily distinguishes the eucalypts from other plants.

The eucalypts are the dominant feature of the vegetation of Australia, comprising in all about three-quarters of the total vegetation. They range in size from the dwarfed and stunted shrubs called 'mailes' or 'marlocks', found mainly in the sandy, desert regions, to the giant, luxuriant trees of the coast and mountain ranges. Some species are found near the sea, some prefer the hot and arid interior, whilst others thrive on the snowy slopes of the Australian Alps. Eucalypts are hardy, adaptable, and versatile, with many species being highly valued for their timber and firewood, and for their ability to thrive in a wide range of climates.

The trees pass through several growth stages before they finally become mature and during growth, layers of wood cells are developed, the nature of which determines the physical characters of the timber. As the trunk grows, it also develops bark, and in the eucalypts there are readily distinguished bark types which are very convenient for classification purposes.

On germination, the eucalypt seed develops two cotyledons. The young plant then develops from five to ten pairs of seedling leaves which form a transition from the cotyledon stage to the juvenile stage. Their size seems to depend, to a large extent, on the vigour of the seedling, and they are very variable in shape. In the third stage, the juvenile leaf stage, then develops. The plant then passes through an intermediate stage in which the leaves show a gradual transition from the juvenile stage to the adult leaf stage, characteristic of fully grown trees. The intermediate stage in some species is not very distinct, the juvenile leaves giving way rapidly to adult foliage. The major part, or all of the foliage of a mature tree, is made up of adult leaves.

The lateral veins, which run from the midrib towards the edge of the leaf, always terminate in an intramarginal vein which runs around the leaf, either close to, or at some distance from, the edge. At all seasons of the year there is a continued rain of leaves, twigs, branches, bark, flower buds, and fruit capsules from the eucalypt. On the ground level, most species of eucalypts develop an underground swelling known as a lignotuber, which is an organ of food storage and regeneration. The origin of the lignotuber is in the axils of the seed-leaves, or cotyledons, or of the first two or three pairs of seedling leaves. At first it takes the form of a pair of small auxiliary protruberances or swellings which develop at varying times after germination, and which swell until they finally fuse together. However, of a number of commercial *Eucalyptus* species, *E. camaldulensis* normally does not develop lignotubers. However, a carrot-like swelling at the top of the root act as lignotuber. Lignotubers are modified stems and occur only in species with a double accessory bud complex.

The author had studied the root system of *Eucalyptus tereticornis* and *E. camaldulensis*, planted in clay-loam soil at Jhablpur, on bauxite mined out areas at Amarkantak (Shahiop), coal mine overburdens at Dhamuri (Sholdi), hard lateritic soils (Bhata lands) of eastern Madhya Pradesh, sandy loam soil of Rewa, and loamy clay at Nevar (Khandwa). The root penetration of tap root was found to vary from 3.00 to 4.00 m in 1-5 years old plantations of both species. A 5-7 years old plant showed a tap root development of 1.42-2.85 m. However, the lateral root spread was found to vary from 6.80 to 11.30 m in 5-7 years old plants 15.70 to 25.50 m in a 15-20 years old plantation. It was further brought out that 80-85% of the total litter responsible for obtaining nutrients and moisture are concentrated in upper 30 cm soil layer.

The development of woody fruit of the eucalypts follows much the same general pattern in all species, although the fruit itself takes a variety of shapes and sizes. The seed, which develops at the same time, is minute, in most species. One kilogram weight of popular *Eucalyptus* (E. camaldulensis and E. tereticornis) contains 2-3 lakhs seeds. Freshly collected seeds give germination of 70-80 per cent. The seeds can be stored for a period of 1-2 years to expect a germination of 40-75% provided the seeds have been stored in air tight containers. The seeds are mixed with 'grass' which resembles the fertile seed. *E. camaldulensis* stored for 5 years gave 32.5 per cent of germination. Similarly, *E. tereticornis* was stored for 4 years gave a germination...
of 19.6 per cent.

The amount of seed produced by a single eucalypt varies considerably. As much as 10 Kg has been obtained in collection from a single mature tree but on the average the amount collected would vary from less than 1 Kg to about 2.50 Kg per tree. This yield can be expected from mature trees.

The seed is always mixed with unfertilized ovules known as 'chaff', and consequently it is difficult to determine exactly how many fertile seeds are represented in a kilogram of seed as gathered from the tree. It is generally impracticable to remove the 'chaff' from seed samples, and consequently the percentage germination may not be as high as expected, although in actual fact the germination percentage of the fertile seed present may be very high. In E. camaldulensis and E. tereticornis the proportion of 'chaff' varies from 80-90 per cent and thus the proportion of fertile seed in a kilogram could be expected to be about 10-15 per cent. One kilogram of pure seeds ('chaff removed) consists of 25-30 lakhs but with 'chaff' the total seeds are about 2-3 lakhs. The seeds being freshly collected (upto 1 year) can thus give a germination of 70-80 per cent which means a kilogram of seed (with 'chaff') may result in a planting stock of 25,000-30,000.

**Natural Regeneration**

Natural regeneration of E. camaldulensis and E. tereticornis is normally not common. Natural regeneration has been observed in both these species at Jabalpur (SFRI) and at bauxite mined-out area at Amarkantak. However, for cultivation purposes, the reliance is normally made on coppicing rather than on natural regeneration. As a farm forestry crop, the main crop could be felled after 5-6 years and then 2-3 rotations of coppice crop could be managed profitably. At the end of this period (30-years) the coppice crops need to be replaced by seeding crop as the coppice vigour tends to decline after 2-3 coppicing.

**INTRODUCTION OF EUCALYPTUS TO INDIA AND MADHYA PRADESH**

This tree was introduced in India from Australia by Tipu Sultan about 200 years ago. According to Troup (1932), a few trees, most probably E. globulus, were planted in the Nilgiris hills in 1843 for the purpose of finding some species capable of yielding regular and plentiful supplies of lintwood. Plantation of E. globulus were subsequently established in the Nilgiris hills in 1856. Small plantations of other species have been in existence in the same hills since 1911.

According to an old account over ninety species have been tried, mainly in arboresca or cultivated as avenue trees in the larger towns. The most important species planted in different parts of India were E. globulus, E. citriodora, E. tereticornis. E. viminalis and E. ruscifolia, whereas, around 1956, a hybrid eucalypt known as 'Mysore gum' became more popular in the then Mysore (Karnataka) State. This variety of Eucalyptus exhibited markedly, better growth rate compared to other eucalyptus tried in India. This new hybrid is stated to be related to E. tereticornis, E. citriodora and E. roxburghiana. Another species, E. microdon was planted in drier parts of the country and has been reported to be quite successful.

**Madhya Pradesh**

Eucalyptus was introduced in this State as early as 1855-56 in the form of small scale experimental plantations. Since then, several Eucalyptus species have been tried with varying success. Large scale commercial plantations of

<table>
<thead>
<tr>
<th>N.</th>
<th>Name of the species</th>
<th>Locality where planted</th>
<th>Age in Yrs</th>
<th>Growth data Survival %</th>
<th>Average Height m</th>
<th>Average Girth cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>E. camaldulensis</td>
<td>Jabalpur</td>
<td>5</td>
<td>51.00</td>
<td>4.83</td>
<td>11.7</td>
</tr>
<tr>
<td></td>
<td>FRI 6968</td>
<td>do</td>
<td></td>
<td>47.00</td>
<td>4.93</td>
<td>11.9</td>
</tr>
<tr>
<td></td>
<td>FRI 7059</td>
<td>do</td>
<td></td>
<td>45.00</td>
<td>5.55</td>
<td>12.7</td>
</tr>
<tr>
<td></td>
<td>ERC 12139</td>
<td>Bilaspur</td>
<td>4</td>
<td>90.60</td>
<td>5.66</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td>ERC 12181</td>
<td>do</td>
<td></td>
<td>100.00</td>
<td>6.63</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td>ERC 12349</td>
<td>do</td>
<td></td>
<td>79.00</td>
<td>3.01</td>
<td>17.1</td>
</tr>
<tr>
<td></td>
<td>ERC 126/0/2</td>
<td>Nopanagar</td>
<td>1½</td>
<td>20.00</td>
<td>3.15</td>
<td>17.1</td>
</tr>
<tr>
<td>2</td>
<td>E. tereticornis</td>
<td>Bilaspur</td>
<td>4</td>
<td>64.00</td>
<td>6.61</td>
<td>15.5</td>
</tr>
<tr>
<td></td>
<td>ERC 11953</td>
<td>do</td>
<td></td>
<td>64.70</td>
<td>4.64</td>
<td>12.9</td>
</tr>
<tr>
<td></td>
<td>ERC 11952</td>
<td>do</td>
<td></td>
<td>76.60</td>
<td>4.60</td>
<td>11.7</td>
</tr>
<tr>
<td></td>
<td>ERC 12140</td>
<td>Semri</td>
<td>2½</td>
<td>32.00</td>
<td>4.60</td>
<td>15.0</td>
</tr>
<tr>
<td></td>
<td>ERC 12180</td>
<td>do</td>
<td></td>
<td>82.70</td>
<td>3.33</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td>ERC 12946</td>
<td>Jabalpur</td>
<td>1½</td>
<td>74.00</td>
<td>3.33</td>
<td>7.0</td>
</tr>
<tr>
<td>3</td>
<td>E. citriodora</td>
<td>Jabalpur</td>
<td>3½</td>
<td>67.00</td>
<td>5.83</td>
<td>12.7</td>
</tr>
<tr>
<td></td>
<td>FRI 12349</td>
<td>do</td>
<td></td>
<td>67.00</td>
<td>5.36</td>
<td>13.1</td>
</tr>
<tr>
<td></td>
<td>FRI 11640</td>
<td>do</td>
<td></td>
<td>83.00</td>
<td>5.82</td>
<td>12.7</td>
</tr>
</tbody>
</table>
Eucalyptus in M.P. (mainly \textit{E. tereticornis}) were started in the year 1966 and continued till 1974 when they were stopped due to poor growth rate and heavy mortality. More than 45,000 hectares area was planted with Eucalyptus species during this period. After 1974 Eucalyptus species are being planted mostly in mixture with other fast growing species under social forestry programme. During the period 1974-82, 11,870 hectares area has been planted with different species of Eucalyptus and other fast growing species.

Provenance and other traits of Eucalyptus species were started by State Forest Research Institute, Jabalpur in the year 1972. So far, 40 provenances of \textit{E. camaldulensis}, 45 provenances of \textit{E. tereticornis} and 8 provenances of \textit{E. citriodora} have been tried. However, it is not possible to say which of the provenances will grow best under different soil and climatic conditions but the latest average girth and average height measurements and survival percent of the plants indicate that the provenances ERC 12348, ERC 12187 and ERC 12136 of \textit{E. camaldulensis} and provenances ERC 10132 and ERC 12146 of \textit{E. tereticornis} are best suited to different ecopro-climatic conditions of this State.

The performance of all the 8 tried provenances of \textit{E. citriodora} have been exceptionally good. Average girth of the \textit{E. citriodora} plants at the age of only 2 years varies from 8.1 cm to 14.2 cm and have average height from 4.15 to 5.95 m. Whereas, the average girth and average height variations for the provenances of \textit{E. tereticornis} of the same age are only 3.1 to 7.1 cm and 1.85 to 3.98 m respectively, the height variations among the different provenances of \textit{E. camaldulensis} of the same age are only 1.18 to 1.61 m.

As mentioned above, State Forest Research Institute, conducted provenance trials of various species of Eucalyptus in different soil and climatic zones of M.P. with a view to study their relative growth performance. The growth data of the most promising first three species/provenances have been summarised in Table-1.

Similarly, introduction trials of various Eucalyptus species have also been carried out on the poor soils such as those in the mine out areas. The results are very encouraging which is evident from the growth data given in Table-2.

Experiments conducted at various sites in the State, have however, shown that Eucalyptus hybrid is the best suited species for M.P. conditions. Growth data recorded from the sample plots laid out by S.F.R.I., M.P. at various localities and the details of the respective site conditions etc. are given in Table-3.

Growth studies of the coppice crop of Eucalyptus have also been conducted by State Forest Research Institute, Jabalpur. It has been observed that 3½ years old first coppice crop has comparable growth parameters with those of 8½ years old seeding crop (discussed in chapter 4).

**CONTROVERSY ABOUT EUCALYPTUS CULTIVATION**

Despite its wide ecological adaptability, fast growth and higher productivity, a controversy has however been going on about the advisability of encouraging Eucalyptus cultivation on farmlands and in the forests. In this chapter, the results of experiments conducted by State Forest Research Institute, Jabalpur and P.R. Dehradun have been examined. The experience of farmers, field foresters and researchers throughout the country have also been summarised in this chapter. The research findings and field experiences bring out the glaring example of misconceptions and prejudices against Eucalyptus by a section of environmentalists and Indian Press. Various aspects of controversies pertaining to the growing of Eucalyptus have been examined in this section.

### Table 2: Growth Data of the most successful Species of Eucalyptus planted at mined out sites.

<table>
<thead>
<tr>
<th>N.</th>
<th>Species</th>
<th>Site Description</th>
<th>Age Yrs.</th>
<th>Survival %</th>
<th>Average Height m</th>
<th>Average Girth cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>\textit{E. camaldulensis}</td>
<td>Bauxite mined out areas in Amarkantak region</td>
<td>6</td>
<td>93</td>
<td>8.41</td>
<td>23.6</td>
</tr>
<tr>
<td>2.</td>
<td>\textit{E. hybrid}</td>
<td>Bauxite mined out areas near Amarkantak</td>
<td>6</td>
<td>95</td>
<td>8.24</td>
<td>20.7</td>
</tr>
<tr>
<td>3.</td>
<td>\textit{E. grandis}</td>
<td>Mined out areas of Dolomite near Bilsapur</td>
<td>3</td>
<td>84</td>
<td>6.27</td>
<td>21.5</td>
</tr>
<tr>
<td>4.</td>
<td>\textit{E. hybrid}</td>
<td>Bilaspur</td>
<td>3</td>
<td>92</td>
<td>2.15</td>
<td>9.1</td>
</tr>
<tr>
<td>5.</td>
<td>\textit{E. camaldulensis}</td>
<td>Mined out areas of coal mine over burden near Shahdol</td>
<td>3</td>
<td>82</td>
<td>8.50</td>
<td>24.6</td>
</tr>
<tr>
<td>5.</td>
<td>\textit{E. camaldulensis}</td>
<td>Sandy loam soil near Bilsapur</td>
<td>8</td>
<td>92</td>
<td>4.50</td>
<td>12.8</td>
</tr>
</tbody>
</table>
Table 3: Performance of Eucalyptus hybrid in various soil and climatic conditions of M.P.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Name of the locality</th>
<th>Age of the plantation in years</th>
<th>Altitude of the site (m) from N.S.L.</th>
<th>Mean Annual Rainfall (mm)</th>
<th>Geology and soil</th>
<th>Site quality</th>
<th>Crop diameter in cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>South Betul Forest</td>
<td>9</td>
<td>733</td>
<td>1230</td>
<td>Trap and metarur origin sandy soil</td>
<td>II/III</td>
<td>12.3</td>
</tr>
<tr>
<td>2</td>
<td>Rajnandgaon Forest Division</td>
<td>6½</td>
<td>850</td>
<td>1750</td>
<td>Granite, ruder soil, shallow sandy soil</td>
<td>III</td>
<td>9.7</td>
</tr>
<tr>
<td>3</td>
<td>Kanker Forest Division</td>
<td>8</td>
<td>450</td>
<td>1250</td>
<td>Sandy loam</td>
<td>III</td>
<td>9.7</td>
</tr>
<tr>
<td>4</td>
<td>South Khanowa Forest Division</td>
<td>8½</td>
<td>275</td>
<td>760</td>
<td>Underlying rocks, Murrum, mixed black cotton soil on top</td>
<td>II/III</td>
<td>8.4</td>
</tr>
<tr>
<td>5</td>
<td>North Shahdol Forest Division</td>
<td>5½</td>
<td>425</td>
<td>1400</td>
<td>Sandy loam</td>
<td>II/III</td>
<td>8.4</td>
</tr>
<tr>
<td>6</td>
<td>North Shahdol Forest Division</td>
<td>7½</td>
<td>365</td>
<td>1400</td>
<td>Sandy loam</td>
<td>II</td>
<td>12.1</td>
</tr>
<tr>
<td>7</td>
<td>Bilaspur Forest Division</td>
<td>7½</td>
<td>400</td>
<td>1400</td>
<td>Granite rock</td>
<td>I</td>
<td>13.8</td>
</tr>
<tr>
<td>8</td>
<td>Bilaspur Forest Division</td>
<td>8½</td>
<td>585</td>
<td>1400</td>
<td>Sandy loam</td>
<td>III</td>
<td>11.1</td>
</tr>
</tbody>
</table>

of the bulletin. The conclusion of this chapter it is hoped, would help dispel many unfounded notions about this species and may this enable prospective growers to take up the programme of tree cultivation on marginal land in a big way.

The Genesis of Controversy

The arguments advanced against Eucalyptus may be briefly mentioned before referring to the experimental data which go against these arguments. In the first place it is said that because of its high water requirement Eucalyptus draws away sub-soil water and is thus responsible for lowering of water table. Secondly, it is apprehended that the cultivation of Eucalyptus greatly impoverishes the soil since its off-take of soil nutrients is much more than what is actually returned through leaf litter, stem flow etc. It is also said that Eucalyptus cultivation leads to soil acidity. Thirdly, being a poor interceptor of rain-water by the sparse crown and branches, accelerates run-off and help soil erosion. Fourthly, the tribals who depend on roots and leaves of various plants growing as undergrowth in the forests for part of their subsistence and livelihood are deprived of the same since Eucalyptus does not allow any undergrowth to come up. It is also said that Eucalyptus has spread out roots which do not decay, thereby preventing the growth of other species even after the Eucalyptus trees have been felled. Fifthly, Eucalyptus is considered as a very poor fuel on account of low calorific value and heat output. Sixthly, it is argued that the large farmers will benefit more as they will try to overcome their labour and management problems by diverting a major part of their lands to agro-forestry. Lastly, some people accuse that large scale planting of Eucalyptus is damaging the environment as it does not support bird population and wildlife, and thus causes degradation of the environment.

The controversy about Eucalyptus has been maximum in the State of Karnataka. The hostility towards Eucalyptus was so much so that some misguided persons organised a section of farmers to even uproot the seedlings of Eucalyptus. In view of these outbursts, the whole issue was examined by Policy and Planning Committee of Karnataka. This Committee was headed by no less a person than Ex-Secretary of Agriculture and Ex-Member of Planning Commission Shri G.V.K. Rao. Panel discussion relating to ecological and socio-economic impact of the cultivation of Eucalyptus were held on 7th September, 1983. The panelists, in addition to the members of Economic and Planning Council of Karnataka, also included Dr. J. Bhandopadhyay and Dr. B.V. Krishnamurti who have been waging war on Eucalyptus environmentalists like Dr. Madhav Gaglivi and Shri Y.M.L. Sharma a retired forester of international repute and a few others. The Panel Chairman was assisted by Prof. A.N Reddy of the Indian Institute of Sciences, Bangalore. The panel discussion examined all the points pertaining to ecological and socio-economic concern both for and against and concluded that the research evidence attests all the ecological fears expressed against this species. It was noted that all the socio-economic arguments for and against Eucalyptus - wood crops would be applicable to any other tree crop as well. Many of these arguments would also be applicable to commercial crops like sugarcane, cotton etc. Further research on various aspects of Eucalyptus was also emphasized by the panelists.

The Indian Forester, an internationally recognized publication of forestry research, has brought out three special issues in December 1984, January and February 1985 on
Eucalyptus. The experimental data collected from different parts of the country have been presented through articles in these issues. The U.P. Forest Bulletin entitled "Eucalyptus for farming" released on the occasion of the national workshop on Agroforestry held at Karnal on July 21, 1983 has also dealt with some of the major issues. Recently, the experience gained in Gujarat has been presented in a brochure by the Forest Department there. The information contained in these publications should allay the fears and apprehensions expressed by the critics. These fears and research evidence about Eucalyptus cultivation are being given in the following paras.

The Research Evidence

Eucalyptus has wide adapto-climatic adaptability. It flourishes from coastal areas to areas situated at 2,000 meters altitude, tropical to warm temperate climate and rainfalls ranges of 400 to 4,000 mm. In Africa in regions receiving only 100 to 150 mm of annual precipitation, Eucalyptus microtheca plantations have been raised. It can colonise bare ground without shelter. It has a subterranean protective organ known as lignotuber which enables the trees to overcome adverse biotic and climatic conditions. The lignotuber survives even when the aerial part of the Eucalyptus is burnt out by fires and continues to produce new shoots. The leaves are not palatable to animals. Eucalyptus plantations, therefore, require minimum care and protection against onslaught of both man and animals. The promise shown by Eucalyptus hybrid in "User" soils of U.P. holds out future possibilities of introducing salt resistant species of Eucalyptus in saline and alkaline soils of the State which cover a substantial area especially after the introduction of canal irrigation. This tree (E. saligna) has also been recommended for planting in water-logged areas of Tawar command in Madhya Pradesh by State Forest Research Institute, Jabalpur. Intensive research work by this Institute has brought out that Eucalyptus establishes fast and is capable of producing maximum biomass in different types of wastelands. Its utility have been proved on mined out areas and mine overburdens of bauxite, coal, colomite, limestone, manganese and iron ores of Madhya Pradesh. State Forest Research Institute, Jabalpur has experimented with many industrial effluents which contaminate the water of rivers and other perennial streams. The results of experiments have shown that these polluted industrial effluents could be gainfully diverted for raising irrigated plantations of Eucalyptus.

Eucalyptus plants are easy to raise in nurseries. Ten kilogram of Eucalyptus seed can produce one million seedlings. A plant of 1 m height can be obtained in about six months. In Gujarat small and marginal farmers and even school children are involved in raising polyprop seedlings. This is a source of additional income to them.

Eucalyptus is also a good coppice and two to three coppice rotations have been tried successfully in India so far. Eucalyptus is classified as very hard wood. It is presently used as construction timber, poles, pulpwood and fuelwood. The air dried wood burns at a slow rate with a calorific value of 4,800 to 5,000 Kcal per kg and when burned into charcoal with 7,900 Kcal per kg. The essential oils extracted from Eucalyptus are rich in cineole (63.2 to 72.3 per cent) and has potential for import substitution for the pharmaceutical industry in India. The bark yields oxalic acid. Honey yields increase in the vicinity of Eucalyptus plantations. The experiments conducted with regard to improved seasoning practices hold much promise for reducing defects like surface cracking, splitting, warping and collapse and in coming years the scope for using Eucalyptus to replace other valuable timber will get enlarged. It takes as good polish as teak and other furniture timber.

The very attractive economics of Eucalyptus plantation is its greatest asset. It yields high volume production on short rotation of 5-6 years. In Terai region of U.P., a mean annual increment of 2.46 cu m (about 2 tonnes) or 17.7 cu m or about 17 tonnes per hectare in 8 years has been recorded. In Tamil Nadu and Karnataka, the maximum volume of production has been recorded as 325.33 cu m and 205.10 cu m respectively. Even with average yield of 100 cu m and 75 cu m (2,222 and 1,600 plants per hectare, respectively) the net return is Rs.30,583 per hectare and Rs.21,656 per hectare, respectively at the eighth year. On the basis of the experience of average farmers in Gujarat it is estimated that the net income over a period of six to seven years is of the order of Rs.50,000 in the agricultural fields under irrigated conditions. In Madhya Pradesh, though the farmers have started planting Eucalyptus on field (burn-out) only recently, the growth pattern indicates that it would be quite remunerative.

Earlier plantation of Eucalyptus raised by various Divisions of State were not very encouraging. They gave a mean annual increment of less than 10 cu m. The poor growth was mainly on account of heavy mortality and lack of tending operations and aftercare. In the absence of any clear policy for the utilization of raw material, these plantations were not harvested at proper time. As a result, most of these plantations which were kept standing for too long, started putting on negative increment. Some of these plantations have been harvested at very late stage (after 15-20 years). However, the coppice shoots from harvested tree stumps have been observed to be more vigorous than even the parent tree. The coppice shoots after one year of felling have attained a phenomenal height of 6-8 m in Eucalyptus plantation near Kondagaon (Bastar) harvested after 17 years.

In recent years, the plantations raised on mine over-burders of bauxite, coal and colomite have given the mean annual increment of 23 cu m of wood and about 30 tonnes of total above ground biomass. Semi-irrigated plantations at Neganagar, Seoni, Jabalpur and Bilaspur have shown that a 5-years old Eucalyptus hybrid plantation would attain an average height of 14 m and average girth at breast height of 54 cm. A modest stocking of about 2,000 trees per hectare can yield about 25 cu m of timber. 50-60 tonnes of pulpwood and about 10 tonnes of firewood. Taking an average figure of Rs.800 per cu m of timber, Rs.500 per tonne of pulpwood and firewood, each hectare of 5-6 years old plantation can fetch an estimated gross return of about Rs.1,000 lakh.

Soil moisture consumption by Eucalyptus: A few species out of the 500 species of Eucalyptus can come up in water logged areas and these have been used for reclamation of some water logged areas in Israel and Italy, and also being experimented by State Forest Research Institute, Jabalpur in different parts of M.P. This has been cited by many critics in support of their argument that Eucalyptus consumes excessive quantity of water. It is, however, recognised that in Australia, the home of Eucalyptus, where more than 500 species are growing, a majority of plantations are thriving in regions with a rainfall of 225 mm to 100 mm. Some of them have been regenerating naturally. Natural regeneration of E. camaldulensis and E. tereticornis have been observed in a plantation at Jabalpur (SFR) where soil and moisture conditions may be comparatively better but it is also coming up at bauxite mined sites of Amarkantak where soil surface is composed of hard and inert lateritic boulders.
An experiment conducted by Forest Research Institute, Dehra Dun, showed that when soil moisture is less, the Eucalyptus plants restricted water loss by triggering on its water conserving mechanisms. Another important finding of the experiment was the reduction in moisture supply by 66 per cent and 94 per cent resulting in reduction of dry matter production by only 25 per cent and 38 per cent, respectively. Water consumed per gram of dry matter was 1.41 ml for Eucalyptus compared to 2.87 ml for chirepine, 3.04 ml for poplars and 2.54 ml for Sissoo (Dalbergia sissoo).

Forest Research Laboratory at Kanpur carried out an experiment (March 1962 to February 1963) on water requirement of plants. It has been found that Eucalyptus produced 2.06 g biomass per litre of water compared to 1.39 g in Acacia, 1.31 g in Sissoo and 1.13 g in Karan. Since Eucalyptus is most economical in water consumption it has greater claims in arid regions where careful water management is most important.

The experiment in the farmer's fields in Gujarat also corroborates the facts that Eucalyptus does not deplete sub-si soils. In a farm of 80 hectares with 200,000 Eucalyptus plants in village Vatava near Ahmedabad and Manu-Vijay farm in village Jethi in the semi-arid areas of Banaskatha district, the levels in the wells located in the farms raising Eucalyptus plantations have not gone deeper than wells in surrounding farms during the last seven years. Similar observations were made in the fields around Eucalyptus plantations near Kondagaon, Bastar. The water level in the wells adjoining Eucalyptus plantations and Sal natural forests was found to be similar.

Interception studies in forests of West Bengal showed that the tree allowed 8.84 per cent of rainfall to reach the ground as compared to 77.5 per cent of Babool (Acacia nilotica). Only 12.15 per cent of rainfall is lost by interception by leaves, branches, etc., in Eucalyptus plantations. The larger volume of water reaching the soil quickly, infiltrates into the soil.

Root system of Eucalyptus have been studied by the author at Regional Forest Research Centre, Jabalpur. It has been established that roots generally reach 3-4 m of soil depth while subterranean water in this locality is found below 30 m. The rise of water due to capillarity is so negligible (less than a few mm) that the sub-soil water is out of the reach of Eucalyptus roots. This study has concluded that Eucalyptus being an efficient user of water, its roots are able to take the benefit from slightest quantity of precipitation percolating to a soil depth of about 15 cm. Economic and Planning Council of Karnataka has also concluded on these lines. The panel discussion of this Council has assigned various reasons for lowering of water tables such as (i) enormous increase in the number of poplars (ii) consecutive drought years (iii) very high density of tree planting (above 10,000 trees per hectare).

To verify the effect of Eucalyptus on groundwater, three different localities in Dehara Dun valley were studied. Eucalyptus and Sal plantations were adjacent to each other. On one of the sites there were 1000 plants recorded under Eucalyptus as compared to only 367 under sal forest. In terms of genetic diversity, there were 44, 29 and 65 plant species at site I, II and III under Eucalyptus as compared to 26, 29 and 27 in adjoining natural Sal forest. Greater light radiation and rainfall infiltration facilitated by lesser density of crown in Eucalyptus plants was found to be conducive to higher genetic diversity and plant population. Observations on the presence of ground flora vegetation under 5-10 years old plantations of Eucalyptus, Anjan (Hochwickia binate), Sissoo (Dalbergia sissoo), Sins (Albizia lebbeck) and teak were also recorded at Regional Research Centre, Jabalpur by the author. This study has brought out that D.sissoo and Eucalyptus plantations carried a larger species diversity, total above-ground biomass of ground flora species and water infiltration rate than the plantations of teak, Anjan, Siris and Acacia auriculiformis. Eucalyptus plantations raised on lateritic waste lands and degraded forest areas of West Bengal and M.P. (Bahetland of Bilsapur, Raipur) are invariably invaded by a number of grasses and weeds. The grasses are source of cattle feed. The vegetation cover harbours insects. The bird population eating these insects is reported to proliferate. In Gujarat, grasses from community and road side plantations of Eucalyptus are being sold regularly. Bamboo, teak and sa-babul have also been successfully grown in the shade of Eucalyptus trees. The promise of SFRI at Jabalpur profuse natural regeneration of Eucalyptus hybrid is seen under 10 and 20 years old plantation of this species. A number of nutritious grasses (Cenchrus ciliaris, Eclantia annulata, Eclantia binate) have been underplanted with Eucalyptus at these sites. In West Mombasa Division, Teak and bamboo growth have come up well with Eucalyptus plantation raised in 1963. All the top canopy species of natural teak forest of this area are happily growing in this plantation. Similarly, the mixture of Sal and Eucalyptus are seen growing on Kapildhura road and near Amarkantak (Shahdol).

Eucalyptus draws nutrients from deeper soil layer which are beyond the reach of annual seasonal crops and does not interfere with the growth of inter-planted agricultural crops. Eucalyptus planted on the paddy fields of J.N. X.V. Jabalpur farm did not show any harmful effect on the growth or yield of paddy crops. Studies conducted by Department of Farm Forestry at University of Agricultural Sciences, Bangalore have shown that Eucalyptus leaf extracts had no harmful effects on the seed germination or root, Jowar, cowpea, green gram, gingil etc.

Soil Fertility: There has been an outcry against mono-culture in the case of afforestation as though mono-culture by itself is an undesirable evil. Eucalyptus mono-culture has also been objected to. The criticism can be valid if Eucalyptus or any other mono-culture replaces an existing viable mixed plantation or stratified natural forest. But it will be meaningless to object to mono-culture when it is introduced in barren areas or areas which support extremely sparse and poor vegetation. Of about seven million hectares of revenue wastelands available in Madhya Pradesh, at least four million hectares is occupied by ravines, hard laterites, mine overburdens, water logged areas etc. These sites have already reached an advanced stage of degradation but afforestation activity could still be able to bring it back to near natural balance. At such highly degraded sites, there is a greater need to introduce some cover, even Eucalyptus, than to try, a most ideal mixture of trees, shrubs and grasses and fall. When some vegetative cover has been established at such sites, the under-planting of other vegetation could always be attempted. Such an attempt has already brought good results at Buxita and coal mine overburdens when Sal, Teon (Cedrela toona) and grasses, are being gradually underplanted with Grevillea pilferidio, Eucalyptus and tropical pines near Amarkantak in Madhya Pradesh.

Regard the acute effect of Eucalyptus hybrid, this is a blessing for saline and alkaline soils. In an experiment in Karnataka, the pH of an alkaline soil in a Eucalyptus hybrid plantation decreased from 8.2 to 8.0 in 11 years. In other words, Eucalyptus hybrid actually improved the soil. Experiments conducted by SFRI, Jabalpur have also shown negligible change in soil reaction (7.9-6.9) under 20-years old Eucalyptus plantation.
Regarding nutrient uptake and soil enrichment also, it has been found that Eucalyptus trees are as efficient in replenishing the soil nutrients as any other mono-culture. The production of leaf litter under Eucalyptus plantations raised in Mohan Bhat (Bhata land) areas of Bilaspur, bauxite mine and heumbers of Amarkantak, coal mine overburdens of Dhanpur (Shahdol) is superior to any other species. In experiments conducted at FRI, Dehradun, in Bangalore Forest Division, in West Bengal, at Jabalpur (SFR) and at Amarkantak, Eucalyptus plantations have been found to increase the nitrogen, phosphorus and potash content of the soil. There is no significant drop in soil pH, in terms of nutrient uptake also. Eucalyptus has not been found to remove these nutrients in excess of what it contributes. In fact, the nutrient balance has been found to improve under Eucalyptus plantations as it is reported to enrich impoverished soil through mycorrhizal association.

Socio-Economic Criterion: With the adoption of tree farming the income levels of the cultivator increase. The Gujarat experience also shows that big farmers need not be the major beneficiaries under the farm forestry program.

The present situation regarding our forests is critical. Between 1961-1961 Madhya Pradesh has lost more forest area than any other State in the country. Madhya Pradesh, which in respect of forest produce was considered as surplus State is facing fire-wood famine especially in Western Madhya Pradesh. Bundelkhand and Rewa areas are also facing shortages of timber, bamboo and other forest produce. Large areas of wastelands in the State, therefore, to be brought under tree cover as quickly as possible before the entire State feels the pinch of shortages of forest produce. Eucalyptus on account of its adaptability to various edaphic, climatic and biotic pressures, appears to be the only answer.

The question of whether Eucalyptus plantation increases water run-off and soil loss; the question of whether it enriches the soil or has deleterious effect on soil properties and growth, depends on what Eucalyptus is replacing. When it is replacing a natural stratified forest of Sal, teak or dense mixed miscellaneous forests, all these arguments against Eucalyptus may be valid. However, when it is planted on mine-over workings which are devoid of vegetation and other form of micro-organisms; when it is planted on barren land leats, in deep ravines, in degraded forests, in water-logged areas, long roadsides and canal banks, along railway track, on field bunds and on community wastelands, the Eucalyptus plantation is more beneficial than any other indigenous or exotic species. No other exotic or indigenous tree species is known to be so adapted to such varying soil and climatic conditions, as Eucalyptus. This species in terms of growth, net primary productivity (NPP) and leaf litter fall, is far more superior than any other indigenous or exotic species. Eucalyptus planted on agricultural field bunds supplements to the farmer’s income, its economy is more glaring and convincing when agricultural crops fail on account of natural calamities such as flood, drought, hailstorm, frost etc. Eucalyptus plantation thus acts as an insurance against crop failure.

The success of Eucalyptus is truly based on sheer competence of eco-adjustments under varied growth conditions and capacity to colonize completely exposed sites, enduring adverse biotic and climatic conditions through lignocellobbers for survival. It has nearly perfect plant architect to suit many afforestation requirements. The roots allow mixed plantations for rational exploitation of soil nutrients. The slim and up right bole allows high plantation density, the thin tree canopy casts minimum shade on agricultural crops when this is raised on agricultural bunds. The tree is acceptable for avenue, field bund plantation and for power and building construction poles. The wood serves as good paper and rayon grade pulp besides being suitable for firewood and charcoal. Good hard boards and particle boards have been converted from this plant and it has also been used as furniture timber.

Eucalyptus has proved to be most useful tool for rural energy planning and as a part of rural upliftment strategy through social forestry programme. Eucalyptus with its vegetative genius meets the requirement of rural economic growth through firewood and a number of other produce supporting cottage industries without impairing the environment.

In view of its versatility to different growing conditions, fast growth, multiple uses and having good response from farmers under social forestry programme, there appears to be no reasons for outright condemnation of this species. Eucalyptus plantations need not aim at replacing natural and stratified forests of teak, sal, bamboo and other mixed hardwoods but should be encouraged for plantations on wastelands, in degraded forests, on mine over-burdened, in deep ravines and on such other retractive sites. Certain indigenous species such as Neem, Sissoo, Kanar etc. should also be adopted for reclothing the barren hills and exposed sites but Eucalyptus should invariably form a major part of afforestation program on such sites.

This subject was discussed in State Forestry Conference at SFR, Jabalpur (18-20 February, 1985). The resolution passed on the subject by the Conference is being reproduced below: (Session VII Social Forestry: 20-2-85):

WHEREAS Rejection of Eucalyptus as a species for plantation by Government is not based on sound technical background and Eucalyptus has proved very useful for farm forestry.

This Forestry Conference Recommends that Government has discarded Eucalyptus as a species for inclusion in plantation activity. Our knowledge of the species indicates, that Eucalyptus is not harmful. On the contrary it is very useful. This is confirmed by experience of a large number of farmers. Eucalyptus is being increasingly demanded and raised. Hence this conference strongly recommends that Eucalyptus should be accepted as a species for being raised, in Social Forestry Plantations.

In most parts of this State, agricultural production depends upon rainfall. Majority of State’s population is comprised of Tribals and other economically weaker sections. They are mostly small and marginal farmers and, therefore, are subjected to miserable hardships when crops fail on account of climatic vagaries. In all these situations, tree farming of species like Eucalyptus may prove a boon to the small and marginal farmers.

CULTIVATION TECHNIQUE

Most growers now cultivate the eucalypts for ornament, fuel, erosion control, sawing, hardwood pulp for paper and rayon industries, pit props, construction material etc. One of the principal factors underlying their widespread introduction is the ease of cultivation. Not only are the eucalyptus readily cultivated, but seed supplies for most of the species are easily obtainable, the germination is exceptionally good, and many species are extremely adaptable to altogether varying soil and climatic conditions. The planting techniques used for eucalypts in all parts of the country differ in detail only from the usual planting techniques used for forest trees. Although direct sowing can be used, for the most
part nursery sowing is practised, followed by transplantation into containers before planting out in the field.

Seed collection:

Seed collection in the eucalypts must be carried out very carefully in order to obtain satisfactory results. The provenance of the seed has been found to be extremely important in selecting the tree for seed collection. The parent tree from which seed is collected should be carefully selected, whether the species is to be used for timber, oil, tannin, ornamental or other purposes. The usual principles of tree selection are used that is, seed should be taken from trees showing a degree of desirable characteristic such as rapid growth, good form, high percentage of oil, tannin, pulp quality, etc. In other words, mass selection should be practised. The selection of elite trees for seed is a desirable practice which has not yet been used extensively enough in this country for the collection of Eucalyptus seed. In case of oil yielding species, it has been shown that oil characters have a high heritability, and consequently the collection of seed from these elite trees has led to progeny with high oil yields and excellent quality oils. The same principles should hold for other chemical constituents of the trees, and efforts should be made always to collect seed from outstanding parents. In the case of timber, however, the matter is more difficult, as it is often impossible to determine exactly the difference in quality between trees without destroying the tree and consequently losing all the seed.

The State Forest Research Institute, Jabalpur undertakes the task of identifying the seed stands of various Eucalyptus species in Madhya Pradesh. This Institute has also established eucalyptus at its nine Regional Forest Research Centres (Jabalpur, Amarkantak, Bilaspur, Raipur, Jagdalpur, Indore, Napanagar, Betul, Seoni) located in different edapho-climatic zones of the State. The seed is collected from elite trees and seed stands is stored at the Seed Bank of the Institute at Jabalpur, after its grading, purification and testing. The indenting agencies are supplied graded and certified seeds on payments.

Gathering the seed is sometimes difficult with large trees owing to the scatter of capsules throughout the crown. Usually, if the seed is very scattered, it is collected by hand after climbing the tree. If the capsules are not scattered, or the tree is heavily laden, the branches are cut off and the capsules removed by hand on the ground. They are then placed in the sun on a tarpaulin, and after a few days of drying, the seed can be sifted from the capsule proper. The rate of collection varies considerably according to the stocking of the collection area, and also to the amount of capsules per tree, but average collection could be taken as 2 kg of seed per man day. Seeds stored in well filled, stoppered bottle in a cool, dry place will keep for years. However, as mentioned earlier, the freshly collected seeds produce best results.

Direct Sowing:

The practice of direct sowing is never successful unless the conditions of germination and subsequent growth are exceptionally good (ideal conditions). As the tiny seed has no reserves of food to draw upon, and must become firmly established in the mineral soil within a few days of actual germination. A sudden heat wave can prove disastrous to newly germinated seedlings in a few hours. In addition to this problem, the process of direct seedling is extremely wasteful of seed as invariably out of only a small proportion of germinated seeds, only a few survive. The seedlings resulting from direct seedling are also not able to withstand the adverse field conditions more so because they are not subjected to any shock treatment which is normally available to the nursery grown seedlings which, in the course of shifting from nursery bed to container and then on to the field, receive numerous shock treatments.

Nursery Sowing:

The success of a plantation to a great extent depends on the planting stock used for raising plantation. Healthy and disease-free planting stock can be obtained only when the nursery is also maintained properly.

The situation of a nursery depends on many factors, including water supply, closeness to plantation etc., and roughly 0.10 acre of nursery is required for each hectare to be planted. A good Eucalyptus nursery is one which has the following essential features:

1. The surface should be flat with gentle slope, facing east or north. It should be sheltered from strong summer and winter winds.

Method of Seed Sowing:

Seed can be sown either in containers in the nursery or in the open ground; for either pricking directly into pots or tubs, or planting as naked rooted plants. If the seed is broadcast sown, it is usual to sow at the rate of 50 g per sq m, but as broadcast sowing is not always satisfactory, in many cases the seed is sown in strips or rows in seed beds of standard size (10 m long and 1 m wide). The latter method facilitates weeding, and the seed is not dislodged by watering, which is the case sometimes when the seed is broadcast.

When the seed is sown directly into pots, a few fertile seeds should be put in each pot. Polystyrene bags of size 15 x 22.5 cm having perforations throughout the length of bags are normally used. The polystyrene bags should be filled with soil, sand and manure in a ratio of 2:2:1. The filled bags should then be watered, a small hole about 2 cm
across and 1 cm deep should be made by hand in
with a dibble. The appropriate amount of seed is
dropped in and covered, and the whole polythene
bag, soil lightly watered. In some cases the
germinated plants are picked out into other bags
but if it is intended to retain the seedlings in the
same pot, surplus plants are removed by hand.
Leaving one seedling only. This method can be
used when ample seed is available, although it is
somewhat wasteful.
The nursery soil used for sowing should
normally be fairly light and permeable and it
should consist of loams, or other soil mixed with river
sand, together with a reasonable amount of organic
manure. It is very unsuitable to add any fertilizer. The
main characteristic of the soil to be used is that it
should drain readily and well.
The soil used for covering the seeds sown in
nursery bed should not be too light, otherwise the
sown seeds may be exposed by the winds or
wasting. The soil should also not be very heavy
as to form crust and prevent the plants from
emerging. Where damping-off is suspected the
seeds should be covered with sterile matter such
as saw dust or fine ash. Before sowing, small
quantities of fungicides should be mixed with soil.
Locally available Gambex is or M.C. powder may
be added at 100-1000 g per bed.
Watering should be carried out once daily with
a very fine spray. Sometimes, however, it may be
necessary to water more than once in very hot
climate. It is most important that watering is done
early in the morning or late in the evening so that
respiration losses could be minimised. Regular
watering is recommended but infrequent and
coarse watering should, as far as possible, be
avoided.
Germination takes from 7 to 20 days after
sowing in most parts of the State. Watering
frequency could be reduced after the emergence of
seedlings so that the germinating seedlings are
able to withstand water stress.
Transplanting:
When the seedlings emerge out in the bed and
reach a height of about 3 cm and when stem
becomes woody, they should be picked out in
the polythene bags of suitable size depending upon
the size of plants to be raised and filled with soil
mixture as described earlier. At the time of
picking out the roots may be 9-12 cm long. If the
roots are curvy or too long then they may be
trimmed. Each seedling should be carefully
separated from the adjoining seedlings. While
picking out the seedlings should be placed by hand
in the centres of polythene and covered with the
soil mixed with organic manure. The picking
out should be done when the weather is neither too
hot nor too windy.
Planting:
The planting of Eucalyptus seedlings is done in
the month of July with the onset of monsoon. If
the water supply through well and irrigation pipes are available, planting may be
done from March to June. Healthy planting stock
(about 45 cm tall polythene plants) planted during
this period (March to June) with about 8-10
irrigation a month can give the best results. The
fourth month's growth before the commencement
rain season would help establish the plant before
rains and in that case the crop can be harvested
earlier than 5-6 years.
Under normal planting scheme, an espacement
of 2 m x 2 m is followed by Forest Deptt. However,
the experience of farm forestry projects shows
that spacing of 2 m x 1 m provides best results. If
intercropping of zinger, curcuma, wheat, palatable
grasses, berseem, sorgamandha (Haworthia serpentina), etc. are to be taken up this
is feasible in first 2-3 years, the row to row
spacing of 3 m (for the easy movement of tractor
plough) and plant to plant spacing of 1 m is
recommended combination. Plantation with still
closer spacing of 1m x 1m could also be done but in
that case the weaker seedlings (about 50% of the
total population) may be cut back at the end of
second or third year. This would provide some
small wood (firewood) at the end of 2-3 years but
later on the yield from coppice would be available
every third year. This practice, if followed, may
ensure best growing space to 50 per cent plants. At
the same time advantage of higher plant
population would be available in full rotation
period. At different spacing the total planting,
material required for raising one hectare of
plantation would be as given in Table 6.
Table 4: The recommended spacing for farm forestry
project would be 3m x 1 m and 2m x 1m in fertile
soil to leamy soil the spacing of 2m x 1m should be preferred. The polythene plants are
planted in the pits of 30 cm or 45 cm size,
depending upon the type of soil. Before planting
about 5 grams of straight is put in each pit to
protect the plants from insect attack. Also, before
planting, the polythene bag should be torn off
carefully, without disturbing the soil body and
thereafter the plant should be planted in the pit.

Site Selection:
Eucalyptus need well drained, deep and fertile
soil for good growth but poor and refractory sites
can also support Eucalyptus plantations provided
inputs such as irrigation and fertilizers are
copiously given. Due to their fast rate of growth, they overlap other crops. The soil requirements
vary considerably for different species of
Eucalyptus. The sites which are low in availability
of moisture during the growing period are not
good for Eucalyptus planting unless the deficiency
is met through irrigation. Eucalyptus also avoids
heavy rainfall areas. It has failed in areas like
Kerala and Assam. Eucalyptus generally do well
without irrigation in the areas having deep
fertile and well drained soil. Sites which have
heavy soils or high concentration of salts are also
not good for many Eucalyptus species. However,
there are salt resistant varieties which can easily
be grown at such sites. Sandy soils may be good,
provided facility of adequate irrigation is
available. Eucalyptus have a tendency to develop
pronounced tap root (3-4 m deep) so the site
having hard clayey pan are not suitable for it.
Eucalyptus hybrid is neither able to withstand
conditions of prolonged water logging nor do they
tolerate the severe drought conditions. But,
Eucalyptus can tolerate mild frost and stand light
fires. However, a number of Eucalyptus species
are recognised which can grown successfully
under adverse climate, and soil conditions.
However, for farm forestry project the favourable
soil and climatic parameters, minimal irrigation and
occasional fertilizer application would ensure
higher returns. General impression that this
species can be grown on degraded wastelands
without any effort may be alright if we want to see
green plants but for higher returns, good soil
would always give better harvests.
Choice of proper species for a particular type of
site is also an important factor for the success
of an Eucalyptus plantation. The list of some of
the species of Eucalyptus and the types of specific
sites where they can be planted are given in Table
5.
Growth Trend and harvesting:
Plantations of various species of Eucalyptus
have been raised in different parts of the State
with the view of studying various aspects of the
growth of these species. These include
provenance trails, input trails, irrigated
plantations etc. To have a broad idea about the
Table 4: Planting Stock for one hectare plantation

<table>
<thead>
<tr>
<th>Spacing</th>
<th>Row to Row &amp; plant to plant</th>
<th>No. of plants required for a hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Main plantation</td>
<td>Casualty replacement</td>
</tr>
<tr>
<td>3m x 1m</td>
<td>3,350</td>
<td>300</td>
</tr>
<tr>
<td>2m x 2m</td>
<td>2,500</td>
<td>250</td>
</tr>
<tr>
<td>2m x 1m</td>
<td>5,000</td>
<td>500</td>
</tr>
<tr>
<td>1m x 1m</td>
<td>10,000</td>
<td>1000</td>
</tr>
</tbody>
</table>

The growth trend, the growth data of Eucalyptus camaldulensis raised in the 'Bhata' lands (hard laterites) of Chhattisgarh are given in Table 6. The Bhata lands of Chhattisgarh are hard and compact laterites and are devoid of nutrients.

The data collected from the Eucalyptus hybrid plantations of various localities of the State have been summarised in Table 8.

The time of the felling is decided on the basis of the fact as for what purpose the trees have been raised. If the plantations have been raised to meet the firewood demands, they should be exploited at an age to give maximum overbark volume production. But, if the objective is to provide pulpwood, the rotation should be fixed so as to give maximum underbark volume production. Pulpwood analysis of Eucalyptus camaldulensis, E. tereticornis and Eucalyptus hybrid at Naga Hills (Khandwa) have shown that harvesting at an age of 4½ years is suitable as the heartwood colour at this stage does not require much chemical for bleaching.

Coppice Crops:

Not much study on the coppice growth of Eucalyptus have been done in M.P. to reach any definitive conclusion about the optimum rotation of the coppice crop. However, growth data of two sample plots laid out in the coppice crop of Eucalyptus hybrid in Bilaspur and Kondagaon Forest Division have been indicative of the rapid growth rate in coppice crop. The studies done on the above sample plots have shown that the growth of coppice crop is much higher than the seedling crop. The comparative growth of coppice crop has been summarised in Table 7.

So far, results in respect of the growth of second coppice crop of Eucalyptus are not available.

**SUITABILITY OF EUCALYPTUS AT DIFFERENT SITES**

Whether the purpose be to get pulp for paper and rayon industries, fuel for domestic purpose, timber for constructional purpose, green view for aesthetic purpose or coloniser for reclothing a barren site, the species which can be grown in a wide range of soil and climatic conditions and which can give quite high volume production in a short period is probably the species of Eucalyptus.

**Table 5: Selection of Species for Different Sites**

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Name of the species</th>
<th>Locality where the species can be planted</th>
<th>General utility</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>E. tereticornis</td>
<td>Successful in hills and plains; minedout areas and other refractory sites</td>
<td>Good as hardwood pulp for paper and rayon industry; firewood, sawing poles etc.</td>
</tr>
<tr>
<td>2.</td>
<td>E. camaldulensis</td>
<td>Suitable to gently slopy areas and well drained plains, drier localities; minedout areas, wastelands, farm bunds, agricultural fields etc</td>
<td>Hardwood pulp, firewood, poles, sawing material etc.</td>
</tr>
<tr>
<td>3.</td>
<td>Eucalyptus hybrid</td>
<td>As above</td>
<td>-90 -</td>
</tr>
<tr>
<td>4.</td>
<td>E. citriodora</td>
<td>Successful in hills upto 1200 m</td>
<td>Good for aviation oil extraction</td>
</tr>
<tr>
<td>5.</td>
<td>E. globulus</td>
<td>Successful in hilly areas above 1200 m but with no snowfall</td>
<td>Planting at higher altitudes</td>
</tr>
<tr>
<td>6.</td>
<td>E. grandis</td>
<td>Plateau, plains, high rainfall areas</td>
<td>Good as sawn material, paper pulp, firewood construction timber</td>
</tr>
<tr>
<td>7.</td>
<td>E. microtheca</td>
<td>Successful in plains</td>
<td>Suggested for Alkaline soil and areas with precarious low rainfall</td>
</tr>
</tbody>
</table>
only. The reply of the greater challenges of the day seems to be possible only through the fast growing species like Eucalyptus. For reclaiming the poor and degraded sites where other species have failed, Eucalyptus has proved to be very useful species. In the context of high target of wastelands afforestation programme the importance of this species is further emphasised. Similarly, for the farm forestry project also this species has become very popular due to its high rate of growth and the utility of its wood. The performance of Eucalyptus species of various types of wastelands and on farmlands have been given in this section. The planting techniques suitable for different sites have been described in this chapter.

Eucalyptus or Wastelands Afforestation:

The wastelands of Madhya Pradesh can be classified into the following broad categories:

1. Bhata lands (hard and compact laterite soils, natural free vegetation is absent).
2. Water-logged and marshy lands.
3. Ravine lands particularly the Chambal ravines.
4. Rocky lands, barren hills.
5. Other degraded lands, degradation of which has been caused by the heavy biotic pressures.
6. Mined out areas.
7. Farm Forestry programme:

State Forest Research Institute, Jabalpur has been carrying out research on the possibilities and methodologies of reclamation and rehabilitation of the various types of wastelands. The results obtained so far in respect of each site type have been discussed in this chapter.

Table 6: Performance of E. camaldulensis on Bhata lands of Chhattisgarh (Eastern Madhya Pradesh).

<table>
<thead>
<tr>
<th>S.M.</th>
<th>Age of the plantation in years</th>
<th>Average Height (M)</th>
<th>Average dia at breast height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1.74</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>3.75</td>
<td>2.5</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>4.88</td>
<td>3.3</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>10.50</td>
<td>9.5</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>12.50</td>
<td>10.8</td>
</tr>
<tr>
<td>6</td>
<td>10</td>
<td>14.50</td>
<td>12.7</td>
</tr>
</tbody>
</table>

quite high as compared to other exotic and indigenous species.

The planting technique of Eucalyptus on Bhata land comprises of digging up of pits of 45 cm² size and filling them with imported humus rich soil and about 3 kg of compost in each pit. About nine-months old seedlings are planted in the filled-up pits after the onset of monsoon. Aftercare includes weeding whenever necessary and protection from the biotic factors, insects and disease. The MAI (mean annual increment) of height at the age of 8-years in Eucalyptus hybrid, has been 1.08 m and that of girth 3.5 cm. For Eucalyptus camaldulensis the MAI for height and girth have been found to be 0.80 m and 2.3 cm respectively.

3. Reclamation of Ravines:

In the past, research has been done for finding out the methods of afforestation of ravines. The results obtained so far have indicated that Eucalyptus hybrid is not successful in the ravines. But still the efforts are going on to develop the technology for using other species of Eucalyptus (E camaldulensis) as a reclamation agent for ravines.

4. Reclamation of Rocky hills:

A project for afforestation of rocky hills situated near Sehora (distt. Jabalpur) has been
Table 7: Average height and Diameter of Eucalyptus hybrid plantation.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Age years</th>
<th>Height (m)</th>
<th>Diam at b.h. (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>6</td>
<td>14.4</td>
<td>11.8</td>
</tr>
<tr>
<td>2.</td>
<td>8</td>
<td>16.7</td>
<td>13.8</td>
</tr>
<tr>
<td>3.</td>
<td>10</td>
<td>18.7</td>
<td>15.8</td>
</tr>
<tr>
<td>4.</td>
<td>12</td>
<td>20.7</td>
<td>17.6</td>
</tr>
<tr>
<td>5.</td>
<td>14</td>
<td>22.0</td>
<td>18.8</td>
</tr>
</tbody>
</table>

taken up in which planting techniques include digging up of trenches of 2.5 x 0.5 x 0.5 m size along the contours, cutting the mixture of soil and compost in the trenches and the planting the species whose water requirement is less. Eucalyptus camaldulensis and E. tereticornis have been found to be the best species for mined out areas.

B. Rehabilitation of other degraded lands:

Degraded and poor sites both, of small and large extent are the subject of research for this Institute. Plantations of Eucalyptus and many other species, found suitable for the purpose, have been planted on such sites. The planting technique varies with the nature, locality, climatic conditions and other factors.

B. Rehabilitation of Mined Out Areas:

Methodologies for reclamation of mined out areas of bauxite, dolomite, coal, iron etc. have been perfected by this Institute. On all these sites, Eucalyptus have been found growing very well. There are a few other species also which are successful on these sites, but Eucalyptus camaldulensis and E. tereticornis have been found to be the best species for mined out areas.

The plantings are in general, comprised of digging of pits of 45 cm size on roughly levelled overburdens, filling the pits with a mixture of parent soil (in the bottom portion of the pit), humus rich forest soil and about 5 kg of compost. About 8-9 months old polypropylene seedlings are planted in the above pits after the break of monsoon. Weeding and spraying of insecticides/fungicides are done whenever necessary.

On the basis of the experience gained so far about the success of Eucalyptus plantations in various types of poor and degraded lands, it can be hoped that Eucalyptus will be a very useful species for the afforestation of wastelands. On compact sites, deep tractor ploughing or bigger sized pits 45 cm* would ensure better growth. Phenomenal growth on mined out sites appears to be on account of soil pulverization rather than initial input. This should be taken into consideration while attempting plantations on refractory sites.

Table 8: Growth Performance of Seedling and Coppice Origin Crops of Eucalyptus hybrid.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Origin of the crop</th>
<th>Age in years</th>
<th>No. of stems per ha</th>
<th>Crop diam at b.h. (cm)</th>
<th>Crop height in m</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Seedling origin</td>
<td>8½</td>
<td>1064</td>
<td>8.8</td>
<td>11.3</td>
</tr>
<tr>
<td>2.</td>
<td>- do -</td>
<td>8½</td>
<td>1305</td>
<td>7.8</td>
<td>11.1</td>
</tr>
<tr>
<td>3.</td>
<td>Coppice origin</td>
<td>3½</td>
<td>1144</td>
<td>7.3</td>
<td>10.5</td>
</tr>
<tr>
<td>4.</td>
<td>- do -</td>
<td>3½</td>
<td>1155</td>
<td>7.8</td>
<td>10.1</td>
</tr>
<tr>
<td>5.</td>
<td>Coppice origin</td>
<td>1</td>
<td>1610</td>
<td>2.9</td>
<td>05.1</td>
</tr>
<tr>
<td>6.</td>
<td>- do -</td>
<td>2</td>
<td>1980</td>
<td>5.1</td>
<td>09.2</td>
</tr>
</tbody>
</table>

2. Eucalyptus For Farm and Agro-Forestry Programme:

Due to continually increasing population pressure of man and animal the existing forests are not capable of fulfilling the increasing requirements of timber, fuel, fodder and minor forest products. The forest boundaries are also shrinking on account of diversion of forest lands for various non-forestry uses. The present need is not so much to produce quality timber but to produce biomass for fulfilling the demands of the people. There is need to ensure public participation in tree growing programme. They should be made shareholders in the development and management of forests. Recently a new concept has emerged encompassing close collaboration between forester and people with the motto 'forestry for the people and by the people' - Social Forestry.

The government and other social institutions are trying to make the public understand that like agricultural crops, people can grow tree crop also and that in some cases, growing tree crop may be more lucrative than raising agricultural crops. The farmers are being encouraged to grow trees on their agricultural lands and on field bunds. People are now coming forward to adopt tree culture as a part of their occupation.

On the agricultural land, trees can be grown in three ways:

1. Growing trees on the land diverted from the...
agriculture totally for tree plantation. This procedure is generally adopted by the big land holders. Growing trees on marginal agricultural land where agriculture is no longer a profitable proposition is also a part of this strategy.

2. Growing trees on the bunds of the agricultural farms. This method is one that can be followed by every type of farmer, big and small.

3. Growing trees in the farmlands and doing intercropping of agricultural crops.

While selecting a species for farm/agro-forestry consideration should be made in favour of those tree species which have the characteristics like self-pruning, light branching habit, low competition for solar energy, nutrients and water, and which possess such root system that occupies the soil layers different to those tapped by the agricultural crops. In other words the tree species should maintain and improve the productivity of the site and help in optimising the joint productivity of both agricultural and the tree crop. Amongst the various species recommended for social and farm forestry programmes, Eucalyptus have been found to be quite successful, the reason being that it can grow on a variety of soil and under varying climatic conditions. Its rate of growth is very fast and it has straight stem and narrow crown. Besides it, it’s multiple uses, Eucalyptus can be harvested early. In Punjab and Gujarat, many progressive farmers have planted Eucalyptus on their agricultural lands and are harvesting good financial returns.

Eucalyptus planted on the farmlands in Gujarat act as a wind break and increases the humidity in air which ultimately, increases the yield of wheat by 23% and that of mustard by 34%. Also intercropping with Eucalyptus increased the sugarcane yield by 30% percent in U.P. This was due to less radiation because of Eucalyptus trees which increases the photosynthetic activity in agricultural crops which were inter-planted with Eucalyptus. These facts show that Eucalyptus is a suitable species for farm/agro-forestry.

Method of Planting

Method of planting will depend on the type of place on which the planting is to be done. If planting is to be done, on the bunds of the agricultural fields, then pits of 30 cm size should be dug up in the month of June, in a row along the bund and at an spacing of 1.2 m. The pits should be filled up with a mixture of dug up soil and about 2 kg of cow dung manure. Planting should be done after the break of monsoon in the month of June-July. It planting can be done in more than one rows on the bund when the bund is broad enough then the row to row distance should be kept 2 m. As far as type of planting stock is concerned it is better to plant up poly potted plants only.

In the first and second year, soil working should be done around the plants at least once a year. Also if the plants are attacked by some pest or disease, spray of insecticide/ fungicide should be done.

When the planting is done in the agricultural fields then the field should be ploughed twice in the month of June-July by tractor. After the onset of the monsoon the field should be ploughed once more and the Eucalyptus (preferably polynia) should be planted on the rows formed by the plough. The planting should be done at the spacing as may be decided in consultation with the forestry experts. However, the spacing of 2 m x 1 m, 3 m x 1 m and 1 m x 1 m are being recommended depending upon the pattern of inter-cropping to be followed. While planting in wide lands, small mounds of soil should be made by putting soil around the plant. The mound should be compacted by pressing the wet soil with hands.

In the months of August and September soil working should be done around each plant. One dose of DAP fertilizer should be given at the rate of 10 g/plant after 20 days of planting. The next dose of the same fertilizer should be given 15 days after the application of the first dose. Again one dose of Muriate of Potash should be applied at the rate of 10 g/plant in the month of September, say 15-20 days after the application of the second dose of DAP. In the second and third years also the above mentioned fertilizer doses should be applied but the first dose should be given in the month of July (after the break of monsoon), second in August and third in September. Soil working should also be done around each plant in the second and third years. It should be done in the months of August, September and October. It is necessary to carry out weeding in the plantation during the rainy season (June to September), whenever weed growth is found suppressing the Eucalyptus plants.

Spray of insecticide/fungicide should be done whenever there is incidence of attack of some insect or disease.

The above method is applicable for the Eucalyptus plantation which is to be done on the agricultural land totally diverted for plantation purpose and which will, in general, not be used again for growing agricultural crops. But in case the land is to be used for double cropping i.e., for raising the Eucalyptus plantation together with the agricultural crops then the method will be slightly different. In this case, the spacing of the planting will generally be, 3 m x 1 m so that sufficient gap is available for the movement of tractor. The soil working will be done by ploughing the field. But since polishing will be done in the months of July, September—October, April and June i.e., 4 times a year. This will be continued till the harvest of Eucalyptus. Also, as is usually done for the agricultural fields, 20–30 cart load of cow-dung manure per hectare can be spread in the field in the month of June. Rest of the method may be the same as discussed earlier.

In Gujarat, many farmers are growing Eucalyptus on their agricultural land, both in rainfed conditions as well as under irrigated conditions. The above methods are almost similar to those followed in Gujarat. Case study of an Eucalyptus plantation raised by a farmer under the rainfed conditions (in Vadodara District of Gujarat) has revealed that against a total expenditure of Rs 30,415 on a 5-year old Eucalyptus plantation, the total receipt of revenue was Rs 567,000. The area of the plantation was 15 ha and, so, the net revenue per ha per year was Rs 8,185 which is many times that of most agricultural cash crops.

If the farmers have resources, they can irrigate the farm land plantations, irrigation will certainly increase the yield both of Eucalyptus and agricultural crops. In Punjab, farmers irrigate even the pure plantations of Eucalyptus raised on the bunds of their agricultural fields. In Gujarat, also farmers have grown irrigated plantations of Eucalyptus. In the irrigated plantations vegetable crops can be grown very well between the rows of Eucalyptus. Some farmers in Jalalpur, Valsad, Dholai and Indore districts also have raised successful irrigated plantations of Eucalyptus. Inter-cropping of vegetable crops, papaya and agricultural crops have been raised by farmers of Jalalpur. These projects were implemented under the technical guidance of State Forest Research Institute, Jalalpur.

Under rainfed conditions or where irrigation potential is not fully developed the plantations could be raised in the month of June-July when the rains have made the about 10–15 cm upper soil layer. However, where well laid out irrigation facility exists, plantation activity need not await the arrival of monsoon. Under favourable soil and moisture conditions (sandy loam or clay loam soil with good irrigation) the land should be deep ploughed by tractors. Well decomposed compost @ 20–30 cart load per hectare should be spread and then mixed with the soil. The planting should then be done on the ridges formed by tractor in the months of
March-April. Frequent irrigation and hoeing as indicated by soil conditions should be done so that the plants establish quickly and are thus ready to take the advantage of coming monsoon. This practice may ensure higher growth rate and in that case, harvesting can be done earlier than 5-6 years.

It may happen that the plantation may get attacked by some pest or disease. In such cases, the concerned farmer can seek the guidance for the remedial measures from State Forest Research Institute, Jabalpur. However, a brief account of pest control has also been given in next chapter of the bulletin

**UTILIZATION**

The wood obtained from Eucalyptus is of many uses but the utility is different for different species. Some species are useful for timber production while a few yield hard wood timber. Eucalyptus are also utilized for poles, posts, railway sleepers, firewood, pulpwod and in the manufacture of chip-board products. Minor forest products obtained from eucalyptus include Eucalyptus oil distilled from the leaves, tan bark and honey. Some varieties are useful for ornamental purposes and for planting as wind breaks and shelter belts.

Eucalyptus hybrid is classified as a heavy hard wood suitable for packing cases, crates, beams, columns, poles, posts and similar purposes. According to the experiments conducted by FRI, DehraDun, Eucalyptus timber can also be used for making furniture, doors or window frames. The tree appears to acquire the maximum strength at the age of about 13-14 years. Various strength properties of some Eucalyptus species have been found almost similar to those of Teak. The comparative strength properties of some Eucalyptus species and those of teak (in green conditions) as given in Table 4.4 provide an idea about the utility of various Eucalyptus species.

**Wood specific gravity of Eucalyptus hybrid:**

In young plantation grown trees, there is no clear trend in the variation in specific gravity from bottom to top. This is contrary to the property reported for the broad leaved and coniferous species. But this property is found in the juvenile Eucalyptus trees only. Further, the specific gravity tends to increase from pith outwards. The average whole tree specific gravity varies with the locality. The above properties of Eucalyptus make it useful in a number of ways.

**Timber:** The use of Eucalyptus as sawn timber by large and small has not been successfully tried, the reason being the cellular structure and the strain in the trunk. However, sawn boards of small length can be easily prepared. It has been found that boards prepared from the standing dead trees have less warping nature than those prepared from living trees.

2. **Poles:** Eucalyptus are increasingly being used for poles but due to the strain in the wood, the poles generally have tendency of splitting up at the ends. However, this tendency can be reduced considerably by air-drying the poles (debarked) under shade or by felling in dormant season and coating the ends with bitumen or immersing them in cold water for 6 weeks.

3. **Pulp for Paper:** Species having basic density less than 500 kg/m³ are considered suitable for pulpwood purposes. The inter-bonding properties and the surface smoothness of paper are better in the paper manufactured from the pulp obtained from young plantation grown trees (4-5 years old). That is why the younger and low density Eucalyptus trees are preferred to older and denser woods. In the case of paper, the pulp yield is higher and the consumption of chemicals during the pulping is also low. In preparing pulp from young trees extraction problems are least. The paper prepared from the pulp obtained from such trees have higher bonded strength. It is observed that no significant difference in pulping qualities takes place up to the age of nine years.

The species of Eucalyptus found suitable for various grades of pulp are E. tereticornis, E. grandis, E. globulus, E. sideroxylon and E. toriliana. Eucalyptus hybrid and E. camaldulensis have been found suitable for paper pulp in mixture consisting of chemical pulp from Ochandra travancorica reed or common bamboo. Newsprint of satisfactory quality can also be obtained from a mixture of mechanical pulp from Eucalyptus hybrid and soda semi-chemical pulp from bagasse. Fibre length of Eucalyptus hybrid has

### Table 4.4: Comparative wood properties of Eucalyptus and Teak

<table>
<thead>
<tr>
<th>Properties</th>
<th>Teak</th>
<th>E. hybrid</th>
<th>E. globulus</th>
<th>E. sucupinia</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Specific gravity</td>
<td>0.596</td>
<td>0.596</td>
<td>0.676</td>
<td>0.671</td>
</tr>
<tr>
<td>2. Fibre stress at elastic limit (kg/sq cm)</td>
<td>509</td>
<td>291</td>
<td>460</td>
<td>544</td>
</tr>
<tr>
<td>3. Modulus of elasticity</td>
<td>100.7</td>
<td>155</td>
<td>-</td>
<td>176</td>
</tr>
<tr>
<td>4. Compressive stress</td>
<td>311</td>
<td>149</td>
<td>227</td>
<td>338</td>
</tr>
<tr>
<td>5. Modulus of elasticity in compression (kg/sq cm)</td>
<td>129.8</td>
<td>66.0</td>
<td>226.6</td>
<td>129.2</td>
</tr>
<tr>
<td>6. Maximum shearing stress parallel to grain (kg/sq cm)</td>
<td>96</td>
<td>77</td>
<td>94</td>
<td>110</td>
</tr>
<tr>
<td>7. Maximum tensile stress perpendicular to grain</td>
<td>73.8</td>
<td>57.5</td>
<td>54.2</td>
<td>80.5</td>
</tr>
</tbody>
</table>
4. Rayon-Grade Pulp: For rayon grade pulp, E. grandis, E. globulosa, and E. urophylla are quite suitable. The bleached pulp yields from these are 32.8%, 41.5%, and 32.2%, respectively, alpha cellulose content being 94.5%, 95%, and 94.5%, respectively.

5. Hard Boards: Hard boards made from Eucalyptus are superior to those made from other species. No supplementary bonding resins are needed to provide a high level of strength as are needed with other softwoods. Because of the short fibre length, the hard boards have better surface properties and are preferred world-wide.

6. Particle Boards: Wood taken from 7 years old Eucalyptus hybrid trees was found quite suitable for preparing particle board. Using chips of 50 mm length, 0.6 mm thickness and 75 to 30 mm width, sample particle boards of 19 mm thickness were prepared.

7. Plywood: Trials of peeling Eucalyptus logs for plywood were found not successful because the ends of the thin sheets got split. But when the wood of density less than 650 kg/m³ was dry and perforated with wires, satisfactory face veneers could be obtained. In this case, the billets were heated before their peeling and appropriate lathe settings were employed.

8. Firewood: Various species of Eucalyptus viz. E. globulus, E. grandis, E. gomphocephala, E. microtheca, E. occidentalis, E. robusta, E. tereticornis, E. camaldulensis, and E. urophylla are used. Eucalyptus hybrid, E. microtheca, and E. occidentalis provide excellent firewood. The caloric values of wood obtained from some Eucalyptus species are given in Table-10.

The above Eucalyptus woods are heavy and burn slowly, so they are good for domestic cooking. Trees of higher age burn better than those of younger age, due to their higher domestic.

Firewood obtained from a 5-6 years old plantation is comparable to the firewood obtained from natural mixed dry deciduous forest tree species.

9. Charcoal: Eucalyptus species are quite good for manufacture of charcoal and acetic acid. Eucalyptus hybrid yields more charcoal and acetic acid, on factors scale, as compared to the yields from mixed woods. The Eucalyptus charcoal is heavier, stronger and more uniform in quality with a caloric value of 4100 K calories per kg.

10. Essential Oils: Eucalyptus leaves are an important source of essential oils. In India, the medicinal Eucalyptus oil is obtained as a by-product from the leaves of E. globulosa, which is mainly grown to supply firewood. It yields about 1% oil containing 60% cineole. Eucalyptus urophylla yields about 0.5 times more essential oil than E. globulosa. The essential oil contents of E. camaldulensis and E. tereticornis are good enough but the oil obtained from E. globulosa is preferred to those obtained from other species of Eucalyptus due to certain desirable qualities in the former.

Presently, Eucalyptus wood is being purchased by Nepa-Paper Mills and Orient Paper Mills situated in Madhya Pradesh. Sweller Rayon Mill may also be interested in Eucalyptus pulp. This demand is likely to increase in years to come because the districts which in respect of forest products were considered to be surplus districts a few years ago are now showing the sign of firewood deficit. Presently 26 districts of the State are considered to be deficit in respect of firewood and timber. This number may swell up to 36 by the turn of this century. This alarming trend of firewood scarcity would enable tree growers to get remunerative prices for their products.

Table 10: Calorific value of some Eucalyptus species.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Species</th>
<th>Calorific value in K calories</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>E. microtheca</td>
<td>4350</td>
</tr>
<tr>
<td>2.</td>
<td>E. grandis</td>
<td>4750</td>
</tr>
<tr>
<td>3.</td>
<td>E. hybrid</td>
<td>4300</td>
</tr>
<tr>
<td>4.</td>
<td>E. globulosa</td>
<td>4950</td>
</tr>
<tr>
<td>5.</td>
<td>E. robusta</td>
<td>4200</td>
</tr>
<tr>
<td>6.</td>
<td>E. tereticornis</td>
<td>4800</td>
</tr>
<tr>
<td>7.</td>
<td>E. camaldulensis</td>
<td>4650</td>
</tr>
</tbody>
</table>

PEST MANAGEMENT

Countrywide surveys carried out by various research workers have shown that Eucalyptus in India is liable to be attacked by the following pests and diseases:

PEST: There are about seventy insect species feeding over Eucalyptus. Out of these, some are only casual feeders while the others cause large scale mortality, particularly in dry regions. Living plants attacked by some disease are more susceptible to termite attack. To prevent the plantation from termite attack, insecticides like BHC, Aldrin, etc. are mixed with the soil in the pit before planting is done. As a preventive measure 0.1% of these insecticides is sufficient for a pit of the size 30 cm². Water solution of these insecticides can also be sprayed uniformly on the soil in the pit.

Babai Borer: A borer which was originally considered harmful only to Adansonia species has recently been found attacking young Eucalyptus trees also, in Tamil Nadu, Andhra Pradesh, Madhya Pradesh, and Bihar. This borer feeds on the bark of the plants and sometimes girdles the new shoots completely and thus causes outright death of plants. Larva also enters the stem and goes up to the root ultimately killing the plant. Mostly the young trees are attacked by this borer. Drier trees are resistant to it. To prevent the Eucalyptus trees from this borer, as far as possible, new plantations should not be raised in captivity. Spray of residual insecticide in young plantations, to kill the adult beetle has also been found effective for checking the attack. Also, injected trees are cut back and solution of some
insecticide is poured into the tunnel of the larvae. This kills the larva and checks its population buildup for the next year.

**Diseases:**
- Diseases affecting Eucalyptus include cankers, galls, wilt, die backs etc. in the trees.
- Most diseases which affect stem are spread by airborne spores or other propagules. The common diseases affecting Eucalyptus plantations in India are listed below.

**Pink Disease:**
This disease was originally known to affect rubber plants but in India it has caused very severe damage to plantations of Eucalyptus tereticornis. Eucalyptus grandis and Eucalyptus globulus in Kamaranaka, Kerala and Goa, under the conditions of high rainfall and temperature. It attacks the young aged plants of eucalyptus. The affected plants suffer repeated die back. To control this disease, in our country, selection of resistant species is being advised by experts at FRI, Dehradun, in other crops the impact of disease has been reduced by the application of copper and di-nocarbamate fungicides to diseased stems and branches and by excision and destruction of diseased trees or plants.

**Fungal Diseases:**
Three virus diseases have been reported in India which reduce the quality and quantity of the oil in the leaves of E. citharum.

**Fungal Diseases: G. curtisiana:**
A wood rotting fungus that is recorded as a root pathogen of a wide range of Eucalyptus species in India. Infection takes place due to infected woody debris in the soil. The roots of the infected tree become rotted and the tree either dies in earlier stage or lost from wind throw. In the plantations, the disease spreads through root contact. Control measures include removal of stumps and other root debris from the area before taking up new planting. Also the attack of this disease can be checked by avoiding the sites which may carry infection.

There is one more species of Ganoderma which causes root disease in Eucalyptus. In the case of attack of this disease, the affected plants are either isolated by digging up trenches around them or some disease resistant species are interplanted.

**Seedsling Blight:**
Some nurseries of U.P. mortality in young seedlings have also been reported. This has been found to be due to Cylindrocladium seedling blight. To prevent the seedlings from this disease, the seeds should be coated with organomercurial-fungicide before sowing. In the case of attack, 0.2% solution of Blixon should be sprayed over the affected polyprop and watering should be stopped from one day before up to one day after this treatment.

However in M.P., so far, only Ganoderma lucidum (causing pink disease) and Cylindrocladium quercuum-plumicola have been reported.

**General Safety Measures:**
On the basis of the knowledge of the causes of attack of various pests and disease some norms can be introduced in the management of the forests. These norms can serve as basic preventive measures against the pest and disease attack for Eucalyptus in nursery as well as in plantations. If these preventive measures are taken timely then the security of the plantations can be assured to a great extent. The measures to be followed are listed below.

1. **New Eucalyptus plantations should not be raised on the sites having old stumps:** If the site cannot be avoided then the old stumps present on the site should be dug up and thrown outside the area. Alternatively, the dug out stumps and other debris should be collected and burnt in situ.

2. **Water logged sites should be avoided for plantation of Eucalyptus:** However, species which are suited to wet sites (E. saligna) could be planted on mounds. Other species could also be planted on mounds during summer months so that the plants establish themselves to withstand partial and occasional inundation.

3. **Plantations should not be done in continuity over a large area.**

4. **Logged, girdling, cutting of branches etc. should be avoided.**

5. **In case there is any attack of disease on the trees of plantation, the affected trees either should be cut and taken away from the area or they should be isolated from the other trees by digging up a trench around them.**

6. **In the case of attack of any disease, suitable remedial measures should immediately be taken up.**

**Air pollution:**
Eucalyptus may suffer large scale mortality if the surrounding air is polluted with higher quantities of dust, gases etc. It has been found that plantations raised in the nearby industrial areas, power plants etc. have suffered mortality. Therefore, Eucalyptus plantations should not be done in the areas in which the air is polluted with dust ash, dust gases etc.

**Disorder due to Deficiency for Excess of Inorganic Salts:**
Sometimes the plantations raised on a particular area show special colourings in their leaves. This is due to the deficiency of some inorganic salts which are essential for the growth of the trees. Though, when the deficiency is not much the special colourings may not be exhibited by the trees but the rate of growth in them is slow. Sometimes the site may not have the deficiency of any salt but the trees may be unable to get them because of poor aeration, such as in the water logged sites.

Excess of salts may also cause physiological disorders in Eucalyptus trees. Sites like those of mined out areas, where industrial wastes are released, the quantities of the salts may be to the limit of toxicity to the plants. Some elements interfere with the internal use or uptake of other elements also, lime induced chlorosis, which affects many species growing on calcareous soils, is often due to the non-availability of iron in the form in which it can be used in the metabolism of the plants. In such cases, the acidification of soil or addition of iron sulphate or iron chelate may be effective. But this is effective in the nurseries and not under field plantations.

Preventive measures at the time of planting should go a long way in controlling the possible outbreak of any pest or disease. When any of the Eucalyptus species is proposed to be planted on an ecological wastelands, the addition of fungicides/insecticides with the soil-rhiz would take care of future problems. Agricultural fields when diverted for tree cultivation also need such precautions, because many insect pests and diseases harbouring the agricultural plants may become adapted to the tree crop also. All these precautions need not frighten the Eucalyptus growers because this species in Madhya Pradesh has not been affected to any appreciable extent, though preventive measures adopted may doubly ensure the future crop.
MODEL FARM FORESTRY PROJECTS

Increasing demands of timber, fuel and other forest produce and high rate of degradation of environment have made the government, and also every sensible person, to realise that government alone cannot meet the challenges of the present and future. It is possible only when the public is combined to share these responsibilities. Some success has been obtained through the Social Forestry Scheme, in this direction. Government is also trying to make the farm forestry and agro-forestry programmes, popular among the farmers. By getting involved in these programmes a major section of the population can become self sufficient in meeting their own requirements of wood and other forest products. When people take up these programmes as part of their farming, the Forest Department may be able to contribute to the economy of the nation in a better way by fulfilling the requirements of raw materials for various industries and by creating surplus stock of forest produce for export. Conservation of natural forests would ensure healthy environment.

In addition to its research activities related to the creation of a base for highest possible yield from forests in the least possible time, State Forest Research Institute has started giving technical guidance to the agencies, particularly agriculturists who are taking interest in the farm forestry and agro-forestry programmes. Projects have been prepared, for farm/agro-forestry programmes and given to the agriculturists concerned so that they can get financial assistance from NABARD (through commercial banks). A couple of model projects have been given in this section of the bulletin.

I — FARM-FORESTRY PROJECT

Revenue Circle — Bargi

Village Thana NB 236 : PC No.36

Tehsil and District — Jabaipur

1. Location : Village Thana, about 40 km from Jabaipur along NH-7 (Jabaipur—Nagpur road): About 5 km from Bargi town.

2. About Project : The present agro-forestry project is to be implemented by 5 persons as their lands are in a compact block and the owners are from the same family. However, for the purposes of loan, the individual Bhumizwadi could be considered. For this purpose loan can be given in the ratio of their land.

3. Details of Ownership :

4. Species to be planted :
   (a) Eucalyptus hybrid
   (b) Su-babul
   (c) Bamboo

   2 x 1 m (2,000/acre) 1 x 1 m (4,000/acre) .4 x 4 m (1,000 plants approx.)

5. Species-wise Calculation of Area :
   (a) Eucalyptus
   (b) Su-babul
   (c) Bamboo

   - 25 acres
   - 04 acres
   - along periphery and field bunds.
   Total 29 acres

I. Costing — Non-recurring :

1) Fencing: R.C.C. post 2.10 m height fixed at 3-4 m interval with additional pillar after every 10 piles; 4 strand barbed wire 1/2 ply.
   Poles — approx. 800 @ Rs. 50/piller = Rs. 40,000
   Barbed wire 5 tonnes @ 1200/tonne = Rs. 60,000
   Total 1,00,000

2) Cost of plants, digging of pits, replacement of soil, addition of organic manures etc:
   i) Cost of plants = Rs. 0.56/plant
   ii) Pit digging = Rs. 0.60/plit
   iii) Soil change = Rs. 0.25/pit
   iv) Manures & insecticides = Rs. 0.20/plant
   v) Planting = Total Rs. 1.75
   a) Eucalyptus @ 2000/plants for 25 acres — add 10% casualty — Rs. 50,000
   b) Su-babul (4 x 4000) — 16,000 plants add 10% casualty 1600 — Rs. 17,600
   c) Bamboo along field bunds, peripheral bunds 73,600 @ Rs. 1.75/plant = Rs. 7,36,000
   Total of a, b & c @ Rs. 1.75/plant = Rs. 1,28,600
   Total of 1 & 2 — Rs. 1,28,600

3) Provisions for Irrigation :
   a) Two pumps
   b) Sinking of well not needed as river flows around this farm
   = Rs. 20,000
4) Construction of a Labour Hut:
   Two room and a kitchen, brick in mud mortar, country tiles, bathroom doors etc., Rs. 20,000

Total Rs. 20,000

Total non-recurring - Rs. 3,23,800.00

II. Recurring:

1) Weeding:
   - l/yr 2 @ 300/- per acre
   - l/hr 1 @ 100/- per acre
   Rs. 8,700
   Rs. 2,900
   Total Rs. 11,600

2) Irrigation and maintenance of channels:
   - l/yr 25 Irrigation
   - l/yr 10
   - l/yr 10
   - l/yr
   Total 65 irrigation @ Rs. 1,000/irrigation over entire area
   Rs. 65,000

3) Insecticides and Manuring in first two years @ Rs. 100/- per acre in l/yr and similar amount in second year:
   (100 x 10 x 200 x 29 acres) = Rs. 5,800

4) Intercropping of zinger, curcuma, tomato, chillies etc. @ Rs. 1,000/acre in about 20 acres -
   - l/yr Rs. 20,000
   - l/hr Rs. 15,000
   - l/hr Rs. 15,000
   Total Rs. 50,000

5) Watch & Ward
   - 2 persons (day & night)
   @ 400/- p.m. x 2 = Rs. 9,600
   5 years x Rs. 9,600 = Rs. 48,000

6) Other unforeseen expenses @ Rs. 2,000 per year for 5 years:
   Total Rs. 10,000.00

Total Recurring - Rs. 1,02,000.00

Abstract Of Project Cost

I. Non-Recurring:
   Rs. 23,800

II. Recurring:
   Total Rs. 5,25,000

III. Bank Interest @ 10.50% (approx.)
   Rs. 55,299 x 5 = Rs. 276,495
   Rs. 27,649.82

IV. Total liability over a period of 5 years
   Rs. 80,045.00
   Rs. 529.96

Returns From Harvest

1. Return from agricultural crops as inter-cropping component in about 20 acres @ Rs. 4,000/- per acre per year.
   = Rs. 2,40,000

2. Su-babul harvested in 4th year. 60% plants of 16,000 surving to maturity approx.
   10,000 plants @ Rs. 25/tree = Rs. 250,000

3. Eucalyptus harvested after 5 years. About 75% trees maturing at the end. 50,000 plants - 37,500 on average each tree would fetch an average price of Rs. 50/tree -
   Rs. 1,87,500

4. Bamboos 1,000 clumps yielding annually about 5 culms/clumps 1,000 x 5 = 5,000 culms
   selling @ Rs. 5/bamboo = Rs. 25,000

Total - Rs. 28,90,000

Schedule of Repayments

1. Inter-cropping of tomato, papayas, chillies, zinger, curcuma would annually yield Rs. 50,000 and this would be enough to pay the interest and part instalments.

2. In fourth year with the harvest of Su-babul the balance instalments due between 1-3 years and interest thereon may be paid back.
Eucalyptus would be harvested in VI year and this would take care of entire balance payments of interest and instalments.

Cost - Benefit Calculation

I. Total payment liability after a period of 5 years - (including simple interest) Rs. 8,01,845.00
II. Return
   Balance (Profit) Rs. 15,88,155.00
III. Annual Returns per acre
    Rs. 54,763.96
IV. Return per acre/year
    Rs. 10,952.79

NOTE:
1. Eucalyptus and Su-babul would continue to provide yield in 10th year and 15th year from coppice growth. Bamboo would give a revenue of Rs. 25,000/- every 3-4th year. If the clumps are divided into 4 parts, they can produce about 1,250 bamboo each year or Rs. 250/- annually. Inter-cropping can also provide annual return at an estimated rate of Rs. 20,000/-/acre.

2. After first harvest of Su-babul and Eucalyptus, the next crops would be available without any non-recurring expenses. Expenses on operations such as sowing of coppice shoots, irrigation and watch and ward etc would, however, be required.

II - FARM FORESTRY PROJECT

Introduction

The present scheme is intended to start an irrigated plantation of Eucalyptus, Teak and Bamboo on 34.14 acres of land located along Jabalpur- Nager National Highway No. 7 at the distance of about 46 km from Jabalpur. This scheme comes under the ‘Social Forestry’ which ultimately comes under the 20-point National Programme.

This scheme envisages tree farming of Eucalyptus, Teak and Bamboo of which the Eucalyptus is to be given priority account of its faster growth rate. It has got multiple uses as timber, rayon grade pulp, pulp wood for paper industry, firewood and as construction material. However, the high economic returns from the vacant land are the main consideration. Financial returns to the extent of Rs. 6,000/- per year per acre which is at least three times that of average returns expected from agricultural crops is the key factor in this project.

Apart from all these financial gains these plantations in private sector are expected to supplement the existing meagre forest resources which are getting depleted at a very fast rate. These plantations would also help ameliorate the climatic extremes and help largely in maintaining the ecological balance. The agricultural production is also likely to get boost as forest farming would ensure soil and moisture conservation.

Basic Details:
(a) soil of land :- The land is situated at village Kaladethi on N H 7 on both sides of road, under the Khasara No. 24, 29 and 30, measuring 34.14 acres.
(b) Irrigation facility :- On one side of land a tributary stream of river Tenner flow throughout the year. However, it is proposed to dig one tube well and one dug well to ensure maximum irrigation throughout the year. This irrigation will be done using electrically driven pump sets, water tanks, pipes and irrigation channels.
(c) Fencing :- The fencing will be done by barbed wire. Seeds of Babool and Khair and seedlings of Bamboo will be sown planted all along the fenced boundary so that the fencing may become more or less permanent within three years. Besides the Bamboo under irrigated conditions may provide good returns after 5-7 years of planting.
(d) Management :- One of the owners being a graduate of Agricultural has the basic knowledge of the subject and both the owners being in timber trade can vary well manage the farm, both from developmental point of view as well as from marketing aspects.

Name of Project: Tree farming of Eucalyptus, Teak and Bamboo on private land on commercial basis.

Name of Farmers: Shri. Ashok Kumar Nagpal and Yuvraj Kumar Nagpal

Location of lands: Village
<table>
<thead>
<tr>
<th>Village</th>
<th>Kaladethi</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Bandobast</td>
<td>515</td>
</tr>
<tr>
<td>Patwari haika</td>
<td>30</td>
</tr>
<tr>
<td>Khasara No.</td>
<td>24, 29 and 30</td>
</tr>
<tr>
<td>Gram Panchayat</td>
<td>Kaladethi</td>
</tr>
<tr>
<td>Tehsil and Districts</td>
<td>Jabalpur</td>
</tr>
</tbody>
</table>

Area: 34.14 acres.

Project report prepared by: State Forest Research Institute, Jabalpur.

Finance: This project of farm-forestry is proposed to be financed by some Government Financial Institution (through NABARD).
Objectives:

a) To motivate agriculturist to adopt tree farming on lands which are laying unutilised.

b) To get best financial returns on sustained basis.

c) To obtain better returns than agriculture.

d) To create additional forest resources in respect of fuel wood, fodder, timber, pulp wood and rayon grade pulp.

e) To strengthen Government's efforts in popularising social forestry scheme.

Highlights of Project:

1. The net return from the project after five years will be more than Rs. 8,000/- per year per acre which is atleast three times that of average agricultural crops.

2. The project is expected to generate employment potential in rural tribal areas to a great extent.

Expected expenditure of plantation of Eucalyptus, Tectona grandis and Dendrocalamus strictus on 34.14 acres of land:

<table>
<thead>
<tr>
<th>Land Development</th>
<th>Cost (Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Land shaping of 34.14 acres @ Rs. 1,500/acre</td>
<td>51,000.00</td>
</tr>
<tr>
<td>ii) Fencing around 34.14 acres @ Rs. 20,000.00</td>
<td>680,000.00</td>
</tr>
<tr>
<td>a) Barbed wire 2 tons @ Rs. 1,000/m.ton</td>
<td>2,000.00</td>
</tr>
<tr>
<td>b) Wooden poles 35 to 40 cm girth and 2½ meter length - 1000 poles @ Rs. 15/each pole</td>
<td>15,000.00</td>
</tr>
<tr>
<td>c) Coal-tar and nails for poles : Coal-tar 50 litres @ Rs. 10/litre</td>
<td>500.00</td>
</tr>
<tr>
<td>Nails 80 kg @ Rs. 9/kg</td>
<td>720.00</td>
</tr>
<tr>
<td>d) Pit digging for poles 1000 nos. @ Rs. 15/each</td>
<td>15,000.00</td>
</tr>
<tr>
<td>e) Fixing of barbed wire (labour charges)</td>
<td>500.00</td>
</tr>
<tr>
<td>iii) Planting of Acacia nilotica (babeoli) and Prosopis juliflora around the fence</td>
<td>5,000.00</td>
</tr>
<tr>
<td>Total</td>
<td>89,930.00</td>
</tr>
</tbody>
</table>

2. Irrigation Facility:

a) Tube well one no @ Rs 45,000/-

b) Dug well 6 mtr dia and 10 mtr depth @ Rs. 10,000/-

c) Electric pumps 5 HP-2 nos. and 2¾ HP-2 nos.

d) Piles for irrigation 1000 running meters @ Rs. 60/- running meter.

e) Water distribution tanks (cement construction) size 6 x 2.5 x 2 meter - 3 Nos. @ Rs. 5000/- each.

f) Irrigation channels for entire plot

Total Rs. 1,62,000.00

3. Watchman quarter 2 nos. @ Rs. 6000/- each

Total Rs. 12,000.00

4. Plantation of Eucalyptus on 28 acres of land.

(6.14 acres of land excluded for plantation of Tectona grandis, Dendrocalamus strictus, roads and residential buildings and irrigation channels etc.):

a) Expenditure under this head includes cost of preparation of seed beds, procurement of seeds, organic and inorganic manures, insecticides, fungicides, covering and shading of seed beds, irrigation of seed beds, polythene bags and transplantation of one and half month old about 45,000 seedlings @ 50 per 100 seedlings

b) Planting at a spacing of 2 x 2 meters i.e. 1,210 plants per acre or 2,500 plants per hectare total plants in 28 acres @ 12,000 plants/acre would be Rs. 33,600.

i) Digging of pits size 45 x 45 x 45 cm and planting of seedlings 33,600 nos. @ Rs. 2/- each

Rs. 67,200.00

Total Rs. 22,575.00
ii) Organic manure 2 trucks load per acre i.e. 56 trucks
14,000.00

ii) Chemical fertilizers @ 50 g/plant/year (composition decided by SFRI)
approx. 150 Qtl. @ Rs. 200/- per Qtl. Rs.3,010.00

iv) Insecticide and fungicide @ Rs. 250/- per acre x 28 acres.
Rs. 7,000.00

c) Watchman 2 nos. @ Rs. 300/- per month each
Rs. 7,200.00

d) Weeding @ Rs. 100/- per acre x 28 acres.
Rs. 2,800.00

e) Maintenance of irrigation channels @ Rs. 100/- per acre x 28 acres.
Rs. 2,800.00

f) Plantation of 1,200 nos. of Dendrexia strictus around fence including the cost of seedlings, organic and inorganic manure @ Rs. 4/- each Rs. 4,800.00

g) Plantation of Tectona grandis 1200 nos., including the cost of seedlings, inorganic and organic manure @ Rs. 6/- each.
Rs. 7,200.00

Total Rs. 18,305.00

5. Requirement of implements :-

a) Pick-axe 24 Nos. @ Rs. 18/- each
Rs. 432.00

b) Spades 40 Nos. @ Rs. 20/- each
Rs. 800.00

c) Ghamela 40 Nos. @ Rs. 40/- each
Rs. 1,600.00

d) Crow-bar 40 Nos. @ Rs. 70/- each
Rs. 2,800.00

e) Kharpi 20 Nos. @ Rs. 5/- each
Rs. 100.00

f) Duster 4 Nos. @ Rs. 300/- each
Rs. 1,200.00

g) Sprayer 4 Nos. @ Rs. 600/- each
Rs. 2,400.00

Total Rs. 4,420.00

Grand Total 1 to 5 Rs. 44,735.00

Recurring Investment during 2nd, 3rd, 4th and 5th Years

<table>
<thead>
<tr>
<th>1. Organic manure @ one truck per acre i.e. 28 trucks @ Rs.250/- per truck.</th>
<th>2nd Yr.</th>
<th>3rd Yr.</th>
<th>4th Yr.</th>
<th>5th Yr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Chemical fertilizers @ 50 Grams per plant X 33600 plants approx. 15 Qtl. @ Rs.200/- per Qtl.</td>
<td>3000/-</td>
<td>3000/-</td>
<td>3000/-</td>
<td>-</td>
</tr>
<tr>
<td>3. Insecticides and fungicides @ Rs.250/- per acre X 28 acres.</td>
<td>700/-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4. Watchman 2 nos. @ 300/- per month each</td>
<td>7200/-</td>
<td>7200/-</td>
<td>7200/-</td>
<td>7200/-</td>
</tr>
<tr>
<td>5. Hoeing and weeding @ Rs.100/- per acre X 28 acres.</td>
<td>2800/-</td>
<td>2800/-</td>
<td>2800/-</td>
<td>-</td>
</tr>
<tr>
<td>6. Maintenance of irrigation channels @ Rs.100/- per acre X 28 acres.</td>
<td>2800/-</td>
<td>2800/-</td>
<td>2800/-</td>
<td>-</td>
</tr>
</tbody>
</table>

Total Investment in five years:

| 1. Initial Investment | Rs. 4,47,135.00 |
| 2. Recurring Investment | Rs. 68,800.00 |
| Total | Rs. 5,15,935.00 |

Returns From Harvest:

A. Eucalyptus:

| 1. Total plant population of 33,600 and assuming the probable mortality of 10% plants, i.e. 33600 - 3360 = 30,240 or say 30,000 plants. | | | | |
2. Assuming 75% of the surviving stock attain desirable height and girth and remaining 25% left in the struggle of existence; Total mature trees ready for harvest in 5th year would thus be 22,500.

3. With very high inputs like irrigation, fertilizers and pesticide application a tree is expected to attain a height of 15 metres and girth of 55 cm.

i) Such trees in market may yield one piece of timber and one piece of pole, anticipated to fetch around Rs. 150 to 200 per tree.

ii) Even assuming an estimated yield of 3 quintals per tree air dried fuel with the present market rate at Jabalpur it may fetch Rs. 115 to 120 per quintal as fuel. Pulp wood or Rayon grade pulp wood would also fetch between Rs. 45 to 50 per quintal thus giving approx. Rs. 150/- per tree.

iii) Basing our experience on the growth pattern of these trees on poor sites such as ‘Bhata’ lands, Bauxtite and Coal mines areas, each tree is expected to fetch on an average about Rs. 100/- per tree for air dried merchantable biomass.

iv) Thus for 22,500 trees at the end of five years an expected return of 22,500 x 100/- i.e. Rs. 22,50,000.00.

We can deduct felling, debarking charges @ Rs. 5/- per tree, i.e. Rs. 1,11,500/- or Rs. 22,50,000.00/(--) Rs. 1,11,500/- = Rs. 21,38,500.00.

Total (A) Rs. 21,38,500.00

B. Bamboo (Dendrocalamus strictus)

Though Bamboo cump formation can be expected around 8th year, by way of cleaning (along with felling of Eucalyptus) approximately 2,000 pieces of thin bamboo would be available which would give an approximate return of Rs. 5,000/-.

(B) Rs. 5,000/-

C. Teak (Tectona grandis)

a) Under irrigated conditions and with fertilizer applications a teak tree is expected to attain a height of 6 to 8 metres and girth of 40 to 45 cm.

b) Each pole/small sized sawn timber from this pole would thus fetch on an average Rs. 100/- per tree.

Total trees planted 1200 nos, and assuming the survival of 1000 plants so 1000 x 100 =

Rs. 1,00,000.00

Less cutting charges Rs. 10,000.00
so Rs. 1,00,000.00 (-->) Rs. 10,000.00 = Rs. 90,000/-

Total (C) Rs. 90,000.00

Cost-Benefit Calculation

I. Total expenditure (recurring and capital) Rs. 5,15,735.00
Interest on loan @ 12.5% for 5 years:
Total Rs. 9,20,735.00

II. Returns from harvest:
   1. Eucalyptus:
      Rs. 21,38,500.00
   2. Bamboo:
      Rs. 5,000.00
   3. Teak:
      Rs. 90,000.00

Total Rs. 22,33,000.00

III. Net profit over a period of five years:
   Rs. 22,33,000 - 9,30,000 = Rs. 13,03,000.00 =

Or 2.60 lacs per year or approximately
Rs. 8000/- per year per acre.

Next Rotations

1. Eucalyptus can provide yield for minimum three rotations.
2. Bamboo can be harvested up to 30 to 40 years.
3. Teak would require replacement for better results.
4. Coppices crops after first felling in 6th year – Eucalyptus coppice can again be cut after 11th year and 16th year without further planting. The profits, etc. would be as follows:
A. 11th Year:
   a) Expenditure over five years @ Rs. 500/- per acre on singling of coppice shoots, irrigation for 2 years and watch & ward for 18 acres @ Rs. 500/- per acre. Rs. 1,80,000.00
   b) Returns on an average total 2000 trees @ Rs. 100/- per tree Rs. 20,00,000/-
   c) Net return Rs. 20,00,000 (-) 1,80,000 = Rs. 18,20,000/-

B. 16th Year:
   Net returns would be reduced to 70 to 75% of 10th year due to loss of vigour thereby giving an expected income of Rs. 13,00,000/-

C. Bamboo in 11th year will give approximately Rs. 30,000/- every year thereby giving a total of Rs. 3,00,000/-

From above calculations it would be seen that the low return in first rotation would be more than compensated in subsequent two rotations. In fact, the growth after first felling is more vigorous in first coppice crop in 11th year (after 1st felling) but is reduced by 20 to 30% in 3rd rotation (at 16th year) on account of loss of vigour.

Experiments are going on to interplant zinger/curcuma and Neem (Sarpgandha) with Eucalyptus. Estimated yield from these crops harvested after 1½ to 2 years is about 9 to 10 quintals per acre. While zinger and curcuma can fetch a return of Rs. 4,000 to 5,000/- per acre, in case of Neem it would be Rs. 15,000 to 20,000/- per acre. The farmer would be guided to undertake these crops (which require shade for better growth) on experimental basis. This is likely to increase the return manifold.