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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 and 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 for these although assuredly adapted to the environment, are too slow in growth.

In many parts of Madhya Pradesh especially the Western Madhya Pradesh, as also in other parts of the country, the most pressing forestry problem is the quick production not so much 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 a variety of exacting conditions and useful for special products and special purposes including protection of soil and water resources. One of the most versatile 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 lateritic 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 craze is gradually building among the farmers to plant *Eucalyptus* on the bunds of their agricultural fields 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 glaring when agricultural crops fail on account of natural calamities. *Eucalyptus* plantation thus act as an insurance against crop failures. Its economics has already proved lucrative 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 1865–66 yet large scale commercial plantations of *Eucalyptus* (mainly *Eucalyptus tereticornis* commonly known as "Mysore 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 Bilaspur, 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 (1956–74). The total area under *Eucalyptus* in the State at the end of 1980 stood at 63,576 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 SIDA 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 Bhata lands (hard laterites) in the eastern region and degraded revenue waste lands every where. 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. Reclamation 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 exotics and indigenous, *Eucalyptus camaldulensus* 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 fulfilment 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-babool, Babul, Neem, Sissoo, Bamboo, Siris, Aonla 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.

Despite the fact that *Eucayptus* is an ideal choice for farm forestry programme, there are some misunderstanding about this species not on account of its bad points, if any, but because general public, the prospective farmers, the practising foresters and other nature lovers are ignorant about its morphology, adaptability, growth potential, ecological behaviour and above all its economic viability. There appears to be gap of knowledge on the factual statistics about *Eucalyptus*. This bulletin has, therefore, been prepared with a view of providing a ready reference to all those interested in tree cultivation as a commercial enterprise using *Eucalyptus*. This bulletin, it is hoped may allay the unfounded controversy and myths of those who are hesitantly willing to take up *Eucalyptus* cultivation. This bulletin provides details about project formulation, site selection, creation of nursery stock, raising plantations and their after-care, coppicing, pest management etc.

HISTORY AND MORPHOLOGY OF EUCALYPTS

The story of the eucalypts, a group of evergreen trees and shurbs, began in 1770 when Joseph Banks, a botanist, and Daniel Carl Solander, his assistant, collected the first specimen known to science (*Eucalyptus gummifera*) 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'Heritier de Brutella, a French botanist. L'Heritier derived the name *Eucalyptus* from the two Greek words, *eu* meaning 'Well' and *kalypto*, 'I cover', 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 'malees' or 'mallocks', 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 snowline of the Australian Alps, or cling precariously to the sides of steep and rocky gorges. Some flourish in areas where the annual rainfall is 3000 mm or more while others prefer the arid regions where the annual rainfall is less than 300 mm. Their preference for soils ranges from the poorest of sands to the richest of loams.

Since their original discovery, the variety, adaptability and usefulness of the eucalypts have made them to be widely planted throughout the world. Some of them yield timbers of great beauty and usefulness, others are suitable only for firewood; some provide honey, other substances of medicinal value, or volatile oils possessing fragrance varying from camphor through pepermint to rose and lemon, whilst a few provide flowers of great beauty and colour. The most commonly grown eucalypts in India (*E. tereticornis* — 'mysore gum' and *E. camaldulensis*) have been extensively planted to provide fire wood, small timber, building material, furniture, and hardwood pulp used in the manufacture of paper and rayon grade pulp. Certain species are cultivated for extraction of essential oils from the leaves (*E. citriodora*), used in the treatment of hypertention. Some species are also being grown to obtain high grade concentrated tannin extracts.

The eucalypts show a tremendous variation in size at maturity perhaps the greatest in the plant kingdom. They vary from small shrubs, less than 3 m high, to mountain giants towering over 100 m into the air, their straight trunks, branchless for over 30 m. The smallest eucalypts are found in regions (Australia) with poor soils and arid climates. The giant, trees occur in high rainfall areas with deep and fertile soils. The tallest eucalypts was measured to be 132 m for *Eculyptus regnans*. Similarly, the greatest girth recorded for the eucalypts was for *E.regnans* which measured 24 m in girth at 2 m above the ground, and 34 m at ground level.

The eucalypts can be classified, according to their growth habit into trees, some of which are extremely tall, and **malees**, which are small, shrubby, multistemmed forms with no definite

trunk. 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 characters for classification purposes.

On germination, the eucalypts seed develops two cotyledons. The young plant then develops from five to ten pairs of seedling leaves which form a transition from the cotyledon stages 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. 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 leave phase to the adult leafy state, 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 eucalypts on to the ground floor.

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 axillary protuberances 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 do 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 Jabalpur, on bauxite mined out areas at Amarkantak (Shahdol), coal mine over-burdens at Dhanpuri (Shahdol), hard lateritic soils ('Bhata' lands) of eastern Madhya Pradesh, sandy loam soil of Seoni, and loamy clay at Nepanager (Khandwa). The root penetration of tap root was found to vary from 3.00 to 4.00 m in 10-15 years old plantations of both species. A 5-years old plant showed a tap root development of 1.42 - 2.85 m. However, the lateral root spread was found to vary from 6.60 to 11.30 m in 5-years old plants and 15.70 to 25.50 m in a 15-years old plantation. It was further brought out that 80-85 per cent of the total roots responsible for obtaining nutrients and moisture from the soil 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 lakh 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 60-75% provided the seeds have been stored in air tight containers. The seeds are mixed with 'chaff' which resembles the fertile seed. *E. camaldulensis* stored for 5 years gave 32.5 per cent of germination. Similarly, *E. tereticornis* which was stored for 6 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 portion of 'chaff' varies from 80-90 per cent and thus the proportion of fertile seed in a kilogram could be expected to be about 100-150 g. 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 (20-years) the coppice crops need to be replaced by seedling 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 Tippu 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 firewood. 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 arboreta, 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. rudis*. However, around 1956, a hybrid eucalypt known as 'Mysore gum' became more popular in the then Mysore (Karnatka) State. This variety of *Eucalyptus* exhibited markedly, better growth rate compared to other eucalypts tried in India. This new hybrid is stated to be related to *E. tereticornis*, *E. citriodora* and *E. robusta*. Another species, *E. microtheca* 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 1965-66 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 1 : Growth Data of the Promising Species / Provenances of *Eucalyptus* planted in different parts of Madhya Pradesh.

S. N.	Name of the species	No. of the provenance	Locality where planted	Age in Yrs	Growth data Survival %	Average Height m	Average Girth cm
1	2	3	4	5	6	7	8
1.	*E. camaldulensis*	FRI 6988	Jabalpur	5	51.00	4.83	11.7
		FRI 7037	- do -	,,	47.00	4.93	11.9
		FRI 7080	- do -	,,	45.00	5.55	12.7
		ERC 12139	Bilaspur	4	90.60	6.88	18.0
		ERC 12181	- do -	,,	100.00	6.83	18.0
		ERC 12349	- do -	,,	98.90	7.01	17.1
		FRI 702/D/2	Nepanagar	1½	79.00	1.61	-
		FRI 789	- do -	,,	83.00	1.59	-
		FRI/68/D/1352	- do -	,,	73.00	1.50	-
2.	*E. tereticornis*	ERC 11953	Bilaspur	4	64.00	4.81	13.5
		ERC 11952	- do -	,,	64.70	4.64	12.9
		ERC 10952	- do -	,,	76.60	4.60	11.7
		ERC 12140	Seoni	2½	100.00	5.60	16.0
		ERC 10182	- do -	,,	92.00	5.87	16.0
		ERC 6970	- do -	,,	70.00	5.63	15.0
		ERC 12947	Jabalpur	1½	62.70	3.37	7.8
		ERC 12946	- do -	,,	53.00	3.33	7.0
		ERC 11034	- do -	,,	58.30	3.44	7.1
3.	*E. citriodora*	FRI 12939	Jabalpur	3¼	74.00	5.95	14.2
		FRI 11640	- do -	,,	67.00	5.26	13.1
		FRI 6737	- do -	,,	83.00	5.82	12.7

Eucalyptus in M.P. (mainly *E. tereticornis*) were started in the year 1956 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 trails of *Eucalyptus* species were started by State Forest Research Institute, Jabalpur in the year 1972. So far, 40 provenances of *E. camaldulensis* 45 provenances of *E. tereticornis* and 8 provenances of *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 per cent of the plants indicate that the provenances ERC 12348, ERC 12187 and ERC 12139 of *E. camaldulensis* and provenances ERC 10182 and ERC 12140 of *E. tereticornis* are best suited to different edapho–climatic conditions of this State. The performance of all the 8 tried provenances of *E. citriodora* have been exceptionally good. Average girth of the *E. citriodora* plants at the age of only 2 years varies from 9.1 cm to 14.2 cm and have average height from 4.19 to 5.95 m. Whereas the average girth and average height variations for the provenances of *E. tereticornis* of the same age are only 3.1 to 7.1 cm and 1.83 to 3.98 m respectively, the height variations among the different provenances of *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 minde 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 seedling 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 FRI 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.

S. N.	Species	Site	Age Yrs.	Survival %	Average Height m	Average Girth (GBH) cm
1.	*E. camaldulensis*	Bauxite mined out areas in Amarkantak region	6	93	8.41	23.6
2.	*E. hybrid*	Bauxite mined out areas near Amarkantak	6	95	8.24	20.7
		Mined out areas of Dolomite near Bilaspur	2	92	2.68	4.15
		Mined out areas of coal mine over burden near Shahdol	3	84	6.27	21.15
3.	*E. grandis*	Mined out areas of bauxite near Amarkantak	3	92	2.15	9.1
4.	*E. hybrid*	Bhata lands (hard laterites) Bilaspur	8	92	8.50	24.6
5.	*E. camaldulensis*	Sandy loam soil Seoni (semi-irrigated)	1½	98	4.50	12.8

Table 3 : Performance of *Eucalyptus* hybrid in various soil and climatic conditions of M.P.

S. N.	Name of the locality where plantation has been done	Age of the Plantation in years	Altitude of the site (m) from MSL	Mean Annual Rainfall mm	Geology and soil	Site quality	Crop ht m	Crop dia-meter in cm
1	2	3	4	5	6	7	8	9
1.	South Betul Forest	9½	733	1230	Trap and -metarur origin sandy loam.	II/III	12.3	7.2
2.	Rajnandgaon Forest Division	8½	850	1750	Granite, rude soil, shallow sandy loam	II	14.2	12.5
3.	Kanker Forest Division	8	450	1250	Sandy loam	III	9.7	8.6
4.	South Khandwa Forest Division	8½	275	760	Underlying rocks, Murram, mixed black cotton soil on top	III	12.0	9.0
5.	North Shahdol Forest Division	5½	425	1400	Sandy loam	II/III	8.4	6.0
6.	North Shahdol Forest Division	7½	365	1400	Sandy loam	II	12.1	8.4
7.	Bilaspur Forest Division	7½	600	1400	Granite rock, Sandy loam soil	I	13.8	11.3
8.	Bilaspur Forest Division	8½	585	1400	-	III	11.1	7.8

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 comeup. It is also surmised 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 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 wild life, 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.Bandopadhyay and Dr. B.V.Krishnamurthy who have been waging war on *Eucalyptus*, environmentalists like Dr.Madhav Gadgil 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 allays all the ecological fears expressed against this species. It was noted that all the socio-economic arguments for and against *Eucalyptus* -vis- food crops would be applicable to any other tree crop as well. Many of these arguments would also be applicable to other 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 edapho-climatic adaptability. It flourishes from coastal areas to areas situated at 2000 meters altitude, tropical to warm temperate climate and rainfall ranges of 400 to 4000 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 'Usar' 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 Tawa 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 mixmum biomass in different types of wastelands. Its utility have been proved on mined out areas and mine overburdens of bauxite, coal, dolomite, limestone, mangnese 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 polypot seedlings. This is a source of additional income to them.

Eucalyptus is also a good coppicer 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 yield of 4,800 to 5,000 K cal per kg and when burnt into charcoal with 7,900 K cal 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 19.7 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 bunds 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-burdens of bauxite, coal and dolomite 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 Nepanagar, 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 2200 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.1.00 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 reclaimation 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 (SFRI) 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, DehraDun, 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 84 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 8.87 ml for chirpine, 3.04 ml for poplars and 2.54 ml for Sissoo *(Dalbergia sissoo)*.

Forest Research Laboratory at Kanpur carried out an experiment (March 1982 to February 1983) 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 *Karanj*. Since *Eucalyptus* is most economical in water consumption it has greater claims in arid regions where careful water management is most important.

The experience in the farmer's fields in Gujarat also corroborates the facts that *Eucalyptus* does not deplete sub-soil water. 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 of wells in surrounding farms during the last seven years. Similar observations were made in the wells 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 88.4 per cent of rainfall to reach the ground as compared to 79.5 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 sub-terranean 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 IP sets (ii) consecutive drought years (iii) very high density of tree planting (above 10,000 trees per hectare).

To verify the effect of *Eucalyptus* on undergrowth, 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 1030 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 *(Hardwickia binata)*, Sissoo *(Dalbergia sissoo)*, Siris *(Albizzia lebbek)* 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 aboveground biomass of ground flora species and water infilteration 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. *(Bhatalands of Bilaspur, 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 su-babul have also been successfully grown in the shade of *Eucalyptus* trees. In the premises 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 spp., Dicanthium annulatum, Eulaliopsis binata)* have been underplanted with *Eucalyptus* at these sites. In West Mandla 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 Kapildhara 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.K.V.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 of ragi, Jowar, cowpea, green gram, gingli 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, atleast four million hectares is occupied by ravines, hard laterites, mine over burdines, 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 fail. 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 broughtout good results at bauxite and coal mine overburdens when Sal, Toon *(Cedrella toona)* and grasses, are being gradually underplanted with *Grevillia pteridifolia*, *Eucalyptus* and tropical pines near Amarkantak in Madhya Pradesh.

Regarding the acidic 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 replenising the soil nutrients as any other mono-culture. The production of leaf litter under *Eucalyptus* plantations raised in Mohan Bhata (Bhata land) areas of Bilaspur, bauxite mine-over burdends of Amarkantak, coal mine overburdens of Dhanpuri (Shahdol) is superior to any other species. In experiments conducted at FRI, DeharDun, in Bangalore Forest Division, in West Bengal, at Jabalpur (SFRI) and at Amarkantak, *Eucalyptus* plantations have been found to increase the nitrogen, phosphorous 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 micorrhizal association.

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

The present situation regarding our forests is critical. Between 1961-1981 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, have 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.

Conclusion

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 undergrowth, 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 burdens which are devoid of vegetation and other form of micro-organisms; when it is planted on barren hard laterites, 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 and 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 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 lignotubers 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 upright bole allows

high plantation density; the thin tree canopy casts minimum shade on agricultrual 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 vepetative 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-burdends, in deep ravines and on such other refractory sites. Certain indigenous species such as *Neem, Sissoo, Karanj* etc., should also be adopted for reclothing the barren hills and exposed sites but *Eucalyptus* should invariably form a major part of afforestation programme on such sites.

This subject was discussed in State Forestry Conference at SFRI, 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 descarded *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 the *Eucalyptus* should be accepted as a species for being raised, in Social Forestry Plantations.

In most parts of this State, agricultrual 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 spcies 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 eucalypts 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 transplanting 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 criterion 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 tree 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 indentifying the seed stands of various *Eucalyptus* species in Madhya Pradesh. This Institute has also established eucalyptoria at its nine Regional Forest Research Centres (Jabalpur, Amarkantak, Bilaspur, Raipur, Jagdalpur, Indore, Nepanagar, Betul, Seoni) located in different edapho-climatic zones of the State. The seed is collected from elite trees and seed stands and is stored in 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.

Quantity of Seeds Required:

The quantity of seeds required for raising nursery stock depends mainly on its quality. Apart from a few species with particularly large seeds, there is no great difference in size among the seeds of various *Eucalyptus* species. The greatest variation is in the proportion of infertile seed. On an average, 25,000–30,000 healthy plants can be grown from one kilogram of *E. tereticornis* seeds of medium quality. Seeds of *E. citriodora* are slightly heavier but on account of its very high germination per cent (more than 90%) one kilogram of seed is capable of producing about 35,000 healthy nursery seedlings.

Direct Seeding:

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 seeding 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 seeding 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 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.
2. It should have good facilities of water. The pH of water should be in the neighbourhood of 7.0).
3. It should be in the same region in which the seedlings raised will be planted. It has been found that seedlings raised in the cooler climate suffer badly if they are transplanted to warmer site.
4. If the locality experience summer winds, windbreaks and shelterbelts should be planted around it. Temporary shade made out of brushwood may also be erected to protect the seedlings from direct sun light, especially during hot summer months.

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 tubes, 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. Polithene bags of size 15 x 22.5 cm having perforations throughout the length of bags are normally used. The ploythene 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 or 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 pricked 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. It should consist of loams, or other soil mixed with river sand, together with a reasonble amount of organic manure. It is very unusual 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 watering. 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 quantity of fungicides should be mixed with soil. Locally available Gamaxene or B.H.C. powder may be added @50-100 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 evaporation losses could be minimised. Regular watering is recommended but infrequent and copious 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 pricked 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 pricking out the roots may be 9—12 cm long. If the roots are curly or too long then they may be trimmed. Each seedling should be carefully separated from the adjoining seedlings. While pricking out the seedlings should be placed by hand in the centres of polypot and covered with the soil mixed with organic manure. The pricking 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. However, if the water supply through well laid irrigation pipelines are avaviable, planting may be done from March to June. Healthy planting stock (about 45 cm tall polypotted plants) planted during this period (March to June) with about 8—10 irrigation in a month can give the best results. The **four month's growth before the commencement of rainy 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 2m x 2m is followed by Forest Deptt. However, the experience of farm forestry projects shows that spacing of 2m x 1m provides best results. If intercropping of zinger, curcuma, wheat, palatable grasses, berseem, sarpgandha (*Rauwolfia 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 1m 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 4.

The recommended spacing for farm forestry project would be 3m x 1m and 2m x 1m. In fertile sandy loam to loamy soil the spacing of 2m x 1m should be preferred. The polypotted plants are planted in the pits of 30 cm^3 or 45 cm^3 size, depending upon the type of soil. Before planting, about 5 grames of aldrine 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, even 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 be grown successfully under adverse climatic and soil conditions. However, for farm forestry project the favourable soil and climatic parameters, initial 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 trials, input trials, irrigated plantations etc. To have a broad idea about the

Table – 4: Planting Stock for one hectare plantation

Spacing		No. of plants required for a hectare	
Row to Row & plant to plant	Main plantation	Casuality replacement	Total
3m x 1m	3,350	300	3,650
2m x 2m	2,500	250	2,750
2m x 1m	5,000	500	5,500
1m x 1m	10,000	1000	11,000

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-7.

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 of *Eucalyptus camaldulensis, E. tereticornis* and *Eucalyptus* hybrid at Nepa Mills (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 definite 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 characteristics of seedling crop and its coppice crop has been summarised in Table 8.

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

S.N.	Name of the species	Locality where the species can be planted.	General utility
1.	*E. tereticornis*	Successful in hills and plains, minedout areas and other refractory sites.	Good as hardwood pulp for paper and rayon industry, firewood, sawing poles etc.
2.	*E. camaldulensis*	Suited to gently slopy areas and well drained plains, drier localities, minedout areas, wastelands, farm bunds, agricultural fields etc.	Hardwood pulp, firewood, poles, sawing material etc.
3.	*Eucalyptus* hybrid	As above	– do –
4.	*E. citriodora*	Successful in hills upto 1200 m.	Good for avenue, oil extraction
5.	*E. globulus*	Successful in hilly areas above 1200 m but with no snowfall.	Planting at higher altitudes.
6.	*E. grandis*	Plateau, plains, high rainfall areas.	Good as sawn material, paper pulp, firewood, construction timber
7.	*E. microtheca*	Successful in plains	Suggested for Alkaline soil and areas with precariously low rainfall.

8.	*E. melanophloia*	Successful in plains	Good for the areas having draught problems.
9.	*E. ochrophloia*	Successful in plains	Suggested for sandy and gravely soils.
10.	*E. rostarate*	Successful in plains	Good for general planting.
11.	*E. rudis*	- do -	
12.	*E. saligna*	- do -	

only. The reply of the greater challenges of the day seems to be possible only from 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 for Wastelands Afforestation:

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

1. 'Bhata' lands (hard and compact lateritic soils, natural tree vegetation is absent).
2. Water-logged and marshy lands.
3. Ravinous 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.

1. **Bhata lands**. These occupy vast areas of eastern Madhya Pradesh (popularly known as Chhatishgarh plains) the extent of which is about 4 lakh hectares. Though success has been obtained in raising plantations of many indigenous as well as exotic species on these land but the *Eucalyptus* species, particularly *Eucalyptus* hybrid, has shown the highest mean annual increment. Also, its survival per cent has been

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

S.N.	Age of the plantation in years	Average Height (M)	Average dia at breast height (cm)
1.	1	1.74	-
2.	2	3.75	2.5
3.	3	4.88	3.3
4.	4	10.50	9.6
5.	7	12.50	10.8
6.	10	14.50	12.7

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 cm³ 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 mansoon. 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 9-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.

2. Water logged and marshy lands:

Eucalyptus has been planted in the water-logged area of Tawa Command in Hoshangabad district in June 1986. As the plantation is quite young, no comment regarding the growth pattern of various species planted can be made at this stage but in U.P. *Eucalyptus* has been successfully planted in saline and alkali soils developed due to water-logging. In this case, the planting technique includes digging of pits of 30 cm³ size, filling the pits with a mixture of non-saline and alkali soil and sand (1:1) and then planting about 9-months old seedlings in the month of February. However, in this case *Eucalyptus* is one of the many species planted. The preliminary observations have indicated that *Eucalyptus saligna and E. camaldulensis* are doing better than many indigenous plant species.

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 reclaimation 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.

S.N.	Age years	Height (m)	Dia at b.h. (cm)
1.	6	14.4	11.8
2.	8	16.7	13.8
3.	10	18.7	15.8
4.	12	20.7	17.6
5.	14	22.0	18.8

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, putting the mixture of soil and compost in the trenches and the planting the species whose water requirement is less. *Eucalyptus* has been found to be the most useful species.

5. 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 of locality, climatic conditions and other factors.

6. Rehabilitation of Mined Out Areas:

Methodologies for reclaimationof 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.

Planting technique in general, comprises of digging of pits of 45 cm^3 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 polypotted seedlings are planted in the above pits after the break of mansoon. Weedings and spray 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^3, would ensure better growth. Phenomenal growth on mined out sites appears to be on account of soil pulverization rather than imitral input. This should be taken into consideration while attempting plantations on refractory sites.

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 bounderies 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 agriculatural land, trees can be grown in three ways:

1. Growing trees on the land diverted from the

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

'BILASPUR'

S.N.	Origin of the crop	Age in years	No. of stemps per ha	Crop dia at b.h. (cm)	Crop height m
1.	Seedling origin	8½	1064	8.8	11.3
2.	- do -	8½	1305	7.8	11.1
3.	Coppice origin	3½	1144	7.3	10.5
4.	- do -	3½	1155	7.8	10.1

'KONDAGAON BASTAR'

5.	Coppice origin	1	1810	2.9	05.1
6.	- do -	2	1980	5.1	09.2

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, and can be, followed by every type of farmers, big and small.

3 Growing trees in the farmlands and doing inter-croping 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-prunning, 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 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'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 per cent 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^3 size should be dug up in the month of June, in a row along the bund and at an espacement 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 months of June-July). If 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 polypotted 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 or/and 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 polypotted or naked seedlings of *Eucalyptus* (preferrably polypotted) should be planted on the ridges formed by the plough. The planting should be done at the spacement as may be decided in consultation with the forestry experts. However, the spacing of 2m x 1m, 3m x 1m and 1m x 1m are being recommended depending upon the patrern of inter-cropping to be followed. While planting in wet lands, small mounds of the 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 plants. 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 fertiliser should be given 15 days after the application of the first does. 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 does of DAP. In the second and third years also the above mentioned fertiliser 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 carryout weedings in the plantation during the rainy season (June to September), whenever weed growth is found supressing 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 agricultrual crops then the method will be slightly different. In this case, the spacement of the planting will generally, be 3m x 1m so that sufficient gap is available for the movement of tractor. The soil working will be done by ploughing the filed but the polughing 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 under 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 13 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 farmland 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 in between the rows of *Eucalyptus*. Some farmers in Jabalpur, Raipur, Vidisha, Bhopal and Indore districts have also raised successful irrigated plantations of *Eucalyptus*. Inter–cropping of vegetable crops, papaya and agricultrual crops have been raised by farmers of Jabalpur. These projects were implemented under the technical guidance of State Forest Research Institute, Jabalpur.

Under rainfed conditions or where irrigation potential is not fully developed the plantations could be started in the month of June–July when the rains have moistened the about 10–15 cm upper soils layer. However, where well laidout 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 cartloads 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 the 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 have 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. Eucalypts are also utilised for poles, posts, railway sleepers, firewood, pulpwood and in the manufacture of chip-board products. Minor forest products obtained from eucalypts 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 shelterbelts.

Eucalyptus hybrid is classified as a heavey, hard wood. It is suitable for packing cases, crates, boxes, beams, columns, poles, posts and similar other items. 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 -9.

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 and large, has not been successfully tried, the reason being the cellular structure and the strain developed 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 airdrying the poles (debarked) under shade or by felling in dormant season/or coating the ends with bitumen or immersing the ends in cold water for 6 weeks.

3. Pulp for Paper: Species having basic density less than 600 kg/m³ are considered suitable for pulpwood purposes. The inter-bonding properties and the surface smoothness of paper are better in the paper manfacturd 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 former, the pulp yield is higher and the consumption of chemicals during the pulping is also low. In preparing pulp from

Table-9 : Comparative wood properties of *Eucalyptus* and Teak

S.N.	Properties	Values of various physical properties			
		Teak	*E. hybrid*	*E. globulus*	*E. eugenioides*
1.	Specific gravity	0.596	0.596	0.676	0.671
2.	Fibre stress at elastic limit (kg/sq cm)	509	291	460	544
3.	Modulus of elasticity	109.7	155	-	176
	Compression parallel to grain				
4.	Compressive stress at elastic limit (kg/sq cm)	311	149	227	338
5.	Modulus of elasticity in compression (kg/sq cm)	129.8	66.0	226.6	129.2
6.	Maximum shearing stress parallel to grain (kg/sq cm)	96	77	94	110
7.	Maximum tensile stress perpendicular to grain	73.9	57.5	54.2	80.5

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 upto the age of nine years.

The species of *Eucalyptus* found suitable for various grades of pulp are *E. tereticornis, E. grandis, E globulus, E. citriodora* and *E. torriliana*. *Eucalyptus* hybrid and *E. camaldulensis* have been found suitable for paper pulp in mixture consisting of chemical pulp from *Ochlandra 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

been found to be between 742 μ to 806 μ.

4. Rayon-Grade Pulp: For rayon grade pulp *E. grandis*, *E. globulus* and *Eucalyptus* hybrid are quite suitable. The bleached pulp yields from these are 32.6%, 41.5% and 32.3% respectively, alpha cellulose content being 94–5%, 96% 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 so they are preferred world wide.

6. Particle Boards: Wood taken from 7-years old *Eucalyptus* hybrid tree was found quite suitable for preparing particle board. Using chips of 30 mm length, 0.6 mm thickness and 1.5 to 3.0 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 splitted. But when the woods of density less than 650 kg/m³ (air dry) were peeled, satisfactory face veneers could be obtained. But 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. gamphocephala*, *E. microtheca*, *E. occidentalis*, *E. robusta*, *E. tereticornis*, *E. camaldulensis*, *Eucalyptus* hybrid etc. provide excellent firewood. The calorific 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 domestick 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* are quite good for manufacture of charcoal and acetic acid. *Eucalyptus* hybrid yields nice charcoal and acetic acid on factory scale, as compared to the yields from mixed woods. The *Eucalyptus* charcoal is heavier, stronger and more uniform in quality with a calorific value of 7200 k. callories per kg.

9. Essential Oils: *Eucalyptus* leaves are an important source of essential oil. In India, the medicinal *Eucalyptus* oil is obtained as a by-product from the leaves of *E. globulus* which is mainly grown to supply firewood. It yields about 1% oil containing 60% cineole. *Eucalyptus fructicetorum* yields about 1.5 times more essential oil than *E. globulus*. The essential oil contents of *E. citriodora* and *E. tereticornis* are good enough but the oil obtained from *E. globulus* is preferred to those obtained from other species of *Eucalyptus* due to certain desirable qualities in the former.

10. Honey: *Eucalyptus* are very good for large scale honey production. So, far, *Eucalyptus* have not been exploited in our country as a source of honey though the countries like Australia are taking this advantage from *Eucalyptus* forests.

Different species of *Eucalyptus* flower between October to June. Even, *Eucalyptus* hybrid flowers twice in a year. So, by selecting proper *Eucalyptus* species for plantation an arrangement to supply the forage to honey bees (*Eucalyptus* flowers), throughout the year can be made.

The *Eucalyptus* honey has been found superior to other honeys in flavour as well as taste.

Thus it is seen that though use of *Eucalyptus* as timber for constructional purposes is not fully explored, it can be used for so many other purposes, in some cases more successfully than other woods.

Table-10 : Calorific value of some Eucalypts

S.N.	Species	Calorific value in K. callories
1.	*E. microtheca*	4850
2.	*E. grandis*	4310
3.	*E. hybrid*	4880
4.	*E. globulus*	4962
5.	*E. robusta*	4890
6.	*E. tereticornis*	4830
7.	*E. camaldulensis*	4650

Presently *Eucalyptus* wood is being purchased by Nepa-Paper Mills and Orient Paper Mills situated in Madhya Pradesh. Gwalior 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 district a few years ago are now showing the sign of firewood deficit. Presently 25 districts of the State are considered to be deficit in respect of firewood and timber. This number may swell upto 39 by the turn of this century. This alarming trend of firewood scarcity would enable tree growers to get remunerative prices for their products.

PEST MANAGEMENT

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

PESTS : 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 succeptible to termite attack. To prevent the plantation from termite attack, insecticides like BHC, Aldrine, 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 cm³. Water solution of these insecticides can also be sprayed uniformily on the soil in the pit.

Babool Borer : A borer which was originally considered harmful only to *Acacia* species have 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 upto the root ultimately killing the plant. Mostly the young trees are attacked by this borer. Older trees are resistant to it. To prevent the *Eucalyptus* trees from this borer, as far as possible, new plantations should not be raised in continuity. Spray of residual insecticide in young plantations, to kill the adult beetle has also been found effective for checking the attack. Also, infected trees are cut back and solution of some

insecticide is poured into the tunnel of the larvae. This kills the larva and check its population buildup for the next year.

DISEASES : Diseases affecting *Eucalyptus* include cankers, galls, wilts, 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 Karanataka, Kerala and Goa, under the conditions of high rainfall and termperature. It attacks the young aged plants of eucalypts. 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 dithiocarbamate fungicides to diseased stems and branches and by excision and destruction of diseased trees or plants.

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

Fungal Diseases : *Ganoderma lucidum* is 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 *Ganodermae* 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.

Seedlings Blight : In some nurseries of U.P., mortality in young seedlings have also been reported. This has been found to be due to *Cylindro caldium* seedlings blight. To prevent the seedlings from this disease, the seeds should becoated with organomercurial fungicide before sowing. In the case of attack, 0.3% solution of Blitox should be sprayed over the affected polypots and watering should be stopped from one day before upto one day after this treatment.

However in M.P., so far, only *Ganoderma lucidum* (causing pink disease) and *Cylindro-cladium-quinquesi-plalum* have been reported.

General Safety Measures : On the basis of the knowledge of the causes of the 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. Lopping, girdling, cutting of branches etc. should be avoided.

5. If 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 ash, dust, gases etc.

Disorder due to Deficiency for Excess of Inorganic salts :

Sometimes the plantations raised on a particular areas 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 calcarious 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-refil 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 challanges 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 takeup 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 material 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 agriculturist 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

Village Thana NB 239 : PC No.35

Revenue Circle – Bargi

Tehsil and District – Jabalpur

1. Location : Village Thana, about 40 km from Jabalpur along NH-7 (Jabalpur-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 *Bhumiswami* could be considered. For this purpose loan can be given in the ratio of thier land.

3. Details of Ownership :

4. Species to be planted :

(a) Eucalyptus hybrid — 2 x 1 m (2,000/acres)
(b) Su-babul — 1 x 1 m (4,000/acres)
(c) Bamboo — 4 x 4 m (1,000 plants approx.)

5. Species-wise Calculation of Area :

(a) Eucalyptus – 25 acres
(b) Su-babul – 04 acres
(c) Bamboo – 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 piller after every 10 pillers; 4 strand barbed wire (2 ply).

Poles – approx. 800 @ Rs. 50/piller – Rs. 40,000
Barbed wire 5 tonnes @ 1200/tonne – Rs. 60,000
Total 1,00,000.00

2) Cost of plants, digging of pits, replacement of soil, addition of organic manures etc.

i) **Cost of plants** — **Rs. 0.50/plant**
ii) **Pit digging** — **Rs. 0.60/pit**
iii) **Soil change** — **Rs. 0.25/pit**
iv) **Manures & insecticides** — **Rs. 0.20/pit**
v) **Planting** — **Rs. 0.20/plant**
Total Rs. 1.75

a) Eucalyptus @ 2000/acres for 25 acres – Rs. 50,000
add 10% casuality – Rs. 5,000
Total Rs. 55,000

b) Su-babul (4 x 4000) – 16,000 plants add 10% casuality 1600 – Rs. 17,600

c) **Bamboo along field bunds, peripheral bunds** Rs. 1,000
73,6000 @ Rs. 1.75/plant **Total of a, b & c @ Rs. 1.75/plant** = Rs. 7,36,000

Total of 1 & 2 – Rs. 1,28,600.00

3) **Provisions for Irrigation :**

a) Two pumps – Rs. 20,000
b) Sinking of well not needed as river flows around this farm.

c) Pipe lines about 1,000 m @ 40/m — Rs. 40,000
d) Preparation of irrigation channels and other accessories — Rs. 15,000

Total Rs. 75,000

4) **Construction of a Labour hut**

Two room and a kitchen, brick in mud mortar, country tiles, baton doors etc., — Rs. 20,000

Total Rs. 20,000

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

II. Recurring :

1) Weedings
Iyr 2 @ 300/- acre — **Rs. 8,700**
IIyr 1 @ 100/- acre — **Rs. 2,900**
Total Rs. 11,600

2) Irrigations and maitenance of channels.

Iyr	-	25 irrigation	
IIyr	-	20	--
IIIyr	-	10	--
IVyr	-	10	--
Vyr	-	--	

Total 65 irrigation @ Rs. 1000/irrigation over entire area — Rs. 65,000

3) Insecticides and Manurings in first two years @ Rs. 100/- acre in Iyr and similar amount in second year
(100 + 100 = 200 x 29 acres) — Rs. 5,800

4) Intercropping of zinger, curcuma, tomato, chilies, etc., @ Rs. 1,000/acre in about 20 acres -

Iyr	Rs. 20,000
IIyr	Rs. 15,000
IIIyr	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 unforseen expenses @ Rs. 2,000 per year for 5 years — Rs. 10,000.00

Total Recurring - Rs. 1,02,000.00

Abstract Of Project Cost

I	Non-Recurring :	Rs. 3,23,800
II	Recurring :	Rs. 2,02,000
	Total	Rs. 5,25,800
III	Bank Interest @ 10.50% (approx.)	Rs. 55,209 x 5 = Rs. 2,76,045
IV	Total liability over a period of 5 years	Rs. 8,01,845.00
V	Per acre expenditure for entire period	Rs. 27,649.82
VI	Expenditure per acre/yr	Rs. 5,529.96

Returns From Harvest

1. Return from agricultural crops as inter-cropping component in about 20 acres @ Rs. 4,000/- acre per year.
I year - III year Rs. 80,000 x 3 = **Rs. 2,40,000**

2. Su-babul harvested in 4th year, 60% plants of 16,000 surviging to maturity- approx.
10,000 plants @ Rs. 25/tree. = **Rs. 2,50,000**

3. Eucalyptus harvested after 5 years. About 75% trees maturing at the end. 50,000 plants - 37,500 on an average each tree would fetch an average price of Rs. 50/tree - Rs. 18,75,000

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. 23,90,000

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.

3. 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	Rs. 23,90,000.00
	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 be giving a revenue of Rs. 25,000/- every 3-4th year. If the clumps can be divided in 4 parts (250 clumps) for working every year, they can produce about 1,250 bamboo each year or Rs. 250/- annually. Intercropping 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 singling 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- Nagpur National Highway No. 7 at the distance of about 40 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 proposed to be given priority on 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. 8,000/- 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) Detail of land :- The land is situated at village Kaladehi 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 Temer 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 6-7 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 very 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 Vijay Kumar Nagpal.

Location of lands	Village	-	Kaladehi
	No. Bandobast	-	515
	Patwari Halka	-	36
	Khasara No.	-	24, 29 and 30
	Gram Panchayat	-	Kaladehi
	Tehsil and Districts	-	Jabalpur
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 *Eucalyputs, Tectona grandis* and *Dendrocalamus strictus* on 34.14 acres of land.

Land Development : i) **Land shaping of 34.14 acres @ Rs. 1,500/acre** **Rs. 46,710.00**
ii) **Fencing around 34.14 acres** **Rs.20,000.00**

a) Barbed wire 2 tons @ Rs. 1,000/m.ton. Rs. 20,000.00

b) Wooden poles 35 to 40 cm girth and 2½ meter length
- 1000 poles @ Rs. 15/each pole. Rs. 15,000.00

c) Coal-tar and nails for poles : Coal-tar
Rs. 50 litres @ Rs. 10/per litre Rs. 500.00
Nails 80 kg @ Rs. 9/kg. Rs. 720.00

d) Pit digging for poles 1000 nos. @ Rs. 1-50 each Rs. 1,500.00

e) Fixing of barded wire (labour charges) Rs. 500.00

iii) Planting of *Acacia nilotica* (babool) and *Prosopis juwiflora* around the fence. Rs. 5,000.00

Total (1) Rs. 89,930.00

2. **Irrigation Facility :-**

a) Tube well one no. @ Rs. 45,000/- Rs 45,000.00

b) Dug-well 6 mtr dia and 10 mtr depth @ Rs. 1000/- Rs. 10,000.00

c) Electric pumps 5 HP-2 nos. and 2½ HP-2-nos. Rs. 16,000.00

d) Piles for irrigation 1000 running meters @ Rs. 60/- running meter. Rs. 60,000.00

e) Water distribution tanks (cement construction) size 6 x 2.5 x 2 meter - 3 Nos. @ Rs. 5000/-each. Rs. 15,000.00

f) Irrigation channels for entire plot Rs. 6,000.00

g) Pump houses 5 nos. @ Rs. 2000/each Rs. 10,000.00

Total Rs. 1,62,000.00

3. **Watchman quarter** 2 nos. @ Rs. 6000/each 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 nalas, residiential 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 Rs. 22,575.00

b) Planting at a spacing of 2 x 2 meters i.e. 1,210 plants per acre or 2500 plants per hector 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

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

iii) 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 *Dendrocalamus strictus* around fence including the cost of seedlings, organic and inorganic manures @ Rs. 4/- each Rs. 4,800.00

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

Total Rs. 1,83,205.00

5. Requirement of implements :-

a)	Pick-axe	24 Nos. @ Rs. 18/- each	Rs.	720.00
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)	Khurpi	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.	35,000.00
		Total	Rs.	44,620.00

Grand Total 1 to 5 Rs. 4,47,135.00

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

		2nd Yr.	3rd Yr.	4th Yr.	5th Yr.
1.	Organic manure @ one truck per acre i.e. 28 trucks @ Rs.250/- per truck.	-	7000/-	-	-
2.	Chemical fertilizers @ 50 Grams per plant X 33600 plants approx. 15 Qtls. @ Rs.200/- per Qtl.	3000/-	3000/-	3000/-	-
3.	Insecticides and fungicides @ Rs.250/- per acre X 28 acres.	7000/-	-	-	-
4.	Watchman 2 nos. @ 300/- per month each.	7200/-	7200/-	7200/-	7200/-
5.	Hoeing and weeding @ Rs.100/- per acre X 28 acres.	2800/-	2800/-	2800/-	-
6.	Maintenance of irrigation channels @ Rs.100/- per acre X 28 acres.	2800/-	2800/-	2800/-	-
		22,800/-	22,800/-	15,800/-	7,200/-

Total investment in five years :

1.	Initial investment		Rs. 4,47,135.00
2.	Recurring investment		Rs. 68,600.00
		Total	Rs. 5,15,735.00

Returns From Harvests

A. Eucalyptus :

1. Total plant population of 33,600 and assuming the probable mortality of 10% plants, i.e. 33600 3360 = 30240 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 6th 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 presuming 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 tree 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, Bauxite and Coal-mines areas, each tree is expected to fetch on an average about Rs. 100/- per tree for air dry merchantable biomass.

   iv) Thus for 22,5000 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. 22,500.000/- (—) Rs. 1,11,500/- = Rs. 21,38,000.

Total (A) Rs. 21,38,500.00

B. **Bamboo** *(Dendrocalamus strictus)* :

Though Bamboo clump formation can be expected around 6th year, by way of cleaning (along with felling of *Eucalyptus*) approximately 2,000 pieces of thin bamboos would be available which will 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**

Total return **Rs. 22,33,500.00**

Cost-Benefit Calculation

I. Total expenditure (Recurring and capital) Rs. 5,15,735.00
Interest on loan @ 12.5% for 5 years. Rs. 4,14,000.00
Total Rs. 9,29,735.00

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 = Rs. 13,03,000.00

Or 2.60 laks 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 upto 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. 5000/- per acre on singling of coppie shoots, irrigation for 2 years and watch & ward for 18 acres @ Rs. 5000/- 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 vigorus in first coppics 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 *Rauvolfia* (Sarpgandha) with *Eucalyptus*. Estimated yield from these crops harvested after 1½ to 2 years is about 8 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 *Rauvolfia* 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.

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