

Bulletin No. 18

# **SPECIES FOR PLANTATIONS IN MADHYA PRADESH**



**STATE FOREST RESEARCH INSTITUTE**  
MADHYA PRADESH, JABALPUR

# **SPECIES FOR PLANTATIONS IN MADHYA PRADESH**

*Compiled by*

**STATE FOREST RESEARCH INSTITUTE**

**MADHYA PRADESH, JABALPUR**

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## PREFACE

The object of this work is restricted and is entirely practical. The Forest Officers of the State have, all these years, handled, with commendable success, problems of **Artificial reproduction** of a few selected species of commercial importance like Teak\* & Bamboo, and more recently *Eucalyptus* & Pines, in the demarcated Reserved and Protected Forests. Now under various plantation scheme, they are called upon to handle, for the first time, **Artificial reproduction** of a large number of hitherto described "Miscellaneous Species" and that too in alien lands. Successful organisation of this work in the State makes it obligatory for every Forest Officer to know the type of climate, topography and soil preferred by the species, their flowering and fruiting season, seed viability and storage, methods of artificial propagation of the species and their rate of growth. The Bulletin intends to place the best possible information available on record on these points at the disposal of the Forest Officers so that they may be able to plan their programme properly, with an assurance of 100 percent success in their mission.

2. No finality is implied nor claimed with respect to the information given in this Bulletin, even with respect to those species which have been some what fully dealt with. Factors bearing on Artificial reproduction and other questions can be found out only after a close study of the varying conditions met with, in different localities in the State. The information compiled in this bulletin should, therefore, be made full use of, but detailed silvicultural notes on the concerned species on all aspects particularly flowering and fruiting periods, period and method of seed collection, seed weight, their viability and loss of germination power with storage, precautions necessary for storage of seeds, nursery techniques adopted and new techniques evolved, success aimed at and achieved in planting, site preferences of the species, etc., must be kept extensively by all the Forest Officers so that at the end of a couple of years of practical experience in the field, the present bulletin could be made much more comprehensive with particular reference to conditions prevailing in different parts of Madhya Pradesh.

3. In all 85 tree species\* , 5 bamboos, 7 grasses and 2 legumes have been listed under plantations. This is not a long list considering the wide climate, topographic and edaphic variations encountered in the State. For any one given locality, the total species to be tried will obviously be less. It is hoped that the bulletin will enable the Forest Officers to make an appropriate choice of the species for planting in respective village environments.

4. It will be appreciated on going through the bulletin that meticulous care is necessary at every stage of the work, from collection and storage of seeds and raising of plants in the nursery to the selection of sites, planting of trees and their after-care. These are all specialised jobs with

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\* Teak has been deliberately omitted firstly because its rightful place is in Production Forestry and secondly because its method of artificial reproduction is too well known to every Forest Officer.

which the Forest Officers are generally well versed. Their work must bear a clear stamp of this authority and make a distinct impact on the public mind. It is hoped that the Forest Officers will find the bulletin useful in this regard.

5. Methods of artificial reproduction\* of the species have been given, under each concerned species. Only in the case of *Eucalyptus* and Bamboos, the nursery techniques have been described in detail in Annex 1 and 2 respectively. This has been done because their successful planting apart from proper site selection, depends entirely on ensuring that every plant produced is of the correct size, i.e., between 45 to 75 cms. long. It has probably not been realised sufficiently by all Forest Officers that seedlings of these two species, which are less than 45 cms. length, get greatly retarded in growth due to weed competition and by the end of the rains, do not acquire a size to ward off ill-effect of the following dry season, particularly the hot weather. Similarly, plants longer than 75 cms. length are costly to produce in the nursery and are ill-equipped to establish quickly in the field. They generally dry up. They often get damaged in transit also, while transporting from nursery to planting site. It is expected that nursery practice of these two species will be made more perfect than ever before.

6. As regards grasses and legumes, development of grazing grounds and grass production areas are, by far, the most important in agriculture based rural economy. Several species of grasses which are palatable to cattle, nutritive and of luxuriant growth, are available locally. Improved variety of grasses and legumes and improved techniques of raising them without irrigation have been evolved by the Indian Grassland and Fodder Research Institute, Jhansi. Seeds of the concerned species should be procured directly by the Forest Officers from the I.G.F.R.I., Jhansi.

7. The undersigned will be grateful for suggestions and improvements. Mistakes, if any, may also kindly be pointed out for immediate corrections.

8. A concise Hindi version of this bulletin, meant for publicity and distribution amongst the users and Panchayats, is also ready side by side to this bulletin.

9. The assistance rendered to the undersigned by Dr. P.C. Kotwal, the then Forest Botanist, SFRI, Jabalpur, in compilation of this bulletin is gratefully acknowledged.

10. Special thanks are due to Shri S.H. Mahalaha, the then Conservator-in-Chief M.P., Bhopal, Late Shri M.A.W. Khan, the then CCF (West) and Shri R. Chakravarti, C.F. (Resources) for giving encouragement and valuable guidance in the preparation of this Bulletin.

Director

State Forest Research Institute, Jabalpur M.P.



**2 - LIST OF RECOMMENDED SPECIES FOR MADHYA PRADESH,  
CLASSIFIED BY PURPOSE AND ZONE**

Purpose	Moist & Semi Moist Zone	DryZone (Less than 900 mm rains)
1	2	3
I. Timber trees for yielding poles	1. <i>Acacia arabica</i>  2. <i>Acacia catechu</i> 3. <i>Acacia leucophloea</i> 4. <i>Albizia lebbek</i> 5. <i>Albizia procera</i> 6. <i>Cleistanthus collinus</i> 7. <i>Dalbergia latifolia</i> 8. <i>Dalbergia sissoo</i> 9. <i>Eucalyptus citriodora</i>  10. <i>Gmelina arborea</i> 11. <i>Lagerstroemia parviflora</i> 12. <i>Terminalia arjuna</i>  13. <i>Terminalia tomentosa</i>	1. <i>Acacia arabica</i> (Enough soil moisture at surface is necessary) 2. <i>Acacia catechu</i> 3. <i>Acacia leucophloea</i> 4. <i>Albizia lebbek</i> 5. <i>Albizia procera</i> - - 6. <i>Dalbergia sissoo</i> (Moist localities) 7. <i>Eucalyptus citriodora</i> (Moist localities) - 8. <i>Lagerstroemia parviflora</i> 9. <i>Terminalia arjuna</i> (moist localities) 10. <i>Terminalia tomentosa</i>
II. Plants yielding tannin	1. <i>Acacia arabica</i>  2. <i>Anogeissus latifolia</i> 3. <i>Bridelia retusa</i> 4. <i>Cassia auriculata</i> 5. <i>Terminalia arjuna</i>	1. <i>Acacia arabica</i> (Enough soil moisture at surface necessary) 2. <i>Anogeissus latifolia</i> 3. <i>Bridelia retusa</i> 4. <i>Cassia auriculata</i> 5. <i>Terminalia arjuna</i> (Moist localities)

Purpose	Moist & Semi Moist Zone	Dry Zone (Less than 900 mm rains)
1	2	3
III. Fuel trees	1. <i>Acacia arabica</i> 2. <i>Acacia auriculiformis</i> 3. <i>Acacia leucophloea</i> 4. <i>Casurina equisetifolia</i>  5. <i>Cleistanthus collinus</i> 6. <i>Eucalyptus camaldulensis</i>  7. <i>E. citriodora</i> 8. <i>E. globulus</i> 9. <i>E. tereticornis</i>  10. <i>Lagerstroemia parviflora</i>  11. <i>Sesbania grandiflora</i>	1. <i>Acacia arabica</i> 2. <i>Acacia auriculiformis</i> 3. <i>Acacia leucophloea</i> 4. <i>Casurina equisetifolia</i> (moist localities but not water logged conditions)  - 5. <i>Eucalyptus camaldulensis</i> (In localities with permanent sub- soil moisture) 6. <i>E. citriodora</i> (Moist localities)  - 7. <i>E. tereticornis</i> (Moist localities)  8. <i>Lagerstroemia parviflora</i>
IV. Fodder trees	1. <i>Ailanthus excelsa</i> 2. <i>Hardwickia binata</i> 3. <i>Leucaena leucocephala</i> 4. <i>Moringa pterygosperma</i> 5. <i>Pongamia pinnata</i> 6. <i>Sesbania grandiflora</i>	1. <i>Ailanthus excelsa</i> 2. <i>Hardwickia binata</i> 3. <i>Leucaena leucocephala</i>  - 4. <i>Pongamia pinnata</i>  -
V. Fruit trees	1. <i>Aegle marmelos</i> 2. <i>Anacardium occidentale</i> 3. <i>Anona squamosa</i> 4. <i>Artocarpus integrifolia</i> 5. <i>Buchanania lanzan</i>	1. <i>Aegle marmelos</i>  - 2. <i>Anona squamosa</i> 3. <i>Artocarpus integrifolia</i> 4. <i>Buchanania lanzan</i>

Purpose	Moist & Semi Moist Zone	Dry Zone (Less than 900 mm rains)
1	2	3
	6. <i>Carissa spinarum</i>	5. <i>Carissa spinarum</i>
	7. <i>Diospyros melanoxylon</i>	6. <i>Diospyros melanoxylon</i>
	8. <i>Eugenia jambulana</i>	-
	9. <i>Madhuca indica</i>	7. <i>Madhuca indica</i>
	10. <i>Mangifera indica</i>	8. <i>Mangifera indica</i>
	11. <i>Mimusops hexandra</i>	9. <i>Mimusops hexandra</i>
	12. <i>Moringa pterygosperma</i>	-
	13. <i>Morus alba</i>	-
	14. <i>Phyllanthus emblica</i>	10. <i>Phyllanthus emblica</i>
	15. <i>Pithecollobium dulce</i>	11. <i>Pithecollobium dulce</i>
	16. <i>Tamarindus indica</i>	12. <i>Tamarindus indica</i>
	17. <i>Zizyphus jujuba</i>	13. <i>Zizyphus jujuba</i>
VI. Shade trees	1. <i>Alstonia scholaris</i>	-
	2. <i>Anthocephalus cadamba</i>	-
	3. <i>Azadiracta indica</i>	1. <i>Azadiracta indica</i>
	4. <i>Cedrela toona</i>	
	5. <i>Cieba pentandra</i>	
	6. <i>Eucalyptus gomphocephala</i>	-
	7. <i>Ficus bengalensis</i>	2. <i>Ficus bengalensis</i>
	8. <i>Ficus glomerata</i>	3. <i>Ficus glomerata</i> (moist localities)
	9. <i>Grevillia robusta</i>	-
	10. <i>Kigelia pinnata</i>	-
	11. <i>Mimusops elengii</i>	4. <i>Mimusops elengii</i>
	12. <i>Parkia biglandulosa</i>	-



Purpose	Moist & Semi Moist Zone	Dry Zone (Less than 900 mm rains)
1	2	3
	13. <i>Polyalthea longifolia</i>	5. <i>Polyalthea longifolia</i>
	14. <i>Pongamia pinnata</i>	6. <i>Pongamia pinnata</i>
	15. <i>Pterospermum aceritolum</i>	-
	16. <i>Putranjiva roxburghii</i>	-
	17. <i>Schleichera oleosa</i>	7. <i>Schleichera oleosa</i>
	18. <i>Schrebera sweetinoides</i>	-
	19. <i>Tamarinds indica</i>	8. <i>Tamarindus indica</i>
VII. Ornamental trees	1. <i>Acacia auriculiformis</i>	1. <i>Acacia auriculiformis</i>
	2. <i>Bauhinia perpurea</i>	-
	3. <i>Bauhinia variegata</i>	-
	4. <i>Cassia fistula</i>	2. <i>Cassia fistula</i>
	5. <i>Cassia javanica</i>	-
	6. <i>Cassia siamea</i>	3. <i>Cassia siamea</i>
	7. <i>Colvillea racemosa</i>	-
	8. <i>Delonix regia</i>	4. <i>Delonix regia</i>
	9. <i>Jacaranda mimosaeifolia</i>	5. <i>Jacaranda mimosaeifolia</i>
	10. <i>Lagerstroemia speciosa</i>	-
	11. <i>Melia azadirach</i>	6. <i>Melia azadirach</i>
	12. <i>Murraya paniculata</i>	-
	13. <i>Parkinsonia aculeata</i>	7. <i>Parkinsonia aculeata</i>
	14. <i>Peltophorum ferrugineum</i>	8. <i>Peltophorum ferrugineum</i>
	15. <i>Samania saman</i>	-
	16. <i>Saraca indica</i>	-
	17. <i>Spathodea companulata</i>	9. <i>Spathodea companulata</i>
	18. <i>Thespesia populnea</i>	10. <i>Thespesia populnea</i>
	19. <i>Thevetia perfolia</i>	11. <i>Thevetia nerifolia</i>

Purpose	Moist & Semi Moist Zone	Dry Zone (Less than 900 mm rains)
1	2	3
VIII. Trees in association with Agriculture crops	1. <i>Acacia arabica</i> 2. <i>Cedrela toona</i> 3. <i>Gmelina arborea</i>  4. <i>Prosopis spicigera</i> 5. <i>Terminalia arjuna</i>	1. <i>Acacia arabica</i> - -  2. <i>Prosopis spicigera</i> 3. <i>Terminalia arjuna</i>
IX. Trees for wind breaks & shelter belts (Drought resistant trees suitable for arid regions)	- - - - -	1. <i>Albizia lebbek</i> 2. <i>Butea monosperma</i> 3. <i>Cassia fistula</i> 4. <i>Casuarina equisetifolia</i> 5. <i>Eucalyptus citriodora</i> 6. <i>Melia azadirach</i>  7. <i>Morus indica</i>  8. <i>Prosopis juliflora</i>
X. Bamboos	1. <i>Bambusa arundinacea</i> (Moist localities only)  2. <i>Bambusa vulgaris</i> (Moist localities)  3. <i>Cephalostachyum pergracile</i>  4. <i>Dendrocalamus strictus</i> (Moisture conservation measures necessary)  5. <i>Oxytenanthera abyssinia</i>	1. <i>Bambusa arundinacea</i>  2. <i>Bambusa vulgaris</i>  -  3. <i>Dendrocalamus strictus</i>  -
XI. a) Grasses	1. <i>Cenchrus ciliaris</i> (IGFRI-3108)  2. <i>Cenchrus setigerus</i> (Yellow Anjan)	1. <i>Cenchrus ciliaris</i> (IGFRI-3108)  2. <i>Cenchrus setigerus</i> (Yellow Anjan)

Purpose	Moist & Semi Moist Zone	Dry Zone (Less than 900 mm rains)
1	2	3
		3. <i>Chrysopogon fulvus</i> (IGFRI-1)
		4. <i>Dichanthium annulatum</i> (IGFRI 495-)
	3. <i>Pennisetum pedicellatum</i> (IGFRI-2808)	5. <i>Pennisetum pedicellatum</i> (IGFRI-2808)
		6. <i>Sehima nervosum</i> (IGFRI-2)
	4. <i>Setaria specillata</i> (Variety conjugla)	7. <i>Setaria specillata</i> (Variety conjugla)
b) Legumes	1. <i>Phaseolus atropurpureus</i> (Australia)	1. <i>Phaseolus atropurpureus</i> (Australia)
	2. <i>Stylosanthes thumilis</i> (Australia)	



### 3. SILVICULTURE NOTES ON INDIVIDUAL SPECIES

#### A - TREES

##### 1. *Acacia arabica* (Babul) Syn. *A. nilotica*

A moderate sized, almost evergreen tree with a short trunk, a spreading crown, and feathery foliage. The pods are rich in tannin, and are also largely used as fodder and the thorny branches as fencing material. The bark exudes a gum.

The two commonest types of soil on which the babul occurs are riverain alluvium subject to inundations and black cotton soil. But the tree is also frequently found on other types of soil, for example on alluvial loam, on loamy soil and in tank beds. In any type of soil, however, it is essential that there should be a sufficient degree of permanent moisture in the soil and subsoil, for in this respect the babul is exacting. Babul will not thrive without irrigation if the climate is too arid. In regions of low rainfall the existence of the tree is rendered possible only by presence of enough soil-moisture at the surface. Shallow soil with underlying sheet rock or beds of kankar have a stunting effect.

Since babul can be raised easily from seeds and is a good coppicer, it is to be preferred for raising in fuel plantations also. It is also a useful tree for growing in association with agricultural crops on the field bunds and also sporadically within the field itself.

**Extraction of Seed** - Removal of seed from the pods by drying them in the sun and threshing them.

**Storage** - In dry conditions, seeds can be easily kept for more than a year (3 to 4 years)

**Treatment** - Seeds should be soaked in hot water for 48 hours and allowed to cool for 24 hours prior to sowing.

**Germination** - 80 to 90% Germination starts in about a week and complete in 2 weeks.

**Plant percent** - 60 to 70%

**Flowering and fruiting** : The flowering season is somewhat irregular, varying not only according to locality but also in the same locality. Flowering is most general in the rainy season, from June to September or October, but trees may be found in flower as late as December or January. The young fruits develop rapidly. The time of ripening varies according to locality, but is usually from April to June, or earlier. About 700 to 1050 seeds weigh 100 gm. or 6600 - 11,000 per Kg. They retain their vitality for some years if carefully stored. They are liable to beetle attacks even when still on the tree. Trees commence to bear fruits (pods) at about 5 to 7 years. Seeds can be collected in May-June.

**Artificial reproduction** : The choice between direct sowing and transplanting from the nursery is easily decided. Owing to the sensitiveness of the taproot, transplanting on a large scale is out of question for forestry purposes. Only when very small plants of the first season are transplanted early in the rains with great care, and watered in the dry weather, that slight success can be attained. On a large scale the cost of such operations would be prohibitive, considering the proportion of failure likely to be met with.

Direct sowing, however, is very successful, provided certain precautions are observed. The chief of these are as follows :

- (i) **Choice of site** : In arid climates, the formation of plantations is useless unless natural or artificial irrigation can be secured.
- (ii) **Treatment of soil** : Except in certain flooded riverain lands, thorough loosening of the soil and removal of matted grass roots are necessary for the success of babul sowings.
- (iii) **Preparation of seed** : Where possible seed collected from sheep and goat pans should be employed, as this germinates more quickly and gives a higher percentage of success. Failing this a common practice is to soak the seed in water or heap it up with moist cow-dung to stimulate germination.
- (iv) **Filling up vacancies** : This should be done at intervals of two weeks as a routine matter.

The results of broadcast, mound, patch and strip sowing are found to vary as under :

- (i) Broadcast sowings have usually proved a failure.
- (ii) Mound sowings, made in areas subject to floods or in swampy or water-logged situations, give good results. Low mounds 15 cm. high and 60 cm. in diameter, spaced 2.50 x 1.25 metres can be made for the purpose.
- (iii) Patch sowings can be made in blanks amongst young growth of babul or other species already on the ground. Patches 60 cm x 30 cm, dug and cleared of roots to a depth of 15 cm. and spaced 2.50 x 1.25 metres have given good results.
- (iv) Strip sowings, with strips 3 metres apart (made by means of three confluent plough furrows and each strip being about 75 cm. broad) have also given good results.

**Planting technique** - Seeds should be directly sown in the polythene bags or in the field, two seeds at one place during May-June. Transplanting naked seedlings should be avoided as the tap-root is sensitive.

**Rate of growth** : The Rate of growth varies considerably, but under favourable conditions it is rapid.



## 2. *Acacia auriculiformis* (Akashmoni)

A medium-sized, evergreen tree with drooping branches and *Eucalyptus*-like leaves (actually phyllodes) and a very graceful habit. Since it can be raised easily from seeds and is a good coppicer, it is recommended for raising in fuel plantations.

**Flowering and fruiting :** It bears thread-like tassels of yellow, sweet scented flowers during September-October. About 4230 seeds weigh per 100 gm.

Fruiting - December.

**Artificial reproduction :** It is easily raised from seed, which germinates readily. This procedure can be adopted provided sufficient seeds can be collected at a small cost. Vacancies must be filled up by the transplants in the same season. Seeds must be soaked in water for 24 to 36 hours before sowing in the field or the nursery. But for ensuring success and better growth, transplanting of nursery raised seedlings is always preferred. The optimum size of seedling for transplanting is 20 to 30 cm. but those of large size upto 75 cm. (i.e. of the previous years stock) can also be used, with most of the lower phyllodes removed. The tip of the taproot should be cut out with a sharp knife.

**Rate of growth :** Rate of growth is moderate.

## 3. *Acacia catechu* (Khair)

*Acacia catechu* is essentially a tree of comparatively dry regions. But it occurs on a variety of geological formations and soils. It undoubtedly thrives best on porous alluvium, composed of sand and shingle and on well-drained sandstone. It is known to occur on granite, gneiss, schist, quartzite, shale, basalt, trap, limestone, conglomerate and laterite. As regards soil it is common on sandy and gravelly alluvium, and on loam or gravel with varying proportions of sand and clay. It grows also on black cotton soil.

**Flowering and fruiting :** The pods develop rapidly, becoming full - sized by September or October, and they begin to ripe by the end of November and continue ripening during December and early January. The pods are dehiscent usually three to six-seeded. About 3200-3500 seeds weigh per 100 gm.

The seed can best be collected by stripping the pods off the trees in December or early January and spreading them in the sun for a few days. The seeds cling tenaciously to the pod valves, and in order to detach them it is necessary to heap the pods on a large cloth and beat them well with sticks, after which the seeds can be separated by shaking and winnowing in a flat basket.

The seed is badly subject to insect attacks. It is advisable, to sow the seed the year in which it is collected. The fertility of fresh undamaged seed is high (73%). The seed germinates readily with moderate rain and requires no special preparation to stimulate germination.

**Germination -** 70 to 75% germination starts in about a week and complete in 3 weeks.



- Extraction -** Pods should be spread in the sun for a few days. In order to detach seeds from the pod valves, it is necessary to spread the pods on tarpauline cloth and beat them with stick. Seeds can be separated by shaking and winnowing in basket.
- Storage -** One year seed is badly subject to insect attack. Sow the seed in the year in which it is collected, therefore, their storage is not recommended.
- Pretreatment -** Soak seed in cold water for 24 hours.
- Sowing -** May-June.
- Ploughing -** July.

Polythene containers are filled with mixture of sieved soil and compost in ratio of 2:1. Sowing is done in Feb-March. 2 seeds in each bag at a depth of 1.5 cm is recommended. Seedlings become fit for planting out in July when they attain a height of 20-30 cm.

**Artificial reproduction :** Transplanting cannot be relied on, but direct sowing, if carried out properly, is highly successful.

The success of direct sowings depends on : (1) the degree to which the soil is kept loose for the first two years or so after sowing; (2) thorough weeding; (3) abundance of light from the commencement. In addition, the thinning out of the young plants has a marked effect on their development. Irrigation undoubtedly stimulates the growth of the plants, but is not essential provided regular loosening of the soil is carried out. Resowing should be done in vacancies at an interval of two weeks as a routine matter.

**Rate of growth :** The Rate of growth is variable. The growth is quite slow in dry localities with a soil of sand and boulders, but it is rapid on better site.

#### 4. *Acacia leucophloea* (Reonza)

A moderate sized to large thorny deciduous tree, with a somewhat spreading crown and a trunk often crooked and gnarled.

**Flowering and fruiting :** The yellowish white flowers appear about April. The pods ripen from April to June. The pods are 10 to 20 seeded, and are scarcely dehiscent. About 700 seeds weigh per 100 gm. or 37,000 per Kg. Seeding age at 6 to 8 years. Seeds almost every year. Pods are plucked from trees. Seeds are extracted by beating up dry pods.

**Artificial reproduction :** Direct sowing is more successful than transplanting. Young seedlings are found to transplant fairly well early in the first rainy season; but the transplanting checks the growth. Line sowing found to be the most successful. Germination 60-85%.

**Storage -** It can be stored for one year. No pretreatment required.

**Rate of growth :** The tree is generally considered to be slow growing.

development should not be transplanted until the rains of the second season or even the third season in the case of backward plants.

**Rate of growth :** The Rate of growth is slow. Seed should be obtained from fruits collected from the trees and not from the ground.

**Storage -** Seed should be coated with red lead to keep off ants.

**Planting :** July (Third year)

### 9. *Ailanthus excelsa* (Maharukh)

**Flowering and fruiting :** The penicles of small yellowish flowers appear in February-March, and the fruits ripen in May-June. About 920 to 1050 seeds weigh per 100 gm. A considerable proportion of the seed loses its viability if kept for one year. The fruits are plucked and collected. The fruits are dried in sun, beaten and winnowed to separate the seeds. The seed loses viability quickly and can not be stored for use in the next year even in sealed containers.

Germination commences in about 10 to 12 days and completed in 50 days. Germination percent - 60-80%. Seedlings can be pricked out in containers also. Transplanting in field in second year only.

**Artificial reproduction :** Plants can be raised easily from seed, transplants or from cuttings. Large cuttings strike readily, and root-cuttings may also be used to produce shoots. For artificial propagation by seed a light porous soil is necessary. The seed should be sown in May or June in well-raised seed-beds in drills about 25 cm. apart, water being given regularly but sparingly, as the seedlings will not stand an excess of it. Under favourable conditions germination takes place 1-2 weeks after sowing. The seedlings will be ready to transplant during the rains of the second season.

**Rate of growth :** The rate of growth is rapid.

### 10. *Albizzia lebbek* (Kala Siris)

A moderate sized tree in dry zone, or large deciduous tree in the moist zone. It grows on a variety of soils and climates, the rainfall varying from 635 mm. to over 2540 mm. It prefers a good well drained loam, but it is not very exacting. It can grow fairly well on the laterite or black cotton soil, though it dislikes heavy clay. In Andamans it thrives on calcareous soil. It is fairly resistant to drought and frost. Seeding age early. Seeding annually.

**Flowering and fruiting :** The flowers, of a somewhat heavy fragrance, appear chiefly in April and May. The fruits develop rapidly, and by August some are nearly full-sized, begin to turn yellow in November, ripening soon on trees which have lost their leaves. By January - February the pods are all ripe and collected, dried, threshed and winnowed. Seeds are extracted from the pods by drying them in sun and then lightly beating them. The seed weight varies from 490 to 1230 (average 810) seed per 100 gm. i.e. average 8,000 per Kg. They can retain their viability well for at least one year. They are liable to damage by insects, both on the tree and on the



ground. Fresh seeds have a higher percentage (94%) of fertility than seeds that have been kept for some time. However, seeds kept for a year germinate more rapidly than fresh seeds.

**Artificial reproduction :** *Albizzia lebbek* can be grown by direct sowing and by transplanting or by stump planting from the nursery, but transplanting checks the growth to some extent. The seed may be sown without any pre-treatment in the nursery in March-April in drills not less than 25 cm. apart, the beds being watered regularly but moderately and kept well weeded. Germination commences after about 5 days and continues for a month. But soaking seeds in boiling water for 24 hours or for 48 hours in cold water increases germination percentage. The young plant will be ready to transplant early in the rainy season. Under favourable condition of soil, moisture and sunlight, seedlings grow very fast and attain a height of about 30 cms. by the commencement of the rains, when they are ready for planting out in the field. This method gives a survival of about 75%.

For stump planting, nursery seedlings are pricked out when about 8 cm. high. Stumps can be made when the plants are about 15 months old (the break of the second rains), consisting of 3.5 to 5 cms. shoot and 22 to 25 cm. of root, with a thickness of 8 to 18 mm. at the collar. Stump planting gives anything upto 100% success.

**Storage -** 4 to 5 years. Keeps well in gunny bags, provided pods are collected on trees as soon as they ripen. Seeds are subject to attack of insects if they remain for some time on the tree when ripe.

**Rate of growth :** Plants reach a height of 60 to 90 cm. by the end of first rains and a height of about 5 metres after 4 years.

### 11. *Albizzia procera* (Safed Siris)

A large tree with a long clean bole, often branching at a considerable height and forming a somewhat light crown. It prefers clayey soils.

**Flowering and fruiting :** Flowers appear from June to September. The pods soon commence forming, and in the cold season from October to February, they have a rich red colour. The pods ripen from February to May. About 1760-3000 seeds weigh per 100 gm.

**Artificial reproduction :** Transplanting can be carried out successfully in the rainy season. The seeds should be sown in nursery beds about March to May in drills about 25 cm. apart, the seeds being placed 10 cm. apart in the drills and lightly covered.

Direct sowing in line has proved more successful than transplanting, provided regular weeding and loosening of the soil is carried out.

*Albizzia procera* can be propagated quite successfully by using root and shoot cuttings (stumps) from one year old nursery stock. Stumps having one to two cm. diameter at the collar can also be used.

**Rate of growth :** The rate of growth is rapid.



## 12. *Alstonia scholaris* (Chhaturan)

A large evergreen tree with a tall stem, often fluted and buttressed, whorled branches, and dark green shiny leaves in whorls of 4 to 10. Scattered throughout the greater part of India, where the rainfall is over 1500 mm, preferring fairly moist situations. Not good in the dry regions.

**Flowering and fruiting** : Seeds ripen in the beginning of the monsoon. About 660 seeds weigh one gram.

**Artificial reproduction** : Seeds germinate easily in the nursery. One year old seedlings are transplanted with some of the lateral leaves stripped off with care.

**Rate of growth** : Moderate.

## 13. *Anacardium occidentale* (Kaju)

It thrives best on sandy soils. It is a good soil binder.

**Flowering and fruiting** : Flower appears from December to April and the fruits ripen from March to June.

**Artificial reproduction** : It is best propagated by seeds. Seeds should be soaked in water for 12 to 24 hours and sown directly, one to two seeds per stake, covered with about 2 1/2 cm. of soil. Seed weighs 200 in number per Kg. As the seed is expensive, only one seed per stake may be used. Germination 90-95%. Storage - One year.

**Rate of growth** : Fairly good.

## 14. *Anogeissus latifolia* (Dhaura)

A moderate sized to large deciduous tree with a somewhat feathery rounded crown and drooping branchlets.

**Flowering and fruiting** : Flower appears from June to September according to locality. The fruits ripen from December to March, fall soon after ripening, and may be found scattered over the ground from February-March onwards. As a rule the tree seeds abundantly every year, but the fertility of the seed is usually very poor. About 1060-1235 seeds weigh per 100 gm.

**Artificial reproduction** : It is rather a difficult species to raise artificially. The infertility of the seeds is a serious drawback to artificial reproduction. The best result appear to be obtainable after dry years when a fertile crop of seed is obtained. Under ordinary conditions the infertility of the seed would preclude any great success by direct sowings, though in years of fertile seed-production they should prove successful.

Seeds should be pre-germinated by soaking and baking in a shallow tray or sunken nursery beds with a light shed on top for two to three weeks in April-May. When about 5 percent of the seeds break-up, the seed should be sown in polythene bags 15 to 20 cm. long and 8 to 10 cm. in diameter placed in a sunken and shaded nursery beds. About 10 seeds should be sown per bag and covered by 6 mm. soil. The polythene bags should be watered twice daily till the seedlings are about 5 cm. high, when they will be transplanted in the field on a rainy day.

Successful germination is obtainable also by sowing the seed on well-irrigated raised beds, the soil being mixed with a large quantity of coarse sand and the seed being sown in June and lightly watered by hand every day. Germination commences after about twenty days. It is successful only where the beds are well shaded by a thick covering of leaves and branches some 45 cm. above the ground; under the shade a large mass of seedlings come up, whereas in beds exposed to the sun hardly any seed germinates.

**Rate of growth :** Moderate. Attends about 9-10 1/2 meters height in 16 years.

### 15. *Anona squamosa* (Sitaphal)

The species is suitable for covering denuded hills, stony areas and blanks. It is also found in granite gneiss formations with sandy and gravelly soils, as in Chhindwara district. In the Trappean area it is less common but comes up profusely with care and protection. In such areas bushes are cut down and used as fuel along with other bushy yield and hence the species has no chance of establishing itself and yielding fruits. The species is not browsed by cattle or goat and can therefore be tried on bare grounds, where the problem of grazing is acute. The best variety of fruit, famous for its largeness and sweetness of pulp with few seeds are from the Mahboobnagar District in Andhra Pradesh.

**Flowering and fruiting :** Fruits ripen in the cold season and come out in the market from the middle of October to end of January. There are 2750 seeds per Kg.

**Artificial reproduction :** The best results are obtained from direct sowing of ripe seeds *in Situ* in ploughed lines about 4 metres apart.

Experiments in grafting have not been carried out. Seedlings are also easily raised.

### 16. *Anthocephalus cadamba* (Kadamb)

A large deciduous tree with spreading branches. It is a tree of moist warm regions. It is a gem of a tree. It is fast growing and lends itself naturally to coppice method of reproduction, thus showing high promise for raising as plantations.

**Flowering and fruiting :** It flowers from April to June and the fruits ripen and fall in January-February. The fallen fruits should be collected early because seeds are relished by ants. Seeds are very minutely packed in capsules. About 17000 seeds weigh one gram. Extraction of seed requires special techniques. Essentially the technique involves maceration of the outer pulpy portion of the fruit which bears the seeds. Plenty of clear water is needed to separate effectively the seed from the pulp.

**Artificial reproduction :** The artificial raising of this species from seed is not difficult, but requires great care owing to the small size of the seeds and the seedlings and their liability to be washed away, or getting buried into the soil and to the sensitiveness of the seedlings to drought on one hand and excessive moisture on the other. Young plants should be raised in seed boxes kept under a shade. A germinating medium consisting of rich and mellow garden soil is desirable. It should be of similar texture as the seed and to obtain good aeration and drainage, the bottom



should be filled with gravel topped with a layer of fairly coarse top garden soil. Only sterilized soil should be used to obviate the ravages of damping off, to which the seedlings are very susceptible. Before sowing, the soil should be watered first by half-submerging the seed box containing the soil, and the water being allowed to rise by capillary action. Overhead watering used with a watering device turns the water in fine mist will also serve the purpose. Any of these methods will prevent the seeds from being buried deeply in the soil. Boiled or clean rain water should be used to ward off damping off. Finally, the seed box should be allowed to drain, after which it is ready for sowing. To obtain uniform sowing, the seeds should be mixed with washed sterile fine sand. After sowing, the seeds should be lightly covered with fine sterile soil or sand. Subsequent watering should be regulated in fine mist; otherwise the fine seeds will be buried in the soil. The seeds germinate into seedlings, 12-30 days after sowing. One and half month after germination they are ready for potting in 5 cm. x 15 cm. polythene bags. After a lapse of another 1 1/2 month the seedlings are ready for transplanting in the field. At this stage the seedlings are about 15 cms. in height and bear 6-8 leaves.

**Rate of growth :** Very fast growing. 9 metres height in five years and 17 metres in 9 years are on record.

### 17. *Artocarpus integrifolia* (Kathal)

A large evergreen tree with a short thick bole and a dense round crown of dark green foliage. The chief importance of the trees lies in its fruit, for which it is extensively cultivated.

**Flowering and fruiting :** The numerous yellowish green flowers, appear from December to March. Fruits ripen during the rainy season. The seeds quickly lose their viability. It has, therefore, to be sown immediately after collection in June-July. About 45 seeds weigh one Kg.

**Artificial reproduction :** Owing to its long and delicate taproot the seedlings does not bear transplanting well, and seed should therefore be sown *in situ* or seedlings should be raised in polythene bags. The seed should be sown preferably fresh at the commencement of the rains in June-July immediately after collection in polythene bags. Polythene plants should be watered regularly in dry weather and are ready to plant out at the beginning of the rainy season when one year old.

**Rate of growth :** The growth is slow at first, but later it is more rapid.

### 18. *Azadirachta indica* (Neem)

It will grow on most kinds of soil, does well on black cotton soil, and does not do badly even on clay. It thrives better than most other species on dry stony shallow soil with a waterless sub soil, or in places where there are seeds available annually hard calcareous or clay pan not far from the surface. It will not grow well on land liable to inundation.

**Storage -** Seeds viability falls down rapidly after two weeks, seed should be sown immediately.

**Presowing treatment -** None.



**Flowering and fruiting** : The panicles of small white flowers, smelling of honey, appear from March to May and the fruit ripens from June to August. The seed does not retain its viability long. 4,400 seeds weigh per Kg. Germination - 70-75%.

**Artificial reproduction** : Direct sowings have proved more successful than transplanting. Care is necessary in the collection of the seed. It should be collected from the trees about July when thoroughly ripe, and should be sown as soon after collection as possible. The seedlings will be fit to transplant during the first rains, when they are 8 to 10 cm. high, the taproot then being about 15 cm. long. Transplanting may be carried out successfully after pruning down the stem and roots; this system has been adopted successfully in the afforestation of Telankheri hill, Nagpur.

**Rate of growth** : The rate of development of young plants after the first season is fairly rapid. As a rule trees put on a mean annual girth increment of 2.5 cm. though more rapid growth is attained under favourable conditions.

**Extraction** - Easy as the pulp rots easily.

### 19. *Bauhinia purpurea* (Keolori)

The tree is characteristic of mixed deciduous forests often of a dry type, occurring on hill slopes, in valleys, and along streams. It is frequently cultivated for the sake of its handsome flowers.

**Flowering and fruiting** : It is a small tree. Flowers start appearing from September to December. They ripe from January to March. The seeds germinate readily and have a high percentage of fertility, which they retain unimpaired for at least one year. About 300 seeds weigh per 100 gm.

**Artificial reproduction** : Best results are attained by line sowings kept regularly weeded. Irrigation also has a marked effect on the growth. The seedlings are somewhat sensitive to transplanting, which have to be done with care. The seed should be sown in the nursery in April or May in drills 25 cm. apart, and covered to a depth of about 6 mm, regular watering and essentially weeding needed. The seedlings appear in about 4-10 days and can be transplanted while still of small size during the first rains. A certain amount of success has been attained by transplanting in the second rains as stumps. The stem and taproot are to be pruned down to 5 and 25 cm. respectively, but this checks the growth severely for a time.

**Rate of growth** : The growth rate is fast. Attains about 4.5 metres height in two years.

### 20. *Bauhinia variegata* (Kachnar)

It is essentially a tree of the mixed deciduous forests, often of a somewhat dry type, and occurs frequently on hilly ground. It is a moderate sized deciduous tree.

**Flowering and fruiting** : Flowers appear from February - April. The pods ripe in May and June. They germinate readily and show a high percentage of fertility, which is retained to some extent for at least a year. About 250 to 350 seeds weigh per 100 gm.

**Artificial reproduction :** The most successful means of raising the tree artificially is by sowing in lines, in which the soil has been well loosened, followed by regular weeding and subsequent loosening of the soil. Unless regular watering can be carried out, transplanting is difficult except in the case of small plants during the first rains.

Trees planted for ornamental purposes can be raised in polythene bags or in the nursery and kept for one year; but regular watering is necessary in the dry season following transplanting in the second rains. In this case either the seedlings should be pricked out in the nursery during the first rains or the drills should be at least 30 cm. apart, and the seedlings should be thinned out where necessary.

**Rate of growth :** As such the growth is fast but under less favourable conditions, it becomes considerably less.

### 21. *Bridelia retusa* (Kassai)

A moderate-sized or large deciduous tree. Wood used for house-posts, carts, cart-shafts and agricultural implements. The bark is used for tanning, and the leaves for cattle-fodder.

**Flowering and fruiting :** Flowers appear from May to August, sometimes later, and the fruits ripen in January-February. About 1590-1760 pyrenes weigh per 100 gm. Seeds show 75 percent fertility.

**Artificial reproduction :** Seedlings can be most successfully raised in the nursery if the beds are kept shaded from the sun in the heat of the day and regularly watered. The seed should be sown about March, and the seedlings can be transplanted without much difficulty during the first rainy season. Transplanting in the second rains requires more care owing to the length of the taproot. Direct sowing have not been tried.

**Rate of growth :** Fairly fast.

### 22. *Buchanania lanzan* (Char)

Silviculturally it is a useful tree for clothing dry hill-sides within its natural region. It is often found in abundance on clayey soil, but it avoids water-logged ground.

**Flowering and fruiting:** The pyramidal penicles of small greenish white flowers appear from January to March and the fruits ripen from April to June. About 350-450 stones weigh per 100 gm. Fresh seed has a fertility of about 70 percent. Those stored in air-tight tins for one year have a fertility of 50 percent. Seeds exposed to sun lose their viability.

**Artificial reproduction :** Care should be taken not to collect seeds which have lain on the ground exposed to the sun for any time, as these have a low percentage of fertility. Direct sowing is more successful than transplanting from nursery beds, and the latter is carried out during the first or the second rains.

**Rate of growth :** The rate of growth of seedling tree is slow. Coppice shoots grow about 3.90 metres in height in 10 years.



### 23. *Butea monosperma* (Palas)

The tree is very typical of open grass-lands, where it is frequently gregarious. It grows in water-logged situations, on black cotton soil, and even on saline soils. It is a characteristic tree of the plains, often forming pure patches in grazing grounds and other open places, escaping extermination owing to its immunity from grazing. It has a power of reproduction from seeds and root-suckers. Also, it has a peculiar power of recovery from the effects of constant lopping.

**Flowering and fruiting :** The blackish flower-buds appear on the bare branches in January and from the end of that month and through February and March the trees herald the hot weather by bursting forth in a blaze of scarlet blossom, presenting gorgeous sight which if once seen can never be forgotten. The tree is on this account appropriately termed the 'flame of the forest.' Flowering continues, according to locality, until the end of March or the end of April. Seasonal conditions influence the time of flowering to a considerable extent. It takes place earlier than usual in dry seasons.

The fruit forms very rapidly, the scarlet flowers quickly giving place to pale green flat pods. The pods ripen in May-June, and fall soon after ripening, being blown to some distance from the trees by the stiff breezes which are common at that time. The seed loses its viability within a year, but fresh seed has a very high germinative power.

**Artificial reproduction :-** Artificial reproduction may be effected successfully both by direct sowing and by transplanting from the nursery, though the former is undoubtedly the more successful and economical method. In forest operations the young plants suffer greatly from the attacks of pigs and porcupines and of rats on grass lands. In places where these animals are prevalent it is almost hopeless to attempt raising plantations of *Butea* unless some means of preventing their depredations can be applied.

**Direct Sowing :-** It can be raised with great success by line sowings. Weeding during the first year or two is essential to the proper development of the plants, while the thinning out of congested plants should be commenced if necessary, at the end of the first season and continued regularly. It is unnecessary to extract the seed from the pods, though the wing of the pod may be broken off if desired. The pods should be placed about 25-30 cm. apart along the lines and lightly covered with earth. One Kg. of pods will ordinarily suffice for 180 metres of line. The seed should be collected before the rains commence, either off the trees or from the ground and should be sown soon after collection. For ordinary afforestation a distance of about 3-4 metres between the lines will be found suitable. For lac cultivation, the trees require to be spaced more widely in order to induce full crowns, and a distance of 6 metres or more between lines will probably be found sufficient. In irrigated sowings, the most satisfactory method is to sow the seeds in the loose soil near the base of the ridge of earth, thrown up along side irrigation trenches, 30 cm. X 30 cm. in section, on the side facing the trench. For unirrigated line sowing the ground should be ploughed or hoed up to a width of about 30 cm, before sowing.

**Transplanting :-** Fair success can be attained by transplanting from the nursery during the first rainy season, particularly, if the stem is pruned down to about 5 cm. and the taproot to about 25 cm. Owing to the length of the taproot transplanting with unpruned stem and root is not,



only more difficult but less successful. Transplants tend to die back during the winter, whether pruning is done or not. In order to raise plants in the nursery the seed should be sown as soon as it is ripe, and as long before the beginning of the rains as possible, in order to obtain sufficiently large transplants before the rainy season is too far advanced. The pods should be placed about 10 cm. apart in shallow drills 25 cm. apart, and lightly covered with earth. Great care in the preparation of the seed-beds is unnecessary, since the young plants come up well under unfavourable conditions. Regular watering and weeding should be carried out after sowing. The seedlings usually commence to appear in one to two weeks.

**Rate of growth :-** Under favourable conditions seedlings and saplings grow rapidly and it is probable that tended plantations would show a very fair rate of growth for some years at least. In irrigated and unirrigated line sowings at Dehra Dun dominant plants seven years old had attained the following girths :-

	<u>Irrigated</u>	<u>Unirrigated</u>
Mean girth	40 cm.	33 cm.
Maximum girth	60 cm.	37 cm.

#### 24. *Carissa spinarum* (Karaunda)

It is an evergreen shrub. It springs up readily not only in open places but also as an undergrowth species, and is useful for clothing dry rocky grounds. It is the only species which survives heavy grazing and the trampling of the soil. Under natural conditions the seeds germinate during the rainy season. The seedlings have good power of penetrating grass and weed growth but succumb to excessive damp.

**Flowering and fruiting :-** Flowers appear in the hot season from April to June. They are extremely fragrant. The fruits ripen in the hot season.

**Artificial reproduction :-** It can be raised by direct sowing of seeds. The Rate of growth of seedlings is slow, about 5 to 8 cm. being attained in the first season, about 15 to 20 cm. in the second season and about 25-35 cm. in the third season. It is therefore desirable to transplant the seedling in the second rains.

**Rate of growth :-** Slow.

#### 25. *Cassia auriculata* (Tarwar)

It is an evergreen often gregarious shrub. The species can be grown in conjunction with other trees and is also a good soil binder. It is a useful plant for clothing dry bare rocky ground and poor shallow and eroded soils. Its multiple shoots can be cut on annual basis and bark of the shoots is rich in high quality tannin.

**Flowering and fruiting :-** The yellow flowers appear at various seasons, chiefly from October to May. The flowering and fruiting seasons overlap, and ripe fruits may be found for a considerable period of the year. Good Seeds have no difficulty in germinating, and the

percentage of fertility is fairly high. The plant begins to flower and fruit at an early age, usually when about a year old. About 3880 seeds weigh per 100 gm.

**Artificial reproduction** :- Planting on stiff, water-logged or alkaline soil and frosty localities should be avoided, care being taken to select places with soil which is light, and not too moist. The site should be an open one, trees and bushes being removed if they are present. Direct sowing has given much better results than transplanting and it has been found advantageous to plough up the land before sowing. The sowing may be done either broadcast or in lines. Lines 1 to 1.20 metres apart produce a dense crop.

**Rate of growth** :- About 1.20 to 1.50 metres height in two years.

## 26. *Cassia fistula* (Amaltas)

A moderate sized deciduous tree with a rather open crown. Wood hard and durable, in demand for house-posts, carts and agricultural implements. It is found on a variety of geological formations and well grown on poor shallow soil. In climate requirements it shows a wide range.

**Flowering and fruiting** :- The long pendulous racemes of large bright yellow flowers appear chiefly with the new leaves from April to June, but it is not uncommon to find the tree in flower even as late as September, particularly in dry years. Pods commence ripening in December and continue ripening from January till March or April. About 550 seeds weigh per 100 gm. Seeds retain their vitality unimpaired from at least two years. Seeds from pods one year old germinate more quickly than that from fresh pods, though the percentage of sound seeds with former may be low owing to insect attack.

**Artificial reproduction** :- The seeds germinate tardily, that kept for one year germinating more readily than fresh seeds. Fresh seeds require pre-treatment. Boiling of seeds in water for five minutes is said to give good results. The seeds should be sown in seed-beds in drills about 25 cm. apart in March or April and regularly watered. Germination ordinarily takes place early in the rains. Transplanting requires some care, but it can be carried out satisfactorily while the plants are still comparatively small during the first rains. Using polythene bag is the most satisfactory method, the seedlings being transferred in the polythene bag in the first rains and planted out in the second rains.

**Rate of growth** :- The Rate of growth is moderate only.

## 27. *Cassia javanica* (Java ki Rani)

It is a medium sized, quick growing tree, with a graceful spreading crown.

**Flowering and fruiting** :- The flowers are shaded rose coloured borne in clustered racemes during April-May, laterally covering the branches. Fruits ripen in the cold season.

**Artificial reproduction** :- The seeds germinate easily in this case. Transplants should be prepared on the lines given for *Cassia fistula*.

**Rate of growth** :- Fast.



## 28. *Cassia siamea* (Kassod tree)

A large, fast growing, evergreen tree with some what malshaped bole and very brittle branches. It thrives best on the moist soils, provided the drainage is good. Seeding at the age of 2-3 years, seeds every year.

**Flowering and fruiting** :- It is strikingly attractive during September-October with its bright yellow flowers borne in erect panicles. The pods ripen towards the end of the hot season. Seed ripening - November, Seed Wt. 35,000-37,000 per Kg. Germination - 75-80%.

**Presowing treatment** :- Scarification with concentrated Sulphuric acid for 10-30 minutes can give a germination of more than 90% within 6 days, soaking in water is advantageous to some extent.

**Artificial reproduction** :- It is very easily raised by direct sowing of seeds. Seedling raised in polythene bags can also be transplanted in the first rains. Larger plants can be transplanted as root-shoot cuttings in the second rains.

**Storage** :- It can be stored successfully for several years in dry conditions.

**Rate of growth** :- It grows fairly rapid.

## 29. *Casuarina equisetifolia* (Casurina)

A large evergreen tree with a straight stem and feathery foliage. It is used sometime for poles and rafters, but chiefly for fuel for which purpose it is excellent. The selection of proper site for raising such plantations in Madhya Pradesh is of utmost importance. Some indications are given hereafter.

Based on half a century of successful raising of *Casuarina* plantations in the plateaux round about Bangalore (elevation 900 metres and over), Dr. Kadambi has described the favourable ecological factors necessary for growing *Casuarina* plantations successfully inland and without watering as under :-

(i) **Rainfall** :- The Bangalore plateaux enjoys an average annual rainfall of 850 mm. (34 inches) which is well distributed in the year. This fact makes quantities of moisture available for the tree over the greater part of the year and thus enables the tree to tide over the dry hot months of February-March.

(ii) **Temperature** :- Where *Casuarina* plantations have been attempted, the temperature can be described as moderate with the result that the tree can continue its vegetative activity practically uninterrupted in all the season, except perhaps for a very short period in summer when the available moisture reaches the minimum. Normally the mercury does not rise even to 95°F and rarely sinks below 58°F, a temperature range which is very favourable to plant life. Even in the month of March, the relative humidity never sinks below 67% and in rainy months, namely August and September, it never rises above 89%.

(iii) **Edaphic factors** :- The soil round about Bangalore is conspicuous on account of its bright colour and can be described as loam to sandy loam containing sand in varying proportion



from 30 to 60 percent or more, clay from 0 to 20%, the remaining portion consisting of silt with a small proportion of organic matter. The bright red loam, which probably is lateritic in origin, has a high content of oxides of iron and aluminium and owing to the moderate rainfall there is not leaching of the silica and sesquioxides. The proportion of sand often varies within wide limits, but the sand is generally always of the fine variety which, mixed with loam has high water retaining capacity. The sub-soil water level is not generally at any great depth, but this does not play such an important part in the development of *Casuarina* plantations in the locality round about Bangalore. It is the moisture retained in the upper soil layers which plays the primary role. Fed by the well distributed rainfall of the year, the close textured loam, especially during the north-east monsoon rains of September to November, which bring in slow dripping rain lasted for several hours, absorbs adequate quantities of moisture and retains it throughout the hot season. The field moisture holding capacity of the soil, which is a measure of the amount of rain water retained by the soil after the excess of water has sunk by gravity to the sub-soil moisture level, has been found to be very favourable in the localities where *Casuarina* thrives best. The moisture retentivity of the soil is reduced with the increasing proportion of the sand and the decreasing proportion the red earth in it. In other words, with the increasing proportion of sand in the soil, a heavier rainfall will be required to prevent the *Casuarina* from dying of drought.

A detailed investigation of the soils in relation to large scale mortality of *Casuarina* has also been conducted by Dr. R.S. Gupta, Soil Chemist, F.R.I. Dehra Dun. His conclusions are summarised below :-

- (i) The main requirement for the healthy growth of *Casuarina* from the point of view of the soil are (i) an adequate supply of moisture (but not water logging), and (ii) an adequate supply of nutrients particularly Nitrogen, drawn either from natural humus or by fixation of atmospheric Nitrogen by the root nodules. These are particularly important in the initial stages of development of *Casuarina* plant, because they induce a good root development, which is necessary for the healthy and tall growth of the tree.
- (ii) As regards the suitability of soil for *Casuarina*, it is generally seen that a moisture retentive soil layer of a closure texture than sand, in the proximity of the water-table, with a sandy layer on top, is helpful to *Casuarina*. When reverse is the case, i.e., a coarse sandy layer occurs below the loamy top soil, in localities with low water table, there is inadequate ascent of moisture due to thick layer of intervening sand, leading to soil drought and consequent plant casualties. In the later case the plantation may keep on doing well during favourable monsoon but when there is a long stretch of year of drought due to failure of rains and the water-table goes down, there is a likely danger of large scale casualties in *Casuarina* plantations.
- (iii) Drought conditions could also be caused due to another sub-soil factor. It is seen in some areas specially in the sandy localities that the sub-soil layer is sometimes a very coarse grained sand, that is coarser than normal top sandy layer. Ascent of moisture is hard in such a layer of extra coarse sand soil and creates soil drought in the upper horizons, thus causing casualties. This top soil drought is also detrimental to the development of root nodules, which are of such vital importance in the sandy soils.

- (iv) Root nodules play an important role in the growth of *Casuarina* in sandy soils. These soils being poor in humus have to depend mainly on the fixation of atmospheric Nitrogen by root nodules as the only source of Nitrogen supply. For the healthy development of these nodules, the top layer of soil (nearly 6 cm.) in which they occur should not become dry. In comparison with sandy soils, however, for the alluvial loams and clay, the importance of root nodules is not so great because these are well supplied with humus from which the plants can draw their Nitrogen supply.
- (v) pH of soil does not appear to have correlation with *Casuarina* growth or casualties therein. One important point, however, is that *Casuarina* tolerates highly alkaline soil with pH as high as 9.9 to 9.5. This, combined with the acidic nature of its humus, has the power of neutralising alkalinity and can make it a suitable species of planting in alkaline and saline lands with a view to reclaiming them for cultivation.

**Flowering and fruiting** :- The tree ordinarily flowers twice a year, from February to April and in September-October, the fruit ripening in June and December. About 700 seeds weigh one gm. The seeds retain their vitality for a few months, and to some extent for a year. It is always desirable to use fresh seeds. They are very liable to the attack of ants, which carry them off in large quantities from the nursery beds.

**Artificial reproduction** :- The method almost universally adopted for establishing *Casuarina* plantations is to transplant seedlings raised in the nursery beds. The Bangalore method is described by Dr. K. Kadambi as under :-

The seed is sown broadcast in seed beds, rather densely, some time generally in December, and lightly covered with soil. The beds are watered daily until the plants are two to three months old. The plants are then removed and the main root is coiled upon itself into a loose loop and transplanted to separate beds at regular intervals generally about 5 cm. apart. They remain in these beds and are watered, as and when required, until they are ready to plant out. Owing to the coiling of the main root, the plants develop a bushy root system. The main root does not descend deep into the soil but remains twisted up and from its surface as well as from the region of the hypocotyl, a large number of adventitious roots spring up. The absorbing root surface is thus increased, but the penetration of the root to any depth is reduced. The advantages arising from this appear to be :-

- (i) that the main root system is not injured or cut while raising the plants from the nursery beds and during the planting operation.
- (ii) that the main root of *Casuarina* which generally grows down-wards into the soil, is induced to develop a more superficial habit. This is particularly useful to the tree, because the root system can spread out in the upper layers of the loam (say within a depth of 60-90 cm.), which has a fairly high field moisture capacity and can provide all the moisture which the root requires practically throughout the year. Not much depth of soil is found in the localities round about Bangalore, there being a layer of quartz or quartzite stones and granitic boulders underneath at no great depth which offers mechanical obstruction to the penetration of roots.



- (iii) that the development of the bacterial root nodules is facilitated by the development of superficial adventitious roots which have easy access to the air.

The plantation area is ploughed up once or twice so as to break up the surface soil and increase its moisture retentivity by holding to break the capillary rise of water. The planting spacing is generally 2 x 2 metre. The plants are transplanted into pits previously prepared, and often require to be supported for a year by stakes. After the seedlings have been transplanted from the nursery, they require to be watered at once. Regular watering is also necessary for one, two or three years after transplanting, according to the locality. Watering is done as far as possible in the evening.

**Rate of growth :** Very fast.

### 30. *Cedrela toona* (Tun)

A large deciduous tree with a spreading crown. The tree, owing to its rapid growth and the demand for its timber, deserves wider cultivation in localities suitable for it.

In Madhya Pradesh it is found in Balaghat, Mandla and Bilaspur along valleys. Generally speaking, in its wild state, it prefers moist localities, such as ravines, banks of streams, and even swamps, but if it is watered in its younger stage, it is capable of growing in comparatively dry climates and situations. For its best development, deep rich moist loamy soil is required. Actually however, it is cultivated in localities where the temperature reaches 120°F. and sinks below 30°F., where the rainfall may be as low as 750 mm. The root system is largely superfluous and the tree is thus harmful in the neighbourhood of field crops.

**Flowering & fruiting :** The flowers appear in February-March or April. The five valved capsules ripen in May and June and the winged seeds escape at different times from the end of May till July, covering the ground for some distance round the trees. In the early rains they are washed into heaps. The fruits should be collected from the trees in May when just ripe and about to open. The fruits are spread out in the sun for three or four days until they start opening. They are then broken by beating with sticks and the seeds separated by winnowing. One Kg. of fruits gives about 200 gm. of clean seeds. About 280 to 425 seeds weigh one gram. Seeds have fertility varying from 60 to 80 percent but seeds kept for one year fail to germinate. Tree usually bears fruits abundantly every year.

**Artificial reproduction :** By direct sowing, or broadcast, in lines or on ridges, are not to be relied upon owing to the loss occurred by the washing away of the light seed, even when covered with earth. Also occur the beating down or washing away of the young seedlings by the heavy monsoon rains. Thus, although surviving seedlings develop well if kept regularly weeded, the sowings invariably prove to be patchy and badly stocked. In west Bengal seeds are usually sown in May direct in hoed lines 1.8 metres apart or in patches at an spacing of 1.8 m. x 1.8 m. For line sowings 22 Kg. seeds are required per hectare. In U.P. the usual practice is to sow the seeds just before the break of rains in refilled trenches (30 cm. x 30 cm. to 60 cm. x 40 cm. in section; 3.7 to 4.6 m. apart), failures being beaten up with transplant or stumps. Some success has also noticed by direct sowings on lines cleared through the forest, and also in gaps of 9 to 12 metres square in which the ground well dug up and levelled where the seed was sown by broad-



casting; resulted into the seedlings come up plentifully enough to allow of excess plants which being transplanted into other parts of the forest.

The best results are, however, achieved by transplanting nursery raised seedlings in the second rains, after pruning down the stems and roots. For this purpose, seeds should be sown soon after collection in well-raised nursery beds, either by broadcast or in drills, lightly covered with fine earth. Regular watering is necessary, but great care is required to prevent the light seeds being washed away. A good plan is to cover the beds with a thin layer of grass and to water through a fine nozzle, the grass being removed as soon as the seedlings appear. In the first season, the young seedlings should be protected from the direct heat of the day unless the beds are shaded by trees. Regular weeding and loosening of the soil is essential. The seedlings require growing soon, and if at all congested should be pricked out about 15 cm. x 15 cm. or 20 cm. x 20 cm. when about 5-8 cm. high, during the first rains. Transplanting is done early in the second rains the stem being pruned down to about 8 cm. from ground level and the taproot being pruned down to about 25 cms. Stumps of 1.5 cm. to 2.5 cm. diameter give good results.

**Rate of growth :** The Rate of growth is rapid. Some specimen show just one ring per cm. of radius.

### 31. *Cieba pentandra* (Kapok tree)

A moderate size, soft wooded, deciduous tree with whorled horizontal branches and digitate leaves. Stems of young tree are armed with conical prickles.

**Flowering and fruiting :** It flowers in December-January and the fruits ripen in March-April. The fruits are collected when they are just begin to open, with the help of a long bamboo pole bearing a small hook at the upper end, the seeds and fibre are pricked out and then separated by beating.

**Artificial reproduction :** It can be propagated by seed or from cuttings. The seed is sown in the nursery in drills 25 to 30 cm. apart and lightly covered with earth. The seedling are shaded until about 12 to 15 cm. high and then exposed to the sun. Eight to twelve months old seedlings at a spacing of about 6 metres x 6 metres are recommended for plantation. Before transplanting it is advisable to strip off the leaves and prune the stem down to a height of 45 to 60 cm., and also to prune down the chief root to some extent. The trees begin to bear in the third or the fourth year, but some times not till later. A large crop is never obtained until the sixth year. A large tree produces 1000 to 1500 fruits per annum. Hence on an average a well-developed tree may be expected to produce an annual yield of 3/4 to 1 1/2 kilograms of clean fibre.

### 32. *Cleistanthus collinus* (Garari)

The tree is very hardy and survives fire and grazing better than almost any other species. It is seldom browsed, and is said to be poisonous, on which account it is often the commonest species on grazed areas.

**Flowering and fruiting** : The small greenish flowers appear with the new leaves in April-May, sometimes also in September and the fruits ripen following March-April. Fruits (capsules) are to be collected before dehiscence.

**Artificial reproduction** : Direct sowing of seeds gives satisfactory results. They need to be soaked in water for 24 hours before sowings.

**Rate of growth** : The rate of growth is quite fast, 1.35 metres height being attainable in two years.

### 33. *Colvillea racemosa* (Kilbili)

A moderate-sized, fast growing tree with a somewhat spreading crown. It thrives best in moist to moderately dry localities, preferring low lying shady situations.

**Flowering & fruiting** : The flower-buds appear during July-August to October in large drooping clusters. The fruit is a pod, two-halved and rounded in cross section.

**Artificial reproduction** : It is easily propagated from seeds which germinate readily. Transplants should be used for planting out in the field.

**Rate of growth** : Fast.

### 34. *Dalbergia latifolia* (Shisham)

In Madhya Pradesh, it is fairly wide distributed in mixed deciduous forests, though now very abundant. The tree grows on a variety of geological formations, including gneiss, trap, laterite, boulder deposits, and alluvial formations, but it requires good drainage, and reaches its best development where the soil is deep and moist particularly in the neighbourhood of perennial streams. It will grow fairly well on black cotton soil and also accomodates large dimensions.

**Flowering and fruiting** : The flowering season is variously recorded. Brandis (Northern and Central India) says April (with the new leaves); Bourdillon (Travancore) says January-February; Talbot says April-May (with the new leaves) in the drier parts of Bombay, but adds that in moist localities (Kanara) it does not flower regularly or abundantly, and as far as is known only in August; Haines (Central Provinces and Chhota Nagpur) says September, when in full leaf and Foulkes (Walayar Working Plan, South Malabar) gives the same month.

The pods ripen from December to April, according to locality, and hang some time on the tree, the majority falls on the beginning of the monsoon, thus escaping damaged from forest fires. Fresh seeds have high percentage of germination, though a considerable proportion of the seed lose its viability when kept for one year. Seeds of this species are difficult to procure as most of the trees in a given locality do not flower every year. About 2400 fruits weigh per 100 gm.

**Artificial reproduction** : The tree can be propagated artificially from cuttings put to early rains by planting root-suckers or sections of lateral root, or from seed by direct sowing or by transplanting from the nursery. It has generally been found that in dry situation drought is the chief danger to be feared. Fairly good results have been obtained in some localities, particularly in the moist ones, by sowing under partial shade in the forest on patches cleared and burnt. This



species would appear to be a suitable one for raising as an under-story in Teak plantations provided Teak is sufficiently thinned out.

Direct sowing is preferable than transplanting, the mortality may be considered in dry weather favours transplanting. In either case it is unnecessary to extract the seeds from the pods, though it is advisable to break the pods into sections, each containing one seed.

In order to raise plants for transplanting the seed should be sown in well-raised seed-beds of porous sandy loam in drills about 25 cm. apart. The sowing should be carried out in March or April, the beds being regularly watered, weeded and protected from the sun during the heat of the day. The seedlings may be planted out early in the first rains either with entire roots and stems or with stems pruned down to about 5 cm. and taproots to about 15 cms. Surplus seedlings if any, can be used next season, either as transplants or as stumps.

So far as direct sowing concerned, the great secret of success lies in regular weeding and loosening of the soil. In actual practice the best results obtained by line sowing. A spacing of about 3.5 metres between lines should be sufficient when well ploughed or hoed up to a width of about 45 cm. and the seed sown shortly before the commencement of the rains and lightly covered with earth. The pods should be broken up, soaked in water for 24 hours and sown direct, 10 cm. apart. Resowing may be done in blanks after three weeks, if weeds are available. Otherwise the blanks should be filled up with nursery raised seedlings with ball of earth. For every 30 metres of line 150 gm. of pods should suffice. Weeding and loosening of the soil should be commenced before the weeds become dense, as it has been found that the sudden removal of heavy growth from over the seedlings may cause them to die of drought. Direct sowing can be resorted to only when the seeds are in plenty.

**Rate of growth :** The Rate of growth is slow.

### 35. *Dalbergia sissoo* (Sissoo)

It is most typically found on alluvial ground in and along the beds of the streams and rivers, very often on sand or gravel along the banks of rivers or on islands, very often gregariously. It also springs up on land-slips.

Where fresh soil is exposed sissoo does not tolerate stiff clay, on which if the trees survive, they remain stunted. It prefers porous soil with adequate moisture. Irrigation promotes most rapid growth. The species can be grown closely round orchards as windbreak.

**Flowering and fruiting :** The young flower-buds appear with the new leaves, and the yellowish flowers, in axillary panicles of short racemes, appear in March or April. The young pods form very rapidly, and by July they are full-sized but remain unripe and turn yellowish green until November, then they commence to turn brown towards ripening at the end of that month and till December and early January. About 13,200 to 15,400 pods weigh one Kg.

**Artificial reproduction :** The sissoo can be grown from ordinary branch cuttings or from root sections or root suckers. Such methods, however, are not in general vogue, as the tree can be raised so easily from seed. Seeds are also available in plenty for line sowing. For line sowing a spacing of 3 to 4 metres between lines is sufficient, and one Kg. of sissoo pods should suffice

for 1,30 metres of line. The ground should be cleared and earth well loosened along the lines with a hoe or plough. The pods should be sown not long before the commencement of the rains. For infilling of blanks, seedlings or stumps should always be preferred to direct sowing.

For transplanting, the pods should be sown in drills in seed-beds of light soil thoroughly worked up, and lightly covered with earth. The sowing should be carried out well before the rains (March-April), and the beds should be regularly and copiously watered by hand or by irrigation; regular weeding and loosening of the soil is necessary. If small transplants are required, the drills should be 25 cm. apart, running across the beds. Transplanting with entire stems and roots is successful only with small plants early in the first rains, before the taproot reaches too great a length. Transplanting with pruned stems and roots has invariably given better results, not only as regards the percentage of success, but also as regards the vigour of the plants after transplanting. The stem should be pruned down to a height of about 5 cm. from ground level and the tap root to a length of about 15 cm. if transplanting is done in the first rains, or about 30 cm. if it is done in the second rains. For infilling of blanks, seedlings or stumps should always be preferred to direct sowing.

**Rate of growth** : Young plants attain rapid growth provided regular weeding and loosening of the soils is carried out.

### 36. *Delonix regia* (Gulmohar)

A medium sized, fast growing tree with an umbrella-like crown of finely-cut, bright-green foliage.

**Flowering and fruiting** : Flowers appear when the tree is completely leafless in April-May, covering the crown entirely with dazzling large flaming-red flowers. Fruits ripen through the rains, till winter, seeds can be collected during Nov.-Jan.

**Artificial reproduction** - It is usually grown from seed, which are somewhat obdurate to germinate. Seeds placed in boiling water and allowed to soak in it, as it cools, give the highest germination. Only those seeds whose testa gets swollen by this treatment should be used for sowing in the nursery beds and transplants prepared for raising in the field in the second rains.

### 37. *Diospyros melanoxylon* (Tendu)

A small to moderate-sized, occasionally large tree. This is one of the most characteristic tree of the dry mixed deciduous forests throughout India.

**Flowering and fruiting** : The flowers appear from April to June. The fruits mature in the following year from April to June. Seeds are easily extracted after removing the edible pulp from ripe fruits, dried for about a week in the sun. For getting one Kg. of air dry seed, 8 Kg. of freshly collected ripe fruits are required. About 90 to 140 seeds weigh per 100 gm. Fresh seeds have a high percentage of fertility. Those kept for one year decline in fertility by 40 to 90 percent.

**Artificial reproduction** : Transplanting from the nursery is attended with much risk owing to the large size of the taproot. Stump planting is not successful. The most successful method



would be to sow the seeds in long narrow polythene bags and to plant these out in the second rains. Sowing should be carried out about April-May, care being taken to cover the seeds with earth. Pure sand or sandy loam has been found to be a better germination medium than ordinary soil or clayey loam. The seedlings are sensitive to excessive moisture.

Direct sowing is usually preferable to transplanting. The best method is to sow seeds in lines and to keep the lines weeded during the first two or three years.

**Rate of growth** : The Rate of growth is slow.

### 38. *Eugenia Jambulana* (Jamun)

A large evergreen tree with a dense shady much-branched crown of shining dark green foliage and usually a rather crooked bole.

**Flowering and fruiting** : Flowers appear chiefly from March to May. The fruits ripen from June to August. The germinative power of fresh seed is high, but the seed very quickly loses its viability. The fruits fall as soon as they ripen. About 125 seeds weigh per 100 gm.

**Artificial reproduction** : Direct sowing is preferable to transplanting, usually a considerable proportion of failure during transplanting, occur inspite of precautions. Line sowing kept regularly weeded have proved to be most successful, but it is essential that the soil should be kept moist, where irrigation cannot be carried out. Shade is also necessary.

For transplanting purpose the greatest success is obtained by sowing in polythene bags, two or three seeds in each, and retaining the healthiest seedlings in each bag and planting them out in the second rains.

**Rate of growth** : The Rate of growth is rapid. The mean annual girth increment for eight years is 0.8 cm.

### 39. *Eucalyptus camaldulensis* (Murray Red Gum)

In Australia grows upto 20-50 metres in height and may reach 200 cm. in diameter. When isolated, the tree develops a globular crown. As a forest tree, the trunk may taper to a great height and the undergrowth remains relatively open.

This species is most wide-spread of all *Eucalyptus* in whole of Australia except Tasmania. It grows fairly well in areas receiving 750-1000 mm. of rains. In other localities, the species is restricted to sites where additional ground water is available to supplement the general low rainfall, e.g. along river water courses or flood plains. In most of the dry zone of its occurrence, the temperature of over 100° F is common. In Australia it does not appear to be restricted by edaphic conditions in any way. Extensive stands occur on clayey soils, which may be water logged for several months of the year and dry out with deep cracks, during the dry season. In dry regions, where the top soils at least are generally loose gravel and sand it grows well and it also grows on laterites as well as on calcareous soils. It gives best yield on deep sandy soils with some clay in various horizons, and with one horizon of clay concentration at a depth of 40 cm. to

100 cm. On shallow soils with higher clay content, the species will grow but its yield will be lower. On limestone, it tends to be chlorotic. The species is fairly resistant to cold.

The species is recommended to be raised throughout Madhya Pradesh on suitable sites possessing the aforesaid features. In essence, the species prefers silty soils of good depth, but will also grow on sandy or silty soils with permanent sub-soil moisture. It tolerates both the acid (5.5 pH) and alkaline (9.5 pH) reaction. In the Dry Zone of Madhya Pradesh, the species should be planted on deep soil and in the semi-moist and moist Zones, it can be planted on comparatively shallow soil. A clayey sub-soil is preferable in all cases.

**Flowering and fruiting** : Phenological studies of this species in Neapanagar plantations by the State Forest Research Institute, Jabalpur have shown that the flower buds start appearing from September. Flowering starts from November and the tree comes in full bloom in January. Fruits ripen during March-April and are fit for collection in April-June.

**Artificial reproduction** : It is best raised by transplanting seedlings. Nursery technique is given in Annex 1.

**Rate of growth** : Fast.

#### 40. *Eucalyptus citriodora* (Lemon scented spotted gum)

A tall, straight, clean-bole tree, attaining height of 20-40 metres and girth of 60-120 cm. The crown has sparse foliage. The species is usually excellent for poles.

In its native land i.e. Australia, the species grows in the following type of locality -

(i)	Mean annual rainfall	-	640 to 1020 mm
(ii)	No. of rainy days	-	60 to 110
(iii)	Temperature	-	Summer - 21 to 29.5°C - Winter - 9 to 22°C
(iv)	Frost	-	Nil
(v)	Altitude	-	15 metres
(vi)	Soil	-	An adaptable species which grows freely on gravelly, somewhat poor soils and pod soils of lateritic material. In plantations it succeeds on many-types of soil including grey and reddish soils and deep red loams. It will grow on hard gravelly clays and coarse soils, preferably with a well-drained slightly gravelly sub-soil.

Based on the above characteristics, this species recommended to be raised in whole of Madhya Pradesh except the Dry Zone. The soil should be fairly deep and areas affected by prolonged dry periods (like Chhattisgarh plains or areas abutting Berar plains) should be avoided. It can grow in almost any type of soil except clayey soil and black cotton soil. In lateritic loam and



black sandy loam, the growth is found to be rapid. The species is fairly delicate when raised in the nursery and is affected by even the slightest frost.

**Flowering and fruiting** : Seeds can be collected in April-May. There are about 1650 seeds per gram and the germination capacity is about 7 percent and plant percent is 6. One Kg. seed will yield about 9900 plants.

**Artificial reproduction** : It can be raised from seedlings. Detailed nursery technique is given in Annex I.

**Rate of growth** : Fast.

#### 41. *Eucalyptus globulus* (Blue Gum)

It thrives best in a moderately cool, moist equable climate on deep fertile soil with a rain fall of 1000 mm. and above. It can be grown on any type of soil but later on the tree dies back except the most favourable sites. It is moderately hardy to frost and cannot be grown in the coldest parts. In cooler regions, it should be grown on undulating topography. Elsewhere, it prefers moist valleys. It requires heavy soil or good quality loam with adequate but not excessive moisture. It fails on poor soils. Sub-soils may be clayey but should be moderately well drained. It does not withstand very severe drought particularly when planted in shallow soil. The species is resistant to wind break. Reproduction from coppice stools is usually very satisfactory.

**Flowering and fruiting** : About 11,000 seeds weigh 100 gm. Ripe seeds are collected about May. Fresh seeds give the highest percentage of fertility.

**Artificial reproduction** : The plantations can be raised by transplanting, the stock being raised in the nursery. Detailed nursery technique is given in Annex 1.

**Rate of growth** : Under favourable conditions it can grow very rapidly in height. During first few years a height of 3 metres per annum has been recorded.

#### 42. *Eucalyptus gomphocephala* (Tuart)

The tree attains 20-40 metres height and about 90-180 cm. diameter in Australia as well as in Mediterranean countries where it has been acclimatized. It is erect and sturdy tree with a fairly well developed crown. Hence it is recommended as a shade tree.

In its native land, i.e. Australia, the species thrives best in the following type of area -

(i)	Rainfall	-	Mean annual 760 to 1020 mm.
(ii)	No. of rainy days	-	100 to 140
(iii)	Temperature	-	Summer - 17 to 29° C Winter - 8.5 to 17.5° C
(iv)	Frost	-	Nil
(v)	Altitude	-	Low lying plains along the coast

This species was tried out in the Central Arid Zone Research Institute, Jodhpur. It showed quick promising growth, but unfortunately after two years of trials, the species showed certain symptoms of diseased conditions both in the nursery and the field. In the nursery, young seedlings of 30 to 45 cm. in height showed either black streaks at the collar region or these streaks were irregularly distributed all along the shoot during the month of July-August. The leaves became flacid, drooping and the affected seedlings succumbed. In the field, the trees showed incipient wilting in October-November. Wilting continued and leaves started drying from bottom to top and the trees died. The cause was suspected to be root fungus.

In the State, this species is recommended for initial trials in moist-localities, such as Amarkantak, Ambikapur, Jagdalpur, Pachmarhi. Sites should have fertile soils. Frost holes should be avoided. It grows well on calcareous soils also.

**Flowering and fruiting** : Ripe seeds can be collected in April-May.

**Artificial reproduction** : From seedlings to be raised in polythene bags in the nursery. Detailed nursery technique is given in Annex 1.

**Rate of growth** : Fast.

#### 43. *E.territicornis* or *Eucalyptus hybrid* (Forest Red Gum)

In Australia, the tree grows 30-45 metres in height and 90-150 cm. in diameter. It is chiefly used for heavy construction and also serves for mined timber, paving blocks and piles. The tree generally does not form dense forest. It has very distinctive occurrence on determined topographical positions. Climatic features in the natural range vary as under :

(i)	Rainfall	-	510 - 1520 mm.
(ii)	No. of rainy days	-	60 to 150
(iii)	Temperature	-	Summer - 19 to 31°C Winter - 6 to 22°C
(iv)	Frost	-	Nil
(v)	Altitude	-	Upto 1800 metres
(vi)	Soil	-	The species generally prefers fairly rich alluvial soils, sandy loams and moist but not water-logged gravelly terraces. It will grow on a fairly wide range of better quality soils, but does not like those of arid type. The species does not like dry shallow soils.

As far as Madhya Pradesh is concerned this species has been raised extensively in large scale plantations in Napa, Shahdol, Bilaspur and Jagdalpur, with quite variable results. In cooler and drier areas, the species prefers alluvial flats with some flooding but not regular seasonal inundation. In dry inland areas it grows on hill slopes (upto 1800 metres). It requires fairly rich alluvial soils, sandy loams etc., which should be moist, but not water-logged. Acidic soils should



be avoided. Dry shallow soils are also not preferred. Hence this species should be tried only in moist and semi-moist zone of Madhya Pradesh, areas containing soils derived from sandstones should be excluded.

**Flowering and fruiting** : Phenological observations at State Forest Research Institute, Jabalpur have shown that the tree is in full bloom during November - December and fruits ripe for collection in April-May.

**Artificial reproduction** - The species is best raised by transplant seedlings. Detailed nursery technique is given in Annex I.

**Rate of growth** : Fast.

#### 44. *Ficus bengalensis* (Bar)

A very large evergreen tree. The tree is decidedly drought-hardy.

**Flowering and fruiting** : The fruits ripen chiefly from March to May, but they may often be found at other season of the year.

**Artificial reproduction** : The tree can be propagated from seed or from cuttings. The seed should be sown as soon as it ripens, preferably in pots or boxes of fine mould mixed with powdered brick or charcoal, and the young plants should be kept shaded during the heat of the day. Large cuttings 2.5 to 3 metre high should be planted from January to March and well watered until the rainy season, or if the watering cannot be carried out, they may be put down at the commencement of the rains, though this is usually less successful. Small cuttings put down in pots or polythene bags in March and well watered sometimes prove successful.

**Rate of growth** : The Rate of growth is fairly fast.

#### 45. *Ficus glomerata* (Gular)

A moderate size to large deciduous tree with a spreading crown. It is a common forest tree, of moist localities along the banks of streams, the sides of ravines and similar places. It may also be found, sometimes almost gregariously, on rocky hill slopes.

**Flowering and fruiting** : The fruits ripen chiefly from March to July. They are edible, but are usually too full of insects to be agreeable.

**Artificial reproduction** : It can be raised directly by seed or as transplant raised in polythene bags in the first rains.

**Rate of growth** : Slow to moderate.

#### 46. *Gmelina arborea* (Sewan)

A moderate sized to large deciduous tree. Its choice of locality is wide, but it shows a preference for moist fertile valleys. It does not thrive where the drainage is bad. On dry sandy or

otherwise poor soil it remains stunted. It is apt to assume little more than a shrubby form owing to its being repeatedly killed back by drought.

**Flowering and fruiting** : Flowers appear from February to April, when the tree is more or less leafless. The fruits ripen from the end of April to July. The germinative power of fresh seed is high, but when stored for a year, a considerable proportion of the seed loses its viability. About 140 seeds weigh per 100 gm. It has been calculated for the International Provenance Trials of this species that one Kg. of cleaned assorted stones (cleaned fruits) can normally be expected per tree in the natural stand.

**Artificial reproduction** : The tree can be raised easily either by transplanting or by direct sowing in the nursery.

For transplanting purpose the fruit-stones should be sown in drills in the nursery as soon as the fruit ripens, as a rule shortly before the rainy season commences. No shading is necessary, but the beds should be regularly watered and weeded. The seedlings ordinarily begin to appear in about two to three weeks.

Transplanting may be carried out in the first or in the second rainy season. If the plants are to be kept for a year in the nursery, they should be pricked out and separated to about 25 cm. apart in the first rain. In the next rainy season they should be planted out with the stem pruned down to about 5 cm. from ground-level, and the root trimmed to a length of about 30 cm.

Plantation of this species should never be made except on fertile soil in a climate at least moderately damp.

**Rate of growth** : The growth is fast.

#### 47. *Grevillea robusta* (Silver oak)

A moderate sized evergreen tree with a long conical crown, a definite leader, and deeply pinnatifid leaves. It grows very rapidly, and is a graceful tree upto an age of about fifteen to twenty years, after which it often becomes ragged and unsightly.

**Flowering and fruiting** : The trees flower from March to May, when masses of golden-yellow flowers cover the branches in flat horizontal tiers. The fruit is a small 1 or 2 seeded follicle; about 1060 seeds weigh per 100 gm. Fruits ripen between September-November.

**Artificial reproduction** : It is easily raised in the nursery, standing transplanting well in the first rains.

**Rate of growth** : Fast

#### 48. *Hardwickia binata* (Anjan)

The dimensions of the tree vary greatly according to locality. On trap formations, characterised by a shallow and somewhat stiff soil, the tree rarely attains a height of 18 metres and often does not reach a height of more than 9-12 metres with a maximum girth of 90 cm. On deeper sandy soil overlying sandstone, conglomerate, quartzite, granite and schists, it may attain



a height of 24-30 metres and a girth of 2-3 metres with a clear cylindrical bole 12-15 metres in length. It is an excellent fodder tree, branches being lopped heavily for this purpose.

**Flowering and fruiting** : Yellowish green flowers appear from July to September, pods ripen in April or May. The seeds can not be store well. Fruits can be collected during May-June. Seed can be extracted by exposing the fruits to sun. Fresh ripe seed has a high percentage of fertility and germinates readily with moderate moisture. About 390 fruits weigh per 100 gm.

**Artificial reproduction** : It can be propagated artificially by direct sowing and also by transplanting, though it is generally agreed that the former is more successful.

Seeds should be soaked in cold water for 24 hours prior to sowing. Germination commences after about 22 days and continues upto 5 weeks. About 7.5 Kg. seeds will be required to get 1000 plants.

**Rate of growth** : Slow growing in the beginning and dying back annually in the hot weather, it eventually shoots up and will attain a height of 4.5 metres in 10 years.

#### 49. *Jacaranda mimosaeifolia* (Jacaranda)

A medium sized, fast growing tree. An ornamental tree in every sense.

**Flowering and fruiting** : Its violet-blue, bell-shaped flowers appear in large clusters during April-May. Seeds ripen in January-February.

**Artificial reproduction** : Seeds, which germinate readily, should be sown in polythene bags and transplanting carried out in the first rains.

**Rate of growth** : Fast.

#### 50. *Kigelia pinnata* (The Sausage Tree)

A large, handsome tree with a heavy, shining foliage. Essentially a shade tree.

**Flowering and fruiting** : The flowers are large, dark-maroon in colour, appearing in April on long pendulous panicles, later developing into gourd-like fruits, which ripen in October-November.

**Artificial reproduction** : It is very easily raised from seed which should be sown in nursery beds or polythene bags. As the seedling growth is very slow, it should be transplanted in the second rains.

**Rate of growth** : It is fairly fast growing under good soil conditions both in humid as well as dry areas.

#### 51. *Lagerstroemia parviflora* (Lendia)

A large tree but in poor localities a small deciduous tree. It is a par excellent tree for the production of poles. The tree is immune from damage by grazing and has good power of recovery from the effects of fire and mutilations. It occurs happily on loamy to clayey soil. As the

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species is easily raised from seeds and is also a good coppicer, it is preferred for fuel plantations also.

**Flowering and fruiting** : The flowers appear from April to June and the capsules ripen and open from December to February. The germinative power of the seed is frequently poor. Fertile seeds are not produced in abundance every year.

**Artificial reproduction** : It can be raised from seed as well as by transplanting. For its best development the young plants require a porous, well drained soil. They do not stand heavy shade or suppression from a dense growth of grass. Young seedlings are very frost-tender.

**Rate of growth** : The Rate of growth of seedling tree is rather slow. Germination 7% Germination starts after 10-15 days. Germination period 15 days.

## 52. *Lagerstroemia speciosa* (Jarul)

A large deciduous tree with a rounded crown and large handsome mauve flowers. Its growth is best on rich deep alluvial loam. On badly-drained swampy ground it is usually small and crooked.

**Flowering and fruiting** : The large terminal panicles of mauve flowers appear from April to June, at which time the trees are extremely handsome. The capsules ripen from November to January, according to locality, though they do not actually open and scatter the seeds for some little time. The seeds are often infertile. 1,60,000 seed weigh one Kg.

**Artificial reproduction** : Direct sowings are less suitable than transplanting in the nursery. The latter should be raised in the field in the second rains.

**Rate of growth** : Growth is somewhat slow.

## 53. *Lucaena leucocephala* (Su-Babool)

An unarmed evergreen small tree. It is essentially a fodder tree. The leaves are rich in protein (21%), forming an excellent fodder for the cattle. The tree can be lopped from the second year and yields about 250 quintals of fodder per year in two or three cuttings. Suitable for growing in areas with rainfall 500-1075 mm. and on well-drained loamy soil.

**Flowering and fruiting** : The plant flowers and fruits at a very early age, good seeds being produced by vigorous plants in the first or second year. Flowering takes place during May to August and fruits ripen during October-December. Seed Collection : December-January.

**Artificial reproduction** : Before sowing the seeds should be boiled in water for 2-3 minutes. Alternately seeds can be treated with Sulphuric Acid for 10 minutes and then washed thoroughly. The seed should be sown in polythene bags and the plants can be planted in the ensuing rainy season at a spacing of 4 metres if grown with grass or one metre if grown singly. Grass can be grown in the understory.

**Rate of growth** : The Rate of growth is fairly fast.



#### 54. *Madhuca indica* (Mahua)

A large deciduous tree, usually with a short bole, spreading branches and a large rounded crown. The tree is a characteristic of mixed deciduous forests, usually of a somewhat dry type.

**Flowering and fruiting** : Flowers appear from the end of February to April. They are collected in large quantities off the ground. The fruit ripens from June to August and falls at once to the ground. Fresh seed has a high percentage of fertility, but it quickly loses its viability if kept, and is much subject to insect and fungus attacks. About 440 seeds weigh one Kg. on average.

**Artificial reproduction** : The tree may be propagated either by direct sowing or by transplanting from the nursery. For forest purposes direct sowings in prepared lines or patches are preferable, as transplanting gives trouble and is attended with much risk owing to the long and rather delicate taproot developed by the seedling. In either case fresh seed should be sown about July-August, and care should be taken to cover it with earth to a depth of about 12 mm.

For transplanting purposes, it is preferable either to sow the seed direct in long polythene bags or to transplant the seedlings from nursery-beds into polythene bags, during the first rainy season a few weeks after germination. The transplants may be put out in the field early in the second rainy season. While they are in the nursery, watering should be somewhat sparingly carried out, and the soil should be kept loose.

**Rate of growth** : The growth of seedling is slow, growing about 65 cm. in first year, 30 cm. in second season. Subsequent growth is also slow.

#### 55. *Mangifera indica* (Am)

Mango is a large, evergreen tree 10-45 m. high, with a heavy, dome-shaped crown. It is a long lived tree. It is extensively cultivated throughout the greater part of India in orchards and home yards, along field bunds and roadside avenues, and occupies nearly 20 percent of the total area under fruit cultivation. As a forest tree, however, it is not of much importance, being now found in great abundance.

The mango thrives in a wide variety of soils. It prefers a deep fertile, moist, well-drained loam, attaining an immense size under optimum conditions. It also grows in rich clayey loam as well as on poor, sandy and gravelly soil, provided it is fairly deep and well-drained. It does not grow and fruit well if the sub-soil is rocky, calcareous or clayey. In the mountainous regions of western and southern India, trees growing in shallow soil, less than 90 cm. deep, remain stunted and are short-lived, while those planted in loamy, medium black soil, 1.5 metre or more deep, overlying a porous, murrum (disintegrating Trap rock) substratum give good results.

The cultivated varieties are known to thrive in humid as well as dry climates, but the yield is better in regions with a rainfall of 750-2,500 mm. in the months of June to September, followed by a dry-period of about 8 months.

**Flowering and fruiting** : Flowering takes place from February to April and the fruits ripen in June-July. Large crops of fruit are not produced every year, and in some localities they are

produced not more than once in four or five years. Most mango trees are biennial bearers, producing profuse blossoms and sparse vegetative growth in one year ('on' year), reverse being the case in the next year ('off' year). Various methods such as ringing, manuring, pruning, partial deflowering in the 'on' year are being tried to encourage trees to bear annually, but by and large, the problem of irregular or biennial bearing continues to pose a challenge to the horticulturist.

**Artificial reproduction** : Mango is easily propagated from seed, but this method is not satisfactory for establishing commercial orchards of choice varieties, since seedlings usually bear fruits which are inferior in quality to those of the parent. Further, seedling trees are slow to come into bearing. To obtain good quality fruit and early bearing, choice varieties are always propagated by layering or grafting. Inarching or simple approach grafting is the method commonly practised all over India. The root-stock is raised from seed selected for its vigour of growth. The seedlings, when a year old is grafted with a branch of the scion tree. The grafted seedlings are planted out during the rains. The best time for sowing is the commencement of the monsoon i.e. June or July. Soaking the seeds in cold water for 24 hours is found to increase the germinative power/capacity significantly. One year old potted seedlings are ready for grafting. About 2 years are required for preparing potted inarch grafts. Root grafting has also been successfully tried. Promising results have been obtained by budding, shield budding by the inverted 'T' method being the simplest and the most successful.

Planting distance, which varies according to the type grown, climatic and soil conditions, may be anything from 10 to 15 metres.

Mango is usually not grown in plantations for timber in forest tracts; but in view of its easy propagation, rapid growth and useful timber, such plantations may be found to be feasible in forest areas, young seedlings are liable to be damaged by wild pigs. In such cases, wire proof fencing is necessary. Experiments in Tamil Nadu indicate that while direct sowing gives 80% survival, planting out nursery raised plants give 93% survival. The fruits are obtained in April to July when ripe. The pulp would be removed from the stone and the latter sown as soon after collection as possible, as the seed quickly loses its viability. Nursery-raised plants can be planted out without much difficulty during the first rains, provided this is done fairly early, before the taproot has developed to any great extent. It is preferable, however, to raise the seedlings in bamboo baskets or pots. During the first two or three years, it is advisable to protect the young plants from frost and sun and also, to water them in dry weather.

In Uttar Pradesh, the common practice for raising large sized planting stock for roadside avenues is to prick out the seedlings at least twice in the nursery (spacing them 23 x 23 cm. to 46 x 46 cm.) during successive rains. The transplants are then removed from the nursery beds with a ball of earth and wrapped with munj grass to hold the soil around the roots intact, at the break of early monsoon shower in June. These are kept in shade in the nursery for at least a fortnight and watered regularly before they are planted out in pits, previously dug, after the regular rains have set in. The planting stock is at least 1.3 metres in height, though plants 2 to 3 metres are preferred. These plants are watered regularly during the dry season, as and when necessary (about twice a month), during the first year. During the cold weather, the plants are protected with munj grass cover against frost till such time as they grow to a height beyond the danger of frost.



Mango is suitable for afforestation in low lands. It is suitable for planting along roads, canals, waste lands adjoining groves, railway strips and yards, village common lands, etc. It forms a good shady avenue.

**Rate of growth** : Mango is a fast growing tree.

### 56. *Melia azadirach* (Bakain)

A moderate sized deciduous tree with a short bole and spreading crown.

**Flowering and fruiting** : The handsome panicles of lilac flowers appear from March to May. The fruits ripen in the cold season, but remain on the tree in yellow clusters during the flowering season, and some may be still on the trees in July. The fruits may be most conveniently collected in January-February when the trees are leafless. About 140 fruits weigh per 100 gm.

**Artificial reproduction** : Artificial propagation may be carried out by direct sowings or by transplanting seedlings in the nursery. The tree can also be grown from cuttings or from transplanted root-suckers.

For raising plants in the nursery the fruits should be sown about 5-8 cm. apart in drills from February to April or May and lightly covered with earth. Transplanting may be done in the first rains, when the seedlings are a few inches high. For transplanting, seedlings should be 10-15 cm. high. It is advisable to transplant with earth round the roots.

Transplanting may also be done during the second rains by preparing stumps. By this time the seedlings are often as much as 1.5 to 2.5 metres high or more. In this case the stem should be cut off at about 10 cm. from ground level and the long taproot pruned down to about 25 cm. in length. The plant stand this treatment well, and quickly start shooting up again. If kept until the second year in the seed-beds, the seedlings will require thinning out in order to produce vigorous plants.

If direct sowings are carried out, rapid development can be stimulated by thorough and regular weeding.

**Rate of growth** :- The Rate of growth during the sapling stage is very rapid. It slows down before large dimensions are attained and trees of large girth are often hollow.

### 57. *Mimusops elengii* (Molsari)

A large evergreen tree with a dense crown of shiny coriaceous leaves with undulate margins. The tree is largely cultivated in India for ornamental and for the sake of its fragrant flowers.

**Flowering and fruiting** : Flowers appear from February to April. Fruits ripen the following year from February to June or later. About 175-210 seeds weigh per 100 gms. The seeds do not retain their viability long.

**Artificial reproduction** : The best method of propagating the tree is to sow the seeds singly in polythene bags and plant these out bodily when the seedlings are large enough, that is usually two years after sowing in the rainy season.

**Rate of growth** : Rather slow growing.

#### 58. *Mimusops hexandra* (Khirni)

A large handsome tree with a spreading crown and straight massive bole. The fruits are sweet and edible, and are largely collected for food. It is one of the most characteristic and important tree of the dry zone.

**Flowering and fruiting** : Flowers appear from November to January and the fruits ripen from April to July.

**Artificial reproduction** : It is best raised by transplanting seedlings from the nursery in the first rains or after a year.

**Rate of growth** : Slow grown tree.

#### 59. *Moringa pterygosperma* (Munga)

A small to moderate size tree. The wood is soft and useless, but the fruit is used as vegetable and the branches are much lopped for fodder.

**Flowering and fruiting** : The fragrant handsome white flowers, in numerous penicles near the ends of the branches, appear from January to March, and fruits ripen from April to June.

**Artificial reproduction** : The trees can be raised either from seed or from large cuttings, the latter striking well if watered sufficiently. It coppices and pollards vigourously.

**Rate of growth** : The growth is quite fast.

#### 60. *Morus alba* (Shahtoot)

A moderate sized deciduous tree. This is the chief mulberry used for silkworm rearing.

**Flowering and fruiting** : Flowers appear from January onwards and fruits ripen in April-May. Ripe fruits so collected are allowed to dry. They are then beaten with sticks for extracting the seeds. The extracted seeds should be spread out atonce to dry in the shade. Seeds can also be extracted by washing out the pulpy fruit and on decantation of water the seeds settle down and can be collected.

**Artificial reproduction** : The tree is very easily raised from direct sowing of seeds. For this purpose, the seed should be sown in June *in situ*. In this case irrigated line sowings are to be recommended, if the locality is dry.

For transplanting purposes seedlings should be raised in seed boxes under shade or in well-raised beds shaded from the sun and protected from drip during heavy rain. The seeds and seedlings are subject to insect attacks, and it is therefore sometimes the practice to soak the



seeds in water mixed with camphor, and to sprinkle the seed-beds with a mixture of lime, ashes, and a small quantity of white arsenic. The seeds should be sown in June, picked out about 45 cm. apart in the nursery when about 10-15 cm. high and finally transplanted either when the monsoon has completely set in as transplant or in the following rainy season as stump. Before transplanting the lower branches should be pruned off and the upper branches stripped off all but one or two terminal leaves. In the early stage some sort of shade is beneficial for its establishment, particularly in arid areas with high summer temperatures, but the advantage of shade is not perceptible after the seedlings have established.

Superior cultivated varieties of mulberry may be budded on to seedlings of the common variety. Budding is carried out towards the end of the cold season on nursery raised seedlings, one or two years old, cut off at about 30 cm. from ground level.

It can be raised by stump planting also prepared from one year old seedlings, shoot being pruned to 5 cm. and root to 25 cm.

The species can be raised from cuttings also. Mature shoots not thicker than a man's thumb are cut into lengths of about 25 cm. and planted in clumps of six or seven, the clumps being 45 to 70 cm. apart in lines. The cuttings, planted about 3-5 cm. apart in each clump are inserted slanting, at an angle of about 60°, and buried except for about 2.5 to 5 cm. or in dry soils completely buried. The ground is well dug, repeatedly ploughed for some months prior to the planting of the cuttings. The planting is carried out in September-October after the rains are over in dry soils and in January-February in moist soils. After the cuttings sprout, the ground is hoed up, care being taken not to shake or loosen the cuttings. About 2 to 3 months after planting, when the shoots ought to be about 50-75 cm. high, they are cut down almost to the ground level, and ploughing is then done between the lines. The leaves from this first crop are considered bad for silk-worms and are generally used as cattle fodder. All subsequent crops are used for rearing silk-worms. As a rule, four crops of leaves are obtained, in November, March, June or July and August. If irrigation is carried out, two extra crops, in January and May, are obtained. The shoots are cut back to ground level annually in August or September. Intensive earthing, manuring tillage is carried out. The earthing consists of annually spreading in April or May fresh earth dug up from tanks or trenches. At the same time ground is well manured. A thorough digging is carried out in January and ploughing or superficial digging is carried out in May, after manuring, September and November. Weeding is done during the rainy season. From two years after the plantation is formed, a regular yield of 28000 Kg. of leaves per hectare per annum should be obtained, from which 545 Kg. of Cocoons can be reared.

**Rate of growth :** The growth is rapid for the first six years, after which it is somewhat slower.

### 61. *Morus indica* (Indian Mulberry, Tut)

A moderate sized deciduous tree. It closely resembles *Morus alba* and is sometimes regarded as a mere variety. It is drought hardy recommended for wind breaks and shelter belts.

**Flowering and fruiting :** The fruits ripen in April-May.

**Artificial propagation :** This species may be raised from seed and cuttings in the manner described for *Morus alba*.

**Rate of growth :** Moderate.

#### 62. *Murraya paniculata* (Madhu-Kamini)

It is a very small evergreen tree with a very compact crown of handsome foliage and extremely sweet scented flowers like those of orange.

**Flowering and fruiting :** This species in flowers during April-May. Fruits ripen during December-January when they become red.

**Artificial reproduction :** It can be raised from cuttings and also by transplanting. Seeds should be sown in the same year of collection.

**Rate of growth :** Moderate.

#### 63. *Parkia biglandulosa*(Parkia)

A tall, graceful, nearly evergreen tree with an elegant, feathery foliage. It prefers fairly moist soils.

**Flowering and fruiting :** Seeds ripen in May.

**Artificial reproduction :** Seeds germinate readily. Seeds of it should be sown in polythene bags or nursery beds and seedlings then be transplanted in the first rains.

**Rate of growth :** Fast.

#### 64. *Parkinsonia aculeata* (Vilayati Babul)

A small, evergreen, fast growing, thorny tree, grow even in the driest localities. It is a good hedge plant.

**Flowering and fruiting :** It bears numerous bright yellow flowers in loose racemes chiefly in March-April and also at other times of the year May-June.

**Artificial reproduction :** Seeds germinate readily. Seeds should be sown directly. The tree can also be propagated easily from cuttings.

**Rate of growth :** Fast.

#### 65. *Peltophorum ferrugineum* (Peltophorum)

It is moderate-sized evergreen tree, giving excellent shade.

**Flowering and fruiting :** It is very attractive when its rusty yellow flowers appear in erect panicles during October. Seeds can be collected during February-April.



**Artificial reproduction** : Seeds should be sown in nursery beds in March-April. Seedlings can be transplanted with ball of earth in the first rains.

**Rate of growth** : Fast.

#### 66. *Phyllanthus emblica* (Aonla)

A moderate sized deciduous tree with feathery light green foliage.

**Flowering and fruiting** : The minute yellowish flowers, densely fascicled in the axils of the young leaves, appear from March to May and are visited by swarms of bees. The fruits ripen from November to February or sometimes later. The seeds may be extracted by placing the ripe fruits in the sun until the hard putamen dehisces and the seeds escape. Percentage of fertility is comparatively low, and the seed does not retain its viability long. Seed kept for a year fail to germinate. About 50,000 seeds weigh per Kg.

**Artificial reproduction** : Seedlings are raised successfully by sowing the seed in the nursery about March, watering regularly but sparingly essential. In the first few months seedlings are somewhat delicate. They are sensitive to drought and are apt to be washed away or beaten by rains. They are also subject to attack by insects, rats and squirrels. Protection of the seedling for the first few months from the sun and from heavy rains and insects etc., is essential. If the beds are regularly weeded, the seedlings should be large enough to plant out in the first rainy season. The seedlings are somewhat sensitive to transplanting.

Direct sowing has been tried on a small scale, but owing to the infertility of the seed, gaps are apt to be frequent. The best results can be obtained by sowing at the commencement of the rainy season and subsequently weeding regularly.

**Rate of growth** : The growth of young plants is fairly rapid, but subsequent growth appears to be somewhat slow.

#### 57. *Pithecollobium dulce* (Vilayati Imli)

A moderate sized evergreen tree with stipular spines in pairs. A native of Mexico but commonly cultivated in India. In Madras, it has been planted on pure sand with *Casuarina* plantations as a safeguard against fungus disease in *Casuarina*.

**Flowering and fruiting** : Flowers appear in January-February and the pods ripen from April to June. About 7000 seeds weigh per Kg.

**Artificial reproduction** : It can be grown easily by direct sowing of seeds. For hedges it is usual to sow the seed on site and to trim the plants.

**Rate of growth** : The growth is fast.

#### 68. *Polyalthea longifolia* (Pseudo-Ashok)

An evergreen medium sized tree.

**Flowering and fruiting** : Seeds ripen in July-August and do not retain their germinative power long. The seeds have short viability.

**Artificial reproduction** : The seeds are required to be sown as soon as possible after ripening. Plants do not stand transplanting well, and to ensure the best results, the seeds should be sown on site or raised in polythene bags and transplanted in the second rains.

**Rate of growth** : Somewhat slow growing.

### 69. *Pongamia pinnata* (Karanj)

It is not exacting as to locality. It grows best, however, in fairly moist situations, on porous well-drained soil, thriving even on pure sand. It will also grow on black cotton soil. It is primarily used as fuel. Locally the wood is used for oil mills, solid cart wheels, agricultural and house-hold implements. The foliage is eaten by cattle and readily by goats.

**Flowering and fruiting** : The racemes of lilac flowers appear from April to June. The pods ripen from March to May in the following year. The percentage of fertility is high, and the seed retains its viability at least a year, if carefully stored. The trees bear fruits in sufficient quantities every year. The dry fruits weigh 46-53 per 100 gm. and dry seeds 81-148 per 100 gm. About one Kg. of seeds is required to yield 1000 plants.

**Artificial reproduction** : The tree is easily raised from seed or from cuttings. The seed may be sown in the nursery when it ripens about April to May. Germination commences after about 10 days and is practically complete in about a month's time. The seedlings attain a height of 60 cm. upto the rains of the second year. Seedlings can then be transplanted, otherwise, root-shoot cuttings are convenient for large scale work. Stumps 1-2 cm. in diameter at collar give best results. Young plants need protection on against weeds for the first 2-3 years. As avenue tree *Pongamia* tends to branch early and needs pruning to get a proper bole.

**Rate of growth** : The Rate of growth is fast.

### 70. *Prosopis juliflora* (Vilayati babul)

It is a moderate sized, deciduous thorny tree. The species is very drought resistant as it does well in dry sandy areas and tracts of low rainfall. It does not thrive in damp localities. It is a good fuel. The timber is also used for agricultural implements. It has been successfully planted to check the sand drifts. But this species should not be planted in association with the agricultural crops as it tends to invade agricultural fields.

**Flowering and fruiting** : The fruits ripen in May-June. The pods can be collected by shaking the branches or by lopping off the branches. About 206 to 413 pods or 30,718 seeds weigh one Kg. There are different ways of extracting the seeds from pods as under :

- (i) The pods are avidly eaten by donkey and these animals can be mobilized into seed collection.
- (ii) Seeds can be extracted by putting dried pods inside a bag and beating them.



- (iii) The seeds can be extracted by soaking the pods in concentrated Sulphuric Acid or dilute solutions of Sodium hydroxide for a period of thirty minutes and later washing them in tap water between two folds of a coarse cloth.
- (iv) Water soaking for 72 hours can also give clean seeds, but addition of a small quantity of Sodium hydroxide expedites the operation, within 15 to 20 minutes only.

**Artificial reproduction** : The species can easily be raised by direct sowing. Pot plants have also given the success. Seedlings can be raised in the nursery beds. Germination commences after 5 to 21 days. When seedlings are 8-10 cm. high, they should be transplanted in polythene bags and planted out with the early rains in the same year. Direct transplants and stumps do not do well.

**Rate of growth** : The Rate of growth is moderate. Plant start fruiting in 2-3 years.

### 71. *Prosopis spicigera*

A moderate sized thorny tree, evergreen or nearly so. The tree occurs in the dry and arid regions of India. Although the seedlings are sensitive to frost and drought, the older plants are very drought resistant. A most important characteristic of the tree is that it develops an extremely long tap root. This enables it to retain possession of the ground in the dry regions, which it inhibits, by obtaining its water supply from down in the subsoil. The tree reproduces freely by root suckers. It is a good species to be raised on bunds in association with the agricultural crops.

**Flowering and fruiting** : Flowers appear from March to May after the new leaves. The pods ripen from June to August.

The ripe yellow pods can be collected either by shaking the pod bearing branches with long hooked sticks or by hand plucking. These should then be fed to penned cattle (Bovine, goats, and sheep), the dung and droppings where of should be spread out to dry. It is important that all cattle fed on these pods should be confined to a restricted area in order to collect every grain of seed and the pan floor be dressed smooth and swept clean like a threshing floor. The dry dung and dropping should then be thrashed with three feed wooden beaters and the seed winnowed. The seed should then be filled in gunny bags and stored in some cool dry place, raised by a few inches from the floor.

The seed retains its viability upto the next monsoon or one year. About 11-19 Kg. seeds will be required for broadcasting per hectare and 3.5-4.5 Kg. for other methods.

**Artificial reproduction** : The following methods are in vogue and any one or a suitable combination of two or more methods is employed in one and the same area :

- (i) **Broadcasting** : This should be so regulated as to obtain an espacement of approximately 1.5 metres in the resultant seedlings. The operation should be completed at least a fortnight before the expected break of the monsoon so as to enable the wind-brown soil to cover the weed to a depth of about 2.5 mm. The date of commencement of this operation will, naturally, vary later in loose soils subject to shifting.

- (ii) **Dibbling** : This consists of digging pits with a spade, about 30 cm. diameter and 60-90 cm. deep, the soil of the pits being broken loose. Three grains of seed should then be thrown into each pit and lightly covered with loosened soil. The pits should be approximately 1.5 metres apart. This method is economical on seed but is slower and more costly in labour. It is, consequently, advocated for adoption in filling up of small blank patches or failures in other cheaper methods like (i) above.
- (iii) **Patches** - This consists of sowing seeds in selected patches in blanks, grassy weed areas by any one or combination of the method described above.
- (iv) **Strips** - This method is suitable for such land as contain rank growth of grasses or other abnoxious growth. Parallel strips 60-120 cm. wide and 6-12 metres apart, running at right angles to the direction of the prevailing breeze, should be cleared of all undesirable growth and seeds should sown broadcast or dibbled in furrows.
- (v) **Trenches** - This method is applicable to lands under canal irrigation.

In all the methods of sowing an initial espacement of 1.5-1.8 metres is adopted. This is increased to 4.5-6 metres at the time of felling of the coupe.

All sowing operation should be so timed as to complete them some days before the first fall of the monsoon in order to take advantage of every drop of rain-water.

*Prosopis* seed starts germinating a week after sowing and continuous for another week or so.

**Rate of growth** :- Seedlings attain a height of 15-20 cm. in the first season. In 30 years the trees grow 6 to 11 metres in height. Annual rate of diameter growth during the first 5-6 years is 12 to 24 mm. later on the rate of diameter growth declines. Ultimately an average girth of 75 cm. is attained in 30 years.

## 72. *Pterospermum acerifolium* (Kanak Champa)

It is a medium sized, evergreen tree with disc-like leaves which are velvety below.

**Flowering & fruiting** :- It bears large, white, delicately scented flowers in the axils of the leaves in the hot weather in March to June. Fruiting take place in November to January. The fertility of seed is usually good and it retains its viability for one year. Seeds kept for a year show 70 percent fertility and that for two years only ten percent.

**Artificial reproduction** :- Direct sowings kept weeded and watered, produce the best results, the growth after the first season being very rapid. To obtain transplants, the seed should be sown in drills in nursery beds in April or May, the beds being kept well watered and weeded. The seedlings can be transplanted without much difficulty during the first rains, when they are about 8 cm. high. Transplanting in the second rains is more difficult and requires special care to prevent the stems dying down. In either case the growth of the plants is checked by transplanting and the development for the first year or two, is poor compared with that attained by direct sowings properly tended.



**Rate of growth** :- After the seedling has established itself and commenced to shoot up, growth is rapid.

### 73. *Putranjiva roxburghii* (Putranjiva)

A moderate sized graceful evergreen tree with drooping branches and glossy leaves with wavy margins.

**Flowering and fruiting** :- The flowers appear from March to May and the fruit ripens in January and February. The drupe is normally one-seeded, but is occasionally two-seeded. The germinative power of the seed is somewhat uncertain. Fertility is retained to some extent, however, for at least a year. Seeds one year old have about 23 percent success.

**Artificial reproduction** :- The fruit-stones should be sown in nursery beds about April and lightly covered with earth, the beds being kept regularly watered and weeded. Germination takes place in six weeks to six months. The more vigorous plants will be ready for planting out the following year, when about a year old, while the less vigorous ones should be kept for another year in the nursery. Transplanting should be carried out during the rainy season, and the seedlings stand it well, provided care is taken not to injure the taproot, which is often of some considerable length.

**Rate of growth** :- Rather slow growing and sensitive to excessive heat and cold.

### 74. *Samanea saman* (The Rain Tree)

A large, fast growing tree with a clean bole, upward tending, large branches and an umbrella-like crown of elegant, graceful foliage. It prefers moister localities. It cannot stand very cool localities. It is not particular as to soil. It will thrive even in comparatively dry climates. It kills out grass rapidly with its broad crown. It is therefore, suitable tree for planting up grassy blanks in the wet localities with a view to kill out grasses and enable other tree species to be introduced afterwards. The pods contain a sweet edible pulp and are readily eaten by cattle. The wood, however, is of little value.

**Flowering & fruiting** :- The flowers appear in March-April and pods ripen in April to May.

**Artificial reproduction** :- Easily raised from seed or cuttings. Transplants can also be raised in polythene bags and planted out in the first rains.

**Rate of growth** :- The growth is very rapid.

### 75. *Saraca indica* (Asoka)

A large evergreen, somewhat unshapely tree with a dense crown of dark leaves. The important feature of the tree is its deliciously scented flowers. The tree prefers moister localities.

**Flowering & fruiting** :- Flowers appear in large clusters from January to April or May. The pods are collected in May-June when they are still quite green. They lose their viability quickly.

**Artificial reproduction** :- Easily raised from its large seeds, which must be sown after they have fully developed and the pods are still quite green i.e. in May-June.

**Rate of growth** :- Slow growing.

#### 76. *Schleichera oleosa* (Kusum)

In general it thrives best on a light well-drained gravelly or loamy soil.

**Flowering and fruiting** :- The racemes of greenish yellow flowers appear with the young leaves in March-April. Some trees produce only male flowers. The fruits ripen in June-July, and quickly fall to the ground. About 140 to 175 seeds weigh per 100 gm. The seed does not retain its viability long.

**Artificial reproduction** :- The transplanting of nursery-raised seedlings during the second rains is attended with a good deal of failure owing to the length of the taproot. Pruning the root and stem has not yet been tried, but possibly this may result in greater success. Transplanting in the first rains is not to be recommended owing to the small size of the plants, and even at this stage the seedlings require great care in transplanting. Good results have been obtained by direct sowings in well-loosened soil, the seeds being covered with earth. Regular weeding for the first few years is essential.

**Rate of growth** :- The Rate of growth is slow to moderate, The growth of coppice shoots is fast during the first few years, becoming slower afterwards.

#### 77. *Screbera swietenoides* (Mokha)

The tree is found in rather dry mixed deciduous forests often on hilly ground.

**Flowering & fruiting** :- Flowers appear with the young leaves from April to June and the fruits ripen during the following cold season i.e. November to January.

**Artificial reproduction** :- Not studied previously. But direct sowing and transplanting of seedlings in the first rains should be tried.

**Rate of growth** :- It is moderate.

#### 78. *Sesbania grandiflora* (Agast)

It is a small quick-growing, short-lived tree with very pretty evergreen foliage and a graceful habit.

**Flowering & fruiting** :- It bears large and showy red or white flowers (two varieties). seeds Jan-Feb

**Artificial reproduction** :- Easily raised from seed, which apparently breeds true. Begins to flower in the first year.

**Rate of growth** :- Fast.



### 79. *Spathodea campanulata* (Fountain Tree)

A fast-growing, elegant, nearly evergreen tree with large orange-red clusters of erect flowers at the tips of the branches, very conspicuous from a distance against the bright green foliage. An extremely beautiful tree.

**Flowering & fruiting** :- Flowering takes place in April-May and fruits ripen in September-October.

**Artificial reproduction** :- Propagated easily from root suckers and also from seed. Seedlings are ready for planting out after 12 months.

**Rate of growth** :- The tree is fast growing.

### 80. *Tamarindus indica* (Imli)

A very large, nearly evergreen, somewhat slow growing tree with a dense, round crown of very small leaves. Pods are edible. The tree is not exacting as regards soil, though it thrives best on deep alluvium.

**Flowering & fruiting** :- The flowers are small, variegated yellow and red appearing from April to June and pods ripen from January to March. The germinative power of the seed is fairly high. The pods are collected by shaking the branches and the pulp is separated from the seed by pushing the seeds out.

**Artificial reproduction** :- It is not difficult to propagate, whether by direct sowing or by transplanting. In either case regular weeding and loosening of the soil stimulate growth. The seed should be sown about April in raised nursery beds composed of red porous soil, the beds being kept regularly watered and weeded. Germination ordinarily commences in about five to ten days. Transplanting can be most successfully carried out during the first rains before the tap root reaches too great a length. Transplanting during the second rains should be done after pruning stem and taproot down to a length of about 5 and 25 cm. respectively.

**Rate of growth** :- It is somewhat slow.

### 81. *Terminalia arjuna* (Kahu)

A large handsome tree, evergreen or nearly so, with trunk often buttressed, a large crown and drooping branchlets. It may be tried along water-courses and also on dry lands where soil working is well done. It also grows well on field bunds and can be associated with the agricultural crops.

**Flowering and fruiting** :- Flowering appears from April to July, and the fruits ripen the following February to April in the next year. Seeds are fit for collection during April-May. About 450 fruits weigh one Kg. But in Madhya Pradesh 463 fruit weigh per Kg. One Kg. fruit yield about 776 seeds. The germinative power of the seeds is often indifferent. It is generally about 50 to 60 percent. Every third year is a good seed year.

**Artificial reproduction** :- The plants bear transplanting well during the first rainy season before the tap root becomes too long. 2 1/2 months old seedlings have average length of root and shoot as 30 cm. and 13 cm. respectively. The fruits should be sown in the nursery about April-May, covered lightly with loose soil, and watered regularly. If transplanting is done in the first year, then all except the top pair of leaves should be removed at the time of planting out in the field. Stumps can also be prepared from one year old nursery stock. But size of stumps to be used, varies from 12 mm. to 25 mm. diameter at the collar. Irrigated line sowings have been found successful, but if the soil is well loosened, irrigation can probably be dispensed with.

**Rate of growth** :- Rate of growth of seedlings and saplings, properly weeded and looked after carefully, is quite fast.

## 82. *Terminalia tomentosa* (Saj)

A large deciduous tree with a long clean bole and a full crown. It is one of the commonest and most widely distributed of Indian forest trees. It can be grown on variety of soils, without any specific preference. The tree attains its largest dimensions on deep rich, alluvial soil. On poor shallow soil, it remains stunted. It favours stiff clayey soil. It is not exacting as to soils and is tolerant of water-logging.

**Flowering & fruiting** :- The fruits rapidly become full sized by about October, though still green, they remain pale or yellowish green from November to January, ripening about February-March. The ripe fruit falls chiefly from March to May. The percentage of fertility of the seed is comparatively low (35-70 percent). About 40 seeds weigh per 100 gm.

**Artificial reproduction** :- Direct sowings in the field prove quite successful. In order to ensure regular weeding at small cost, sowing in lines is preferable to other forms of sowing. In order to allow for indifferent germination the fruits should be sown in the lines fairly close together, at intervals of about 15 cm. superfluous plants being afterwards transplanted to fill gaps in the lines.

The species can also be raised by transplanting from the nursery during the first rains, before the tap root becomes too long. For this purpose the fruits should be sown in the nursery not long after they ripen, about March-April, and if the beds are regularly watered and weeded the seedlings should be ready for transplanting early in the rainy season. But this method does not necessarily give satisfactory results.

Root shoot cuttings from one year old nursery stock have given satisfactory results.

**Rate of growth** :- Rate of growth is moderately fast under normal conditions.

## 83. *Thespesia populnea* (Paras Peepal)

It is a small, evergreen, rapidly growing tree with a dense foliage of cordate-acuminate leaves. It prefers light porous soil.

**Flowering & fruiting** :- The holly-hock-like yellow flowers with dark-purple blotch at the centre fading to rosy-violet, are borne throughout the year.



**Artificial reproduction** :- Propagated from seed or cuttings and grows quickly. Cuttings of all sizes strike quickly, but trees raised from large cuttings are said to be short-lived and liable to decay, and it is preferable to raise plants from small cuttings put down in the nursery.

**Rate of growth** :- Fast.

#### 84. *Thevetia nerifolia* (Pila Kaner)

An evergreen, large-shrub or a small tree with yellowish-green leaves. The shrub is very hardy and will thrive on any soil.

**Flowering & fruiting** :- The large, yellow, funnel-shaped flowers appear chiefly during the rains, and to some extent throughout the year.

**Artificial reproduction** :- Easily propagated from seed (which are poisonous).

**Rate of growth** :- Growth is fairly rapid.

#### 85. *Zizyphus jujuba* (Ber)

A small to moderate-sized deciduous (almost evergreen) tree. The tree is a useful one in furnishing fuel and small timber in dry regions and as well as thorn for fencing agricultural fields. Branches are lopped for cattle fodder. It is generally cultivated for its fruits, which are edible. Silviculturally, the tree, into bushy form, is of great value in enabling other trees to establish themselves in heavily grazed areas.

**Flowering and fruiting** :- The small greenish yellow flowers appear from April to October, the period varies in different localities. The fruits ripen from October to March. The seed retains its viability for at least 2 1/2 years, though the percentage of fertility of old seed is less than that of fresh seed.

**Artificial reproduction** :- The tree may be raised artificially by direct sowing or by transplanting seedlings or root-suckers. In the case of direct sowing the fruits, preferably deprived of the fleshy portion or else thoroughly dried, may be sown about a month before the commencement of the rains, either broadcast on ploughed land or a long lines which have been ploughed or dug up. If quick growth is desired during the first few years, the latter is preferable.

For transplanting purpose the fruits, deprived of their fleshy covering or well dried, should be sown in seed-beds, either broadcast or in drills, in February or March and covered with earth to a depth of 6 to 12 mm. The seedlings may be transplanted either during the first or during the second rainy season, but seedlings with long taproot it is preferable to prune the stem down to about 5 cms. and the taproot down to about 15 cm. The plants survive this treatment well, and soon commence to shoot up during the first rains with reasonable care transplanting may be done with unpruned plants. The plants may die down partially, but as a rule they recover next year.

The cultivated variety is usually propagated by ring grafting on stocks of the wild form. Plants of the latter, about three years old, are pollarded or coppiced in the cold season, and grafting is carried out on a few of the resulting shoots, the remainder being pruned down. Rings of bark about 18 mm. including a bud, are taken from the variety which it is desired to propagate and fitted exactly on to corresponding positions on the wild stock from which similar rings of bark have been removed, then whole being bandaged and covered with clay.

**Rate of growth** :- In open situations the growth is often fast.

## B - Bamboos

### 1. *Bambusa arundinacea* (Katang Bans)

This is a thorny bamboo, making huge clumps of large bamboos. It flourishes along water courses, where soil is loamy or silty, with plentiful sub-soil moisture. It is recommended to be raised throughout Madhya Pradesh in such limited areas only.

**Artificial reproduction** :- The species can be raised from seed or rhizome with large bamboo pieces.

Seeds vary from 69300 to 71400 per Kg. with germination capacity of about 50 percent. In the seeding period during April or May, a man can collect 3.5 to 4.5 Kg. seeds per day by sweeping the fallen seeds under the seeded clumps. Ordinarily seeds can not be stored for the second year.

Seeds are sown in lines in seed beds, the distance between the lines being 7 to 10 cm. The seed beds are watered copiously. Seeds start germinating by about the 7th day and continue for 3 weeks. The seedlings are left in the seed-bed for a year and later transplanted in transplant beds at a distance of 10 cm. in lines, the lines being 10 cm. apart. The seedlings remain in transplant beds for one more year.

The seed beds and transplant beds are raised ones, and are prepared by adding sand, farm yard manure and earth in the proportion of 1:1:1. 2.5 year old seedlings are planted out in the field in pits (30 x 30 x 30 cm.) at a spacing of 5 x 5 m. or 6 x 6 m.

For sowing of seeds in the country ploughed furrow, about 14 to 18 Kg. of seeds per hectare is sufficient. The method of raising this species from rhizomes with large bamboo pieces is described under *Cephalostachyum pergracile*.

**Rate of growth** :- It may take 8 to 10 years for a clump to produce normal size culms.

### 2. *Bambusa vulgaris* (Peela Bans)

This is a par excellent bamboo for growing in home-steads and elsewhere. It is thornless and of large size. Clumps are huge and open for easy working. It grows best on clayey or other heavy soils. Its water requirement is somewhat high. Hence this species is recommended to be raised in different zones of Madhya Pradesh as under :-

Zone	Technique
(i) Moist and Semi-moist Zone	Without irrigation, but soil working for moisture conservation is necessary.
(ii) Dry	Irrigation at least during the first two years of formation is necessary.



**Artificial reproduction** : Culm-cuttings of *Bambusa vulgaris* can be used successfully in vegetative multiplication of this species. Considering establishment, survival, height growth, height increment and culm production, the preferential order of the cutting types is as follows :

- (i) Three-noded cuttings obtained from the middle one-third of the culm.
- (ii) Two-noded cuttings obtained from the middle one-third of the culm.
- (iii) Three-noded cuttings obtained from the lower and upper one-third of the culm.

In order to have the maximum number of viable cuttings from individual culms, they may first be cut into approximately three equal lengths. The middle portion be kept in one lot and the upper and the lower portions in another separate lot. The middle portion of culms be used in preparing two-noded cuttings, and the other portions of the culm into three-noded cuttings.

With the onset of the rains, the culm-cuttings are prepared on a cool, rainy or cloudy day and planted out immediately in nursery beds, containing clay or heavy soil. Only one node is buried in the ground, keeping the cutting in a tilting position. Planting should be done at 45 cm. x 45 cm. spacing, and the upper cut portions including the cuts made due to removal of the branches, be smeared with white oil paint. The bed should be flood irrigated, if it is not a rainy day or the rains are insufficient. Flood irrigations are, thus, repeated at fortnightly intervals, except when rains are heavy and the soil is fully saturated with water. This is continued uninterruptedly for a year, except that in summer season when enough water may not be available, irrigation interval may be increased to one month. By the middle of the following rainy season, when cuttings are fully established, profusely sprouted and having produced many small switchy shoots, they are dug up with a ball of earth and planted out in the field at 12 m. x 12 m. spacing. Planting out is done in pits having 30 cms. depth and a cross-section of 45 cm. x 45 cm. Soil working, around the pits, is done for maximum conservation of moisture. This is necessary where irrigation cannot be provided in a plantation.

In areas where irrigation is feasible, the planting should be done on ridges, separating adjacent water channels.

The rate of irrigation water in such plantations is approximately 1,000 cubic metre per hectare per irrigation. Generally, irrigation is not necessary during the rainy season, but such a necessity may arise during unduly prolonged rainless periods. Roughly, the number of irrigations to be provided in an annual cycle is as follows :

October	November	December	January	February	Total
1	1	1	1	1	11
March	April	May	June		
1	2	2	1		

Due to non-availability of water during summer season, the number of irrigations during April to June may be drastically reduced from 5 to only 2 or 1.

**Rate of growth** : According to general observations, the establishment and growth of *Bambusa vulgaris* plantations is as follows :

Plantation type	Earliest age of cutting utilizable culms (years after planting)	Age of full production of culms (years after planting)
1. Regularly irrigated each year	2	4
2. Irrigated during first two years of formation only	3	6
3. Non irrigated, on suitable soil in moist or semi-moist climate	4	8

### 3. *Cephalostachyum pergracile*

This is Bastar bamboo of elegant appearance. The culms and clumps are large and rate of growth is very fast. It can be grown on plains having silty to loamy soil, with fair amount of sub-soil moisture.

**Artificial reproduction** : It can be grown from rhizomes with large bamboo pieces. The following points are required to be borne in mind while preparing the planting material :

- (i) **Season of preparation** : Active growth of young shoots from buds on the rhizomes is usually initiated with the onset of the monsoon. The vegetative propagule should be prepared just before the initiation of the annual period of active bud growth in the axis involved.
- (ii) **Size of the propagule** : Each propagule will consist of the lower part of the single culm, 90 to 120 cm. in length, attached with the rhizome axis basal to it.
- (iii) **Age of the material** : The age of the rhizome is of critical importance. 1 or 2 year old propagules are to be preferred, since propagules consisting of material 3 years or more in age are likely to give progressively poor results.
- (iv) **Preparation of the propagule** : The critical point to keep in mind in separating the propagule from the mother plant is the importance of severing the rhizome at the right place in its complex branching system. In the preparation of the propagule, a distinct procedure in cutting the rhizome is required. The rhizome should be severed only at one point at the neck of the oldest rhizome axis in the propagule. The cut should be made at the slender neck in order to minimise the damage to the rhizome and keep the raw surface as small as possible. Moreover, the tissues at this point appear to have great resistance to decay. This may be due to the presence of a higher proportion of lignified tissue in relation to parenchyma, and a smaller amount of stored food, in the tissues of the neck than in the tissue of the rhizome proper.



After the propagule to be lifted has been determined and the rhizome has been severed as described, the aerial part of the propagule may be pruned before the roots are severed or promptly thereafter, in order to minimise the loss of water through the leaves. It is advisable to retain as much foliage as many, by ample irrigation and protection of the propagule from the sun and wind, be kept from wilting until the root system is re-established. The root system of the propagule should be preserved as nearly intact as possible. The roots are best preserved and protected by keeping them in a ball of earth when the propagule is taken from the mother plant.

**Rate of growth :** Fast.

#### 4. *Dendrocalamus strictus*

It is a common bamboo, occurring naturally over vast areas in the State. Culms are medium-sized to large. Clumps are thick. Though it prefers loamy and sandy soils of good drainage, it also occurs on stony soils of limited depth, eroded soils and hill slopes. The minimum standards of a bamboo plantation site are as follows :

- (1) Rolling or undulating topography is preferable. Dead flat areas having impeded drainage and accumulation of clayey soil should be avoided.
- (2) Red murramy or coarse-textured soil with a minimum depth of 30 cm. is tolerated, but the growth is generally poor. Only III quality stands may be expected to grow.
- (3) There should be free surface drainage, as well as unimpeded sub-soil drainage.
- (4) Sites having stiff clay or water-logged soils should be avoided.
- (5) There should be no iron, clay or kankar pan within a depth of 45 cm.
- (6) Yellow wash soil, black or brown deposition soils, stiff shallow soils and excessively rocky areas should be avoided.
- (7) Skeletal soils may support III quality bamboo stands, if moisture conservation devices are provided.

This species is recommended to be raised throughout Madhya Pradesh in appropriate sites as defined above. In Dry Zone, irrigation for first two years of formation is necessary for early clump formation. In any case, soil working for moisture conservation must be done everywhere (except very moist area) for early formation of the clumps.

The planting spacements are recommended as under :

	Moist localities	Semi-moist localities	Dry localities
Pure Bamboo plantation :	5 m. x 5 m. (400)	4.5 m. x 4.5 m. (494)	4 m. x 4 m. (625)
Underplanting in Teak plantations	6 m. x 6 m. (278)	5.5 m. x 5.5 m. (331)	5 m. x 5 m. (400)
Underplanting natural forest	7 m. x 7 m. (204)	6.5 m. x 6.5 m. (237)	6 m. x 6 m. (278)

**Notes :** Figures in bracket indicates the number of planting spots per ha.

As far as possible, bamboo or other woody stakes should not be used, as they harbour termites. Pit digging may be done by simple aligning and measuring.

Planting pits will be 45 cm. x 45 cm. x 45 cm. in size. Digging of pits should be completed by the middle of March and dug-out earth will be allowed to weather till the end of May. Thereafter, it will be re-filled loosely in the pits, by discarding larger pebbles and stones.

Planting out should commence only when the rains have set in and soil is wet to a depth of 45 cm. Pits must be well soaked with water.

Having completed planting in an area, each planting line will be systematically gone over and wherever plants are found dead or dying, will be immediately replaced. This should normally be completed by the first week of August. Only average-sized (shoot 60 cm.) should be used for beating up the casualty.

**Artificial reproduction** : It can be grown from the seeds and also from the rhizomes with large bamboo pieces. Since this bamboo occurs most commonly over a greater part of the State, adequate quantity of seeds can always be collected within the State, even from the sporadic flowering. This species has therefore been prescribed to be raised through seedlings raised in the nursery. Detailed nursery technique is given in Annex 2.

**Rate of growth** : Fast. It may take 8 to 10 years for clump to produce normal size culms.

### 5. *Oxytenanthera abyssinica*

This is African bamboo. This bamboo is of par excellent qualities. Culm is thornless and size is medium to large. Clumps are open and easy to work. This is solid bamboo and clumps can be annually worked without impairing growth. It prefers well-drained, deep and silty to loamy soil.

**Artificial reproduction** : It can easily be raised from seed. Seeds will have to be procured from Kenya or Sudan through the Director, SFRI, Jabalpur. The nursery practice given under *Dendrocalamus strictus* may be followed in this case.

**Rate of growth** : Fast.



## C- GRASSES AND LEGUMES

### 1. *Chrysopogan fulvus* (I.G.F.R.I.1)

This is a perennial grass which can be raised in the rainfall zone of 250-850 mm. The soil should be loamy and well drained.

**Artificial reproduction** :- The nursery beds, each of 6 metres in length and 0.6 metre in width, are dug up to a depth of 60 cms. and the soil thoroughly cleaned of all kankars, stones and weeds and filled in again to prepare raised beds. The beds are then watered for 4-6 days and the weed growth, if any, is taken out. Thereafter the grass seeds are sown 6 mm. deep in the nursery beds in first week of May. The beds are covered with gunny bags and watered with a fine rose. As soon as the germination takes place, the cover should be removed. In places where the temperature in the day goes very high, seedlings should be provided shade to prevent them from excessive heat of the noon. The beds are watered every second day. About 60 gms. of seeds required to sown per bed. In this way 12 beds are enough to provide seedlings for one hectare of grassland.

The seedlings are ready for transplanting in 4-6 weeks when they attain a height of 15-20 cm. At this stage 10 Kg. Nitrogen per hectare (Calcium ammonium nitrate) is added to the beds. This makes the seedlings healthy and vigorous and keeps the weed growth under control. The beds are watered profusely a day before the transplants are to be taken out, so that the roots are not cut out and seedlings are easily taken out. The seedlings are then transplanted in the field at a spacing of 50 x 30 cm. (line to line and plant to plant). Generally two seedlings are put at one place.

All shrubs and useless growth should be cut and removed from the planting area. As soon as the rains have commenced the area is ploughed first by the "Mold Board", followed by two ploughings done by the country plough. The ploughing is done in lines 50 cm. apart and the seedlings are planted (two at one place) 30 cm. apart in lines. For one hectare, 33000 plants are required.

After ploughing, 10 cartloads of cowdung manure is added. Before transplanting the seedlings in the field, 20 Kg. Nitrogen per hectare (100 Kg. Calcium ammonium nitrate) and 20 Kg. Phosphorus per hectare (125 Kg. Single super phosphate) are added to the soil. After a lapse of about one month, 20 Kg. Nitrogen per hectare is again added. In the season two strip weedings are done. In subsequent years, 20 Kg. Nitrogen per hectare and 20 Kg. Phosphorus per hectare are sprinkled in the grassland after the first rains. The Nitrogen fertilizer is added in between the two ploughed lines.

In the first year the grass is cut only once i.e. by the middle of October. The seeds should also be collected at this time for future planting. In subsequent years the first cutting is done 60 days after the rains have set in and the second cutting at a further interval of 30-45 days, depending on the distribution of rainfall in the concerned year. The grass can also be cut in the spring again i.e. in March and April. The grass cutting is done 10 cm. above the ground level.

An yield of 300-400 quintals per hectare can be obtained in 3-4 cuttings.

Legume (Siratro or Stylo) can be grown in admixture with grass. Two rows of grass should be alternated with one line of the legume. In the line meant for the legume, legume is raised by direct sowings of seeds at 1.5 metres apart. The seedlings of grass are planted only after the legumes have established themselves. By this method the initial growth of legume is assured without any competition from the grass.

## 2. *Cenchrus ciliaris* (I.G.F.R.I. - 3108 Molpo wapel)

This is a perennial grass which can be raised in arid and semi-arid zones with precipitation varying from 125 to 1250 mm. The grass can be raised with and without irrigation. The soil should be loamy and well drained.

Nursery practice is similar to the one given above for *Chrysopogon fulvus*.

The planting site is also prepared in the same manner as already described for *Chrysopogon fulvus* with the following exceptions with regard to fertiliser doses :-

- (i) After adding 10 cartloads of cowdung manure, 30 Kg. of Nitrogen per hectare (150 Kg. Calcium ammonium nitrate) and 30 Kg. Phosphorus per hectare (137 Kg. Superphosphate) are added.
- (ii) After one month 30 Kg. Nitrogen per hectare is added in between the two lines.
- (iii) In subsequent years, 30 Kg. Nitrogen per hectare and 20 Kg. Phosphorus per hectare are added after the first rains and after one month 30 Kg. Nitrogen per hectare is further added.

In the first year the grass is cut only once i.e. by middle of October when seeds should also be collected for future planting. This grass can be cut 3-4 times, but if irrigation facilities are available, it can be cut more times. In subsequent years, it should be cut 4 times. First cutting should be after 60 days of the rains and other cuttings followed at an interval of 30 to 45 days depending on the rains of the year. The grass should be cut 5-10 cm. above the ground level.

Yield is expected to be 600 quintals per hectare in 3-4 cuttings in a year of average rainfall.

Legumes (Siratro or Stylo) can also be grown in mixture as described above for *Chrysopogon fulvus*.

The grass once planted give good production for first four years. In the 5th year the stems become hard and the new shoots are not thrown out. The production, therefore, becomes less. To solve this problem the grass should be burnt in the month of February. This results in throwing out of new green, succulent leaves. Care should be taken that the interplanted legumes are not damaged from the fire.

## 3. *Cenchrus setigerus* (Yellow Anjan)

This is a perennial grass which can be raised in 125 to 1250 mm. rainfall zone. It gives better out turn, if irrigated. The soil should be loamy and well drained.



**Artificial reproduction** :- Nursery practices and preparation of site for planting are the same as stated above for *Chrysopogan fulvus*.

300 to 400 quintals per hectare yield is obtainable from the 3-4 cutting done in the year.

The grass gives better production for four years and after that the stems become hard due to which new shoots fail to come up, and the production goes down. To solve this problem the grass is burnt in the month of February, care being taken to ensure no damage to the interplanted legumes.

#### 4. *Dichanthium annulatum* (I.G.F.R.I. 495-1)

This grass can be raised in the rainfall zone of 300-3000 mm. but the best production occurs in an area having 500-900 mm. rainfall. It can come up in a variety of soils like black cotton, murrummy soil, loamy soil, etc.

**Artificial reproduction** :- Nursery practice, preparation of planting site, period of grass cutting, method to those described earlier for *Chrysopogan fulvus*.

300 Quintals per hectare is the expected yield in 3 cuttings. With irrigation, the yield can be raised three fold.

#### 5. *Pennisetum pedicellatum* (I.G.F.R.I. 2808)

This is an annual grass which can be raised in 800-1250 mm. rainfall zone. The soil should be loamy and light.

**Artificial reproduction** :- The nursery practice is similar to that described above for *Chrysopogan fulvus*. The planting site should also be prepared in the same manner with the fertilizer doses varying as under :-

- (i) After applying 10 cartloads of cowdung manure, 30 Kg. Nitrogen per hectare (150 Kg. Calcium ammonium nitrate) and 30 Kg. Phosphorus per hectare (187 Kg. Single super phosphate) are added.
- (ii) After a month, 30 Kg. Nitrogen per hectare is added to get increased production of grass.
- (iii) In subsequent years, 30 Kg. Nitrogen per hectare and 30 Kg. Phosphorus per hectare are added soon after the first showers. A month afterwards, 30 Kg. Nitrogen per hectare is further added to get good growth of grass.

In the first year, this grass is cut only once in September. In subsequent years, although the grass is annual, it comes up again from the seeds fallen to the ground.

An yield of 1000 quintals per hectare can be expected in September cutting done in the first year.

Legumes (Siratro or Stylo) can be grown in mixture with this grass in the manner described earlier for *Chrysopogan fulvus*.

## 6. *Setaria specillata* (Conjugla)

This is a perennial grass and can be grown in 700-1250 mm. rainfall zone. The soil should be loamy, and very well drained.

**Artificial reproduction** :- Nursery practice is the same as given earlier for *Chrysopogan fulvus*. The preparation of the planting site is also similar with the following variation in fertilizer doses :-

- (i) 10 cartloads cowdung manure is followed by 30 Kg. Nitrogen per hectare (150 Kg. Calcium ammonium nitrate) and 30 Kg. Phosphorus per hectare (187 Kg. Single super phosphate).
- (ii) The grass can be cut 2 to 4 times in a year. The first cutting is done after 60 days of planting i.e. in or about September. Depending on rainfall of the year, the other cuttings are done at an interval of 30 days. After each cutting 30 Kg. Nitrogen per hectare is added to get increased production of grass. The grass is cut 5-10 cm. above ground level.

The grass can be raised with legumes (Siratro or Stylo) in the manner described earlier for *Chrysopogan fulvus*.

## 7. *Sehima nervosum* (I.G.F.R.I. - 2)

The grass can be raised in rainfall zone of 300 to 2000 mm. The best yields are, however, obtainable in rainfall zone of 500 to 900 mm. The soil preferred is grey, coarse textured and should be well drained.

**Artificial reproduction** :- This grass is raised by sowing seeds in perforated polythene bags (15 cm. x 7.5 cm.), filled with light soil, mixed with cowdung manure. Ten uncleaned seeds are put in each bag and two healthy are retained per bag after germination has taken place. Ample water is essential for watering the seedlings. Seedlings are raised in June and 33,000 polythene bags are required to raise planting material for one hectare of plantation.

The preparation of planting site, period and method of grass cutting etc., are similar to those described earlier for *Chrysopogan fulvus*.

250 to 300 quintal per hectare yield is obtainable in two cuttings.

The grass can be raised with legume (Siratro or stylo) in the manner described earlier for *Chrysopogan fulvus*.

## 8. *Phaseolus atropurpureus* (Siratro)

This is a perennial deep rooted legume which can be raised in 250-2000 mm. rainfall zone. It promises to do well in Bundelkhand (800 mm. rainfall). The soil should be well drained, grey and loamy.

**Artificial reproduction** :- The seeds are sown directly in the field after the first heavy shower in the month of July. The preparation of site is done as described earlier for *Chrysopogan*



*fulvus* with the exception that after applying 10 cartloads of cowdung manure, 10 Kg. Nitrogen per hectare (50 Kg. Calcium ammonium nitrate) and 30 Kg. Phosphorus per hectare (187 Kg. Single super-phosphate) is added.

If only Siratro is to be raised at the planting site, then the seeds are sown at a distance of 50 cm. in lines and are covered lightly with soil. The lines are 50 cm. apart. Eight Kg. of seeds are enough for one hectare. In the first year two weedings are done and after this deep rooted plant is well established no weedings are needed. Cuttings should not be done in the very first year. It flowers twice in the year, once in September and again in March. The seeds can be collected in the following months viz. October and April. The pods are to be collected as soon as they are slightly ripe, otherwise the seeds get scattered if the pods dehisce. In second year and onwards one or two cuttings can be done in a year, first in the month of September and the other in November. 250 quintals per hectare yield is obtainable in a year.

Where this legume is to be raised in mixture with Grass. Six Kg. seeds are required per hectare. Every two rows of grass is alternated with one line of this legume. In the line meant for legumes, the seeds are sown at a distance of 1.50 metres.

To raise this legume properly, culture of a bacteria called "Rhizobium" is essential. This culture is not easily available in India. The Indian Grassland and Fodder Research Institute can supply the soil, where this legume has been successfully raised. About a cigarette tin of such soil should be obtained, mixed with seeds, and then seeds should be sown at the planting site.

### 9. *Stylosanthes thumilis* (Stylo)

This is an annual legume, which can be raised in a zone having precipitation of 250-900 mm. The soil should be well drained grey and brown loamy.

**Artificial reproduction** :- The seeds are sown directly in the field after the first heavy shower in the month of July. The preparation of site is done as described earlier for *Chrysopogon fulvus*. After applying 10 cartloads of cowdung manure, 10 Kg. Nitrogen per hectare (50 Kg. Calcium ammonium nitrate) and 30 Kg. Phosphorus (187 Kg. Single super-phosphate) is added.

If only stylo is to be raised in the plantation, the seeds are sown direct, 1.25 cm. deep and 50 cms. apart in lines and covered lightly with soil. Ten Kg. of seeds are sufficient for one hectare of grassland. In the first year two weedings are needed and afterwards no weedings are necessary.

In first year, only seeds should be collected. In subsequent years, only one cutting can be done in a year as it is an annual legume, the planting site should be divided in two parts, one meant for collection of seeds and another for obtaining fodder. 200 quintals per hectare is the expected yield.

If the legume is to be raised in mixture with grasses, it can be done in the same manner as described above for siratro.

















S.No.	Species	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
78.	<i>Terminalia arjuna</i>	.	.	.	.	.	.	.	.	.	.	.	.
79.	<i>Terminalia alata</i>	.	.	.	.	.	.	.	.	.	.	.	.
80.	<i>Thespesia populnea</i>	.	.	.	.	.	.	.	.	.	.	.	.
81.	<i>Thevetia nerifolia</i>	.	.	.	.	.	.	.	.	.	.	.	.
82.	<i>Zizyphus jujuba</i>	.	.	.	.	.	.	.	.	.	.	.	.

**N.B. :-** 1. Seeds/ fruits of 69 species (S.No. 1, 3 to 11, 13, 16 to 23, 25, 27 to 34, 36 to 49, 51 to 64, 66, 67, 69 to 72, 74, 75 and 77 to 82) can be collected between January to May

2. Seeds/fruits of 35 species (S.No. 1, 4, 5, 6, 9, 10, 14, 15, 17, 19, 20, 24, 25, 26, 27, 34, 35, 36, 37, 42, 43, 51, 52, 55, 56, 58, 61, 64, 65, 67, 68, 72, 73, 77 and 81) can be collected between June to August

3. Seeds/fruits of 20 species (S.No. 2, 3, 7, 11, 12, 21, 22, 31, 32, 33, 44, 47, 48, 49, 50, 63, 74, 75, 76 and 82) can be collected between September to December.

TABLE-2  
COLLECTION AND STORAGE OF SEEDS

A-Species of which seeds cannot stand storage  
(Hence to be used in full in the year of collection it self.)

I - TREE SPECIES

- |                                    |                                     |
|------------------------------------|-------------------------------------|
| 1. <i>Acacia catechu</i>           | 16. <i>Hardwickia binata</i>        |
| 2. <i>Aegle marmelos</i>           | 17. <i>Lagerstroemia speciosa</i>   |
| 3. <i>Ailanthus excelsa</i>        | 18. <i>Lagerstroemia parviflora</i> |
| 4. <i>Anongeissus latifolia</i>    | 19. <i>Madhuca indica</i>           |
| 5. <i>Anthocephalus cadamba</i>    | 20. <i>Mangifera indica</i>         |
| 6. <i>Artocarpus integrifolia</i>  | 21. <i>Mimusops elengi</i>          |
| 7. <i>Azadirachta indica</i>       | 22. <i>Murraya paniculata</i>       |
| 8. <i>Bauhinia variegata</i>       | 23. <i>Phyllanthus emblica</i>      |
| 9. <i>Butea monosperma</i>         | 24. <i>Polyalthea longifolia</i>    |
| 10. <i>Casuarina equisetifolia</i> | 25. <i>Pterospermum acerifolium</i> |
| 11. <i>Cedrela toona</i>           | 26. <i>Putranjiva roxburghii</i>    |
| 12. <i>Dalbergia latifolia</i>     | 27. <i>Saraca indica</i>            |
| 13. <i>Diospyros melanoxylon</i>   | 28. <i>Schleichera oleosa</i>       |
| 14. <i>Eugenia jambolana</i>       | 29. <i>Terminalia arjuna</i>        |
| 15. <i>Gmelina arborea</i>         | 30. <i>Terminalia tomentosa</i>     |

II - GRASSES

- |                                 |                                   |
|---------------------------------|-----------------------------------|
| 1. <i>Cenchrus ciliaris</i>     | 5. <i>Pennisetum pedicellatum</i> |
| 2. <i>Cenchrus setigerus</i>    | 6. <i>Sehima nervosum</i>         |
| 3. <i>Chrysopogon fulvus</i>    | 7. <i>Setaria specillata</i>      |
| 4. <i>Dichanthium annulatum</i> |                                   |

III - LEGUMES

- |                                   |                                 |
|-----------------------------------|---------------------------------|
| 1. <i>Phaseolus atropurpureus</i> | 2. <i>Stylosanthes thumilis</i> |
|-----------------------------------|---------------------------------|

BAMBOOS

- |                               |                                  |
|-------------------------------|----------------------------------|
| 1. <i>Bambusa arundinacea</i> | 2. <i>Dendrocalamus strictus</i> |
|-------------------------------|----------------------------------|



**B -Species of which the seeds retain viability for a year or so if carefully stored.**

- |                                      |   |
|--------------------------------------|---|
| 1. <i>Acacia arabica</i>             | 8. <i>Eucalyptus globulus</i>                                     |
| 2. <i>Albizzia lebbeck</i>           | 9. <i>Eucalyptus gomphocephala</i>                                |
| 3. <i>Bauhinia perpurea</i>          | 10. <i>Eucalyptus teriticornis</i> or<br><i>Eucalyptus hybrid</i> |
| 4. <i>Buchanania lanzan</i>          | 11. <i>Pongamia pinnata</i>                                       |
| 5. <i>Cassia fistula</i> (two years) | 12. <i>Prosopis spicigera</i>                                     |
| 6. <i>Eucalyptus camaldulensis</i>   | 13. <i>Zizyphus jujuba</i> (2 1/2 years)                          |
| 7. <i>Eucalyptus citriodora</i>      |   |

**C - Species of which seed viability & storage conditions are not correctly known**

- |                                    |                                    |
|------------------------------------|------------------------------------|
| 1. <i>Acacia auriculiformis</i>    | 21. <i>Kigelia pinnata</i>         |
| 2. <i>Acacia leucophloea</i>       | 22. <i>Leucaena leucocephala</i>   |
| 3. <i>Albizzia procera</i>         | 23. <i>Melia azadirach</i>         |
| 4. <i>Alstonia scholaris</i>       | 24. <i>Mimusops elengii</i>        |
| 5. <i>Anacardium occidentale</i>   | 25. <i>Moringa pterygosperma</i>   |
| 6. <i>Anona squamosa</i>           | 26. <i>Morus alba</i>              |
| 7. <i>Bridelia retusa</i>          | 27. <i>Morus indica</i>            |
| 8. <i>Carissa spinarum</i>         | 28. <i>Parkia biglandulosa</i>     |
| 9. <i>Cassia siamea</i>            | 29. <i>Parkinsonia aculeata</i>    |
| 10. <i>Cassia auriculata</i>       | 30. <i>Peltaphorum ferruginium</i> |
| 11. <i>Cassia Javanica</i>         | 31. <i>Pithecollobium dulce</i>    |
| 12. <i>Cieba pentadra</i>          | 32. <i>Prosopis juliflora</i>      |
| 13. <i>Cleistanthus collinus</i>   | 33. <i>Samanea saman</i>           |
| 14. <i>Colvillea racemosa</i>      | 34. <i>Schrebera swietenoides</i>  |
| 15. <i>Dalbergia sissoo</i>        | 35. <i>Sesbanea grandiflora</i>    |
| 16. <i>Delonix regia</i>           | 36. <i>Spathodea campanulata</i>   |
| 17. <i>Ficus bengalensis</i>       | 37. <i>Tamarindus indica</i>       |
| 18. <i>Ficus glomerata</i>         | 38. <i>Thespesia populnea</i>      |
| 19. <i>Gravillea robusta</i>       | 39. <i>Thevetia nerifolia</i>      |
| 20. <i>Jacaranda mimosaeifolia</i> |                                    |





## By transplanting

Species	By transplanting							
	By direct sowing of seeds	In the first rains	In the second rains	By root shoot cuttings or stumps	Branch cutting	Root cutting	Grafting	
	2.	3.	4.	5.	6.	7.	8.	

1. cadamba	.	.	.	.	.	.	.
14. <i>Artocarpus heterophyllus</i>	.	.	.	.	.	.	.
15. <i>Azadirachta indica</i>	.	.	.	.	.	.	.
16. <i>Bauhinia purpurea</i>	.	.	.	.	.	.	.
17. <i>Bauhinia variegata</i>	.	.	.	.	.	.	.
18. <i>Bridelia refusa</i>	.	.	.	.	.	.	.
19. <i>Buchanania lanzan</i>	.	.	.	.	.	.	.
20. <i>Butea monosperma</i>	.	.	.	.	.	.	.
21. <i>Carissa spinarum</i>	.	.	.	.	.	.	.
22. <i>Cassia auriculata</i>	.	.	.	.	.	.	.
23. <i>Cassia fistula</i>	.	.	.	.	.	.	.
24. <i>Cassia Javanica</i>	.	.	.	.	.	.	.
25. <i>Cassia siamea</i>	.	.	.	.	.	.	.
26. <i>Casuarina equisetifolia</i>	.	.	.	.	.	.	.
27. <i>Cedrela toona</i>	.	.	.	.	.	.	.
28. <i>Ceiba pentandra</i>	.	.	.	.	.	.	.
29. <i>Cleistanthus collinus</i>	.	.	.	.	.	.	.

## By transplanting

Species	By transplanting							
	By direct sowing of seeds	In the first rains	In the second rains	By root shoot cuttings or stumps	Branch cutting	Root cutting	Grafting	
1.	2.	3.	4.	5.	6.	7.	8.	
30. <i>Colvillea racemosa</i>	-	+	-	-	-	-	-	
31. <i>Dalbergia latifolia</i>	+	+	+	+	-	-	-	
32. <i>Dalbergia sissoo</i>	+	+	-	+	-	-	-	
33. <i>Delonix regia</i>	-	-	+	-	-	-	-	
34. <i>Diospyros melanoxylon</i>	+	-	+	+	-	-	-	
35. <i>Eugenia jambolana</i>	-	+	-	+	-	-	-	
36. <i>Eucalyptus camaldulensis</i>	-	+	-	+	-	-	-	
37. <i>Eucalyptus citriodora</i>	-	+	-	-	-	-	-	
38. <i>Eucalyptus globulus</i>	+	+	-	-	-	-	-	
39. <i>Eucalyptus gomphocephala</i>	+	-	+	+	-	-	-	
40. <i>Eucalyptus tereticornis</i> or <i>Eucalyptus hybrid</i>	-	+	-	-	-	-	-	
41. <i>Ficus bengalensis</i>	+	-	+	-	+	-	-	
42. <i>Ficus glomerata</i>	+	+	-	-	-	-	-	
43. <i>Gmelina arborea</i>	-	+	+	+	+	-	+	
44. <i>Gravillia robusta</i>	-	+	-	+	+	-	+	



Species	By transplanting						
	By direct sowing of seeds	In the first rains	In the second rains	By root shoot cuttings or stumps	Branch cutting	Root cutting	Grafting
1.	2.	3.	4.	5.	6.	7.	8.
45. <i>Hardwickia binata</i>	.	.	.	.	.	.	.
46. <i>Jacaranda mimosaeifolia</i>	.	.	.	.	.	.	.
47. <i>Kigelia pinnata</i>	.	.	.	.	.	.	.
48. <i>Lagerstroemia parviflora</i>	.	.	.	.	.	.	.
49. <i>Lagerstroemia speciosa</i>	.	.	.	.	.	.	.
50. <i>Lucaena leucocephala</i>	.	.	.	.	.	.	.
51. <i>Madhuca indica</i>	.	.	.	.	.	.	.
52. <i>Mangifera indica</i>	.	.	.	.	.	.	.
53. <i>Melia azadirach</i>	.	.	.	.	.	.	.
54. <i>Mimusops elengii</i>	.	.	.	.	.	.	.
55. <i>Mimusops hexandra</i>	.	.	.	.	.	.	.
56. <i>Moringa oleifera</i>	.	.	.	.	.	.	.
57. <i>Morus alba</i>	.	.	.	.	.	.	.
58. <i>Morus indica</i>	.	.	.	.	.	.	.
59. <i>Murraya paniculata</i>	.	.	.	.	.	.	.
60. <i>Parkia biglandulosa</i>	.	.	.	.	.	.	.

## By transplanting

Species	By transplanting							
	By direct sowing of seeds	In the first rains	In the second rains	By root shoot cuttings or stumps	Branch cutting	Root cutting	Grafting	
1.	2.	3.	4.	5.	6.	7.	8.	
61. <i>Parkinsonia aculeata</i>	-	*	-	-	-	-	-	
62. <i>Peltophorum ferruginum</i>	-	*	-	-	-	-	-	
63. <i>Emblica officinalis</i>	*	*	-	-	-	-	-	
64. <i>Pithecolobium dulce</i>	*	-	-	-	-	-	-	
65. <i>Polyalthea longifolia</i>	*	-	*	-	-	-	-	
66. <i>Pongamia pinnata</i>	*	-	-	*	*	-	-	
67. <i>Prosopis juliflora</i>	*	*	-	-	-	-	-	
68. <i>Prosopis spicigera</i>	*	-	-	-	-	-	-	
69. <i>Pterospermum acenifolium</i>	*	*	-	-	-	-	-	
70. <i>Putranjiva roxburghii</i>	-	-	*	-	-	-	-	
71. <i>Samanea saman</i>	*	*	-	-	*	-	-	
72. <i>Saraca indica</i>	*	-	-	-	-	-	-	
73. <i>Schleichera oleosa</i>	*	-	-	-	-	-	-	
74. <i>Schrebera swietenoides</i>	*	*	-	-	-	-	-	
75. <i>Sesbania grandiflora</i>	*	-	-	-	-	-	-	
76. <i>Spathodea campanulata</i>	*	-	*	-	-	*	-	
77. <i>Tamarindus indica</i>	*	*	-	*	*	*	*	



## By transplanting

Species	By transplanting							
	By direct sowing of seeds	In the first rains	In the second rains	By root shoot cuttings or stumps	Branch cutting	Root cutting	Grafting	
1.	2.	3.	4.	5.	6.	7.	8.	
78. <i>Terminalia arjuna</i>	-	*	-	*	-	-	-	
79. <i>Terminalia tomentosa</i>	*	*	-	*	-	-	-	
80. <i>Thespesia populnea</i>	*	-	-	-	*	-	-	
81. <i>Thevetia nerifolia</i>	*	-	-	-	-	-	-	
82. <i>Zizyphus jujuba</i>	*	*	-	*	-	-	*	

## II - BAMBOOS

## By transplanting

Species	By transplanting					
	By direct sowing of seeds	In first rains	In second rains	By rhizome with large bamboo piece	By culm cutting	
1	2	3	4	5	6	
1. <i>Bambusa arundinacea</i>	*	-	*	*	-	
2. <i>Bambusa vulgaris</i>	*	*	*	-	*	
3. <i>Cephalostachyum pergracile</i>	-	-	*	*	-	
4. <i>Dendrocalamus strictus</i>	-	-	*	*	-	
5. <i>Oxytenanthera abyssinica</i>	-	-	*	*	-	

## III (A) GRASSES

Species	By transplanting			
	By direct sowing of seeds	In first rains	In second rains	
1	2	3	4	
1. <i>Chrysopogon fulvus</i> (I GFRI - 1)	*	*	*	*
2. <i>Cenchrus ciliaris</i> (I GFRI - 3108)	-	*	-	-
3. <i>Cenchrus setigerus</i> (yellow Anjan)	-	*	*	*
4. <i>Dichanthium annuulatum</i> (I GFRI - 495 - 1)	-	*	*	*
5. <i>Pennisetum pedicellatum</i> (I GFRI - 2808)	-	*	-	-
6. <i>Setima nervosum</i> (I GFRI - 2)	-	*	*	*
7. <i>Setaria specillata</i> (variety conjugata)	-	*	*	*

## III (B) LEGUMES

Species	By direct sowing of seeds			By transplanting
	1	2	3	3
1. <i>Phaseolus atropurpureus</i> (Australia)	*	*	*	*
2. <i>Stylosanthes thumilis</i> (Australia)	*	*	*	*



**TABLE 4**  
**TIME OF SOWING SEEDS IN NURSERIES**

Time	Species
<b>A-TIMBER SPECIES</b>	
1. December	1. <i>Casuarina equisetifolia</i>
2. Dec. - Jan.	2. <i>Grevillea robusta</i>
3. Jan. - Feb.	3. <i>Carissa spinarum</i>
	4. <i>Eucalyptus camaldulensis</i>
	5. <i>Eucalyptus citriodora</i>
	6. <i>Eucalyptus globulus</i>
	7. <i>Eucalyptus gomphocephala</i>
	8. <i>Eucalyptus tereticornis</i> or <i>Eucalyptus hybrid</i>
	9. <i>Leucaena leucocephala</i>
4. February	10. <i>Schrebera swietenoides</i>
5. Feb. - March	11. <i>Murraya paniculata</i>
	12. <i>Zizyphus jujuba</i>
6. Feb. - March	13. <i>Melia azadirach</i>
7. March	14. <i>Acacia auriculiformis</i>
	15. <i>Anthocephalus cadamba</i>
	16. <i>Bridelia retusa</i>
	17. <i>Jacaranda mimosaeifolia</i>
	18. <i>Lagerstroemia speciosa</i>
	19. <i>Phyllanthus emblica</i>
8. March-April	20. <i>Albizia lebbeck</i>
	21. <i>Cassia fistula</i>
	22. <i>Cassia javanica</i>
	23. <i>Colvillea racemosa</i>
	24. <i>Dalbergia latifolia</i>
	25. <i>Dalbergia sissco</i>

- |     |   |                                     |
|-----|---|-------------------------------------|
|     |   | 26. <i>Kigelia pinnata</i>          |
|     |   | 27. <i>Lagerstroemia parviflora</i> |
|     |   | 28. <i>Peltophorum ferrugineum</i>  |
|     |   | 29. <i>Terminalia tomentosa</i>     |
| 9.  | March-May   | 30. <i>Albizia procera</i>          |
| 10. | April   | 31. <i>Putranjiva roxburghii</i>    |
|     |   | 32. <i>Tamarindus indica</i>        |
| 11. | April-May   | 33. <i>Aegle marmelos</i>           |
|     |   | 34. <i>Bauhinia perpurea</i>        |
|     |   | 35. <i>Ceiba pentandra</i>          |
|     |   | 36. <i>Diospyros melanoxylon</i>    |
|     |   | 37. <i>Mimusops elengi</i>          |
|     |   | 38. <i>Mimusops hexandra</i>        |
|     |   | 39. <i>Pongamia pinnata</i>         |
|     |   | 40. <i>Pterospermum acerifolium</i> |
|     |   | 41. <i>Spathodea campanulata</i>    |
|     |   | 42. <i>Terminalia arjuna</i>        |
|     |   | 43. <i>Ailanthus excelsa</i>        |
|     |   | 44. <i>Parkia biglandulosa</i>      |
|     |   | 45. <i>Samanea saman</i>            |
| 12. | A little before the onset<br>of monsoon or just there-after | 46. <i>Alstonia scholaris</i>       |
|     |   | 47. <i>Anogeissus latifolia</i>     |
|     |   | 48. <i>Artocarpus integrifolia</i>  |
|     |   | 49. <i>Azadrachta indica</i>        |
|     |   | 50. <i>Bauhinia variegata</i>       |
|     |   | 51. <i>Butea monosperma</i>         |
|     |   | 52. <i>Cassia siamea</i>            |
|     |   | 53. <i>Cedrela toona</i>            |
|     |   | 54. <i>Delonix regia</i>            |
|     |   | 55. <i>Eugenia jambolana</i>        |
|     |   | 56. <i>Ficus glomerata</i>          |



57. *Gmelina arborea*
58. *Hardwickia binata*
59. *Madhuca indica*
60. *Mangifera indica*
61. *Morus alba*
62. *Morus indica*
63. *Polyalthea longifolia*
64. *Prosopis juliflora*

### B-BAMBOOS

- |  |   |
|--|---|
| <ol style="list-style-type: none"> <li>1. Sept. - October</li> <li>2. November</li> <li>3. Upto February</li> <li>4. May-June</li> </ol> | <ol style="list-style-type: none"> <li>1. <i>Dendrocalamus strictus</i></li> <li>2. <i>Oxytenanthera abyssinica</i> :-             <ol style="list-style-type: none"> <li>(i) Sowing in germination beds</li> <li>(ii) Direct sowing in polythene bags</li> <li>(iii) Direct sowing in polythene bags with the application of chemical fertilizers</li> </ol> </li> <li>3. <i>Bamboosa arundinacea</i></li> </ol> |
|--|---|

### C-GRASSES

- |  |   |
|--|---|
| <ol style="list-style-type: none"> <li>1. May</li> </ol> | <ol style="list-style-type: none"> <li>1. <i>Cenchrus ciliaris</i>, IGFR1 - 3108</li> <li>2. <i>Cenchrus setigerus</i>, Yellow Anjan</li> <li>3. <i>Chrysopogon fulvus</i>, I GFRI-1</li> <li>4. <i>Dichanthium annulatum</i>, I GFRI-495-1</li> <li>5. <i>Pennisetum pedicellatum</i>, I GFRI-2808</li> <li>6. <i>Setima nervosum</i>, I GFRI-2</li> <li>7. <i>Setaria specillata</i></li> </ol> |
|--|---|

**TABLE 5**  
**LIST OF SPECIES RECOMMENDED TO BE RAISED EXCLUSIVELY BY DIRECT SOWINGS**  
**(No nursery work is called for)**

**A - TREES**

1. *Acacia arabica*
2. *Acacia catechu*
3. *Acacia leucophloea*
4. *Anacardium occidentale*
5. *Anona squamosa*
6. *Buchanania lanzan*
7. *Cassia auriculata*
8. *Cleistanthus collinus*
9. *Moringa pterygosperma*
11. *Parkinsonia aculeata*
12. *Pithecollobium dulce*
13. *Prosopis spicigera*
14. *Saraca indica*
15. *Schleichera oleosa*
16. *Sesbania grandiflora*
17. *Thespesia populnea* (Branch cutting can also be tried)
18. *Thevetia nerifolia*

**B-BAMBOOS**

1. *Bambusa arundinacea* (Rhizome with large bamboo piece)
2. *Bambusa vulgaris* (Culm-cutting)
3. *Cephalostachyum pergracile* (Rhizome with large bamboo piece)

**C-LEGUMES**

1. *Phaseolus atropurpureus*
2. *Stylosanthes thumilis*



## ANNEX-1

**STANDARD NURSERY TECHNIQUE FOR  
EUCALYPTUS****Harvesting and storage of *Eucalyptus* seeds**

The State Forest Research Institute, Jabalpur is undertaking the task of identifying the seed stands of various species of *Eucalyptus* raised in the so-called *Eucalyptus* hybrid Plantations of Madhya Pradesh. Apart from this, the S.F.R.I., Jabalpur has established Eucalyptorium in various Regional Research Nurseries, from which seeds can be harvested and supplied. Seeds of other recommended species but not found in Madhya Pradesh will have to be obtained from within and outside India and supplied by S.F.R.I.

The essential point about harvesting of seeds from local trees is to determine the rhythm of flowering and fertilization of the concerned species. Care has to be exercised in order to avoid deterioration of the seed trees by over-frequent harvesting. It should be noted that with certain species, the ripe fruits remain closed and retain their seed for several years. Therefore, in such cases the feeder branches need only to be cut every two or three years.

The storage of *Eucalyptus* seed does not call for any special precautions. They will retain their viability for many years if kept in well-filled air-tight containers, stored in a cool place and guarded against moisture and violent changes of temperature.

There is no need to separate the fertile from the sterile seeds. The latter are usually longer and often lighter in colour than the fertile ones and can be easily recognised by pressing them. But it is necessary to shake up the mixture before sowing because the fertile and sterile seeds tend to separate out in the sacks owing to their different weights.

**Amount of seeds required**

The quantity of seed required depends mainly on its quality. Apart from a few species with particularly large seeds, as *Eucalyptus calophylla*, there is no great difference in size among the seeds of other species. The greatest variation is in the proportion of infertile seed, which depends on the provenance. As a rough estimate, an average of 10 percent by weight of healthy seed may be expected in ordinary commercial consignments. Generally speaking, one Kg. of medium quality *Eucalyptus* seed is necessary to produce about 1000 nursery plants.

A good *Eucalyptus* nursery should have the following essential features :-

- (i) The terrain should be flat or only slightly sloping, generally facing east or north and sheltered from strong summer or winter winds.

- (ii) As a rough estimate 0.1 hectare (0.25 acres) of nursery land is sufficient for each hectare to be planted annually. This would mean approximately 10,000 - 12,500 potted plants per hectare of nursery land.
- (iii) Water must be plentiful and of good quality. An average output of 1 cubic metre per day is the irreducible minimum for raising about 10,000 plants in a season. It is to be noted that many *Eucalyptus* species are very sensitive, particularly in early life, to water over charged with chlorides, carbonates or clay. A pH in the neighbourhood of 7 is desirable.
- (iv) Apart from central location of the nursery with respect to planting area, it is inadvisable to subject *Eucalyptus* seedlings to change of climate or altitude. For instance, *Eucalyptus* seedlings raised in a cool moist nursery develop broad tender leaves, which suffer badly as a result of transplanting to a drier or warmer site. Similarly plants should not be moved from plain to mountain or vice versa.
- (v) If the nursery site is liable to be windy, particularly in summer, it would be well to plant windbreaks around it.
- (vi) Generally speaking the young *Eucalyptus* plants need great deal of light and it is often possible to raise them without shade. Where there is a risk of excessive exposure to sunlight in the first few weeks, resulting in drying, and even scorching of the stock and the soil surface, it is advisable to shade the seedling, at least for a time.

### Plant containers

The polythene bags, in which *Eucalyptus* seedlings are to be raised, should have the following requirements -

- (i) **Capacity** :- It is generally agreed that the root ball on the average plant should have a minimum volume of 300 cubic centimetre. Polythene bags of 16 cm. x 20 cm. (6" x 8") size meet this requirement.
- (ii) **Bulk & weight** :- Since in most cases, the plants will have to be transported to plantation sites difficult of access, the bulk and weight of the containers should be as limited as possible. 150 gauge polythene bags will suffice for the purpose.
- (iii) **Ease of manipulation of potting & planting out** :- This is an important point which often permits economising man power and avoiding shocks to the seedling which may possible prejudice their recovery after planting out. The containers should have a fairly wide aperture. Those of truncated shape make for easier planting out than the cylindrical ones.
- (iv) **Drainage** :- Water should be able to seep freely from top to bottom of the soil in the container. The latter should therefore either be bottomless, or the bottom



must be pierced with hole large enough to prevent stagnation after watering. The hole should be large enough not to be blocked by the tap root.

### Method of sowing

Seeds can be sown either directly in containers or in the germination beds. Sowing in the germination beds will produce young plants intended to be pricked out into polythene bags during the nursery stage.

Seed will be sown at an average rate of about 3 grams per square metre in rows or strips, perfectly levelled and edged by planks. The seed sown this way is not dislodged by watering as often when it is sown broadcast. If the weather is very hot, the seeded area can be covered by straw resting on the edging planks, to give a temporary shade.

Sowing directly into receptacle involves two to five fertile seeds per bag. As stated before, the seed packets must be shaken well before sowing seeds in polythene bags. The containers are filled with soil, set in place and watered. In a small hollow about 1 cm. deep, and 2 cm. in diameter, pressed by hand, a pinch of seed is placed, covered with a very fine organic compost and lightly watered with a very fine spray. The resulting plants may be pricked out into other pots in the nursery or allowed to grow where they stand. In the latter case, a few weeks after germination, the surplus plants are removed, leaving only one vigorous seedling about 3-4 cm. high, in the centre of the pot.

This method of direct sowing into polythene bags is advisable where there is sufficient seed. It is very simple and gives good results with sturdy species well suited to their intended site.

### Composition of soil in beds and bags

In all cases, *Eucalyptus* seedlings require light and permeable soil, with a fair proportion of humus and very little clay. Moreover, the texture of the soil should be very fine, at least on the surface, or the seeds may be too deeply engulfed. It is well to prepare some carefully screened soil to sprinkle over the surface of the beds or the potted soil just before sowing. The proportion of clay and humus should be sufficient to ensure that, when the plant is removed from the pot, the earth ball remains intact.

In practice, the soil mixtures consist of either good clean soil of loams, or mixtures from the upper horizons of forest soils, enriched with river sand and very diluted manure or compost. Compost can be made in the nursery itself with plant debris piled in pits and watered during the summer. Forest humus and dead leaves can be plentifully mixed with this. In a year or two the waste decomposes and supplies the nursery with a very useful compost fertilizer. One should also make sure before using compost that it does not contain various larvae such as *cockchafer grubs*. If necessary the compost should be shifted and disinfected. It is generally unnecessary to add fertilizer to these mixtures. Young *Eucalyptus* plants do not in fact absorb much mineral matter other than silica.

There is also no need to add Calcium Carbonate in the soil for most of the *Eucalyptus* species appear to be able to do without it. Indeed some species may suffer from an excess of it, like *E. camaldulensis*.

Finally, it should be noted that too much manure may encourage damping off. Highly diluted manure may be used, if necessary before and with insecticides and fungicides.

The soil in the germination beds should have the same characteristics as the potting earth. It is important that the subsoil of the beds, like that of the site where polythene bags are placed, should be very permeable and perfectly drained.

### **Sowing time**

Care must be taken with most of the *Eucalyptus* species so as not to have, at the end of their nursery period, over developed plants with roots escaping from the containers or penetrating too deeply into the seed beds, or with their closely-packed crowns up too high. Seeds should be sown in early spring i.e. January to March. Experience alone will teach the right time for sowing in order to obtain well-proportioned plants.

### **Sowing - Care before germination**

It has already been said that because the *Eucalyptus* seeds are so minute, the soil in which they are to be sown should be very fine. The surface should be as smooth and fine as possible, so that a light tamping will suffice to cover the seed.

Only by testing trial mixtures the nursery man will find the right soil for covering the seed adequately. A soil which is too light would leave the seed exposed to wind or watering; one which is too heavy may result in the formation of a crust which the plants cannot pierce. In certain cases, where there is a risk of damping off, it may be advisable to cover the seeds with sterile matter, saw dust or other cellulosic wastes. In any case, beds or polythene bags should be watered very lightly before and just after sowing.

As soon as the seed is sown, it should be protected from birds and rodents by covering with fine mesh netting, stretched horizontally above the seed beds.

To ensure germination, watering should be frequent rather than copious, always with a very fine spray, frequency being in inverse proportion to the amount of water used. This frequency may vary from once to several times a day according to the relative humidity.



Where sowing has been made directly into pots, the latter should be buried so that their upper edge is level with the surface of the bed; the empty spaces between them can be filled with earth or saw dust.

If the sunlight is too strong, the beds should be protected by high or low shades.

### Care after germination

Watering should be less frequent after germination.

In hotter regions, shades can be used as a protection against strong sunlight, at least for the plants from seeds sown at the end of the season. The plants should not be shaded too early, for they then tend to 'run away' in an exaggerated fashion for the rest of the summer.

Damping-off is encouraged by a very moist atmosphere and by a high content of organic matter or nitrates in the soil, as well as by temperature. The fungi which cause it, chiefly species of *Fusarium*, rarely develop in acidic soils, with a pH lower than 5. When the young plants are a month old, they are usually immune to the disease. There are two ways to avoid damping-off as under :-

- (i) The soil should be sterilized by means of chemicals or heat treatment. The latter is difficult to carry out, and as for chemicals, such as formal or copper sulphate, the concentration to destroy fungi may also damage the plants.
- (ii) Sowing in sterile or acidic soil. For this purpose, saw dust, or pure siliceous sand can be used.

Perennial weeds will have been destroyed during the preparation of the seed beds and polythene bags; but annual weeds must be controlled by hoeing and raking as often as possible. This has the further advantage of preventing loss of soil moisture through capillary action.

### Pricking out in polythene bags

Pricking out into polythene bags helps the development of the lateral hairy root and slows down for a time the upward growth of the stem. This tends to balance top and root growth and makes for better adaptation to dry conditions. When the plants reach about 3 cms. in height and the stem becomes woody, two weeks to two months after germination, the seedlings are ready to be pricked out. Their roots should be about 9-12 cm. in length. It

is important not to prick out overdeveloped plants, for their recovery in the polythene bag is more difficult. One man can be expected to prick out 600 to 800 plants per day.

Each seedling is carefully separated from its neighbours. If its roots are crushed or too long, they should be trimmed. The plant is then placed by hand in the centre of the pot and surrounded by loose, fairly rich shifted soil, artificially mixed or not, like that of the seed beds. The soil is then heaped by hand around the seedling which is covered slightly above the base of the stem, and plentifully watered.

The pricking out should be done when the weather is neither too hot nor too windy, and always under a high shelter, where the plants can be left for a few days to help their recovery. They should not be over watered at this stage. Afterwards they can be arranged in the open or under shelter according to the species and the local weather conditions.

After pricking out into polythene bags under shelter, the plants are taken to the spot where they will remain until their final planting and the polythene bags are buried up to the upper edge.

During the whole of this final stage in the nursery, the seedling should be very regularly watered. The last watering with cane or spray-hose should be as late in the day as possible and should be fairly generous. The nursery man must make frequent checks to see that water is reaching the bottom of the pots. An experienced man can tell this simply by feeling the weight of a few bags in his hand.

If *Eucalyptus* seedlings are over watered, they will grow too vigorously. The number of waterings must then be decreased so that the plants just manage to subsist without loss. This is particularly necessary from the moment when the taproot reaches the soil of the bed at the bottom of the polythene, and threatens to spread downwards into the subsoil. Spraying is more effective than irrigational watering in preventing this downward spread of the taproot outside the pot.

The growth of the tap-root out of the container and into the subsoil below is countered by what is known as "giving the plants their head" all the time they are in the nursery and to cut the tap root a month before planting out. At the same time, care is taken in top-dressing the soil in the pots, watering abundantly and keeping down the plant crown to above 50 cm.. Top-dressing involves spreading over the free surface of the pot a 1-2 cm. layer of fine rich soil mixed with well-diluted manure. This brings on vigorous young adventitious growth at the root stock within a month. The latter helps the plant to recover and give the tap-root a chance to spread downward as soon as it is planted where it is to grow.



### **Precautions before dispatching seedlings to planting site**

The plants will profit from a generous watering immediately before their dispatch to the site.

Planting should be carried out after 50 mm of rain has fallen, sufficient to moist the soil to a depth of 75 cm. Pits should be dug in March-April so that the sides and bottom of the pits and the excavated soil may benefit from exposure to the air. Square pits should be of 40 cm. width and 40 cm. depth, and rounded pits should be of 40 cm. diameter and 40 cm. depth. In drier areas, contour trenches, terraces, 'V' shaped channels should be made to lead the moisture to the planting pits.

### **Subsequent treatment**

In the case of *Eucalyptus* species, it is essential to clear the soil of competing plants and to keep the soil clean until the plants, with established root and a more or less complete canopy formed, are strong enough to overcome competition on their own. This treatment has been proved on comparatively shallow soils, on deep soils, as well as sand dunes.

### **Replacement of casualties**

In case of industrial and fuel plantations of *Eucalyptus*, raised with 2500 plants per hectare it is reckoned useless to replace failures where these amount to less than 20 percent of the original number of plants, because the costs do not justify the possible results.

An isolated seedling planted a year late in the midst of a stand will be permanently dominated by its neighbours and would wither and eventually die. Restocking, therefore, should be carried out by group planting of about 10 trees as a minimum.

## ANNEX - 2

# STANDARD NURSERY TECHNIQUE FOR *D. STRICTUS*

### Seed collection and storage

About 25,000 bamboo seeds weigh per Kg. Freshly collected seeds have a viability of more than 60 percent. With passage of time, this viability stands for a maximum period of two years.

To ward off damage by insects and rats, the seeds should be kept in cool place in air-tight sealed drums. Cotton soaked in E.D.C.T. (Ethyl Dichloride Carbon Tetrachloride) may be placed inside. It is volatile and about one pound of this chemical is sufficient for about 3 1/2 quintals of seed. However, if seeds are stored in gunny bags, then they should be placed one over the other, after profusely dusting with 10% B.H.C. or D.D.T. powder. The room should also be dusted and all outlets plugged to prevent entry of rats. There is comparatively more loss of viability when seeds are stored in gunny bags.

### Germination beds

The germination beds should be of sunken type of size 15 cm depth, 10 metres long and 1.25 metres wide. Each year the soil should be turned upside down, cleared of pebbles, stones etc. and mixed with adequate quantity of decayed farm yard manure.

### Polythene bags as plant-containers

The polythene bags of 23 cm. x 15 cm. size (when flat) and 150 gauge are sufficient. Gussetted polythene bags with punch holes are not necessary, firstly because the individual polythene-bagged plants are not required to stand individually in the nursery; and secondly because about 20 prick-holes, within the lower 2/3 of the bag length, can be made locally and easily with a sharp nail.

### Soil-filling or potting mixture in polythene bags

Potting mixture should consist of thoroughly dried up finely beaten and well sieved soil and thoroughly decayed, finely beaten and well dried up farmyard manure, mixed thoroughly and intimately in the following proportions :-

Nursery Soil	Imported Soil	Farmyard Manure
Alluvial or Loamy Soil - 3 parts	Nil	1 part
Clayey Soil - 3 parts	Sand 1 part	1 part
Sandy Soil - 3 parts	Sift 1 part	1 part



The polythene bags should be filled right upto the brim with perfectly dry potting mixture.

### **Sowing in germination beds**

Sowings in germination beds should be done during September-October, in drills 5 cm. apart. About one Kg. of seed is sufficient for a standard bed. The thickness of the fine soil covering the sown seeds should not be more than twice the thickness of the dehusked seed. The entire bed is, then, lightly covered with straw and profusely watered with a fine rose. Such a watering is to be continued 2 to 3 times a day, till germination commences within about 10 days. Thereafter, watering is limited to twice a day. At each watering, care is necessary to ensure that there is no free accumulation of water in the bed. Similarly, bed should not be over-saturated with water, in order to cause even incipient water-logging. When, sufficient number of seeds have germinated and drill lines appear fairly stocked with young seedlings, the straw cover should be removed and watering continued, as prescribed before. 6,000 to 10,000 seedlings are necessary per standard germination bed depending on the viability of bamboo seed used.

### **Pricking-out in polythene bags**

The seedlings should be pricked out and transplanted in polythene bags, when they are about 7 cm. in height in germination beds. The best results can be obtained if pricking out is completed before November end. Pricked out seedlings should be watered and weeded regularly. NPK mixture may be given to seedlings when they are well-established in the bags.

Often the shoot of the pricked-out seedling dries up but soon new and vigorous shoots arise, with the establishment of the seedlings in the polythene bag. Each subsequent shoot is taller and thicker than the previous one.

### **Direct sowing in polythene bags**

Every effort should be made to popularise this safe and economical practice amongst the staff, but certain precautions are necessary -

- (i) The seed used must be of a high germinative capacity (50 percent and over). If test-sowings show lesser germinative capacity, then the alternative method of sowing the seed in germination beds and pricking out of seedlings in polythene bags should be followed.
- (ii) Direct sowing in polythene bags, should be done in November. If there is possibility of applying doses of chemical fertilizers, then such sowings can be delayed to even February.
- (iii) In each bag 3 seeds should be sown at 3 corners of a triangle having 2 to 3 cm. sides, marked on the soil surface, in the bag. The polythene bags after such sowing are arranged in bed. The entire bed be covered lightly with straw and watering done as indicated earlier. As soon as germination is started and the majority of bags in a bed are stocked with young seedlings, straw may be removed.

## Shading

Artificial shade is not required at any stage except straw cover on germination beds and directly sown polythene bags, till the germination commences. Besides this, tall trees of *Eucalyptus* and widely spaced trees in the nursery are advantageous to provide shade.

For proper growth of bamboo seedlings in polythene bags maximum sun-light is necessary. Under full sun, proper regularisation of watering is essential and if necessary chemical fertilizers may also be applied as the watering and nutrients should not be limiting factors.

## Use of chemical fertilizers

Whenever, it is desirable to reduce the nursery period or to obtain plantable sized seedlings (45-75 cm. tall) during a short period, efforts should be made to provide profuse watering, coupled with ample sunlight and frequent doses of urea. 2% urea solution may be spread on seedlings, to establish in polythene bags, and this dose may be repeated at a monthly interval, till plantable sized seedlings are obtained.

## Use of pesticides in nursery

In nurseries where fear of termite damage is occurred *chlorodono* powder should be mixed with potting mixture at the rate of 10 to 16 gm. per bag and applied.

If damping off is noticed in the nursery, apply 2% solution of Balitox, Blue Copper or Fitalon. They are patent chemical formulations having 50% copper fungicides.

## Splitting of Bamboo seedlings

Presently, difficulties are encountered in procurement of bamboo seeds. There is no guarantee for obtaining the desired quantity of viable bamboo seeds annually for achieving prescribed bamboo planting targets. Accordingly, there is strong urge to make the best use of all the seeds which are obtained. Similarly to guard against the loss of viability, it is generally necessary to sow fresh seed immediately after procurement. Thus whenever such sowing is necessary, they should be carried in sunken germination beds in drills 15 cm. apart. The plants are allowed to grow in beds till February. In March, they are individually dug out and split into a number of seedlings. Each such seedling has one shoot and many of freshly looking rhizomes, which may be 2 to 6 in numbers. The shoots, if unduly long, are clipped to about 45 cm. They are pricked in standard sized polythene bags and kept in storage beds. Watering is done in the usual manner and in due course, they are ready for planting out.



## ANNEX - 3

**PLANTING POLICY FOR VILLAGE ENVIRONMENT**

The Table given below suggests some planting patterns depending on the type and extent of land available in the village :-

Type of land	Extent of land	Type of planting to be preferred for planting
1	2	3
1. Village water land	1. Large areas (over 10 hectares at one place)	A. Timber trees yielding poles to be combined with the cultivation of plants yielding tannin and bamboos  B. Fuel trees  C. Fodder trees, grasses and Legumes
	2. Small areas (Less than 10 hectares at one place)	A. Fodder trees, grasses & legumes  B. Fruit trees
2. Premises/compounds of Government and Public buildings, like Primary Health Centres, Schools, Rest-Houses, Block quarters, Panchayat Bhawan, etc.	Generally small in extent	A. Ornamental trees  B. Shady trees
3. Village roads	Generally small in extent	A. Shady trees  B. Ornamental trees
4. Lands in individual ownerships	1. Agricultural fields (Generally bunds or marginal lands, small in extent)	A. Suitable trees which can grow in association with agricultural crops.

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**Type of land****Extent of land****Type of planting to be preferred for planting****1****2****3**

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B. Any plant required by the individual.

2. Household compounds, court-yards, Khaliyan, etc.

A. Fruit trees

B. Shady trees

C. Ornamental trees

D. Any plant required by the individual

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## ANNEX - 4

# COLOUR SCHEMES FOR AVENUES

### Colour Scheme

Shri M.S. Randhawa has grouped some of the flowering trees which flower in the same season in schemes with due regard to colour harmony and these schemes are accordingly recommended for planting as avenues on roads under Social Forestry Schemes :-

#### Scheme No. 1

Amaltas (Yellow)

Gul Mohar (Scarlet orange)

Amaltas (Yellow)

This is a very striking colour scheme, the rich yellow colour of Amaltas flowers contrasting with the scarlet-orange colour of Gul mohar flowers in the month of May when both the trees are flowering.

#### Scheme No. 2

*Peltophorum ferrugineum*  
(Golden yellow)

*Colvillea racemosa*  
(Orange red)

*Peltophorum ferrugineum*  
(Golden yellow)

This colour scheme is very effective in October when both these trees are flowering, and a colour effect similar to that in scheme No. 1 is produced.

#### Scheme No. 3

*Jacaranda mimosaefolia*  
(Blue)

*Grevillea robusta*  
(Yellow)

*Jacaranda mimosaefolia*  
(Blue)

Both these trees flower together in April and afford a beautiful colour effect. Blue flowers of Jacaranda are soothing in the glare of April.

In order to enable Forest Officers to evolve such colour schemes locally, the 19 ornamental species recommended to be raised under Social Forestry are arranged below by the colour of their flowers :-

	Colour of flower	Species	Month of flowering
1.	Blue	1. <i>Jacaranda mimosaeifolia</i>	April-June
2.	Lilac	2. <i>Melia azadirach</i>	May-June
3.	Orange	3. <i>Colvillea racemosa</i>	September-October
		4. <i>Saraca indica</i>	February to April
4.	Pink	5. <i>Lagerstroemia speciosa</i>	April-June
5.	Red	6. <i>Bauhinia purpurea</i>	September to December
		7. <i>Bauhinia variegata</i>	February to April
		8. <i>Cassia javanica</i>	April to June
		9. <i>Delonix regia</i>	April-June
		10. <i>Samania Saman</i>	May-June
6.	White	11. <i>Spathodia campanulata</i>	September-January and April-May
		7. <i>Bauhinia variegata</i>	February to April
7.	Yellow	12. <i>Murraya paniculata</i>	April to May
		13. <i>Acacia auriculliformis</i>	September-October
		14. <i>Cassia fistula</i>	April to August
		15. <i>Cassia siamea</i>	June-July
		16. <i>Parkinsonia aculeata</i>	September-October
		17. <i>Peltoforum ferrugianum</i>	August-October
		18. <i>Thevetia nerifolia</i>	January to December
		19. <i>Thespesia populanea</i>	June to February

### Planting avenues in two rows on each side

For this purpose, it is proposed that shade trees may be planted in the outer row and ornamental trees in the inner row.

## ANNEX 5

**SOME OTHER USEFUL PLANTS FOR VILLAGE  
PLANTING*****Hyphaene thebiaca* :**

It is African palm, which grows tall, has dichotomous branching and looks graceful. It grows on flood plains having silty soil and plentiful sub-soil water. It is a tree of many uses. Timber is highly resistant to insects and fungi and has high tensile strength. It is useful in house construction, where large beams are required. Annually, it produces a huge-crop of fruits which are hard and may be stored for long period. On crushing, they produce highly nutritive cattle and poultry feed. Leaves, on decortication, produce very fine quality fibre for making large sized storage secks. Seeds of this species can be supplied after importing them through S.F.R.I., Jabalpur.

***Acacia albida (African Babul)* :**

It remains thoroughly leafless during rainy season, when everything else is green and thus, allow agricultural crops, growing underneath, to flourish. During hot weather, when everything else is leafless, this tree remains fully green and affords beneficial protection to field soil and its micro-organisms. Its pods are greedily favoured by cattle and are highly nutritive. 20 trees of this species raised in 1975 are alive in S.F.R.I. Campus at Jabalpur.

***Conocapus lancifolius* :**

It is a tree from Somali land. It grows very happily where water-table is close to land surface. It is an evergreen tree of very pleasing appearance. Stem is straight and without large branches. Its rate of growth is fast and it lowers down the water-table, due to high consumption of water. Timber is highly useful in construction work. 39 plants of this species were sown in 1970 in S.F.R.I. campus.



## ANNEX - 6

**ENSURING SUCCESS OF THE PLANTS  
THROUGH SOIL WORKING TECHNIQUES**

Some of the common methods of soil preparation in vogue or suggested for trials, have been grouped under the following heads for convenience. They are diagrammatically represented in attachment No. 1 to this Annex.

**1. PIT****Recommended for plantings only**

**1. A-pit (ordinary).** Recommended for clayey soil and almost all annual rainfall classes. It should have a high crest and the deepest part of the water storage ring should be rather far away from the highest point of the mound. This will minimise water-logging near the seedlings. In black cotton group of soils it may be desirable to mix with the soil some coarse organic mulch like grass, leaves and small twigs in order to improve the structure and hence water permeability and to eliminate or reduce cracking which promotes evaporation losses.

**1 B-Saucer pit.** This kind of pit is suitable for all loamy types of soils in almost all annual rainfall classes. The crescent trench is necessary only on sloping ground.

**1 C-Ring pit.** Recommended for dry sandy areas. The crest need not be very high because deep planting will be necessary in order to place the main mass of roots about 12" below the surface where a zone of moisture accumulation usually occurs in the case of very sandy soils. The ring trench will infiltrate water near the planting site and improve its moisture status.

**2. RIDGE- DITCH**

Ridge-ditch is a partly-filled-in trench and a suitable type of soil working for sowings on sloping ground. A few plants or stumps may also be put in to reinforce the sowings or to replace casualties.

**Vertical sides**

**2 A-Small ridge-ditch.** This is the normal pattern suitable for areas towards the moister part of the dry zone with a rather large number of rainy days and for loamy soils.

**2 B-Large ridge-ditch.** This is a typical suitable for low rainfall and deep soil conditions. If the soil is sandy and the rainfall rather low but the number of rainy days is not small this pattern will trap a large amount of moisture in the worked-up soil. It is also suitable for low and ill-distributed rainfall types for non-sandy soils.

**2 C-Shallow ridge-ditch.** This pattern corresponds to 2A and is recommended for slopes from which most of the real soil has been washed away and the surface consists of

loose gravel or murrum resting on a shallow depth of partly decayed rock lying on intact rock beds. Under such conditions the soil is extremely granular and open, has low moisture retentive capacity. Since hard rock is encountered relatively near the surface, a large volume of worked up soil is easily obtained by doing wider rather than deeper excavation. As the excavated material is stony and gritty it is advisable to do some sorting and to put the larger pieces at the bottom of the trench and at the toe of the ridge on the lower side of the slope. The moisture retentive capacity can be increased by incorporating coarse and fine organic mulch in the fill-in. Better moisture conservation may also result if the open portion of the trench is loosely filled with grass with a few stones placed on the top to prevent the stalks from being blown away.

### Slanting sides

The adoption of slanting rather than vertical cuts may confer some advantages in certain cases. In clayey profiles, where water may remain standing for relatively long periods this device will keep the main mass of water slightly away from the sowing or planting lines (at original ground level or slightly higher) and may reduce damage from waterlogging. There being greater seepage of moisture in a vertical direction, the roots will lie in a comparatively drier zone.

## 3. SHELFED TRENCH

Some soils in the peninsular region derived from granitic or basaltic rocks contain a proportion of very fine tenacious clay dispersed in a matrix of fine to coarse grained murrum. This clay forms an impermeable crust on wetting and subsequent drying up and also binds the granular murrum into hard clods. In such cases not only the sides and bottom of the trench but also the slopes and top of the ridge develop a hard crust after the first showers. For such an area a shelfed trench with sowing or planting at the original ground level or a little above it may prove superior to the conventional trench.

**3 A-Shallow-field shelfed trench.** Water will be mainly contained in the deeper part of the trench, not in direct contact with the major part of the worked-up soil, but able to infiltrate into and beneath it.

**3 B-Deep filled shelfed trench.** This method is suitable for areas with low to high rainfall received in a small number of rainy days in the form of heavy or torrential showers, which require a relatively large storage capacity.

## 4. DOUBLE TRENCH

In the case of badly stony and detrital slopes which contain only a small amount of soil in the interspaces of large and small pieces of stones and in the creacks and crevices of the partly disintegrated rock, the water holding capacity is extremely small and the surface run-off and sub-surface drainage is very high. Under these exacting conditions it is desirable to impound a large volume of water in an unfilled trench and allow it to seep downwards into a mass of sorted and richer soil packed in a granular condition in a trench or pit excavated on the lower side. Sowings or plantings at the top of the ridge or deep into the soil mass respectively have much better chances of success.



## ARTIFICIAL REGENERATION

Fig. 3

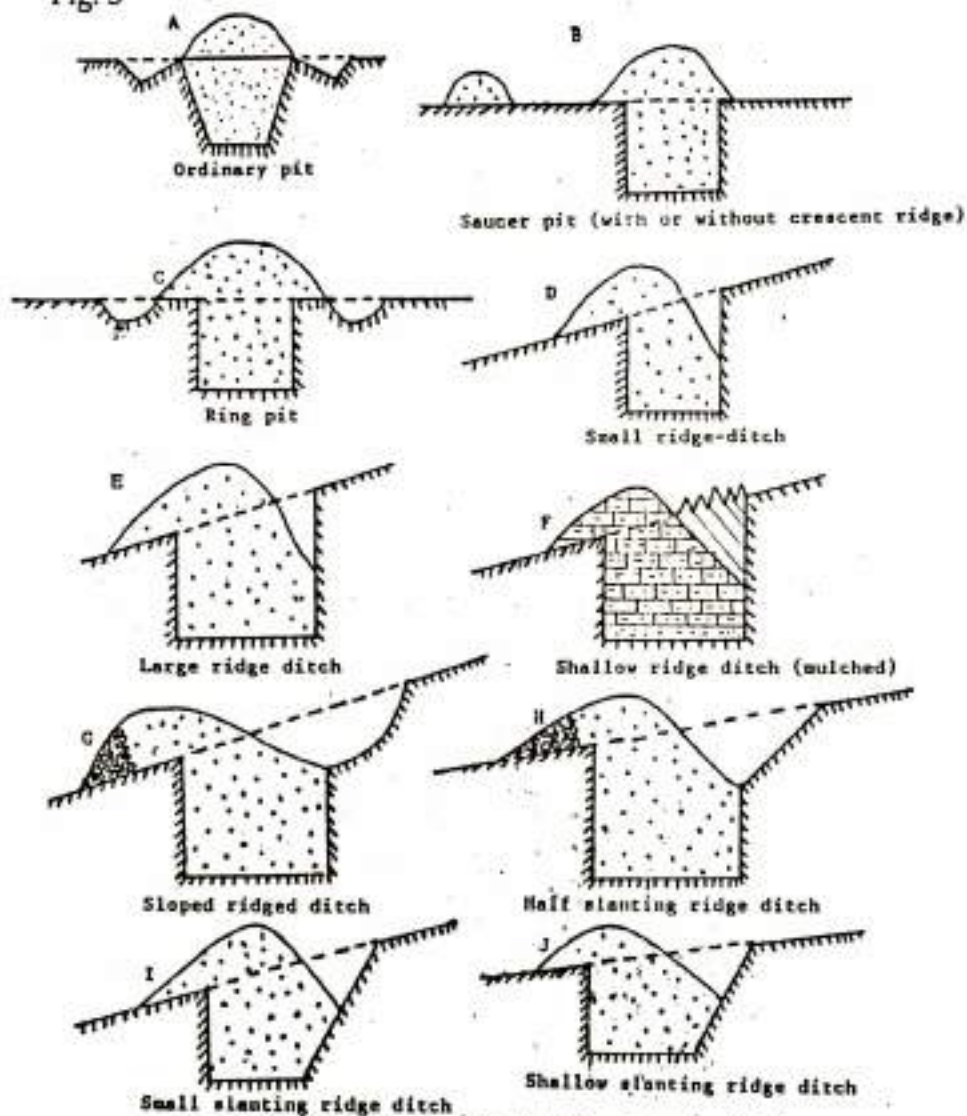
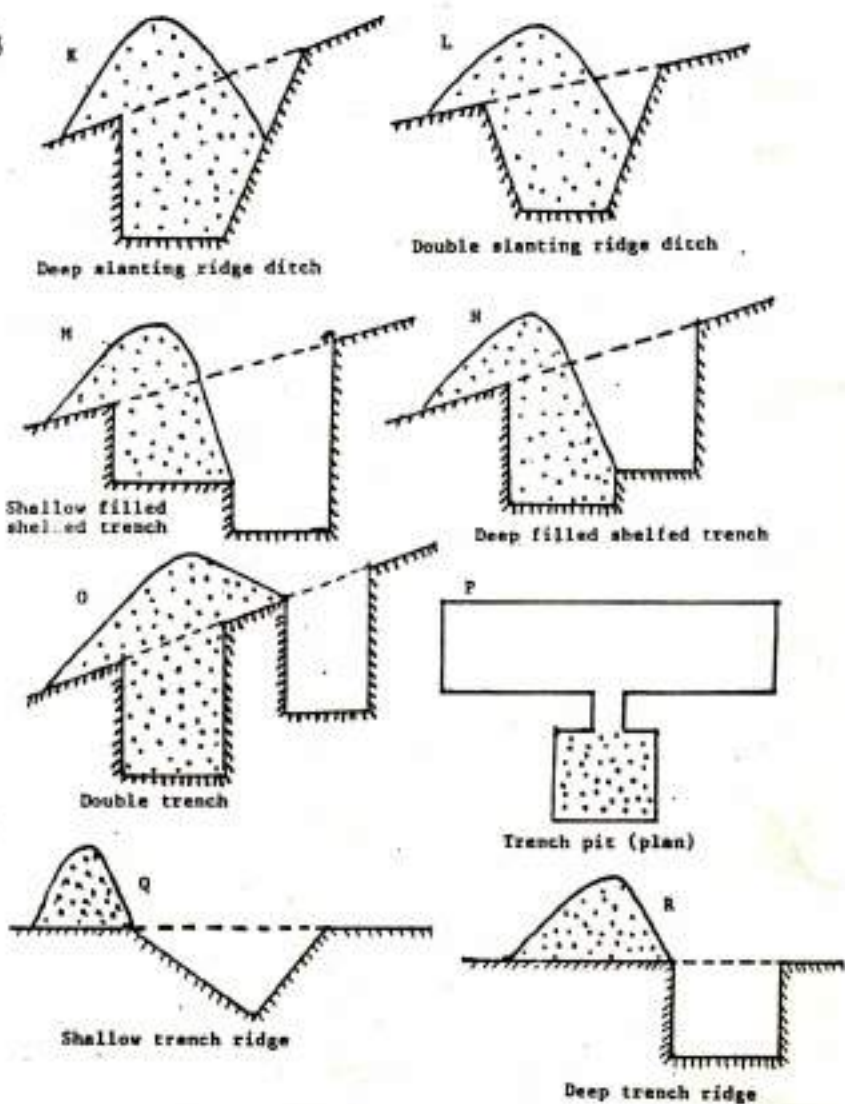


Fig. 7.3 - Soil Working Techniques - Contd.



# CLEARING OF AREA FOR PLANTING

Fig. 3



## ARTIFICIAL REGENERATION

Fig. 3

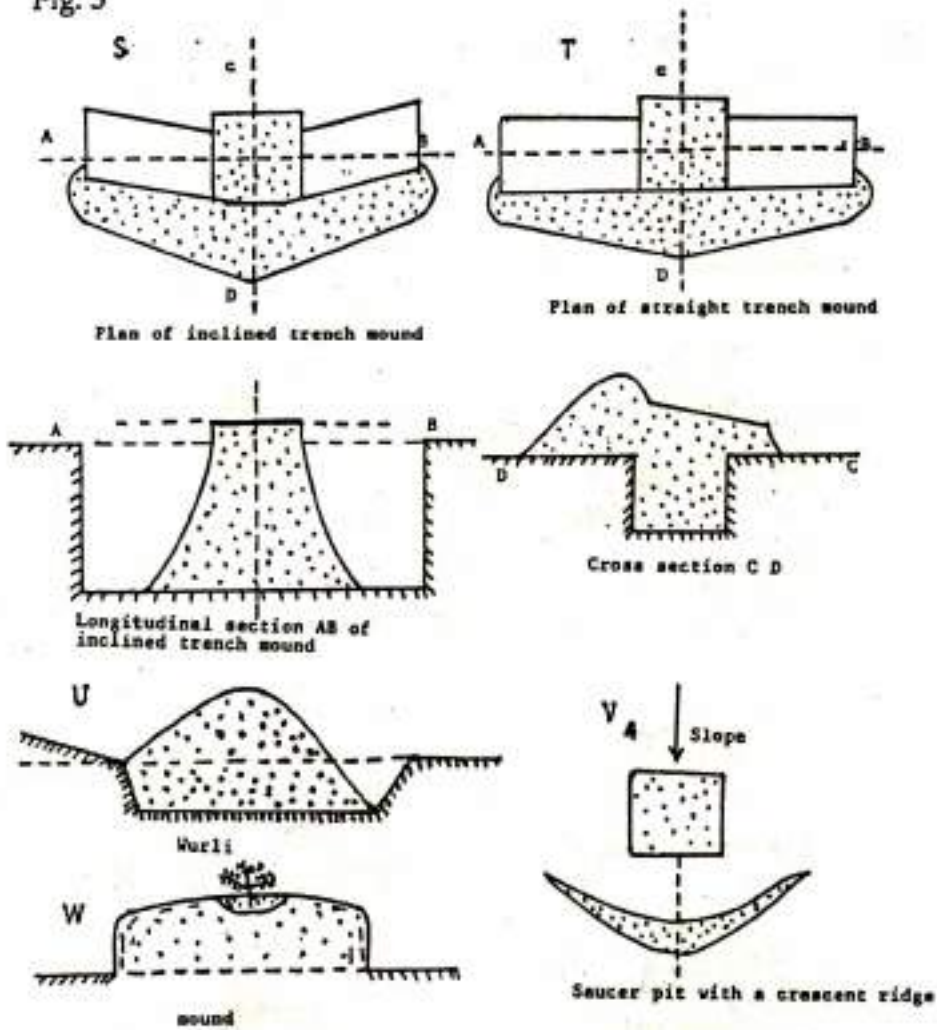


Fig. 7.3 Soil Working techniques

## CLEARING OF AREA FOR PLANTING

Fig. 4,5,6

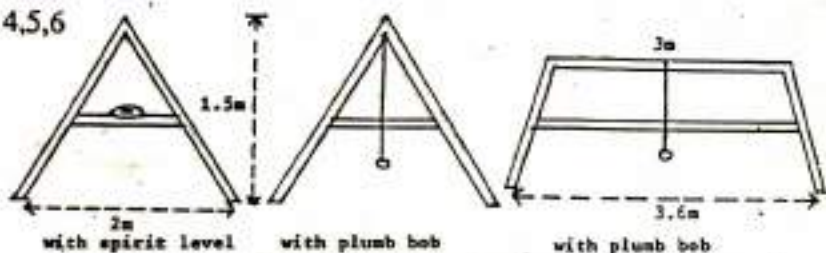


Fig. 7.4 - Contouring frames

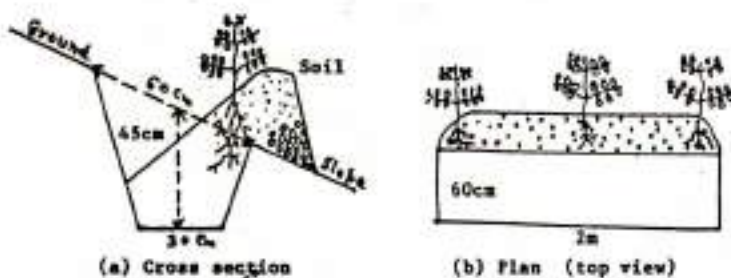


Fig. 7.5 - Contour trench

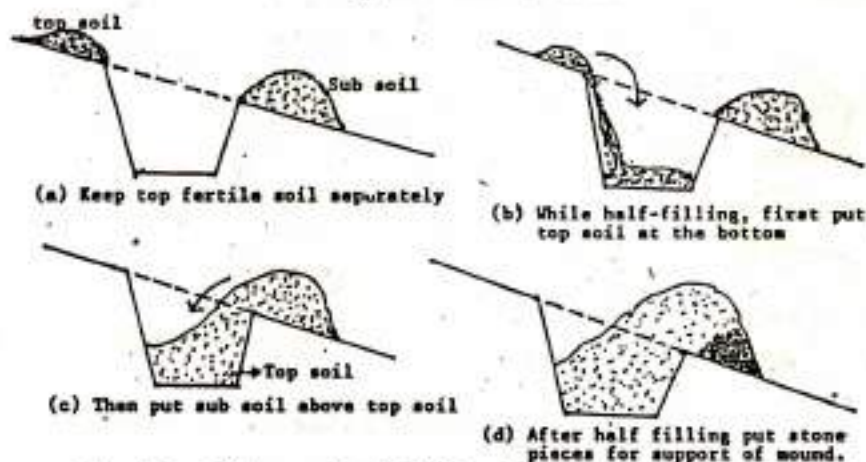


Fig. 7.6 - Digging and half-filling of trenches - the same principle applies to pits also.



**4 A-Double Trench** These techniques are suitable for all annual rainfall classes, especially the deficient ones under

**4 B-Trench-pit.** conditions of topography and soil described above.

## 5. TRENCH MOUND

Like the double-trench and the trench-pit these methods are suitable for ensuring success of plantings and sowings under conditions of low, erratic and badly distributed rainfall. Whereas the double-trench or trench-pit is suitable for moderately to steeply sloping ground, the trench mounds are more adapted to flat or gently sloping areas.

**5 A-Inclined trench-mounds.** If the areas has a gentle slope it is preferable to have the two arms of the trench a little off the contour in order to allow the water to accumulate near the mound. The surplus earth should be formed into a low sloping ridge on the downward side. The smallest practicable size has been shown in the diagram. It may be profitable to increase the width of the mound 2 or 3 feet and the lengths of the arms proportionately.

**5 B-Straight trench-mound.** If the slope is in constant and gentle, straight trench-mounds may be made, as inclination of the trench-arms will have little effect.

These suggestions are based on common-sense considerations and are neither complete nor final. On the contrary, they are suggested as a base for trials so that in due course the best technique of soil working for a given locality, depending upon its climate, topography, rock and soil, may be evolved to ensure better results than are currently obtained.

## ANNEX - 7

## PLANNING FOR THE PROTECTION OF THE PLANTS

The protection of the planted-out plants under plantations must receive the highest priority. In this regard few suggestions are given below in the order of preference :

### I - If individual plants are to be protected

1. Dead, thorny branches of tree and shrubs, as may be available locally.
2. Circular trench of sufficient width and depth round individual plants (To be preferred in drier climates in order to conserve soil-moisture in addition)
3. Tree guards made of bamboo splits, fuel, timber, coaltar drums, wire-meshes (Type of guard will depend on the extent of funds available).

### II. If plants raised in grooves

(less than 10 hectares at one place) are to be planted

1. Dead thorny branches of tree and shrubs as may be available locally.
2. Erection of Live hedges (to be erected and year in advance of planting)

#### Thorny

- (I) *Agave americana* (Agave)
- (ii) *Caesalpinia crista*
- (iii) *Capparis xylenica* (Ulat Kanta)
- (iv) *Gymnospora montana* (Baikal)
- (v)
- (vi) *Mimosa rubicaulis*
- (vii) *Opuntia dillenii* (Nagfani)
- (viii) *Parkinsonia aculeata*

#### Non-Thorny

- (I) *Clerodendron inerme*
- (ii) *Dodonia viscosa*

3. Cattle Proof Trench as given in III below.

### III- If large-scale plantations (more than 10 hectares at one place) are to be protected

1. Live-hedges : As listed above.
2. Cattle Proof Trenches (CPT) with/without live hedges. A suitable size for the CPT is 1.5 metres width at the top, one metre at the bottom and 1.20 metre deep. Live hedges as listed above, may be put on the mounds.
3. Barbed-wire (Provided funds are available)

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