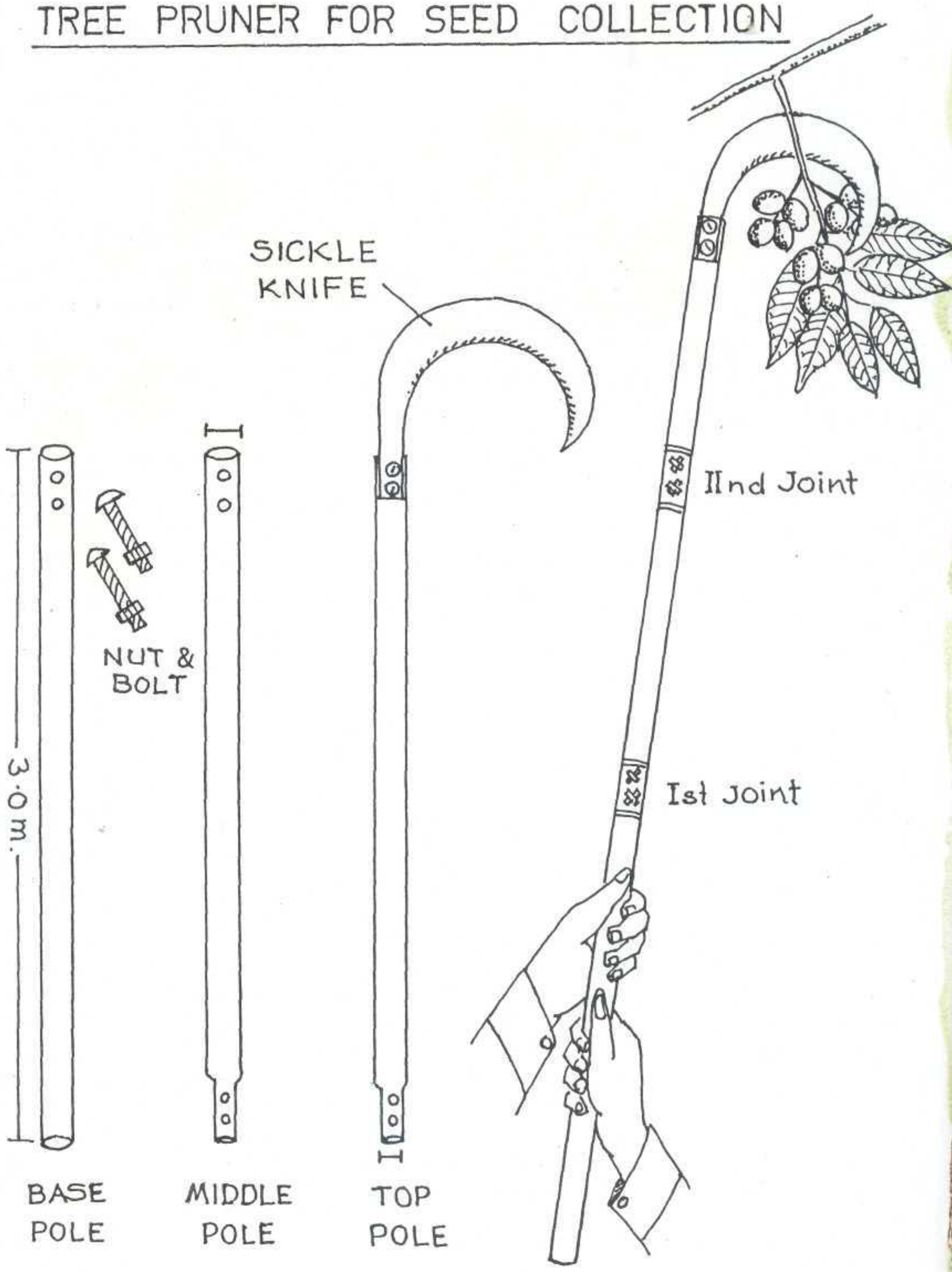
SEED TECHNOLOGY

N.S. BISHT
AND
S.P. AHLAWAT

STATE FOREST RESEARCH INSTITUTE
Department of Environment & Forests
Government of Arunachal Pradesh
Itanagar - 791 111 (India)

TREE PRUNER FOR SEED COLLECTION



CORRUGATED ALUMINIUM PIPES

ARUNACHAL PRADESH

MINISTER
ENVIRONMENT AND FORESTS
GOVERNMENT OF ARUNACHAL PRADESH
ITANAGAR.

Dated the 7th May, 1999.

FOREWORD

Arunachal Pradesh is the northern most and the biggest state in the northeast India. It has 82% of its area under forest cover and has the privilege of having the highest per capita forest area in the country (7.94 ha). The population of the state is increasing day by day thereby demanding more and more from the forests. We approach the millenium in a world in which loss of biodiversity, shrinking forest cover, land degradation, loss of top soil and climate change are the major concerns to today's foresters. Massive afforestation efforts are required to meet up the demand of growing population and to reduce the pressure on natural forests.

The availability of the quality seed is the first and the most important requirement for the success of any afforestation programme. Useful information has been compiled on the local tree species regarding the collection and processing of seeds, its storage and testing, breaking of dormancy and different methods of seed treatment to enhance germination. I congratulate the department for bringing out such a comprehensive publication and hope that it will go a long way to help in biodiversity conservation and sustainable management of our forests on scientific basis.

Nabam Tuki

GOVERNMENT OF ARUNACHAL PRADESH

PRINCIPAL CHIEF CONSERVATOR OF FORESTS
ITANAGAR-791 HI

Dated Itanagar, the 6th April 1999

PREFACE

Quality seed is an integral component of great relevance in tree improvement programme. In forestry efforts are now on for production and use of superior and quality seeds to ensure better survival and growth of plantations undertaken under various programmes. Seed quality depends on factors like source, time and techniques of harvest, processing and storage practices. Unlike agriculture, the forestry seeds have great variation in size, shape, dormancy, viability, moisture content, etc. It needs special techniques for collection, handling, processing and storage of the seeds of the large number of forest species. The information available is scattered in diverse literature and publications. There was an urgent need to assemble some of this basic information in a comprehensive manner to be of use readily by foresters and others interested in growing trees.

This bulletin gives information on various aspects of seed namely seed collection, method of processing, storage and its treatments for optimum time of germination and to find out viability. Dr. N.S. Bisht, D.F.O. Silviculture and Dr. S.P. Ahlawat, Forest Geneticist have put in lot of efforts to bring out this information. The table of tree seeds that highlights fruiting and collection period, seed weight and other aspects is very useful and cover most of the tree species found in the state. I am sure that the bulletin will be useful to field staff, students, researcher and others interested in growing trees.

S.R. Mehta

CONTENTS

1. INTRODUCTION

A seed has been defined as a 'mature ovule' or a reproductive unit formed from fertilized ovule, consisting of an embryo, reserve food, and, a protective cover. Seeds of woody plants exhibit a great range of variation in shape, size, colour and behaviour.

The most essential factor for the success of plantation is the ready availability of quality seeds. The quality of seed is totally responsible for the future return/performance of each and every seedling. The poor quality seeds may have following problems :

- low germination percentage
- poor emergence
- poor survival
- poor adaptability to site
- susceptible to disease and pests
- poor growth
- low productivity

Characteristics of good seeds :

- must be well ripened, healthy and true to type,
- must be pure and free from inert materials and weed seeds,
- must be viable and have good germination capacity,
- must be uniform in its texture, structure and look, and
- must not be damaged, broken and affected by pests and diseases.

2. SEED COLLECTION

It requires good planning in advance regarding deployment of trained staff, arrangement of transportation facilities, seed collection equipments, measures to ensure the safety of workers, packing and labelling material, and maintenance of the records, etc. The other important points are :

- information about the location, time of flowering and fruiting,
- information about the periodicity of seed crop,
- prefer seeds of well-adapted local source to the unadapted sources of different places,
- avoid isolated trees of naturally cross-pollinating species, since these are likely to be self-pollinated. Seeds from such trees are likely to be few or may have low viability and produce weak or malformed seedlings,
- avoid stands of poorly formed, excessively flimsy, off-colour, abnormal or diseased trees,
- change in latitude , humidity, temperature and attack of pests greatly affects the seed quality, yield and periodicity,
- fruit ripening gets delayed due to rains and advanced due to high temperature and drought,
- flowering and fruiting is earlier by 10-15 days in western parts of Arunachal Pradesh in comparison to the eastern parts.

In most of the tree species seed matures in a phased manner within a few weeks. At first, few seeds ripen and the number gradually increases till it reaches a peak **(synchronised maturity)** and then there is a gradual decrease. The mature seeds collected during the peak phase give more uniform germination and have greater longevity in storage than immature seeds.

2.1. Seed Periodicity

Most species do not produce abundant crops of seed annually. Good seed year occurs at intervals that are better thought of as sporadic rather than predictably periodic. The first essential requirement is an ill-defined state of physiological readiness for flowering and supply of nitrogen and phosphorus. Sometimes good seed crops follow years of total failure. In general, the more favourable the conditions of soil and climate for plant growth, the more frequent are good crops of seed.

Seed crop can be estimated by

- flower count,
- immature fruit and seed count,
- fruit count on standing trees, some trees e.g., *Bombax ceiba, Delonix regia, Gmelina arborea, Pinus kesiya, Tectona grandis,* produce good seed crop every year,
- Dipterocarps like hollong and mekai bear irregular heavy seed crops at an interval of one to six years,

- some species (e.g. *Eucalyptus)* produce heavy seed crops every year when grown in plantation, and
- species like Teetasopa *(Michelia champaca),* Pines and *Araucaria* take one to two years from pollination to ripen their fruits.

The best seed producers are ordinarily dominant trees that have attained middle age and are healthy with reasonable good form. The likelihood that their seeds will be of acceptable genetic quality is greatest if similarly good trees are chosen. Unfortunately, it is easier to gather seed from short or easily climbed and poor crowned trees, which should be avoided.

It is always advisable to examine the seeds of a tree in the field before effort is expended in gathering more of them. Cutting a cross section to see that how many seeds are hollow, empty and immature can do this.

Seeds can be collected from the ground i.e. collection of naturally fallen fruits/seeds or it can be collected directly from the trees. Large-sized fruits/ seeds e.g. *Ailanthus, Canarium, Dipterocarpus, Elaeocarpus, Gmelina, Quercus, Tectona,* etc. are easy to see and pick-up from the ground. It is easy and low cost method applicable to species having large seeds or fruits. However, there are certain drawbacks if seeds are collected from the ground :

- chances of attack by fungi/insects/animals are more if not collected immediately. Seeds of legumes are more prone to insects,
- chances of collection of non-viable, immature and empty seeds are more in case of seeds having short viability, and
- it is difficult to know the parentage of seed.

Seed from the standing trees can be collected by following methods :

- by using light weight poles for striking and shaking of branches,
- by using poles with knife and sickle for cutting the small branches (Fig. 1),
- by climbing on the tree with the help of tree-bicycle, rope-ladder, one-legged ladder, tree pruner, etc. and
- by using nets and other local materials.

Cones or fruits should be collected after the seeds have completed their development but before their dispersal. Most cones and some fruits mature when desiccation starts, if so, this is the most reliable indicator. It is very difficult to collect the fully mature seeds of *Acer laevigatum, Ailanthus grandis, Bombax ceiba, Oroxylum indicum, Ulmus lancifolium, etc.* because their samaroid fruits/winged seeds are liable to be blown over wide distances while plucking them.

3. SEED EXTRACTION AND PROCESSING

The method of seed extraction depends on the type and nature of fruits. The cones and dry fruits generally shed seeds if dried in open air or sunlight. Seeds from fleshy or pulpy fruits may be removed by macerating/crushing and washing, while the seeds borne in pods or husks can be extracted by thrashing. Other methods like drying of seeds under cover (e.g. *Abies, Cedrus, Dipterocarpus, Hopea, Quercus, Shorea),* thrashing, de-winging and picking by hand, etc. are used as per the morphology of seed/fruit. However, care should be taken during all these activities so that seeds are not damaged .

3.1. Seed Cleaning

It can be done by the following methods :

- screen cleaning by using sieves of different pore sizes,
- air separation/winnowing or by aspirators,
- de-winging reduces storage volume, make upgrading possible, sowing easier and removes pathogen,
- empty seeds can be removed by liquid floatation, and
- seed drier, seed grader, seed separator, seed blower, seed scarifier, sieves, etc. are some of the useful equipments of seed processing.

3.2. **Seed Upgrading**

It reduces the chances of disease, quantity of the seed to be procured as well as its costs. It is done as follows :

— remove weak and damaged seeds,

— remove empty, immature, and discoloured seeds.

3.3. **Post-harvest Care**

The time between collection and extraction of seed is very important to maintain high germination and vigour. Some of the important points to be remembered during seed collection and storage are as follows :

— the freshly collected seed should not be exposed to sun except cones of conifers, *Alnus, Betula, Casurina,* capsules of *Eucalyptus* and *Toona,* etc. The sun's heat may kill the seeds,

— the safest drying method for delicate species like Dipterocarps, Deodar, Fir, Neem, Oak, Vitex, etc. is to spread a thin layer of fruits in well ventilated rooms and stirring at regular intervals,

— seeds should not be left in wet areas otherwise it will rot and die,

— the soft and fleshy seeds such as ash, bonsum, gamari, leteku, neem, etc. should not be kept in heap or large sacks/bags immediately after harvest. They can be kept in small-untied perforated sacks or open basket after cleaning of pulp and drying of seeds. The large and closed sack generate much heat as well as thermophilic fungi that can kill the seeds.

— seeds should be completely dried and labelled before putting them for storage under species-specific conditions,

— fruit storage is advantageous in some species for **after—ripening,**

— recalcitrant seeds deteriorate if their moisture content is reduced too much or too rapidly.

Seeds can be categorised into following three groups on the basis of their harvesting and collection behaviour:

(i) harvest dry and keep dry e.g. *Acacia, Albizia,* and pine,

(ii) harvest moist then dry e.g. gamari, and

(iii) moist forever e.g. hollong and mekai.

4. **SEED STORAGE**

Seed storage is the preservation of viable seed until their sowing/requirement. It is essential to offset the uncertainty of seed production/availability during bad seed years. It delays deterioration, maintains viability and protects seed from rodent and insect damage. The longevity of seeds is a species-specific characteristic. The seed of most of the species can be stored at low temperature and low moisture content in sealed containers. It is important to dry the seed uniformly to prevent fluctuation in moisture content during storage. The moisture content of most of the seeds for storage ranges between 10 to 12 per cent. The respiration continues at low temperature, which is necessary to keep the embryo alive. **Polythene bags make good containers because they are impermeable to water but less so to oxygen and carbon dioxide.** However, many species of moist tropical forests are so thoroughly adapted for germination that their seeds are almost impossible to store or even to transport. On the basis of storage behaviour seeds can be divided into following broad categories :

4.1. **Orthodox Seeds**

Seeds, which can withstand drying down to low moisture content of around 5% to 10% and successfully stored at low or sub freezing temperature for long periods. For example, *Acacia, Anthocephalus, Betula, Duabanga, Eucalyptus, Fraxinus, Pinus, and Picea* etc.

4.2. **Sub-Orthodox** Seeds

Seeds of *Abies, Juglans, Salix* and Poplar loose viability within a few months in open air. These can be stored under same condition as true orthodox, but only for six months to a maximum of six years in some cases, loss of viability ranges from 0% to 34% when stored at -5°C to -20°C and moisture content between 5 to 10 per cent.

4.3. Temperate-Recalcitrant Seeds

Seeds are desiccation sensitive and can be dried to 35 to 50 per cent moisture content of fresh weight. Storage temperature varies from 3°C to-3°C e.g. *Acer, Aesculus and Quercus.*

4.4. Recalcitrant Seeds

Seeds which cannot tolerate drying below a relatively high moisture content (often in the range of 20% to 50% net basis) and which cannot be stored successfully for long periods, e.g. Hollong, Mekai and other dipterocarps, cane, champ, neem, rubber, and members of family Lauraceae, etc. Their seeds are sensitive to low temperature, chilling damage and death may occur if stored in low temperature. These are most difficult group to store even for short period.

The storage result of different categories of seeds are presented in table 1 and 2 to give an idea about the storage conditions and viability thereof.

5. SEED DORMANCY

Seeds are usually produced during a favourable period but must often survive a dry or cold period and are ready to germinate during the next growing season. To achieve this they develop varying degree of dormancy, a condition in which they do not grow and their physiological processes become very slow. Seed of many species are often adapted to remain dormant and do not germinate until condition of moisture and temperature becomes favourable. The conditions under which they are stored or treated in nature usually work for the breaking of dormancy at the right time, so that it will germinate only when conditions are favourable for survival. However, if seeds are stored under artificial conditions, it may be necessary to treat them in a way that simulates the natural processes of germination. **The seeds of many species in tropical rain forests do not develop dormancy because conditions are always favourable for growth.** It is a species-specific natural phenomenon. To a large extent dormancy is under genetic control. The dormancy may occur due to following reasons (types of dormancy):

— seed **coat imposed dormancy** due to hard seed coat, e.g. *Acacia, Elaeocarpus, Robinia, Terminalia spp.,* and other legumes,

— **seeds with morphologically immature embryo** e.g. *Abies, Adina cordifolia, Casia fistula, C. siamea, Fraxinus, Lagerstroemia parviflora, Panax spp,, Picea, Terminalia chebula, Pinus etc.,*

— seeds **with internal dormancy** i.e. factors located in the inner tissues like metabolic blocks in the mature embryo or presence of some inhibitors, e.g. *Adina cordifolia, Albizia labbeck, Castanea spp., Dalbergia latifolia, Ginkgo biloba, Picea, Taxus baccata, Terminalia chebula,* and *Tsuga.* It is further divided into following categories on physiological basis :

(a) shallow dormancy,

(b) intermediate dormancy,

(c) deep dormancy,

Double dormancy •—caused by the factors related to seed coat as well as embryo. The latter may be caused either by the physiological deficiency in the embryonal axis or due to the presence of metabolic blocks within the cotyledons, e.g. *Emblica officinalis, Gmelina arborea.* Some of the common methods to overcome dormancy are described in para no.8.

6. SEED TESTING

Seed testing is essential to assess the physical and biological aspects of seed. Seed tests are commonly done immediately after extraction and shortly before actual sowing. It is also done periodically on seed lots kept in long storage. For small nurseries, common sense, clean hands, a clean working table and one good knife are sufficient for most seed testing tasks. Some of the common terms and methods have been described below :

6.1. Seed Lot

A seed lot is defined as a **specified quantity of seeds** of reasonably uniform quality from a particular geographic source.

6.2. **Purity Test**

It determines what proportion of the seed sample by weight has pure seed and what proportion is other material. The four recognized components of a seed lot are pure seeds, other seeds, damaged seeds and inert matter such as seed wings, twigs, stone soil or other non-seed materials. The separation is done manually by placing seeds on a working table. The immature, shrivelled, cracked, and damaged seeds larger than one-half of the original seed-size, including those with internal insect damage and those starting to germinate, are designated as "pure" seeds. Thus, if the initial weight of a seed sample is 50 gm and the pure portion weighed 40 gm, purity of the lot is :

$$\frac{40}{50} \times 100 = 80\%$$

6.3. **Seed Weight**

It is normally expressed for 1000 pure and full seeds. Factors affecting seed weight are size, moisture content and proportion of full seeds in the lot. It is generally calculated by taking 10 random samples of 100 seeds from a pure lot. If the difference between any two replicates exceeds 10% of the mean weight, additional replicates should be drawn. To convert number of seeds per kilogram following formula is applied :

$$\text{No. of seeds per kg.} = \frac{10,00,000}{\text{1000 seed weight in gm.}}$$

6.4. **Seed Moisture Content**

Knowledge of seed moisture content is essential to determine the viability and storage conditions. Seeds of high moisture content cannot be stored and overdrying can make them non-viable. It can be determined by drying of l0g sample in oven at 103°C for 17 hrs (or at 130°C for 1 to 4 hrs), weighing and calculating through the following formula.

$$\text{MC\%} = \frac{\text{Original wt. of seed - oven dry wt. of seed}}{\text{Original wt. of seed}} \text{X}100$$

6.5. **Germination Test**

The most reliable test of seed viability is to germinate a representative sample (four replicates of 100 seeds each) under laboratory conditions. Under field conditions cutting the seeds into two equal parts can test viability. Seeds having fully grown, firm and undamaged embryo can be presumed to be good. However, this is not a reliable test for stored seeds because loss of viability in storage may not produce immediate visible changes.

6.5.1. **Laboratory germination counts (LGC)**

Seeds (100 nos.) are placed on moist blotting paper or cotton-wool in a petridish after giving the necessary pre-treatment In case of very small seeds, e.g. khokan and kadam, one-gram seed is taken. The petridishes are placed in a warm **(not hot)** place and kept moist regularly. The number of seeds, which germinate, is counted every day and after 4 weeks or more LGC is calculated as :

$$\text{LGC\%} = \frac{\text{No. of seed germinated x 100}}{\text{No. of seeds sown in petridish}}$$

It is expressed as the number of seeds germinate per kilogram.

6.5.2. **TTZ** Test

Another simple test is **tetrazolium (TTZ) staining test,** which indicates the presence of live tissue. 1% solution of TTZ (2,3,5 - triphenyl-tetrazolium chloride) is applied to fully imbibed seeds, which have been cut opened length-wise without damaging the embryo. The seeds are left overnight (18 to 24 hrs in the dark at 30° C). The live embryo, cotyledons and other tissue stain pink to red indicating that the seeds are viable. Comparatively larger seeds like *Albizia, Bauhinia, Phoebe goalparensis,* etc. can be conveniently tested in this way.

6.5.3. Germination energy

It is a measure of the speed of germination and hence it is assumed value of seed vigour and seedlings it produces.

It is the percentage of seeds that germinate up to the time that the rate of germination reaches a peak. It is expressed in percentage terms as per the following formula:

$$GE\% = \frac{\text{No. of seeds germinate in time 'A' x 100}}{\text{No. of seeds sown in the } \textbf{pelridish}}$$

7. SEED VIGOUR

It comprises of those properties, which determines the potential for rapid, uniform emergence and development of normal seedlings under a wide range of field conditions. It is rather a loose term used to describe observable germination differences in seed lots of similar or different genetic make up.

8. SEED TREATMENT

Some of the common methods of seed treatment and overcoming dormancy are mentioned below :

8.1. Boiling Water Treatment

It is generally used for the seeds having very hard seed coat e.g. *Acacia auriculiformis, A. mangium,* etc. The seeds are kept in boiling water for about two minutes after that they are kept in cold water for 1 to 2 days before sowing.

8.2. Hot Water Treatment

This method is generally used for the seeds having hard shell e.g. *Albizia, Cassia, Leucaena leucocephala,* etc. After boiling the water, it is allowed to cool for 10 minutes. The seeds are soaked for 1 to 2 days till they get swelled. The water is changed every day (cold water) and the seeds floating on the top are discarded.

8.3. Cold Water Treatment

This method is used in most of the species to get a uniform germination. The seeds are soaked at room temperature for a period ranging from 2 to 48 hrs depending on the species. The seeds, which float on the top of water, are discarded e.g. *Acacia, Albizia,* and Poplars.

8.4. Wet and Dry Method

It is generally used for teak. Seeds are soaked one night in cold water and next morning the seeds are spread in the sun for drying. This process is repeated 8 to 10 times after that seeds are sown in the nursery beds.

8.5. Scarification

It is the process of breaking, scratching, or altering the seed coat mechanically/chemically to make it permeable to water and gases.

8.5.1 Acid scarification

Some species, which have very hard seed coat, require 10 to 60 minutes soaking in concentrated sulphuric acid followed by 1 or 2 days soaking in cold water to break the dormancy, e.g. *Albizia falcataria, Elaeocarpus ganitrus.* Before soaking in water wash the seeds thoroughly to remove acid. However, care should always be taken that **never add or splash water on acid**

8.5.2. Mechanical scarification

Impermeable seed coats can be broken mechanically with files, sand paper and electric needle (hot wire). Care should be taken to ensure that the embryo is not damaged. For large quantities filling seeds with sharp gravel-stones in a rotatory drum having abrasive disks on inner side is very useful e.g. *Acacia catechu, A.-nilotica, Albizia spp. Cassia fistula, Delonix regia, Elaeocarpus spp, Sapindus spp, and Terminalia arjuna.*

8.6. Stratification

In many species such as *Abies, Acer, Primus persica, Fagus,* etc. dormancy can be overcome by keeping the seeds at low temperature, usually between 1℃ to 5℃, with abundant aeration and moisture for periods varying from 30 to 120 days. Alternating temperature treatments (like day and night) are required for some species. After stratification seeds should be sown without delay. Seeds of some temperate species germinate better if placed in moist sand or soil and kept in the cold during winter.

8.7. Light Requirement

Providing illuminated white light to the hydrated seeds can terminate dormancy of many tree species. Seeds of *Albizia procera, Casia fistula, Gmelina arborea, Pterocarpus dalbergioides* and *Pinus merkusii* are positively photo blastic and light hastens the termination of seed dormancy.

9. TREE IMPROVEMENT AND QUALITY SEED PRODUCTION

Seed quality involves both genetic and the physiological quality of seeds. Good seed means that has both high physiological quality and genetic suitability. Methods for improvement of physiological qualities have been discussed in the previous sections. Genetic improvement of seed quality means the ability to produce trees that are best suited to the plantation sites and for the desired products. Genetic gains, wider adaptability and conservation of forest genetic resources are main aim of tree improvement programme. Genetic gains can be obtained from selection among species, provenance within species and/or trees within provenance. Some of the important points are mentioned below :

— the largest, cheapest and fastest gain in most tree improvement programmes can be obtained by use of already adapted and productive provenance of the desired species.

— test plantings are the only sure method to determine the genetic quality and suitability of exotic species. Without analysing their result and to avoid failure or sub-standard performance, the safest rule is to use seeds of phenotypically selected stands or trees in local provenance of native species.

— exotic tree species should be used only when the desired product cannot be obtained with native species at comparable cost.

9.1. Selection of Plus Trees

The first step in a tree improvement programme is the selection of plus tree in which best and promising phenotypes are identified. Immediate use of this selection process can be made by harvesting seeds from selected parent (plus trees) to get modest genetic gains specially for stem form and growth rate. One of the important effects of plus tree selection is to avoid the degradation of genetic quality which may occur when seeds are collected from short, branchy or easily climbed trees of poor quality. Culling out the undesirable trees and fertilizing the soil around the selected trees can encourage seed production in the selected stands. Local efforts can also be made to protect the seed from damage. In Arunachal Pradesh, State Forest Research Institute (SFRI) has identified nearly 800 plus trees of different species of commercial importance which are being used for creation of clonal seed orchards, germplasm bank as well as for seed collection.

Selection criteria

It varies from species to species and depends on the objectives of improvement programme i.e. weather for timber production, social forestry or NTFP purposes. Some of the important characteristics considered for selection of plus tree for timber purpose are as follows :

— straight, cylindrical, non-forking, non-twisting bole, without buttress,

— fast growth, (maximum height and girth in comparison to neighbours),

— narrow and minimum crown,

— thin branches with wide branch angles,

— high wood density and long fibers, and

— resistance to pests and diseases.

Selection is carried out in natural stands or preferably in plantations. Certain considerations of importance in the choice of the site for selection are mentioned below :

- selection should be made from stands that are as pure in species composition as possible,
- selection should be concentrated on stands or plantations that are average or better in traits of interest,
- selection works better in an even aged stand, since the age difference can be eliminated from the evaluation,
- selection is best carried out in **a** mature stand i.e. near to maximum height and girth, and
- selection in natural forests where selective logging has taken place should be avoided since the best trees might have already been removed, leaving the poorer behind.

The plus trees should not be selected too close to each other, since closely growing trees may be genetically related, i.e. involving same parent (s). A thumb rule suggests to select one tree per hectare or one per 1000 trees. The various parameters for selection and maintaining the record of plus trees are mentioned in Annexure **1.**

9.2. Seed Production Area (SPA)

These are developed from the existing stands of natural or plantation origin to meet the immediate requirement of quality seed in bulk on interim basis until the seed orchards come into production. It is a phenotypically superior stand made up of vigorously growing healthy trees upgraded by thinning to remove the inferior trees and are managed scientifically to cause abundant seed production. It is a short-term improvement programme used for immediate genetic gains. The main advantages are the availability of good quality seed from compact area of known provenance, ease of collection, maintenance and surety of sustained seed supply. The details of the seed production areas developed by SFRI are given in Table 3.

9.3. Seed Orchards

It **is** the plantation of genetically superior trees, isolated to reduce pollination from genetically inferior outside source, and managed intensively to produce regular and abundant seed crops of sound and easily harvested seeds. It is a long-term programme coupled with progeny tests. The expected genetic gains from such orchards vary from 30% to 40%. These are of two types :

9.3.1. **Seedling** seed orchards (SSO)

These are raised from the seeds collected from plus trees and involve progeny testing. Culling is done to remove inferior families and trees, leaving only the best trees to cross-pollinate for seed production. It takes long time to come into seed production stage and genetic gain is also less than the parents. Generally it is raised for those species that are difficult to propagate through vegetative methods.

9.3.2. **Clonal** seed **orchards (CSO)**

These are developed by collection **of** the vegetative propagules (usually grafts) from the selected plus trees and grafted on the root-stocks. The clones are planted together systematically as per the design to form an orchard. The progeny tests of plus trees are simultaneously conducted **for** culling of inferior trees or clones.

The advantage **of** clonal seed orchard is that they come into flowering stage at very early age. The management and cultural operations like seed collection is very easy. The chances of crop failure are minimised. Further breeding and improvement programmes can be taken easily and germplasm of the selected individuals are preserved. SFRI has developed the CSO of 9 commercially important tree species at Van Vigyan Kendra , Chessa and Namsai (Table 4).

10. ESTIMATION OF SEED REQUIREMENT

The first requirement of a nursery/plantation manager is to know the quantity of the seed required for each species/provenance as per their annual targets. This can easily be calculated on the basis of the example given in Annexure 2.

The details of the fruit types, seed-collection period, number of seeds per kilogram, pre-sowing treatment, germination percentage and viability of local tree species along with some common exotic species is given in Table 5.

PLUS TREE RECORD FORM

Species ....

Plus tree No.

Forest Division

Range

R.F. and Compartment No.

Locality

Age

Area of crop

Quality class

Type of Forest

Annual Rainfall Altitude '•

Basal area/ha

Average crop height

Average crop diameter

Number of trees per ha

Selected by. . . . . Dt.

Certified by. . . . . Dt.

Discarded by. . . . . Dt.

Part I

	Plus tree	Comparision trees 1 2 3 4 5	Av. of Comparision trees
1. Totalheight(m) 2. Clear Bole height (m) 3. Crown length (m) 4. Crown diameter (m) 5. Girth at b.h.(cm) 6. Diameter at b.h.(cm) 7. Diameter at mid point of Ht. (cm) 8. Bole volume 9. Straightness of bole lO.Crown (light/medium/ heavy) 11. Taper (normal/moderate) 12. Grain (straight/spiral) 13. Fluting/buttress (absent/moderate) 14. Branches (thick/thin etc.) 15. Epicormic branches (absent/present) 16. Flowering/Fruiting (normal/not observed) 17. Natural pruning (present/absent) 18. Diseases (absent/ present) 19.Shape (cylindrical/ conical)			

Part-n

Selection differential:

Bole Volume

Total Height.

Bole Height.

d.b.h.

Part-Hi

Photograph of plus tree Yes **No**

Part-IV

Sketch plan (map) showing location of plus tree with detailed description of area.

Estimation of Seed Requirement per ha

S.N.		Items of work	Pinus kesiya	Tectona grandis
1.		Spacing	3mx2m	3m x3m
	(a)	Number of seedlings required	1,670	1,111
	(b)	Requirement of seedlings for casualty replacement @ 20%	334	222
		Total requirement of seedlings for planting operations	2,004	1,333
	(c)	Nursery losses/culls	20% (+)	62.5%•(++)
		Number of seedlings	400	833
	(d)	Total requirement of germinated seedlings	2,404	2,166
2.		Estimated number of germinated Seedlings obtained from one kg seeds	32,000	500
3.		Seed requirement (one hectare)*	0.075 kg	4.33 kg
4.		Planting area (ha)	100	100
5.		Seed requirement	7 kg	433 kg

+ = Losses and culls represent 20% of the germinated seeds in *P. kesiya*

++ - 25% of germinated seeds are estimated to produce plantable seedlings in the first year and an additional 12.5% at the end of second year in the nursery. Losses and culls thus amounts to 62.5% of germinated seeds for teak.

* = In P. *kesiya* sowing unit is a true seed. In T. *grandis* it is a fruit which may contains 0 to 4 seeds.

Table 1. Storage conditions for four storage classes of tree seeds (Bonner et al. 1994)

Storage class		Storage period (years)	Seed moisture (per cent)	Storage Temperature CO	Container type
True orthodox		<5	6-10	0-5	Air tight
		>5	6-10	-18	Air tight
Sub-orthodox		<5	6-10	0-5	Air tight
		>5	6-10	-18	Air tight
Temperate recalcitrant		<3	30-45	-1 to-3	4 mil* plastic un-sealed
Tropical recalcitrant		<1	30-45	12-20	4 mil plastic un-sealed

* mil = 1/1000 inch = 0.025 mm.

Table 2. Storage conditions and results of different class of tree seeds (Modified from Bonner, 1990)

Species	Class*	Storage conditions		Storage results	
		Temperature (^{0}C)	Moisture (%)	Time stored (Yr)	Viability loss (%)
Abies procera	Orth.	0	9	7.0	11
Acacia mangium	Orth.	4-8	-	1.2	6
Acer saccharinum	Temp. rec.	-3	50	1.6	8
Albizia falcataria	Orth.	4-8	-	1.5	10
Araucaria cunninghamii	Orth.	-15	16-23	8.0	Few
Azadirachta indica	Rec.	26	10-18	56 days	**65**
Bambusa tulda	Rec.	26	4.5	0.10	24
Casuarina equisetifolia	Orth.	-3	6-16	2.0	0-5
Dendrocalamus strictus	Rec.	5	8	2.6	31
Gmelina arborea	Sub-orth	-5	6-10	2.0	10
Hopea helferi	Rec.	15	47	37 days	2
Michelia champaca	Rec.	5	—	0.8	90
Populus deltoides	Sub-orth	-20	6-10	6	21
Pinus merkusii	Orth.	4-5	<8	4.0	0
Quercus falcata	Temp. rec.	3	33	0.3	10
Salix glauca	Sub-orth	-10	6-10	1.2	0
Shorea robusta	Rec.	13.5	40-50	30 days	60
Shorea roxburghii	Rec.	16.0	40	270 days	+30
Tectona grandis	Orth.	0-4	≃12	7.0	0
Terminalia myriocarpa	Rec.	-	5	0.6	20
Tsuga heterophylla	Orth	5	8	2.0	0

* Orth-Orthodox, Rec-Recalcitrant, Sub-orth-Sub-orthodox, Temp. rec.-Temperate Recalcitrant

Bonner, F.T. 1990. Storage of seeds : potential and limitations for germplasm conservation. Forest Ecology and Management. 35 : 35-43.
Bonner, F.T., J.A. Vazzo, W.W. Elam & S.B. Land (1994) Tree Seed Technology Training Course. U.S.D.A. New Orleans, Louisiana.

Table 3. Seed Production Areas of important timber species developed by SFRI

Species	Area (ha)	Year of creation	Location
Bombax ceiba	2.0	1985-86	Changmara, Pasighat
Dipterocarpus macrocarpus	8.0	1985-86	Namsai
	8.0	1995-96	Madhuban, Namsai
Terminalia rnyriocarpa	1.0	1994-95	Pasighat
	5.0	1998-99	Sile, Pasighat
	5.0	1998-99	Madhuban, Namsai

Table 4. Clonal seed orchards of important timber species developed by SFRI

Species	Area (ha)	Spacing (m)	Total clones	Total ramets	Total blocks	Year of creation	Annual Seed Yield (kg)
A crocarpus fraxinifolius	1.0	7 x 7	16	144	9	1985	35.0
Altingia excelsa	3.0	7 x 7	16	560	35	1986	15.0
Bombax ceiba No.-l	0.6	8 x 4	22	157	6	1981	35.0
No.-2	1.0	8 x 8	22	144	6	1986	10.0
Chukrasia tabuleris	0.6	7 x 7	16	96	6	1985	10.0
Gmelina arborea No.-l	1.0	7 x 7	20	180	9	1985	125.0
	3.0	7 x 7	25	600	24	1986	310.0
No.-3	3.0	7 x 7	25	600	24	1993	35.0
No.-4	4.5	7 x 7	25	900	36	1995	10.0
Michelia champaca	0.6	7 x 7	25	100	4	1985	8.0
Phoebe goalparensis	1.0	7 x 7	20	180	9	1985	40.0
Tectona grand is No.-l	1.0	8 x 8	24	144	2	1981	28.0
No.-2	4.0	8 x 8	24	625	25	1986	300.0
No.-3	1.0	8 x 8	24	144	2	1989	30.0
Terminalia myriocarpa	1.0	4 x 4	25	250	10	1985	15.0

Table 5. Details of the fruit types, collection time, seed weight, viability and germination characteristics of the common trees, bamboos and canes species of North-East India.

Species	Local/common Name	Fruit type	Fruiting-time	Seeds per Kg. (App.)	Viability (Months)	Pre-sowing treatment	Germination period (days)	Germn. %	Sowing season
1	2	3	4	5	6	7	8	9	10
Acer campbellii	Maple; Kapathi	Double samara	Oct-November	31,000	6	N	25 to 60	42	Oct-November
A. oblongum	Maple	Double samara	Oct-November	20,500	6	N	—	50	Oct-November
Acacia catechu	Khair	Pod	Dec-January	33,000	12	HW	4 to 24	85	March-April
Acrocarpus fraxinifolius	Mandhani	Pod	April-May	29,300	27	HW	6 to75	40	May and Sept.
Adina cordifolia	Haldu, Laupatia	Capsule	March-April	1,12,85,000	12	N	6 to 55	50	Feb-March
Aegle marmelos	Bel	Berry	March-May	5,300	1	N	13 to 65	35	April-May
Aesculus indica	Horse chestnut	Capsule	Sept-October	36	12	ST	—	80	Sept-Oct.
Ailanthus excelsa	Maharukh	Samara	June-July	9,500	8	—	15 to 25	36	June-July
A. grandis	Borpat	Samara	Dec-January	1,720	7	N	25 to 120	85	Feb-March
Albizia arunachalensis	Siming	Pod	Sept-October	50,900	24	HW	6 to 10	43	Oct-April
A. chinensis	Siris; Saw karoi	Pod	Nov-December	42,000	12	HW	4 to 10	70	March-April
A. falcataria	Sengon	Pod	Oct-December	42,000	13	HW	4 to 10	75	March-April
A. lebbek	Karoi; Kothia	Pod	December	9,200	24	HW	5 to 20	80	Feb-March
A. lucida	Moj	Pod	Dec-February	9,200	12	N	4 to 25	75	March-April
A. procera	Korai	Pod	Feb-March	21,000	12	HW	5 to 10	70	March-April
Alnus nepalensis	Alder ; Otis	Cone	Nov-December	18,00,000	4	ST	8 to 36	60	Feb-March

1	2	3	4	5	6	7	8	9	10
Alstonia scholaris	Satiana; Chhaiten	Follicle	Mach-April	6,69,100	2	N	5 to 25	40	May-June
Altingia excelsa	Jutuli ; Duang	Capsule	Nov-December	8,00,000	4	N	10 to70	39	Feb-March
Amoora wallichii	Amari	Capsule	June-July	230	2	N	10 to 55	60	Feb-March
Anacardium occidentale	Cashewnut		June-July	180	8	FW	12 to 92	80	July
Anthocephalus chinensis	Kadam; Roghu	Capsule	Aug-Nov & Jan-Feb	16,00,000	12	N	8 to 28	60	March-April
Aquilaria agallocha	Agar; Sasi	Capsule	June-July	1,500	2	N	9 to 52	62	July
Artocarpus chaplasha	Sam		June-July	1,230	1	N	6 to 21	62	June-July
A. integrifolia	Kathal	Achene	June-July	58	1.5	N	6 to 30	70	June-July
A. lakoocha	Dewachali	Drupe	June-July	2,820	1	N	6 to 21	65	June-July
Azadirachta indica	Neem	Drupe	June-July	4,000	1	N	7 to 10	75	June-July
Bauhinia purpurea	Boga Kanchan	Pod	April-July	4,250	12	N	9 to 30	87	June-July
B. variegata	Kanchan; Kotora	Pod	March-May	3,600	12	N	9 to 30	90	April-May
Baccaurea sapida	Leteicu	Capsule	Aug-September	334	6	N	—	—	Sept-Oct.
Betula alnoides	Bhoj-patra	Cone	May-June	1,38,00,000	4	ST	12 to 35	60	May-June
B. cylindrostachys	Birch	Cone	May-June	1,40,00,000	4	ST	12 to 112	40	May-June
Bischofia javanica	Urium	Berry	Dec-January	1,05,000	12	N	12 to 28	75	April-May
Bombax ceiba	Semul	Capsule	March-April	33,000	9	N	4 to 28	80	Feb-March
B. insigne	Didu; Dumboil	Capsule	March-April	15,000	9	N	2 to 30	90	April-May
Bridelia retusa	Kuhir	Capsule	Dec-January	8,240	6	HW	34 to 60	19	Feb-March
Butea monosperma	Palas; Polah	Pod	June-July	2,000	9	N	5 to 32	82	July

1	2	3	4	5	6	7	8	9	10
Callistemon viminalis	Bottle brush	Berry	May and Oct.	2,50,000	12	N	15 to 56	30	Sept-Oct
Canarium strictum	Dhuna	Drupe	Dec-January	3,00	18	N	26 to 140	90	Feb-March
Cassia fistula	Sanaru/Amaltas	Pod	Jan-March	6,800	36	HW	5 to 73	65	March-April
C. jiodosa	Gulabi Amaltas	Pod	Jan-March	8,000	36	HW	5 to 42	52	May-June
C. siamea/C. florida	Chakudi, Kasod	Pod	May-June	35,000	37	HW	5 to 42	55	May-June
Castanopsis indica	Hingori	Achorn	Oct-Nov.	1,300	6	N	35 to 50	45	Feb-March
Casuarina equisetifolia	Beef-wood; Saru	Cone	Dec. and June	7,50,000	6	FW	5 to 45	20	Feb-June
Chukrasia tabularis	Bogipoma	Capsule	Jan-February	90,000	6	N	6 to 36	88	Feb-March
Cinnamomurn camphora	Camphor; Kapoor	Drupe	Sept-October	9,000	6	HW	35 to 55	55	Feb-March
C. glaucescens	Gonsorai	Drupe	Sept-October	2,050	1.5	N	24 to 49	45	Oct-November
Dalbergia assamica	Mauhit	Pod	Nov-December	92,500	12	FW	7 to 35	85	March-April
D. sissoo	Shisham	Pod	Dec-January	55,000	12	FW	7 to 34	85	March-April
Delonix regia	Gulmohar	Pod	Jan-March	1,850	24	HW	6 to 31	85	March-Aptil
Diospyros melanoxylon	Tendu	Berry	May-June	1,100	12	AWD	7 to 25	65	June
Dipterocarpus macrocarpus	Hollong	Samara	Jan-February	64	1	N	8 to 21	70	Feb-March
Duabanga grandi flora	Khokan	Capsule	April	5,40,00,000	6	N	6 to 40	70	April-May
Dysoxylum hamiltonii	Gandheli-Poma	Capsule	Nov-December	2,400	3	N	7 to 30	60	April-May
Elaeocarpus aristatus	Gahorisopa	Drupe	Aug-Sept	500	4	HW	27 to 60	35	March-April
E. floribundus	Jalpai	Drupe	Dec-January	500	3	HW	30 to 75	42	February
E. ganitrus/E. sphaericus	Rudraksha	Drupe	Sept-October	430	6	HW	30 to 200	10	Nov - March

1	2	3	4	5	6	7	8	9	10
Emblica officinalis	Amlokhi, Aonla	Drupe	Nov-January	1,00,000	6	HW	9 to 30	30	March-April
Endospermum chinense	Phul-gamari	Capsule	Oct-November	25,000	6	N	20 to 35	50	Feb-March
Erythrina stricta	Madar	Pod	May-June	6,500	6	N	10 to 35	55	June
Eucalyptus citriodora	Lawn scented gum	Capsule	Dec-January	1,80,000	6	N	5 to 30	80	June-Sept
E. globulus	Bluegum	Capsule	Feb-April	3,50,000	16	N	10 to 35	85	April-May
E. grandis	Red gum, Safeda	Capsule	Sept-October	20,00,000	24	N	5 to 30	85	March-April
E. robusta	Swamp-Mahogany	Capsule	Feb-March	4,20,000	24	N	5 to 25	84	April
E. tereticornis	Mysore gum	Capsule	Sept-October	3,00,000	12	N	5 to 15	90	October
E. torelliana		Capsule	March-April	5,30,000	24	N	8 to 25	75	April
Ficus roxburghii	Autha-dimaru	Achene	Sept-October	33,00,000	4	FW	5 to 20	60	Oct.-Nov.
Gmelina arborea	Gamari	Drupe	May-June	2,500	12	FW	7 to 30	65	June
Grevillea robusta	Silver oak	Follicle	May-June	1,00,000	8	ST	17 to 48	60	June-July
Hevea brasiliensis	Rubber	Capsule	May-June	700	1	N	5 to 25	75	Oct.-Nov.
Hovenia acerba	Chetia bola	Pod	Dec-January	-	6	FW	10 to 30		March-April
Jacaranda acutifolia	Jacaranda	Drupe	December	50,000	12	FW	6 to 18	70	March-April
Juglans regia	Walnut; Kheshing	Drupe	Sept-October	80	12	ST	28 to 50	65	November
Kayea assamica	Sia nahar	Drupe	March-April	30	3	N	90 to 150	70	March-April
Kydia glabrescens	Pichola	Capsule	Dec-January	2,20,000	5	N	6 to 78	35	Feb-March
Lagerstroemia parviflora	Sida	Capsule	Nov-December	28,000	24	N	10 to 62	40	March-April
L. speciosa	Ajar	Capsule	Dec-January	1,10,000	30	N	6 to 58	85	Feb-March

1	2	3	4	5	6	7	8	9	10
Lannea coromandelica	Jiapoma	Drupe	May-June	8,000	4	N	10 to 35	41	June
Leucaena leucocephala	Subabul	Pod	Feb.-May, July-Nov.	20,000	12	HW	10 to 20	85	June-July
Livistona jenkinsiana	Tokopat (Palm)	Drupe	July-August	230	3	FW	44 to 80	60	Aug.-September
Machilus globosa	Kawla	Drupe	Feb.-March	2,500	6	N	21 to 80	40	March-April
Madhuca butyracioides	Pinshing (Hill mahua)	Drupe	June-July	1,030	1	N	10 to 36	70	July
M. longifolia	Mahua	Drupe	June-July	450	1	N	15 to 30	90	July-August
Magnolia globosa	—	Follicle	Oct.-November	3,500	2	FW	30 to 65	60	November
Mallotus albus	Morali	Capsule	April-May	25,000	1	FW	30 to 40	15	May
M. philippensis	Losan; Sindudi	Capsule	March-April	2,500	4	FW	10 to 20	30	March-April
Manglietia hookeri	Phul-sopa	Follicle	Aug.-September	—	1	N	28 to 43	25	September
M. insignis		Follicle	Aug.-September	10,480	1	N	26 to 48	25	September
Mangifera indica	Aam	Drupe	June-July	10-237	1	FW	20 to 30	60	July
Mesua ferrea	Nahar	Capsule	Aug.-September	230	5	N	8 to 95	70	September
Michelia champaca	Titasopa, Champ	Follicle	Aug.-September	12,000	1	N	10 to 55	50	September
M. doltsopa (M. excelsa)	Safed-champ	Follicle	Aug.-September	11,500	2	N	25 to 50	40	September
M. kisopa	Chobsi	Follicle	Aug.-September		1	N	25 to 50	40	September
M. montana	Pan sopa	Follicle	Aug.-September	14,000	1	N	23 to 50	30	September
Mimusops elengi	Bokul	Berry	Feb.-March	4,000	5	N	15 to 44	70	March-April

1	2	3	4	5	6	7	8	9	10
Moringa oleifera	Saijna	Pod	June	8,500	6	FW	20 to 30	66	May-June
Morus alba	Shahtut	Acorn	May-June	4,48,000	24	N	30 to 45	70	June-July
M. indica	Tutadi	Acorn	March-April	5,12,500	6	FW	60 to 90	40	May
M. laevigata	Bola	Acorn	March-April	3,50,000	6	N	20 to 85	40	April-May
Oroxylum indicum	Bhatghila	Pod	Dec.-January	10,700	8	N	5 to 21	95	March
Parkia roxburghii	Manipuri urahi	Pod	March-April	945	3	N	5 to 15	80	April-May
Phoebe cooperiana	Mekahi		Oct.-November	140	5	N	25 to 90	50	Oct-November
P. goalparensis	Bonsum	Berry	Oct.-November	950	5	N	35 to 90	75	Oct-November
Polyalthia jenkinsii	Kari	Berry	May-June	32,500	3	N	10 to 32	70	June
Pongamia pinnata	Karanj	Pod	March-April	1,100	6	N	30 to 40	80	June-July
Phyllanthus pinnata	Amlokhi	Drupe	Nov.-December	1,10,000	12	N	9 to 21	30	Feb.-March
Populus ciliata	Poplar	Capsule	June-July	12,50,000	2	N	12 to 30	50	July
P. gamblei	Poplar	Capsule	Jan.-February	12,50,000	2	N	10 to 28	22	March-April
Premna milleflora	Gohora	Drupe	Oct-November	1,400	6	N	12 to 40	80	Feb-March
Prunus nepalensis	Saiong	Drupe	Oct-November	1,400	4	FW	12 to 40	85	Feb-March
Pterocarpus dalbergioides	Padok	Pod	Jan-March	1,450	12	FW	20 to 90	40	March-April
P. santalinus	Red sanders	Pod	Feb-April	1,000	12	FW	10 to 35	80	March-April
Pterospermum acerifolium	Hatipoila	Capsule	April-May	4,200	4	N	8 to 50	50	April-May
Pterygota alata	Badam	Follicle	Feb-March	910	3	N	12 to 17	70	March-April

1	2	3	4	5	6	7	8	9	10
Putranjiva roxburghii	Putranjiva	Drupe	Dec-January	1,700	12	FW	20 to 40	62	March-April
Quercus incana	Oak	Acorn	Sept-October	500	3	N	35 to 55	90	Oct-November
Q. lamellosa	Bajrat	Acorn	Sept-October	150	6	N	40 to 55	65	Oct& February
Q. griffithii	Bajrar, Sokuban	Nut	Sept-October	740	4	N	43 to 60	75	Oct& February
Robinia pseudoacacia	Black locust	Pod	Sept-October	45,000	24	H	10 to 42	90	March-April
Santalum album	Sandal wood	Drupe	July-August	8,500	12	FW	35 to 90	75	March-April
Sapindus mukorossi	Ritha	Drupe	Nov-December	489	12	HW	30 to 45	70	March-April
Sapium baccatum	Selleng	Capsule	Aug-September	1,800	1	N	7 to 15	80	September
Schima wallichii	Makri sal	Capsule	Feb-March	2,00,000	2	N	12 to 20	40	March
Shorea assamica	Mekai	Samara	Feb-March	1000	1	N	14 to 24	35	March-April
S. robusta	Sal	Samara	May-June	600	1	N	10 to 35	60	May-June
Spondias pinnata	Amora	Drupe	Dec-Jan	250	6	N	30 to 65	20	March
Sterculia villosa	Udal	Follicle	April-May	320	4	N	4 to 15	92	May-June
Stereosperrnum chelonoides	Paroli	Capsule	Dec-January	40,000	3	' N	5 to 20	35	Feb-March
Swietenia macrophylla	Mahogani	Capsule	Dec-February	2,450	4	FW	30 to 60	35	Feb-March
Syzygium jambolanum	Jamun	Drupe	May-June	1200	1	N	10 to 25	74	June-July
Talauma phellocarpa	Khorika sopa	Follicle	Aug-September	11,400	1	N	25 to 40	15	Sept-Oct
Tamarindus indicus	Imli/Tetuli	Pod	Feb-March	800	24	HW	15 to 20	66	April-May
Tectona grandis	Segun ; Teak	Drupe	Dec-January	1200	12	AWD	10 to 40	54	March-April

1	2	3	4	5	6	7	8	9	10
Terminalia arjuna	Arjun	Drupe	March-May	775	10	FW	40 to 60	55	April-May
T. bellirica	Bohera	Drupe	Nov-January	340	18	AWD	20 to 85	35	Feb-March
T. citrina	Hillika	Drupe	Nov-December	590	16	AWD	25 to 67	50	March-April
T. myriocarpa	Hollock	Drupe	Dec-January	5,00,000	4	N	10 to 35	58	Feb-March
Tetrameles nudiflora	Bhelu; Dubong	Capsule	May-June	5,95,00,000	2	N	7 to 25	50	May-June
Toona ciliata	Jatipoma	Capsule	April-June	5,50,000	2	N	10 to 15	75	May-June
Trema orientalis	Phakdima	Drupe	Dec-January	1,53,850	4	N	6 to 20	60	Feb-March
Trewia nudiflora	Gutel	Capsule	July-September	5,285	3	FW	30 to 45	82	Oct-May
Zanthoxylum limonella	Bajrang	Capsule	Aug-September	14,000	24		46 to 67	15	Feb-March
Zizyphus mauriliana	Ber	Drupe	Feb-March	1,295	8	FW	16 to 60	82	April-May

Conifers									
1	2	3	4	5	6	7	8	9	10
Abies spectabilis	Himalayan Fir	Cone	Oct-November	20,500	6	N	30 to 40	70	February
Cedrus deodara	Deodar	Cone	Oct-November	8,000	4	ST	25 to 62	70	Dec-January
Cephalotaxus griffithii		Cone	Nov-January	12,800	4	N	42 to 95	15	Feb-March
Cry ptomeri a j aponica	Suji	Cone	July-October	3,38,000	6	ST	21 to 28	30	Feb.-March
Cupressus recurva	Dhupi	Cone	Sep-November	2,40,000	18	ST	20 to 40	55	June
Juniperus recurva	Himalayan Cedar	Cone	Sep.-October	3,600	24	N	25 to 62	50	Oct & March
Larix griffithii	Larch	Cone	Oct-November	1,00,000	5	ST	30 to 75	55	November
Picea spinulosa	Spruce	Cone	Oct-November	62,000	7	ST	28 to 52	40	March-April

1	2	3	4	5	6	7	8	9	10
Pinus gerardiana	Chilgoza pine	Cone	Sep-October	3,000	6	N	10 to 25	60	Feb-March
P. kesiya	Khasi pine	Cone	Feb-March	58,800	24	N	6 to 15	- 87	Feb-March
P. merkusii	Merkus pine	Cone	Oct-November	76,000	24	N	6 to 15	74	Feb-March
P. roxburghii	Chir pine	Cone	Nov-December	10,000	24	N	5 to 15	85	March-April
P. wallichiana	Blue pine	Cone	Sep-November	19,250	18	N	6 to 15	82	March-April
Taxus baccata	Yew	Berry	Oct-November	40,000	6	ST	45 to 80	30	Oct-Nov.
Tsuga dumosa	Himalayan Hemlock	Cone	Oct-November	4,00,000	6	ST	30 to 45	80	March-April

Bamboos									
1	2	3	4	5	6	7	8	9	10
Arundinaria falcata	Ringal	Caryopsis	May-June	—	6	FW	15 to 55	50	June-July
Bambusa arundinacea	Kanta bans	Caryopsis	April-May	90,000	6	FW	12 to 30	55	April-May
B. nutans	Mokal	Caryopsis	April-May	60,000	3	N	10 to 30	80	April-May
Bambusa tulda	Jati bans	Caryopsis	April-May	25,600	3	N	9 to 30	92	May-June
Cephalostachyum capitatum	Payong	Caryopsis	July	1,885	6	N	31 to 90	25	July-August
Dendrocalamus giganteus	Tabou	Caryopsis	May-June	17,000	12		10 to 30	70	May-June
D. hamiltonii	Kako bamboo	Caryopsis	March-April	38,500	12	N	8 to 28	60	May-June
D. sikkimensis	Pugriang	Caryopsis	April-May	16,700	13		9 to 31	55	May-June
D. strictus	Bans	Caryopsis	June-July	32,000	24	N	8 to 26	75	July
Melocanna bambusoides	Muli bans	Caryopsis (fleshy)	May-August	**6-8**	**3**	N	**6 to 14**	80	June-August

Canes									
1	2	3	4	5	6	7	8	9	10
Calamus acanthospathus	Tasar bet	Drupe	Oct-November	400	2	FW	—	—	Oct-Nov.
C. erectus	Jeng bet	Drupe	April-June	250	2	FW	40 to 75	60	June
C. flagellum	Raidang bet	Drupe	Sep.-October	220	6	FW	50 to 100	53	Jan.-February
C. floribunclus	Lejai bet	Drupe	June-July	2,400	2	FW	70 to 120	40	July-Sept
C. gracilis	Chuli bet	Drupe	Oct.-November	2,400	2	FW	—	—	Jan-Feb.
C. inermis	Takit bet	Drupe	Sep.-October	200	2	FW	—	—	Oct-Nov
C. latifolius	Hauka bet	Drupe	January	210	2	FW	120 to 183	15	Feb-March
C. leptospadix	Lejai bet	Drupe	Oct-November	1,800	6	FW	77 to 180	50	Oct-Nov
C. tenuis	Jati bet	Drupe	May-June	5,100	4	FW	70 to 120	30	June
Daemonorops jenkinsianus	Raidang bet	Drupe	April-June	300	3	FW	35 to 60	5	May-June
Plectocomia assamica	Hathy bet	Drupe	June-July	135	2	FW	30 to 70	15	July-Aug.

Abbreviations : Seed Treatments (column No. 7)

FW	-	Seeds are soaked in fresh water for 24 to 48 hrs
HW	-	Hot water treatment, Water is boiled and removed from heat and seed is kept for 24 hrs
AWD	-	Alternate wetting and drying
ST	-	Stratification
N	-	No treatment
—	-	Information not available

Literature suggested :

1. Beniwal, B.S. and Singh, N.B. (1985). Observation on flowering, fruiting and germination behaviour of some useful forests plants of Arunachal Pradesh. Indian Forester (4): 216-227.

2. Khullar, P., Thapliyal, R.C., Beniwal, B.S. Vakshasya,, R.K. and Sharma Ashok (1991). Forest Seed. Indian Council of Forestry Research and Education, Dehradun. 409 p.

3. Willium, R.L. (1984). A guide to forest seed handling with special reference to tropics. Danida Forest Seed Centre, Denmark.

Erratum   Back cover Altingia excelsa = Canarium strictum.

S.F.R.I Publications

Information Bulletins :

1. Jhum Cultivation in Arunachal Pradesh.
2. Alder - a Promising Tree for Afforestation of Jhum Fallows.
3. Botanical and Vernacular Names of Important and Common Forest Plants of Arunachal Pradesh.
4. Pipli - an Important Income Generating Eco-friendly Non-wood Forest Products.
5. Medicinal Plants of Arunachal Pradesh.
6. Broom Grass
7. Seed Technology.

Journals :

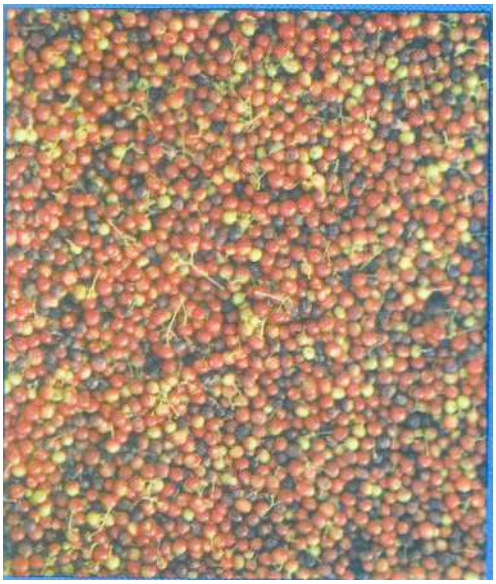
1. Arunachal Forest News - Vol. 1-to 15
   (Half Yearly)

Books:

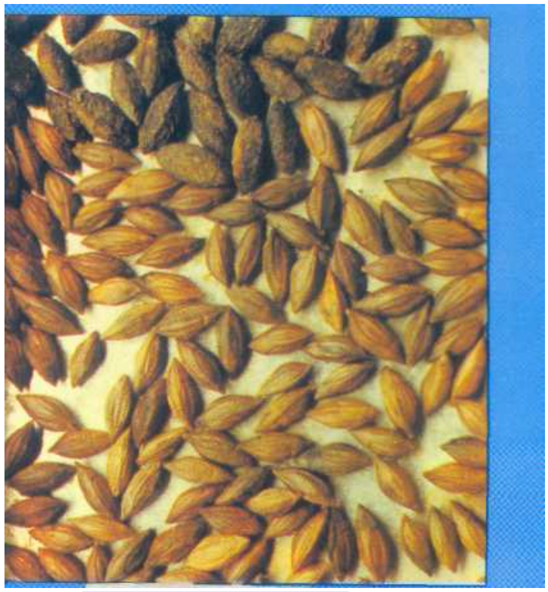
1. Orchids of Arunachal Pradesh - by Dr. S.N. Hegde

For further details, please contact:

THE DIRECTOR,
STATE FOREST RESEARCH INSTITUTE
Department of Environment & Forests
Government of Arunachal Pradesh
Itanagar - 791 111 (India)



Rauvolfia tetraphylla



Canarium strictum

Calamus erectus

Ormosia robusta

Front Cover : *Illicium griffithii*

Printed at Government Press, Naharlagun, Arunachal Pradesh