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**WOODY PLANT SEED MANUAL  
(PAKISTAN)**

**BY**

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## INFORMATION ABOUT THE FIRST DRAFT COPY OF THE WOODY PLANT SEED MANUAL FOR PAKISTAN

This is a draft copy of the beginning of a woody plant seed manual for Pakistan. It is the result of diligent efforts by Mohammed Khan and Raja Khan in the very short period they were able to work at Mississippi State University. The dedicated, careful efforts and perserverence of Mrs. Polly Hodges in doing the typing and making the countless changes also aided immensely in this effort. All are to be commended.

This draft covers botanical data and specific seed handling methods on 8 genera and over 20 species. The completed manual will contain this information on approximately 100 genera. In addition to specific handling information, the completed manual will contain a section on the principles and general methods of producing and handling woody plant seed. This part of the book has not been written, however, the outlines for the chapters are presented in part one.

The specific handling methods and data in this draft were compiled through use of the computer-aided information retrieval service (CAIRS) at the library of Mississippi State University, from the holdings of the MSU library and through interlibrary loans. The personal collections of the staff of the tree seed program at MSU were also utilized.

The illustrations for species are not complete. It proved very difficult to locate useable illustrative material of the desired species. Ideally, for a species the illustrations would include a picture or a drawing of (1) the fruit, (2) seed, (3), a longitudinal section through a seed and (4) germination and normal

seedling development. This portion will be completed in Pakistan as the remainder of the manual is compiled.

In compiling the information it readily became apparent when data was not available or knowledge gaps existed. This pinpoints areas in which research efforts are needed. Lack of data on pregermination treatments and germination are good examples.

The Woody Plant Seed Manual for Pakistan will serve more than one purpose:

It will provide a single reference source for selected woody plant seed.

Unpublished data and technical information will be included and disseminated.

It will point out gaps in knowledge where further seed research is needed.

It will provide technology transfer to other countries which grow similar species thus enhancing Pakistan's international reputation in Forestry.

It will provide information on how to correctly handle and use the more costly seed which will be produced as a result of tree improvement programs.

Overall, this manual will provide information necessary to obtain better quality woody plant products through the use of better quality woody plant seed.

William W. Elam and Franklin T. Bonner, Advisors

PAKISTAN PRIORITY SPECIES LIST COMPILED AT THE  
PESHAWAR SEED TECHNOLOGY WORKSHOP WHICH WILL  
BE INCLUDED IN THE WOODY PLANT SEED MANUAL.

CONIFERS

*Abies pindrow*  
*Cedrus deodara*  
*Cupressus arizonica*  
*Cupressus sempervirens*  
*Juniperus excelsa*  
*Picea smithiana*  
*Pinus wallichiana*  
*Pinus roxburghii*  
*Pinus halepensis*

BROAD LEAVED

*Acacia nilotica*  
*Acacia catechu*  
*Acacia modesta*  
*Acacia senegal*  
*Acacia tortilis*  
*Acer caesium*  
*Acer oblongum*  
*Aesculus indica*  
*Ailanthus altissima*  
*Albizzia lebbek*  
*Albizzea procera*  
*Alstonia scholaris*  
*Azadirachta indica*  
*Bauhinia purpurea*  
*Bauhinia variegata*  
*Bischofia javanica*  
*Bombax ceiba*  
*Broussonetia papyrifera*  
*Butea monosperma*  
*Cassia fistula*  
*Casuarina equisetifolia*  
*Cedrela toona*  
*Celtis australis*  
*Cordia dichotoma*  
*Crataeva religiosa*  
*Dalbergia sissoo*  
*Delonix regia*  
*Eleagnus angustifolia*  
*Emblica officinalis*  
*Erythrina indica*  
*Erythrina subrosa*  
*Eucalyptus citriodora*  
*Eucalyptus camaldulensis*  
*Ficus religiosa*  
*Fraxinus excelsior*  
*Gleditsia triacanthos*

Gmelina arborea  
Grevillea robusta  
Heterophragma adenophyllum  
Jacaranda mimosifolia  
Juglans regia  
Kigelia pinnata  
Lagerstroemia indica  
Lagerstroemia speciosa  
Leucaena leucocephala  
Magnolia grandiflora  
Mangifera indica  
Melia azedarach  
Millingtonia hortensis  
Moringa oleifera  
Morus alba  
Nannorrhops ritchiana  
Parkinsonia aculeata  
Peltoporum pterocarpum  
Phoenix dactylifera  
Phoenix rubicola  
Pistacia integerrima  
Platanus orientalis  
Pongamia glabra  
Prosopis cineraria  
Prunus armeniaca  
Pterospermum acerifolium  
Putranjiva roxburghii  
Pyrus pashia  
Quercus incana  
Quercus semicarpifolia  
Robinia pseudoacacia  
Sapindus mukorossi  
Sapium sebiferum  
Saraca indica  
Schinus molle  
Sesbanea aegyptiaca  
Sterculia alata  
Syzygium cumini  
Tamarix aphylla  
Tamarindus indica  
Tecoma undulata  
Terminalia arjuna  
Terminalia belerica  
Terminalia catappa  
Thespesia populnea  
Zizyphus mauritiana

# Tree Seed Manual for Pakistan

## PREFACE

Seed, being the principal means of reproduction of trees, is the main ingredient in the afforestation programs of any size and magnitude. Keeping in view its importance, some countries have prepared their tree seed manuals but we in Pakistan did not have such a specialized document. The most authentic referral book so far available on trees and tree seeds of Pakistan is that by R. S. Troup namely, "Silviculture of Indian Trees." This book was published in the year 1921 and since then a lot of new information and enhancement in knowledge has been gained on the subject and therefore there is urgent need to update the knowledge. Keeping this point in view, a start has been made to initiate preparation of a tree seed manual for Pakistan with the active collaboration and assistance of the Forestry Department of Mississippi State University. Efforts have been made to consolidate all the available information on tree seed and seed technology that already exists in technical publications of international basis and to incorporate it in this manual. The world wide data base available in U.S.A. on tree seeds has been screened through electronic search and retrieval service like CAIRS for selection of relevant portions for incorporation in this document.

This manual is meant to provide necessary information to those who are interested in tree seed collection, its handling and use in forest nurseries. It will be first of its kind in the Indo-Pakistan sub-continent when it is completed for all the one hundred

species which are included in the programs. When completed, the manual will be made up of two sections. One section will contain brief information about various tree species, their growth habit, occurrence, use, flowering and fruiting and some detailed information (to the extent available in the literature) about collection, extraction, storage, pregermination treatments and germination of seeds in addition to nursery and field practice. The present endeavor is limited to taking a start and producing a draft covering 22 species of 8 genera for that section.

An outline for the other section of the manual concerning principles and general methods of producing and handling seed has also been prepared. The detailed write-up under this outline and completion of handling methods, etc. of remaining species will be taken up later on.

The balance of the work, including research work on tree seeds to fill in knowledge gaps and to obtain data required for completion of this manual, will be accomplished by various forest scientists of Pakistan in collaboration with the Forestry Department of Mississippi State University.

The authors express their sincere thanks and appreciation to Dr. William W. Elam and Dr. Franklin T. Bonner for their guidance and help in the preparation of this document. Thanks are also due to Dr. Douglas P. Richards, Head, Department of Forestry, Mississippi State University, for providing office facilities and taking keen interest in the project.



**PART ONE**

**PRINCIPLES AND GENERAL METHODS**

**OF PRODUCING AND HANDLING SEED**

PART ONE

Principles and General Methods of Producing and Handling Tree Seeds  
(Chapter Outlines)

- I. THE IMPORTANCE OF WOODY PLANT SEED
- II. SEED AND FRUIT DEVELOPMENT, GERMINATION
  - FLOWER INITIATION AND EARLY DEVELOPMENT
  - POLLINATION AND FERTILIZATION
  - SEED DEVELOPMENT
  - FRUIT DEVELOPMENT
  - HAZARDS OF SEED PRODUCTION
  - GENERAL TYPES AND CLASSIFICATION OF MATURE FRUITS
    - Gymnosperms
    - Angiosperms
  - RIPENESS AND DISPERSAL
    - Indices of Ripeness
    - Dispersal Season and Duration
    - Modes of Dispersal
  - FACTORS AFFECTING FLOWER, FRUIT, AND SEED PRODUCTION
    - Physiological Factors
    - Weather
    - Biotic Agents
  - SEED GERMINATION
    - Environmental Requirements
    - Biochemical Changes
    - Physical Development

### III. PLANNING SEED COLLECTION

Selecting Species, Provenances and Stands

Determining Seed Quantities

Collecting Season

Determining the Year for Collection

    Effect of Periodicity

    Estimating the Fruit Crop

Determining Dates for Collection

Collection of Immature Seeds

Selecting Trees From Which to Collect

Assembling Resources for Seed Collection

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Unclassified Stands

Classified Stands

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    Purpose and Advantages

    Stand Selection

    Crop-tree Selection and Release

    Isolation

    Cultural Treatments and Protection

Seed Orchards

    Purpose and Advantages

    Selection of Plus Trees

    Design and Establishment

**V. SEED COLLECTION**

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From Standing Trees with Access from the Ground

From Standing Trees with Access by Climbing

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Maintaining Identity

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Drying of Fruits with Artificial Heat

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Threshing

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Recalcitrant Seeds

Factors Affecting Longevity in Storage

Storage Methods

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Recalcitrant Seed

Other Considerations

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Design and Engineering of Seed Storage Facilities

#### IX. SEED PRETREATMENT

Classification of Types of Dormancy

Treatments Designed to Break Seed-coat Dormancy

Physical Methods

Soaking in Water

Acid Treatment

Biological Methods

Dry Heat and Fire

Special Treatments for Mechanical Dormancy

Treatments Designed to Break Endogenous or Embryo Dormancy

Overcoming Morphological Dormancy

Overcoming Physiological Dormancy - Cold Stratification

Other Moist Prechilling Methods

Chemical Treatment of Physiological Dormancy

Other Treatments for Endogenous Dormancy

Treatments Designed to Overcome Double Dormancy

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Sampling

Purity Analysis

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Combining Purity and Germination Tests

Indirect Tests of Viability

Testing Moisture Content

Special Considerations for Recalcitrant Seeds

Seed Certification

**PART TWO**  
**SPECIFIC HANDLING METHODS AND**  
**DATA FOR SEED OF 22 SPECIES**

# BOMBAX

A. KHAN RAJA

MALVACEAE - Cotton Family

## BOMBAX CEIBA

Synonym - B. malabaricum, Salmalia malabaricum, B. meptaphyllum.,  
Cotton Tree (Simal)

GROWTH HABIT, OCCURRENCE, AND USE: Bombax ceiba is a strong light-demanding, large deciduous tree with a straight cylindrical stem and horizontally spreading whorls of branches (2,3). Each whorl or internode represents a year's growth and it is possible to estimate the age of standing trees fairly accurately by counting the number of internodes between whorls of branches. Large trees are nearly always buttressed at the base. The bark is smooth, grey and thick, which enables established seedlings to resist damage by fire. A height of 40 meters and a diameter of 116 cm above the buttresses is commonly obtained. Simal is fast growing, but its wood is soft, light and perishable (3).

Bombax ceiba is found throughout Pakistan except in arid areas and sites above 1524 meters altitude (3) and has been successfully cultivated in irrigated plantations and farm land. It yields industrial wood which is used for manufacturing of matches, plywood, packing cases, and planks (1,3,4). B. ceiba capsules furnish floss or silk cotton which is used for stuffing pillows and cushions. The flowers form fodder and gum used in medicines (1,3).

**FLOWERING AND FRUITING:** Flowering takes place in January and February and may continue until March (3). The showy, scarlet coloured flowers attract birds, insects and small mammals. The fruits develop very rapidly and the capsules which are oblong,



woody, five-valved, and 10-15 cm long appear in April and May (3). The seeds are numerous and surrounded by masses of white silky hairs which form the floss (1,3). The seeds are 0.5 - 0.6 cm long, irregularly obovoid, dark brown and smooth, with a brittle testa (1,3). One hundred dry capsules weigh about 2 kg and will yield 600 gm of seed and 450 gm of floss (1). The number of seeds per kg varies from 21,400 to 38,500 (4) and good seed crops are expected every year (1,3).

**COLLECTION, EXTRACTION AND STORAGE:** The fruits should be collected in April and May before they begin to open (1,3). The capsules may be knocked off the trees and placed in the sun until they burst open (1). After removal of the woody pericarp by hand, the floss and seeds should be placed in a well-ventilated room. The floss will come up and seeds will sink on the floor. The floss can then be skimmed to separate the seeds. The seeds should be cleaned by winnowing and packed in gunny bags. The seeds lose viability rapidly under ambient conditions, and fresh seed should be used when possible (3). However, simal seed is orthodox in nature and storage of dry seed in sealed containers in a cool place should prolong its longevity (1).

**PREGERMINATION TREATMENTS:** No pregermination treatment is normally required (1). This aspect, however, requires further research.

**GERMINATION:** Germination is epigeal and takes place 1-4 weeks after sowing (1). The testa splits and the radicle emerges. The hypocotyl elongates and carries the cotyledons above ground where they soon expand. The testa is either left in the ground or

carried up with the cotyledons, falling with their expansion (3). Typical germination is about 50 percent (1).

**NURSERY AND FIELD PRACTICE:** Seeds should be sown on raised beds or in polypots in April to June. Seedlings will emerge in 1 to 4 weeks and will attain a height of 0.9 to 1.5 m by the end of the growing season. Out-planting of bare-rooted seedlings should be carried out in February and March. The polybag seedlings or rooted shoot cuttings/stumps obtained from seedlings grown on raised beds can be planted in the field from February until August. However, out-planting during the dry hot season should be avoided.

## ILLUSTRATIONS:

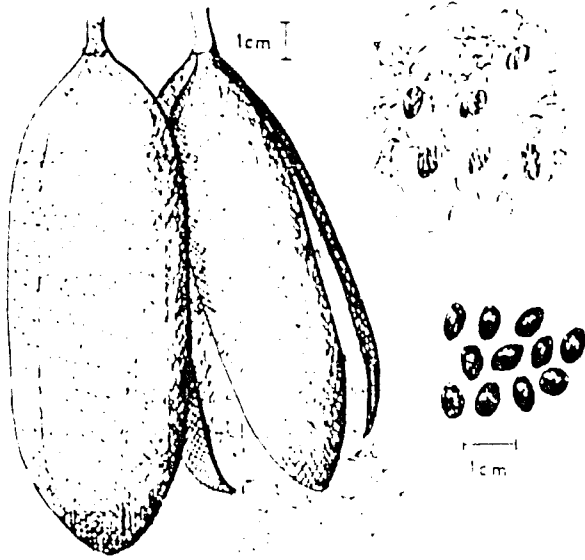


Figure 1. Bombax ceiba. Seed pod, seeds, and the associated floss. (From 1).

**LITERATURE CITED:**

1. Napier, I. and Robbins, M.  
1989. Forest Seed and Nursery Practice in Nepal. Sahayogi Press (Pvt.) Ltd., Kathmandu. 98 p.
2. Stewart, R. R.  
1972. Annotated catalogue of the vascular plants of West Pakistan and Kashmir. Fakkri Printing Press, Karachi. 484 p.
3. Troup, R. S.  
1921. Silviculture of Indian Trees. Oxford at the Clarendon Press. 135-145 p.
4. VonCarlowitz, P. G.  
1986. Multipurpose Tree and Shrub Seed Directory. ICRAF Nairobi, Kenya. 31, 172 p.

# DALBERGIA

A. KHAN RAJA

LEGUMINOSAE - Legume family

Dalbergia sissoo, Roxb. (Shisham, Tali, Sissu)

GROWTH HABIT, OCCURRENCE AND USE: Dalbergia sissoo is a large deciduous tree which can reach a height of 30 meters and attain a diameter of 78 cm. In dry areas it remains a comparatively small tree. It is light demanding, frost hardy, coppices vigorously and produces root suckers (16). Its bole is somewhat crooked and it is therefore difficult to obtain long logs (9,13). The sapwood at breast height of mature trees can make up 40% of the stem (2). D. sissoo is distributed throughout the sub-Himalayan tract and in Himalayan valleys in the Indo-Pakistan sub-continent. It can grow up to 914 meters elevation, sometimes ascending to 1524 meters. It descends the river valleys for some distance into the plains (13,16) and is widely cultivated on farm lands.

D. sissoo forms one of the most important timbers of Pakistan. Its heartwood is very strong, hard, durable and can be finished to a smooth surface (8,16). Its timber is used for building, furniture, plywood veneer and carving (7,16,17,18). It makes excellent fuel-wood and charcoal (7,16,17,18), the calorific value of its wood ranging from 4900 to 5200 k cal per kg (9). Other uses include medicine, fodder and bee-forage (1,17,18). The annual litter fall of D. sissoo forests can be 4.79 tons per hectare (10).

FLOWERING AND FRUITING: Yellowish flowers open in March and April. Pods attain full size by July and ripen in December and January (12,16). Ripe pods, one to three seeded, are indehiscent, pale

brown in colour and measure 5-9 cm by 0.8-1.3 cm (12). About 13,200 to 18,500 pods weigh one kg (7,16,18). There are 33,000 one seeded pod segments in one kg. One litre of pod segments contains 1600-3000 seeds (7). Germination percent is 70-80 or even 90 (7,12,18). Seeding in D. sissoo occurs almost regularly from the age of 4 years (16,18). Abortion of seeds is common in D. sissoo which explains why the number of seeds varies from one to three per pod (3).

**COLLECTION, EXTRACTION AND STORAGE:** Seed can be collected from December to March (7). Pods fallen naturally on the ground should not be collected. Pods should be harvested by climbing the trees, pulling branches inward, removing clusters of pods by hand and placing them in a cloth bag. Another method is to beat the pods off with sticks onto the ground which has been previously swept clean (7,16). Pods should be cleaned by winnowing, dried in the sun and broken into segments without removing the seeds from the pods (7,16). If the seed is to be utilized within the same season it can be placed in hessian bag. D. sissoo seed is orthodox (7), so if it is necessary to store the seed for over a year, it can be sealed in plastic bags and stored under refrigeration or in a cool place such as above an elevation of 1500 meters (11,12). Under such conditions the seed can retain a germinative capacity of 70% after 2 years of storage (11). Stored under ambient conditions in tracts where D. sissoo is generally cultivated, germination decreased to 41% after 11 months storage and to 22% after 18 months (11).

**PREGERMINATION TREATMENTS:** Soak pods for 48 hours in water at normal temperature (do not use hot water) and sow immediately (7). Soaking in cold/tepid water for 24 hours has also been suggested (17). Another method is to pregerminate seed: (1) soak seed 36-48 hours in standing water; (2) spread on a bed of grass or leaves which is 15-20 cm deep, and cover with gunny bags and grass. Seed start to germinate 4-5 days and germination is about 50% complete within a week. Without pregermination, complete germination takes 3-4 weeks. Seed are sown in a bed 3-4 days after starting the above treatment (4).

**GERMINATION:** Germination is epigeous and starts one to two weeks after sowing of treated seed (7,16). Germination percentage is usually 70-80 (7), however, 87% to 100% has been reported (11,17). Laboratory studies of germination of D. sissoo revealed that the highest percent and quickest germination were obtained from seed placed between paper at 30°C (6).

**NURSERY AND FIELD PRACTICE:** D. sissoo pods should be sown in March to June in raised seed beds which should be kept moist until germination starts. Thinning and culling of seedlings is needed to produce uniform, good quality stumps. The suppressed and surplus seedlings should be uprooted one month after germination starts. Thinning is necessary and should not be delayed. The tops of all very large plants should be cut back to the same height as the majority of plants to prevent them from suppressing other seedlings around them. If necessary, repeat the top pruning operation (7).

Many insects and fungi can attack the plants in the nursery.

The leaf defoliator Plecoptera reflexa and leaf rollers may cause considerable damage by defoliation. Similarly, rusts (Uredo sissoo and Maravalia achroa) and wilt caused by Fusarium solani and leaf blight sometimes become a problem (7,18). The insecticide Aldrin and Blitox fungicide should be sprayed to prevent and control infestation (7). Seedlings attain a height of 1.2 to 1.5 meter by November when the season's growth ceases (16) and can be planted in the field during the next growing season, i.e. February to August. To prepare stock for planting out, lift the seedlings and convert into stumps (root-shoot cuttings). Stumps should be wrapped up in jute cloth and kept moist under shade if they are required to be stored for a few days. Stumps may be stored for over 3 weeks after they are prepared when they are kept under shelter and kept moistened with water (5). D. sissoo seedlings obtained from seed treated with a culture of Azospirillum (a nitrogen fixing bacterium) showed an 34.2 and 62.93% increase in the growth of root and shoot respectively (15).

D. sissoo can also be grown in polypots. Soak the seed and sow it in a raised bed. Prick out the seedlings in polypots just after the first leaves start to emerge (7). Polypot seedlings are useful for planting on roadsides or for the filling of gaps in afforestation/regeneration areas.

D. sissoo plantation can also be grown by root-suckers which have proven highly successful in some areas (16).



## ILLUSTRATIONS:

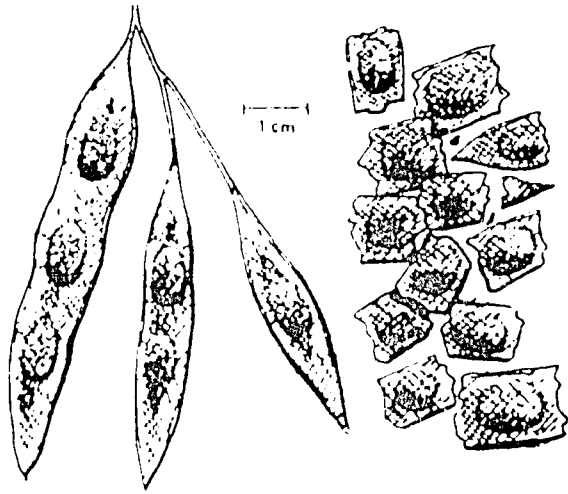


Figure 1: Dalbergia sissoo. Seed pods and pod segments containing seed (planting unit). (From 7).

**LITERATURE CITED:**

1. Ahamed, S.  
1984. Nectar and pollen plants of Pakistan. Pakistan Journal of Forestry 34 (2): 75-78.
2. Ayaz, M.  
1985. A note on the sapwood percentage in Shisham (Dalbergia sissoo Roxcb.) in Changa Manga and Daphar plantations. Pakistan Journal of Forestry 35 (2): 89-93.
3. Ganeshaiah, K. N. and Shaunker, R. U.  
1988. Seed abortion in wind-dispersed pods of Dalbergia sissoo: maternal regulation or sibling rivalry. Oecologia 77 (1): 135-139.
4. Kaushik, R. C.  
1961. Use of pregerminated seed of Dalbergia sissoo in nurseries. Proceedings of the Tenth Silvicultural Conference, Forest Research Institute and Colleges, Dehru, Jan. 411-413.
5. Krishnaswamy, V. S.  
1955. The life of stumps of some forest species under moist dry conditions. The Indian Forester. 7. 408-410.
6. Kumar, A. and Bhatnagar, H. P.  
1976. Effect of temperature and substratum on the germination of Dalbergia sissoo seed. Indian Forester 102 (9): 608-613.
7. Napier, I. and Robbins, M.  
1989. Forest Seed and Nursery Practice in Nepal. Sahayogi Press (Pvt) Ltd. Kathman du. 65, 103-104.
8. Pant, B. C.; Shukla, K. S.; Badoni, S. P.  
1989. Working qualities of Indian timbers - Part VIII. Indian Forester 115 (9): 644-660.
9. National Academy of Sciences.  
1983. Firewood Crops, Shrub and Tree Species for Energy Production, Volume 2. National Academy of Sciences Press, Washington, D. C.
10. Rajvanshi, R.; Gupta, S. R.  
1985. Biomass, productivity and litterfall in a tropical Dalbergia sissoo forest. Journal of Tree Sciences 4 (2): 73-78.
11. Robbins, A.M.J.  
1988. Storage of Sissoo (Dalbergia Sissoo) seed. Banko Janakari 2 (1): 57-59.
12. Sheikh, M. I.  
1991. Technical note FPDP No. 6 Seed Collection. FPDP Govt. of Pakistan - USAID Islam abad. 5, 6 p.
13. Siddiqui, K. M.  
(1988) Germplasm resources of Acacia nilotica, Dalbergia sissoo and Eucalyptus camaldulensis in Pakistan. Trees on small farms. Winrock International Institute of Agricultural Development. 83-84 p.
14. Stewart, R. R.  
1972. An annotated catalogue of vascular plants of West Pakistan and Kashmir. Fakhri Printing Press Karachi. 402 p.

15. Swaminath, M. H.; Vadiraj, B. A.  
1988. Nursery studies on the influence of Azospirillum bio-fertilizer on the growth and dry matter of forestry species. *My Forest* 14 (4) 289-294.
16. Troup, R. S.  
1921. *The silviculture of Indian Trees.* Oxford at the Claredon Press. 294-318.
17. VonCarlowitz, P. G.  
1986. *Multipurpose Tree and Shrub Seed Directory.* International Council for Research in Agroforestry Hairobi, Kenya. 43, 187 p.
18. White, K. J.  
1990. *Dalbergia sissoo (Roxb) An Annotated Bibliography* F/FRED Project, Winrock International Institute of Agri. Dev. F/FRED Bangkok, Thailand.

# EUCALYPTUS

M. KHAN

MYRTACEAE - Myrtle family

Eucalyptus L'Herit. Eucalyptus

**GROWTH HABIT, OCCURRENCE, AND USE:** The genus Eucalyptus comprises more than 523 species and 133 varieties, and new species and varieties continue to be described (7). The eucalypts are evergreen trees, some are tall, while others are shrubs. All Eucalyptus species are more or less aromatic, containing oil-glands in the leaves (17). Eucalypts are mainly native to Australia, but a few species are also indigenous in the Philippines, New Guinea, and Timor (7,18). Eucalypts are extensively cultivated in the sub-tropical and warm temperate regions of the world, including California (USA), Southern Europe, the Middle East, Africa, India, and South America (7,9).

Eucalypts were first introduced into Pakistan about 1860, when various species were tried in the Punjab (17). On the basis of past performances of different eucalypts, Pryor (1968) proposed five species viz., E. camaldulensis, E. citriodora, E. melanophloia, E. microtheca, E. tereticornis for introduction into Pakistan (Table 1) (11). At present, only E. camaldulensis and E. tereticornis are used in the afforestation programs of the country. The suitability of E. camaldulensis for afforestation programs has been demonstrated in various trials conducted in Pakistan (2,13,14). The species is found growing well under varied environmental conditions of the tropical and sub-tropical regions (15). It is the main species planted in problem areas like saline,

TABLE I. *Eucalyptus*: nomenclature, occurrence and uses.

Scientific names and synonyms	Common names	Occurrence Natural	Occurrence Range Extension	Uses
<i>E. camaldulensis</i> Dehn. <i>E. rostrata</i> Schlecht.	River red gum eucalyptus	Australia	Tropical and sub-tropical regions in Pakistan	T,W,E,F, A
<i>E. citriodora</i> Hook. <i>E. maculata</i> Hook.	Lemon gum eucalyptus	Central and northern Queensland, Australia	Pakistan	O
<i>E. melanophloia</i> F.v.M.	Silver leaved ironbark	New South Wales, Queensland, Australia	Punjab, Pakistan	O
<i>E. microtheca</i> F. Muell. <i>E. cordata</i> Blakely and Jacobs	Flooded box eucalyptus	Australia (except Victoria and Tasmania)	Punjab, Pakistan	O
<i>E. tereticornis</i> Smith	Grey gum	Victoria, NSW, Queensland, Australia	Sub-mountain regions in Pakistan	T,W,E,F
<i>E. torrelliana</i> ....	-	Australia	Pakistan	O

T:Timber production, W:watershed, E:environmental forestry, F:fuelwood,  
A:Agroforestry plantations, O:ornamental.

water-logged and arid areas. *E. tereticornis* is planted in the sub-mountainous regions of Hazara, Swat and Kashmir. *E. microtheca* is sometimes grown in arid and salt affected areas in the Punjab.<sup>1</sup> Other species such as *E. citriodora*, *E. melanophloia* and *E. torrelliana* may be found in gardens or avenue plantations.

Eucalypts in Pakistan have importance for planting in watershed and problem areas and as an agroforestry species on farmland. Its wood is strong, durable and resistant to termites,

<sup>1</sup> Personal communication: A. K. Raja, D.F.O., Faisalabad.

and when fully dry it is a very good fuel (9,17). It is good for pulp, fence posts, fiberboards, particleboards and when properly seasoned, for furniture and construction purposes (13). It is also good for charcoal making, and the steel industries in Argentina and Brazil depend on E. camaldulensis for charcoal (9).

**GEOGRAPHIC RACES AND HYBRIDS:** Many eucalypts have an extensive natural distribution, and the same species often grows under very different environmental conditions. Information about geographic races is lacking, but it can be assumed that races exist (7).

Karschon (1974), studying the relation of seed origin to growth of E. camaldulensis in Israel, reported the occurrence of ecotype variation in natural populations in Australia (6).

Geographic origin must be considered in selecting a suitable seed source from species whose natural ranges are extensive, such as E. camaldulensis which is found over almost all the mainland of Australia (7,9). As a general rule, selection of a seed source should at least be based on the knowledge of the absolute maximum and minimum temperatures under which the species grows in its native range. Precipitation appears to be of less importance, but must also be considered in selecting the proper seed source. The Alice Springs provenance of E. camaldulensis from Australia has shown highest growth rates in Pakistan and seed stands of proven provenances exist in Peshawar and Spina Shiga (15).

Hybridization between species of the same subgeneric group occur under natural conditions and a number of hybrids have been described. When grown under plantation conditions outside their

natural habitat, species hybridization will occur more often, and seed collections from small plantations of closely related species should be discouraged if hybrid seeds are not required (1).

**FLOWERING AND FRUITING:** The flower clusters develop enclosed within an envelope formed by the bracteoles. These bracteoles split and are shed during development, revealing the flower buds. The perfect flowers are white, yellow or red, often in axillary umbols, corymbose, or paniculate clusters (7,17). In a few cases, the flowers develop singly, but most often they are 5- to 10-flowered axillary umbols as in E. camaldulensis. Sepals and petals are united to form a cap in the bud, which drops off at anthesis. The stigma is receptive within a few days after the cap drops. Pollination is mainly by insects. The ovary has 3 to 6 locules with many ovules. There is a wide range in flowering times for the eucalypts (Table 2) (7). The fruit is a hemispherical, conical, oblong, or ovoid, hard woody capsule 0.6 to 2.5 cm in diameter, that is loculicidally dehiscent at the apex by 3 to 6 valves (7). The seeds are numerous and extremely small in most species. The size of fertile seeds within a given seed collection varies widely. Usually only a few seeds are fertile in a single capsule, and seed size can be extremely variable. When more than one seed ripens in a given locule, the seeds are variously shaped and angular. When solitary, the seed will be ovate or somewhat compressed (7,18).

The seedcoat is thin and smooth, but it can be ribbed, pitted, or sculptured in various ways. Usually it is black or dark brown in colour, but it can be pale brown. The embryo consists of 2-

lobed cotyledons which are folded over the straight radicle. There is no endosperm.

TABLE 2: Eucalyptus: height at maturity and phenology of flowering and fruiting.

Species	Height at maturity (meters)	Flowering dates	Fruit ripening dates	Seed dispersal dates	Data source
<i>E. camaldulensis</i>	18 - 37 25 - 40	May - June	September	Within a month or two	9,12,17
<i>E. citriodora</i>	25 - 40 45	February - March	September	do	9,12,17
<i>E. melanophloia</i>	-	May - June	-	do	17
<i>E. microtheca</i>	3 - 20	-	-	-	9
<i>E. tereticornis</i>	23 - 35 30 - 45	January - April Spring - Summer	- -	do do	17 10

The fruits ripen at various times during the years depending on the species. Dispersal is largely by wind within a month or two after ripening for most species. Good seed is produced by most species by 10 years of age. For mature trees the interval between large seed crops varies from 1 to 5 years (7,9,18).

**COLLECTION OF FRUITS:** There is no serious problem in collection of mature eucalyptus fruits as with most species, the interval between seed ripening and opening of the capsule is sufficiently long. Care should be taken to collect only well developed, closed capsules, because on a single branch capsules at different stages of maturity will be found as well as buds, flowers and empty capsules. The capsules should be spread in a thin layer to permit rapid drying and to prevent mold formation. The most common method is to air-dry the capsules for a few hours to a few days, depending on the maturity of the capsules.



**EXTRACTION AND STORAGE OF SEEDS:** Seeds are recovered by vigorously shaking open capsules. If shaking is not done, only unfertile seeds will be recovered. In immature capsules the fertile seeds are attached at the base of the capsule, and may not come loose unless shaken. Viable seeds are extracted with unfertilized or aborted ovules known collectively as "chaff." Large impurities such as the remains of twigs, capsules, and leaves can be removed by a specific gravity separator such as an air column. Viable seeds and chaff cannot be separated by the usual methods, and thus in commercial collections fertile seeds are sold with the chaff. The proportion by weight of chaff to viable seeds is in the range of 5:1 to 30:1 (7). Description of viable seeds and germination is given in Tables 3 and 4. Eucalypt seeds have germinated after 30 years of storage at room temperature, but the germination percent was very low. Most species can be successfully stored for as long as 10 years in sealed containers at a seed moisture content of 4 to 6 percent at temperatures of 0° to 5°C (7,18).

TABLE 3. Eucalyptus: description of viable seeds and chaff.

Species	Seed Size Length (mm)	Seed Size Width (mm)	Seed Colour	Chaff Colour	Data Source
<u>E. camaldulensis</u>	0.8 - 1.8	0.5 - 1.0	Yellow-brown	Yellow-brown to orange	7
<u>E. citriadora</u>	4.3	2.5	Black	Brownish-red	7

TABLE 4. Eucalyptus: viable seeds per gm of seed plus chaff and germination test conditions.

Species	Number of viable seeds per gm of seed plus chaff		Germ %	Germination Test Conditions			Data Source
	Range	Average		Daily light exposure Hours	Temp. °C	Duration Days	
<i>E. camaldulensis</i>	64-2125	782	--	24	35	14	7
	110- 660	--	90	--	--	--	12
<i>E. citriodora</i>	78- 221	142	--	0	25	14	7
	47- 99	--	45-50	--	--	--	12
<i>E. microtheca</i>	400- 450	--	60	--	--	--	12
<i>E. tereticornis</i>	--	367	70	--	--	--	12

**PREGERMINATION TREATMENTS:** Seeds of most eucalypts including those grown in Pakistan need no pretreatment to insure adequate germination, if fresh seeds are used. Most species require light for germination.

**GERMINATION TESTS:** Standard methods for testing germination in other seeds are not used for eucalypts because of their small seed size and the chaff which exceeds the amount of viable seeds. Instead, samples for germination are of equal weight, not number (3). Such methods as the excised-embryo and tetrazolium tests are impractical. The International Seed Testing Association recommends a sample unit of 250 mg of seed. Seeds are placed on one or more layers of moist paper and germinated at a constant temperature of 20°C or with alternating temperatures of 20° C for 16 hours and 30° for 8 hours (3). The tests are conducted under lights.

If an approximate estimate of viability is desired, a known weight of dry seeds is soaked in water and then squashed systematically. All seeds which show a firm white embryo are recorded as viable (7).

**NURSERY PRACTICE:** The most common practice of growing eucalypt planting stock is to germinate the seeds in pots, boxes or brick-flats and transplant into containers. A commonly used brick-flat is 2 to 3 m long, 1 m wide, and about 12 cm deep with good bottom drainage. The sowing medium should be porous, friable, and light textured, as a light, sandy loam. The medium must permit good drainage and should not cake or become hard on the surface after watering. The flats are filled to a depth of 9 to 10 cm and the soil surface is levelled.

Because of their small size, the seeds are mixed with a little sand, and the mixture is then spread evenly over the soil surface. The seeds are covered with 2-3 mm of fine sand to prevent surface drying. If it is too thick germination will be patchy, poor or even completely absent. The flats should be well watered and drained just before sowing and should be protected from wind, rains and excessive heat. Because the seeds are small, and the seedlings very delicate, watering should be with fine spray; care must be taken to maintain adequate soil moisture.

Sufficient seed should be sown to produce about 4,000 seedlings/m<sup>2</sup>, assuming that under nursery conditions only half of the viable seeds will produce plantable seedlings. If a E. camaldulensis seedlot has 770 viable seeds/g, 10 gms of seed should

be sown per square meter. When there is no information about viability, sowing should be done at the given rate (10 gms) for E. camaldulensis and at 15 gms/m<sup>2</sup> for E. tereticornis (8).

Germination is epigeal and begins in 4-5 days for E. camaldulensis and E. tereticornis and in 7-8 days for other species; and is completed in a week or two for the former and in 3-4 weeks for other eucalypts. Delays in germination, and poor germination, are usually caused by sowing too deeply or allowing the seed to dry out. Too much moisture will also reduce germination, and in addition will cause damping off.

Seedlings of E. camaldulensis and E. tereticornis will be ready for pricking out 2-3 weeks after sowing, when the plants have two pairs of primary leaves and a third pair is just visible. Seedlings of other eucalypts may take 6-8 weeks to reach this stage. Pricking out must not be delayed because the roots grow very quickly and become difficult to transplant. The seedlings should be held by one of the leaves, and touching the stem or root should be avoided. Pricking out should be done into previously watered containers filled with a suitable mixture of soil, sand and humus. The containers used in Pakistan are 18 x 7 cm, perforated black polythene bags. Krugman (1974) recommends tubes, 15 to 30 cm long and at least 3.8 cm in diameter (7). Shade is required during, and for a few days immediately after pricking out, which is best done in the early morning or late afternoon. The seedlings should be kept moist and also protected from hail, desiccating winds, and heavy rains. After 2-3 weeks, the transplants can be

placed in the open so that they can become hardy. They should be ready for outplanting in 4 to 5 months. E. camaldulensis and E. tereticornis will have strong tap roots, with abundant very fine lateral roots. It is very important to plan the sowing date for the expected time of planting (spring or monsoon in Pakistan). Leaf spot, leaf blight, charcoal root and stem rot diseases have been observed in the eucalypt nurseries and plantations in India (4,5,16) but none of them has been recorded in Pakistan. Dithane-m-45 (Mancozeb) at 0.2% and Bavistin (carbendazim) at 0.1% levels were used to control these diseases (5).

**ILLUSTRATIONS:**

No appropriate illustrations available for correct species.

**Literature Cited:**

1. Boden, R.W.  
1964. Hybridization in eucalypts. *Indian Forester*, 90(9).
2. Hafeez, M., and Sheik, M.I.  
1972. *Eucalyptus Camaldulensis* Dehn. provenance trials in West Pakistan. *Pakistan Jour. of Forestry*, 22(4).
3. International Seed Testing Association.  
1966. International rules for seed testing. *Proc. Inter. Seed Testing Assoc.* 31(1).
4. Jamalluddin, et al.  
1985. Leaf blight of *Eucalyptus* in nurseries. *Indian Forester*, 111(12).
5. \_\_\_\_\_.  
1987. Some noteworthy diseases of *Eucalyptus* in Madhya Pradesh. *Indian Jour. Forestry*, 10(1).
6. Karschon, R.  
1974. The relation of seed origin to growth of *Eucalyptus Camaldulensis* Dehn. in Israel. *Israel Jour. of Agr. Res.* 23(3/4).
7. Krugman, S.L.  
1974. *Eucalyptus*. In: *Seeds of Woody Plants in the United States*. Forest Service, USDA, Washington, D.C.
8. Napier, I. and Robbins, M.  
1989. Forest seed and nursery practices in Nepal. Saharyagi. Press (Pvt.) Ltd. Tripureshwor, Kathmandu.
9. National Academy of Sciences.  
1980. *Firewood Crops. Shrubs and Tree Species for Energy Plantation*. National Academy Press, Washington, D.C.
10. \_\_\_\_\_.  
1983. *Firewood Crops. Shrub and Tree Species for Energy Production*. Vol. 2. National Academy Press, Washington, D.C.
11. Pryor, L.D.  
1968. *Eucalyptus* in Pakistan. *Pakistan Jour. of Forestry*, 18(1).
12. Sheikh, M. I.  
1991. Seed Collection. Technical Note No. 6. Forestry Planning and Development Project. G.O.P.-U.S. A.I.D.
13. Siddiqui, K.M.  
1977. National programme of tree introduction and improvement in Pakistan. *Proc. Third World Consultation on Forest Tree Breeding, Carberra, Australia, March 21-26, 1977*.
14. Siddiqui, K.M., et al.  
1984. *Eucalyptus camaldulensis* Dehn.: its growth properties and utilization. Bulletin No. 4, Forest Products Res. Div., Pak. For. Inst., Pashawar.

15. Siddiqui, K.M.  
1987. Germplasm resources of *Acacia nilotica*, *Dalbergia sissoo*, and *Eucalyptus camaldulensis* in Pakistan. In: *Trees on Small Farms*. Proc. of the Network Workshop of the Forestry/Fuelwood Research and Development (F/FRED) Project, Karachi, Pakistan, Nov. 16-19, 1987.
16. Soni, K. K., et al  
1985. Charcoal root and stem rot of *Eucalyptus*. *European Jour. For. Pathology*, 15(7).
17. Troup, R.S.  
1921. *The silviculture of Indian Trees*. Vol. II. Clarendon Press, Oxford.
18. Young, J.A., and Young, C.G.  
1992. *Seeds of Woody Plants in North America*. Dioscorides Press, Portland, Oregon.



## CUPRESSACEAE - Cypress family

JUNIPERUS L. Juniper

GROWTH HABIT, OCCURRENCE, AND USE: The junipers include about 70 species of evergreen trees or shrubs, widely distributed throughout the temperate and sub-tropical regions of the northern hemisphere and south of the equator in East Africa (1,9). Troup (1921) has described four species as growing naturally in the Himalayan regions of the Indo-Pakistan sub-continent (8). Stewart (1972) has mentioned five species as native to Pakistan (7). All these species occur at high elevations and ascend to the limit of tree growth; they grow in dry, barren regions with scanty rainfall, and exhibit marked xerophilous tendencies.

Economically some of the junipers are important for pencil cedar wood. The close-grained, aromatic, and durable wood of the tree species are used for furniture, interior paneling, novelties, fence posts, poles, fuel, and charcoal. The fruits and young branches contain an aromatic oil that is used in medicines and to flavor alcoholic drinks (1,8,9).

The most important juniper (Juniperus macropoda) tracts occur in Balochistan, where they are estimated to cover a total area of about 0.39 million hectares (8). Other juniper species are found in Kurram, Chitral, Swat, Astor, Gilgit, Kaghan and Kashmir (Table 1) (7).

In the juniper tracts of Pakistan, the minimum temperature may fall to below  $-18^{\circ}\text{C}$  with considerable snowfall in winter but the rainfall seldom exceeds 300 mm.

Table 1. *Juniperus*: nomenclature, occurrence and uses (7,8).

Scientific names and synonyms	Common names	Occurrence	Uses <sup>1</sup>
<i>J. communis</i> L. var <i>saxatilis</i> Pall. <i>J. sibirica</i>	Common juniper, Pama, betar, thelu	Chitral, Swat, Astor, Gilgit, Kurram and Kashmir Valleys	H,W, F
<i>J. excelsa</i> M.B. <i>J. macropoda</i> Hk. f <i>J. polycarpus</i> C. Koch	Himalayan pencil cedar, Appurz, ghushki, obusht, chalai	Kurram Valley, Chitral and Balochistan	T,H, W,F
<i>J. squamata</i> Buch Ham. <i>J. recurva</i> Don. Var. <i>squamata</i> Parl. <i>J. religiosa</i> Carr.	Weeping blue juniper, betar, thelu, guggal	Kashmir, Chitral, Kurram and Upper Kaghan	H,W, F
<i>J. turkestanica</i> Kom.	Betar, thelu	Chitral, Nauga, Parbat, Astor and Balti	H,W, F
<i>J. wallichiana</i> Hk. f. <i>J. pseudo-sabina</i> Hk. f. <i>H. recurva</i> Buch. Ham	Betar, thelu	Northern areas	H,W, F

<sup>1</sup>T: timber, H: habitat for wildlife, W: watershed, F: fuelwood.

### *Juniperus communis*:

This is an evergreen shrub, sometimes a small tree, growing at high elevations between 1700 and 4300 m. The species is common in Kurram, Chitral, Swat, Astor, Gilgit, and Kashmir valleys (7,8).

### *J. excelsa*:

A moderate sized tree with sparse crown, it commonly forms open crops or occurs in the form of scattered trees on dry, rocky or stony ground in regions of low rainfall; Kurram Valley, Chitral, and Balochistan between 1980m and 3050m elevation.

The tree does not ordinarily attain a height of more than 15m, and seldom reaches a height of 25m, but Troup (1921) mentions an exceptionally tall tree of about 30.5m observed in Chotair forest, Balochistan (8). He reported the following measurements recorded in Balochistan in 1916:

Table 2. - *J. excelsa*: Diameter and height measurements

Forest/Locality	Diameter (m)	Height (m)
Gohar Forest	1. 1.45	24.4
	2. 1.41	22.9
Batsirgi Forest	1.74	12.2
Chotair Forest	1. 1.12	30.5
	2. 0.97	19.8
	3. 1.17	22.9
Shaidan Forest	2.04	17.4 <sup>1</sup>

<sup>1</sup>Diameter near base; the tree branched at 0.76 m from ground.

The trunk is often crooked and gnarled, and sometimes exhibits twisted fibre. The tree rarely forms a clean bole, but usually branches to the base. The lowest branches are often buried in leaf debris near the trunk with their extreme ends coming out, giving them the appearance of young plants surrounding the old tree (8).

#### *J. squamata*:

This is an evergreen shrub, the stems of which creep over the ground, rooting freely and sending up numerous short, erect branches forming a dense thicket. It is common in pure stands or mixed with *J. communis* above the timber line in Kashmir, Chitral, Kurram and Upper Kaghan (7,8).

#### *J. turkestanica*:

A small, erect tree with larger cones and seeds than *J. excelsa*, it is found at high altitudes in Chitral, Nanga Parbat, Astor and Balti.

**J. wallichiana:**

A large evergreen, gregarious shrub, this species occurs at the timber line in the northwestern Himalayas, chiefly in the Northern Areas of Pakistan, associated with Betula utilis.

**FLOWERING AND FRUITING:** The small inconspicuous flowers of Juniperus are borne in the spring along and on the ends of short branchlets. These plants are monoecious or dioecious. Male flowers are yellow and form small catkins; the greenish female flowers are composed of a few pointed scales bearing one or two ovules at their base. Cones are succulent and berry-like, composed of united fleshy scales enclosing one or more seeds, ripening in the second year (Table 3). Immature berries are usually greenish; ripe berries are blue or bluish black (Table 4), (1,8).

There are 1 to 5 brownish seeds per fruit. The seeds are rounded or angled, often with longitudinal pits. The seedcoat has two layers, the outer layer thick and hard, the inner thin and membranous. Embedded within the fleshy, white or cream-coloured endosperm is a straight embryo. Many seeds from a given tree may contain no endosperm or embryo. Junipers begin to seed when 10-20 years old. Seeds are dispersed in the fall, usually by birds, but the ripe fruits will persist on the tree. Heavy seed crops are irregular, but some seeds are produced nearly every year (1,8).

**J. communis:**

The flowers appear in March-April, and the fruit, a bluish black, usually three-seeded berry, ripens in August-September of the

second year. Under natural conditions the seeds are freely spread by birds, which devour the fruits.

**J. excelsa:**

The flowers appear in the spring, and the fruits ripen in September-October in the second year. Male flowers are 2.5-5.0 mm long. Berries are 6.4-8.9 mm in diameter, bluish black when ripe and each containing 2 to 5 seeds. Some seed is produced, as a rule, every year, but good seed-years occur at less frequent intervals (8).

**J. squamata:**

Flowers appear in June-July, and the fruits ripen during July-October of the second year. Berries are ovoid, 7.6 to 12.7 mm long and one seeded (7,8).

**J. turkestanica:**

The cones and seeds of this species are larger than that of J. excelsa (7). It flowers in spring, and the fruits mature that Fall.

**J. wallichiana:**

This species flowers in April-May, and the fruit ripens in August of the second year. Berries are ovoid, one-seeded, 6.4 to 12.7 mm long and blue in colour when ripe (7,8).

Table 3. Juniperus: phenology of flowering and fruiting (8).

Species	Flowering dates	Fruit ripening dates	Seed dispersal dates
<u>J. communis</u>	March-April	August-September	Persists for 2 years <sup>1</sup>
<u>J. excelsa</u>	Spring	September-October	--
<u>J. squamata</u>	June-July	July-October	--
<u>J. turkestanica</u>	Spring	Fall	--
<u>J. wallichiana</u>	April-May	August	--

<sup>1</sup>In the United States (1).

Table 4. Juniperus: height, seed crop intervals and fruit ripeness criteria.

Species	Height at maturity	Interval between large seed crops	Fruit ripeness preripecolour	Criteria ripe colour	Data source
<i>J. communis</i>	0.6-15.2 m.	Irregular	Red	Bluish black	1
<i>J. excelsa</i>	12.2-30.5 m.	Large seed crops less frequent	-	Bluish black	8
<i>J. squamata</i>	Shrub	-	-	-	8
<i>J. turkestanica</i>	Small tree	-	-	-	7
<i>J. wallichiana</i>	Large shrub	-	-	-	8

**COLLECTION OF FRUITS:** Juniper berries are usually collected in the fall by stripping or picking by hand directly into bags, or by shaking the fruits from the plant onto a canvas spread on the ground. Johnsen and Alexander (1974) reported that collection from plants with large numbers of green immature berries should be avoided because they are difficult to separate from the mature berries (1). However, the research work of Zheronkino (1974) suggests that berries should be collected before they are morphologically ripe in order to avoid seed dormancy which occurs with the closure of the lateral suture of the seedcoat at fruit ripening (10).

Since the number of filled seeds varies widely from tree to tree, cutting tests should be made with each tree to determine the percentage of filled seeds. It is advisable to collect the fruit as soon as possible after ripening to reduce losses due to birds and animals. If freshly collected fruits are to be stored, they should be spread out in a well-ventilated area to avoid overheating as they cure (1,9). Seeds may be stored either as dried fruits or as cleaned seed (1).

**EXTRACTION AND STORAGE OF SEEDS:** After twigs, leaves, and other debris have been removed by fanning, the seeds can be recovered by macerating the seed and floatation. Sheikh (1980) worked on floatation systems to improve the quality of J. excelsa seed through seed cleaning (5). For species with resinous fruits, Johnsen and Alexander (1974) suggested presoaking of fruits in a weak lye solution for 1 to 2 days before macerating (1). Small amounts of seed can be cleaned with a blender and floatation (9). After the seeds have been separated from the pulp, they should be dried and fanned to remove the remaining trash. The seeds are then ready for sowing or storage.

Juniper seeds store quite well. The seed should be dried to 10 to 12 percent moisture content and stored in sealed containers at -7° to 4° (1).

**REGERMINATION TREATMENTS AND GERMINATION TESTS:** Germination is often delayed in junipers because of embryo dormancy, seedcoat dormancy, or by inhibitors in the fruit and seedcoat (1). Sheikh (1983) reported that ripe J. excelsa berries were collected in November and December, cleaned through a screen, and recovered by floatation. Initial nursery germination was only 6% at most, but germination started again with the return of the monsoons and continued for two years (5). Various pretreatments have been tried to increase germination of J. excelsa seeds but none of them seem to be very successful (3,5).

Negussie et al. (1991) subjected one year old seed of J. excelsa from western Kenya to various treatments before sowing, and

assessed germination percentage after 18 weeks under controlled growth conditions. Treatments included: soaking in gibberellic acid (200-100 mg/litre), hydrogen peroxide (35%), and sulphuric acid (98%); stratification for 60 days; hot water treatments; and abrasion. All pretreatments failed to increase germination percentage significantly over the control. All hot water treatments prevented germination. A diurnal variation in temperature (20°/30°c) produced significantly higher germination percentage than a constant 25°c (3).

Jones (1989) reported that stratification for 60 days at 5°c increased the germination percentage of J. excelsa seeds from Eritrea (63%) over untreated controls grown in greenhouse (53%) and a growth chamber (47%). Scarification with concentrated sulphuric acid for 15 months, followed by stratification did not significantly improve germination percentage over controls. Treatment with hot water (80° resulted in zero germination after 240 days, while scarification in concentrated sulphuric acid for 60 minutes, followed by stratification, significantly reduced germination (2).

Germination studies on highly dormant seeds of J. occidentalis and J. osteosperma indicated that prechilling for 14 weeks is required for substantial germination and that prechilling in a solution of gibberellin at 5°C, with oxygen maintained at saturation, is an effective treatment (9).

Van Haverbeke and Comer (1985) have reported the results of germination studies on seeds of J. virginiana and concluded that



highest germination was obtained by soaking seeds for 96 hours in 10,000 ppm of citric acid followed by 6 weeks of warm stratification and 10 weeks of prechilling (9).

In the Ukraine, seeds of J. virginicana and J. scopulorum are scarified with sand and sown in Autumn, or are stratified at 0-5C and sown in spring. Other species, such as J. communis and J. sabina, are propagated by cuttings in a cold frame under plastic; callus forms in 40-50 days, and roots form in 75-80 days. The best time for planting cuttings is late March, and the optimum length of cuttings is 8-15 cm (4).

Working on the germination of unripe seed of J. communis and J. virginiana, with seed collection in May, June, July and October, Zheronkina (1974) concluded that in Kazakhstan, the seeds are best able to germinate in early August (J. communis) and late September or early October (J. virginiana) when the lateral suture of the seedcoat is open. When the berry is morphologically ripe, the seeds enter deep dormancy, with closure of the suture, deposition of lignin in the stone cells, and lignification of the parenchyma (10). Germination test conditions for J. communis and J. excelsa are given in Table 5.

J. communis, J. excelsa and J. squamata can be propagated vegetatively from cuttings (1,8). J. squamata is propagated by taking cuttings of the prostrate stems with bushy foliage attached, planting them in nursery beds and watering them regularly until well rooted (8).

Table 5. *Juniperus*: germination test conditions and results

Species	Stratification period (days)		Daily light hours	Medium	Germ. Test Conditions		Duration (days)	Germ. Capacity (Percent)	Data Source
	Warm <sup>1</sup>	Cold <sup>2</sup>			Day	Night			
<i>J. communis</i>	60-90	90+	8	Paper, Sand	30°C	20°C	20-30	7-75	1
<i>J. excelsa</i>	-	60	-	-	30°C	20°C	126	-	2,3

<sup>1</sup> 30°-20°c. alternate diurnally.

<sup>2</sup> 5°c.

NURSERY PRACTICES: In Pakistan, juniper seeds are usually sown in the spring and in the United States in the late summer or fall (1,6). As most of the species require prechilling, sowing in fall should be preferred to take advantage of natural prechilling. The seeds of juniper species which have dormant embryos should be sown in fall or cold stratified and sown either in fall or spring. Germination occurs in the spring. The seeds of those species which may also have impermeable seedcoats may be handled as i) clean, stratify (warm followed by cold), and sow in the fall or spring; ii), store in the fruit for one year, clean, stratify (warm followed by cold), and sow in the fall or spring; or iii) stratify outdoors from spring to sowing time in the fall (1). Fall sown seed germinate the next spring. Untreated seeds may also be sown in the fall and mulched in the seedbed until germination during the second spring after sowing. Sowing of stratified seeds should be done in early spring to ensure complete germination before the air temperature goes higher than 21°c. With stratified seeds, germination should begin 6 to 10 days after sowing and be completed in 4 to 5 weeks (1). Juniper seeds may be drilled into well-

prepared soil in rows 15 to 20 cm apart and covered with 0.6 cm of sand, or hand broadcast onto the seedbed and covered with sand. The beds should be mulched with straw, sawdust, or plastic film to prevent winter drying, alternate freezing and thawing, and premature spring germination. The seedbeds should be kept moist and the mulch should be removed with the initiation of the germination. Light should be provided during the first growing season. Some sort of cover may be used to protect against early spring freezing (1,9). Juniper seedlings may be transplanted into polythene containers after the first or second year. Planting out in the field in early spring gives the best survival.

The age of planting stock used for field plantings varies from area to area. Generally, 1-1, 2-0, 2-1, 2-2, and 3-0 stock is used for different juniper species (1).

**ILLUSTRATIONS:**

**No appropriate illustrations available for correct species.**



It coppices well and produces root-suckers (9). This species is found both wild and cultivated in the Himalayas at 1219 to 2743 meters, occasionally descending lower (9). Its foliage makes good fodder for cattle. The wood is excellent for furniture or cabinet work, and is used for carving and other purposes.

TABLE 1. *Morus*: nomenclature, occurrence, and uses.

Scientific names and synonyms	Common names	Occurrence	Uses <sup>1</sup>
<i>M. alba</i> L.	Silkworm mulberry, toci.	Throughout Pakistan	T,Se,Fr
<i>M. serrata</i> Rosch.	Himalayan mulberry, toot, kimu	Himalayan regions of Pakistan	T,Fr

<sup>1</sup>T: timber production, Se: sericulture, Fr: fruit.

**FLOWERING AND FRUITING:** Flowers are normally dioecious, but can also be monoecious on different branches of the same tree (10). The *M. alba* flowers appear in stalked axillary pendulous catkins in February and March. The multiple fruit is composed of many small, closely appressed drupes (10), which ripen and drop from the tree during April and May. Seed dispersal is through water, birds and animals (6,13). The latter eat the fruit and pass on viable seed in their droppings. The seed bearing age of mulberry is around five years, and large crops of fruit are borne every year.

In *M. serrata*, greenish catkin-like inflorescences appear in March to May and cover the tree. The flowers are dioecious and the fruit ripens in June - July. The seed is disseminated by birds who greedily devour the fruit.

TABLE 2. *Morus*: phenology of flowering and fruiting.

Species	Flowering Dates	Fruit Ripening Dates	Data Source
<i>M. alba</i>	February-March	April-May	10
<i>M. serrata</i>	Spring	June-July	9

**COLLECTION, EXTRACTION AND STORAGE:** Ripe mulberry fruits may be collected by stripping, shaking, or flailing them from the trees onto a cloth spread on the ground. Fruits should be collected as soon as most are ripe to avoid loss to birds and animals.

Fresh fruits are usually mashed immediately after collection, soaked in water, and run through a macerator, where pulp and empty seeds are skimmed or floated off. A 1 percent lye solution aids the extraction and cleaning processes (6). Small seedlots may be cleaned by rubbing gently through a no. 6 screen and floating off the pulp. The extracted seeds should be air-dried in shade, then cleaned by fanning before storage or use. Subfreezing temperatures of  $-23$  to  $-18^{\circ}\text{C}$  are recommended for storage of dry mulberry seeds (6,13).

*M. alba* fruits should be collected when thoroughly ripe i.e. in April-May, by stripping, shaking, or flailing them from the trees onto a ground cloth or by simply sweeping them from the ground (10). The number of seeds per kg may vary from 324,000 to 700,000 (11). Seed yield from fruit on a weight basis is about 2% and the average number of seeds per kg is 520,000 (13).

The seeds are tiny and hard coated (5). Fresh fruit should be mashed or kneaded and rubbed together, soaked in water and given several successive washings to separate the seed and float off the pulp (5,9). A mechanical macerator can also be used (10). Small

lots may be extracted with a laboratory blender. A one percent lye solution aids the extraction and cleaning processes. Fermentation at moderate indoor temperatures for 1 to 2 days before maceration facilitates extraction and improves viability (8). Another method is to spread the fruit at room temperature for 4 to 5 days. Then run them with water through a seed cleaner adjusted so that only the pulp goes through and seed come out clean (3). The seed should be thoroughly rinsed and spread out at once to dry in the shade (9,10). It should then be cleaned by fanning before storage or use. The seed is orthodox and should be thoroughly dried, tightly sealed in polythene bags and kept in a cool place (5). Subfreezing temperatures of  $-23^{\circ}$  to  $-18^{\circ}\text{C}$  are recommended for long-term storage (3,6,13).

M. serrata fruits should be collected in June and July when they turn purple. They should be mashed and washed to clean the seed.

**PREGERMINATION TREATMENTS:** Germination is often variable, because some seeds may be dormant or have impermeable seed coats (5,10). Soaking in water for four days has been used as a treatment (5). Some seeds with no pretreatment, however, have germinated completely under light at low night and high day temperatures, when the fruits were fermented before seed extractions (3). For spring sowing, moist stratification at  $0.5^{\circ}$  to  $5^{\circ}\text{C}$  for 30 to 90 days has improved germination (1,8,10). Soaking in cold water for 48 hours or stratification up to 30 days has also been suggested (11). Information on pregermination treatment of M. serrata seed is not available.

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**GERMINATION:** Tests of pretreated seed can be run on wet absorbent paper, in wet sand, and in a mixture of sand and peat at diurnally alternating temperatures of 30° to 20°C for 15 to 45 days with a daily light period of 8 to 16 hours. Germination capacities ranging from 20 to 92 percent are expected (4,8,10). Seed embryos are curved with cotyledon tips nearly touching the radicle and germination is epigeal (10,13).

**NURSERY AND FIELD PRACTICE:** M. alba seed should be sown in March to June in raised beds either in lines or spread over the bed and covered lightly with soil. Beds should be kept moist until germination starts (10). Germination begins after 4 to 5 days and continues for 3 to 4 weeks (5,10). Nurseries should not be located near older mulberry trees to avoid diseases (2). Damping off may occasionally be a problem (12). Partial shading in the M. alba nursery is useful. The seedlings attain a size of 0.6 to 0.9 meters at the end of the growing season and entire plants with bare roots can be planted in January and February before the start of sprouting. For large scale planting, the seedlings are converted into stumps/root shoot cuttings and then planted in the field from February till August. Some Chinese and Japanese varieties can very easily be propagated through branch cuttings.

M. serrata is easily propagated from seed or from cuttings. Fresh seed should be sown in raised nursery beds in June or July. Seedlings are ready for out-planting during the next rainy season. In case of vegetative propagation, the cuttings should be placed in the nursery during the rainy season and planted out when they have become thoroughly rooted.

ILLUSTRATIONS:



Figure 1. Morus alba. Fruits and leaves, 1 X. (From 5).

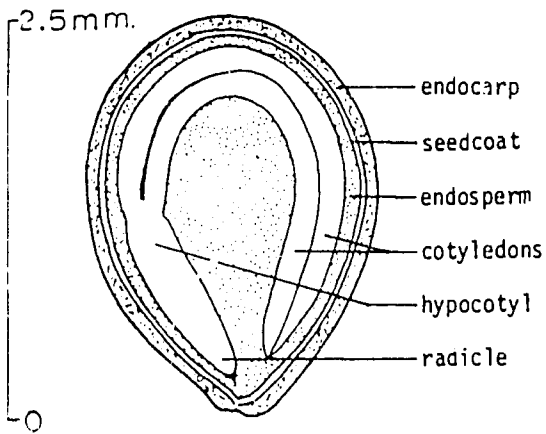


Figure 2. Morus alba. Longitudinal section through a nutlet, 20 X. (From 5).

## LITERATURE CITED:

1. Afanasiev, M.  
1942. Propagation of trees and shrubs by seed. Okla. Agric. Exp. Stn. Circ. C-106, 43 p.
2. Davis, W. C., Wright, E., and Hartley, C.  
1942. Diseases of forest-tree nursery stock. U. S. Fed. Sec. Agency, Civilian Conserv. Corps. For. Publ. 9, 79 p.
3. Engstrom, A.  
Correspondence, 1969. Okla. For. Div., State Dep. Agric., Oklahoma City, Okla.
4. Heit, C. E.  
1968. Thirty-five years' testing of tree and shrub seed. J. For. 66: 632-634.
5. Napier, I. and Robbins, M.  
1989. Forest Seed and nursery practice in Nepal. 118-119.
6. Read, R. A.; Barnes, R. L.  
1974. Morus. In: Seed of Woody Plants in the United States. Forest Service, USDA, Washington, D.C. 544-547.
7. Stewart, R. R.  
1972. An annotated catalogue of vascular plants of West Pakistan and Kashmir. Fakkri Printing Press Karachi. 194,195 p.
8. Taylor, Carl A.  
1941. Germination behavior of tree seeds. U. S. Dep. Agric. Forest Serv., Prairie States for Proj., 64 p.
9. Troup, R. S.  
1921. The Silviculture of Indian Trees. Oxford at the Claredon Press. 885-891
10. USDA Forest Service  
1974. Seeds of woody plants in the United States. U. S. Dep. Agric. Hand book No. 450. 544-547
11. VonCarlowitz, P. G.  
1986. Multipurpose Tree and Shrub Seed Directory, ICRAF Nairobi, Kenya 68, 212 p.
12. Wright, E.  
1944. Damping-off in broadleaf nurseries of the Great Plains region. J. Agric. Res. 69: 77-94
13. Young, J. A., Young, C. G.  
1992. Seeds of woody plants of North America. Dioscorides Press Portland, Oregon. 226 p.

# PINUS

MOHAMMAD KHAN

## Pinaceae - Pine family

### PINUS, L.

**GROWTH HABIT, OCCURRENCE, AND USE:** The genus *Pinus*, one of the largest and most important of the coniferous genera, comprises about 96 species and numerous varieties and hybrids. Pines are widely distributed from all regions of the northern hemisphere southward to Central America, the West Indies and Mediterranean, but mostly confined to high altitudes towards the tropics. In the northern hemisphere pines occur from sea level (*Pinus contorta* var. *contorta*) to timberline (*P. albicaulis*) (9,22).

Pines are evergreen trees of various heights, often very tall but occasionally shrubby. Some species, such as *P. lambertiana*, *P. monticola*, *P. ponderosa*, and *P. strobus*, grow to more than 62 m tall (23); the Himalayan pines, *P. roxburghii* and *P. wallichiana* attain a height of more than 45 m, while others, such as *P. cembroides* and *P. pumila*, may not exceed 10 m in height (7,21,23).

Pines provide some of the most valuable timber, are used to protect watersheds, provide habitats for wildlife, fuelwood for energy, and to extract resin. Seeds of some species, e.g. *P. gerardiana*, are a valuable food source which are roasted and eaten. Pine needles are used for animal bedding and as an insulation material in house roofing. Other pine species are used for aesthetic and environmental planting.

Three species of pines, *P. gerardiana*, Wall. (chilghoza pine), *P. roxburghii*, Sarg. (chir pine), and *P. wallichiana*, A.B. Jacks.

(blue pine) are native to Pakistan. *P. halepensis*, Mill. has been successfully introduced in Balochistan (Table 1).

Table 1. *Pinus*: nomenclature, occurrence, and uses.

Scientific names and synonyms	Common names	Occurrence	Uses <sup>1</sup>
<i>P. gerardiana</i> , Wall. <i>P. aucklandii</i> , Lodd. <i>P. chilghoza</i> , Ehh.	chilghoza pine, Gerard pine	Zhob, Parachinar, Dir, Swat, Chitral and Chilas Valleys in Pakistan, eastern Afghanistan and northern India	T,H,W,E
<i>P. halepensis</i> , Mill. <i>P. alepensis</i> , Poir.	Aleppo pine, Jerusalem	Balochistan (Pakistan), Mediterranean region	T,E
<i>P. roxburghii</i> , Sarg. <i>P. longifolia</i> , Roxb.	chir pine, chir	Monsoon belt of the outer Himalaya in Pakistan; Nepal, Bhutan, and northern India	T,H,W,E
<i>P. wallichiana</i> , A.B.Jacks. <i>P. excelsa</i> , Wall. <i>P. griffithii</i> , McClelland	blue pine, kail, biar.	Mid and high elevations in the Himalayas in Pakistan, India, Afghanistan, Nepal, Burma	T,H,W,W,E, O

<sup>1</sup>T: timber, H: habitat or food for wildlife, W: watershed, E: environmental planting, O: Avenue or ornamental planting.

#### **P. gerardiana:**

*P. gerardiana* is found in northern Balochistan, Hariab district of the Kurram valley and somewhat locally in the inner arid valleys of Dir, Swat, Chitral and Chilas between 1800 and 3350 m. It forms a somewhat open forest, though moderately dense pole crops are also found. It is sometimes found associated with *Cedrus deodara*, or with *Quercus ilex* and *Fraxinus xanthoxyloides*, or in the trans-Indus with *P. wallichiana*. It is found only in the dry regions outside the influence of the monsoon, where the rainfall is scanty but there is a heavy winter snowfall. Total precipitation in the range probably amounts to between 375 and 750 mm. It endures severe cold in winter; the summer temperature within its habitat seldom, if ever, exceeds 38°C. The chilghoza pine makes little demand on the fertility of the soil, and is capable of growing on excessively dry, barren hill-sides with shallow soil, and even on bare rocks (21).

**P. roxburghii:**

P. roxburghii occurs naturally in the outer ranges of the Himalaya, in Siran valley, Gallies forests, Khanpur range, Murree-Kahuta forests, Buner valley, and Azad Kashmir from 1000 to 1800 m and occasionally higher. In Siran valley it grows excellently on granite and gneiss with a porous sandy and gravelly soil. The tree attains large dimensions, and natural reproduction springs up in abundance wherever sufficient light is admitted. The undergrowth consists chiefly of grass and Indigofera. The pine stands are for the most part pure, though in moist ravines, broad-leaved species, including Rhododendron arboreum are found. Above 1675 m chir pine is mixed with blue pine. In the Dungagali and Thandiani ranges of Hazara the chir occurs on limestone or shale on southern aspects up to 2125 m and is mixed chiefly with P. wallichiana. In the Khanpur range, on the outer hills of Hazara, the chir pine occurs from 760 m upwards on hard limestone with shallow soil. Here the trees as a general rule are stunted, with tapering and much-branched boles and poor height growth; trees over 65 cm diameter are not uncommon. On northerly slopes with deep fertile soil the quality of the forest is very good. Where there is sufficient depth of soil natural reproduction is often good. The chief associates of the pine are Pistacia integerrima, Olea cuspidata, Punica granatum, Ficus palmata and F. roxburghii, while on the cooler aspects and in moist ravines are found Quercus incana, Q. glauca, Cornus macrophylla, and other broad-leaved trees. The undergrowth species are Rhus cotinus, R. punjabensis, Dodonea viscosa, Myrsine africana, Rosa

moschata, Woodfordia floribunda, and Indigofera gerardiana (21).

**P. wallichiana:**

P. wallichiana is found in the Karakurram, Hindukush, Parachinar valleys and throughout the temperate regions of the Himalaya in Pakistan primarily at 1800-3000 m, but sometimes ascending to 3600 and descending to 1200 m. The tree is typically gregarious, often forming extensive pure stands owing to its capacity for springing up in dense even-aged masses on open hillsides. In spite of its tendency to form pure stands, blue pine very frequently occurs mixed with other species, of which the commonest are, among conifers, deodar (Cedrus deodara), spruce (Picea smithiana), and silver fir (Abies pindrow), and among broad-leaved species, oaks (Quercus incana, Q. dilatata, Q. semicarpifolia), Rhododendron arboreum, Pieris ovalifolia, Populus ciliata, Cornus macrophylla, Prunus padus, Cedrela serrata, Aesculus indica, Acer caesium, A. pictum, Ulmus wallichiana, and others. Undergrowth in the blue pine forests is usually absent due to the density of the stands (21).

Blue pine is found on a variety of geological formations. It thrives on moderately dry soils, but provided the drainage is good, it grows best on moist, deep soil; it avoids very wet and poorly-drained ground. Some of the best blue pine forests are found on mica schist, which decomposes into a moist fresh soil, often of considerable depth. On shale the growth varies much according to the hardness of the rock and the depth of the soil. Limestone is favourable where there is sufficient depth of soil, otherwise the soil becomes too dry for the pine to thrive.

Most of the important blue pine forests are situated in regions where the rainfall varies from 1000 to 1875 mm. Blue pine does not extend so far as deodar into the inner dry valleys of the western Himalaya. Throughout its habitat snow falls during the winter (21).

The importance of planting seeds or seedlings from the proper seed source is well realized throughout the world. Seed origin is extremely important in determining the ability of a species to grow and succeed in a given environment. Many pines with an extensive range, as well as some of limited natural range, have developed geographic races that are morphologically and physiologically distinct (7). These differences make each race best suited for growing in certain environments. As a general rule, seeds from sources in moist regions are smaller and produce faster growing and less deeply rooted seedlings than seeds from sources in drier regions. Information about geographic races of the pines grown in Pakistan is summarized below:

**P. gerardiana:**

No varieties are recognized, but local variations due to site conditions do exist. In exposed situations and on poor, shallow soil the trees are stunted and gnarled, but under favourable conditions they are fairly tall and straight.

**P. halepensis:**

There is some confusion in the literature regarding nomenclature of P. halepensis, Mill. (Aleppo pine) and P. brutia, Ten. (brutia pine). Schopmeyer (1974) and Young (1992) have listed them as



separate species (7,23), whereas, Dallimore and Jackson (1948) have described P. brutia as a variety of P. halepensis (2). P. halepensis is native to the mediterranean region, from Spain and Morocco to Turkey and Jordon, and P. brutia is found in Crete, Cyprus, and Lebanon north through Turkey.

For P. halepensis, Mill. two elevational ecotypes are recognized in Israel. For P. brutia, several varieties have been described in the Black Sea region. The variety pithyusa is found along the northern and north-eastern shores of the Black Sea and var. eldarica is found in the central Transcaucasus (7). Dallimore and Jackson (1948) have described P. pityusa, Steven. as a synonym for P. halepensis, Miller. and P. eldarica, ( Med.) as a synonym for P. halepensis, var. brutia, (Ten.) Elwes and Henry (2). This confusion regarding species and varieties of the species in question needs clarification.

The Afghanistan source, introduced in California, is described as related to eldarica pine (7), and the same has probably been introduced in Pakistan, as it is sometimes named as P. eldarica. If this is true, the correct scientific name of the species should be P. halepensis, var. brutia, (Ten.) Elwes and Henry.

**P. roxburghii:**

No varieties are recognized, but local variations associated with elevation and site exist.

**P. wallichiana:**

Based on morphological studies, blue pine in Pakistan can be separated into two major groups, one growing in the moist temperate

and the other in the dry temperate region (13). Trees in the moist temperate areas are more vigorous and have better form than those in the dry temperate region. Local variations due to elevations and environmental conditions also exist within each major group. Sahni (1989) has described two varieties of P. wallichiana in the eastern Himalaya also. P. wallichiana var. parra is distinguished from P. wallichiana var. wallichiana by shorter needles and smaller female cones, seeds and wings (14).

**FLOWERING AND FRUITING:** In Pakistan, P. wallichiana and P. halepensis start producing fertile seed when the trees are 15 to 20 years old. In chir pine, the age of producing reproductive structures depends largely on local environmental factors. Under ordinary forest conditions it is probable that few chir trees produce cones younger than thirty years, while it is by no means unusual to find trees forty years old or more with no sign of ever having borne cones. For P. gerardiana, the youngest age of seed production is not known. However, Troup (1921) reported that trees under 29 cm diameter, in Balochistan, produced an average of 28 cones per tree (21).

The male and female strobili of the Pakistani pines emerge from buds during February-June. The male strobili are arranged in indistinct spirals in clusters 1.3 to 5 cm long (7,21). Before ripening they can be green or yellow to reddish purple, but are light brown to brown at the time of pollen shed; in most species they fall soon after ripening. Female strobili emerge from the winter buds shortly after the male strobili and are green or red to

purple (7,21). At the time of pollination they are nearly erect, and 1 to 3.8 cm long and sometimes longer. After pollination, scales of the female strobili close, and the strobili begin a slow development. At the end of the first growing season they are about one-eighth to one-fifth the length of the mature cones.

Fertilization takes place in spring or early summer about 13 months after pollination, and the cones begin to grow rapidly. Growth of a new shoot leaves the developing cone in a lateral position. As the cones mature they gradually turn from green, purple, or violet purple to yellow, light brown, reddish brown, or dark brown. Cones and seeds of most species mature rapidly during the summer and fall of the second year. Cones of a few species mature during late winter of the second year or early spring of the third year; e.g., P. roxburghii.

The interval between large cone crops is variable and depends on the species and environmental factors. Some species, such as P. wallichiana in Pakistan, consistently produce a large crop almost every year, while others, like P. roxburghii show a cyclic pattern of 2 or more years between large cone crops (15,17,21).

The mature cone consists of overlapping woody scales, each of which bears two seeds at the base on the upper surface. The cones of most species open on the tree shortly after ripening, and the seeds are rapidly dispersed. Drying causes the cone scales to separate owing to differential contraction of two tissue systems: woody strands of short, thick-walled, tracheid-like cells extending from the cone axis to the tip of the cone scales, and the thick-

walled sclerenchyma cells in the abaxial zone of the scale (7).

In all Pakistani pines, the cones open on the tree without assistance and the seeds escape and fall to the ground, or in large-winged species, being carried some distance by wind. The cones remain for a time on the tree, in some cases for several years.

Mature seeds vary widely in size, shape, and colour. They range in length from 6 to 10 mm for P. wallichiana to more than 20 mm for P. gerardiana. They are ellipsoid in P. roxburghii and P. wallichiana, and cylindrical in P. gerardiana. The seedcoat is hard and greyish-brown in colour.

In most species, a membranous wing is attached to the seed, but in some species the wings are absent or rudimentary; e.g., P. gerardiana. The seed wings are easily detachable from the seeds of all pines except P. roxburghii, P. pinea, and P. canariensis.

The mature seed consists of a seedcoat which encloses an embryo imbedded in a food-storage tissue, the endosperm (female gametophyte). At the micropylar end of the whitish endosperm is attached a brown papery cap, the remnant of the nucellus. The endosperm and papery cap are covered by a thin, brown, membranous material--the remnant of the inner layer of the ovules integument.

**P. gerardiana:**

The flowers appear in May-June, when pollination takes place (Table 2). The young female cones increase in size slightly during the first year and rapidly during the second year. The cones attain full size in July and ripen in September-October of the year after

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pollination. The mature cone is 13-23 cm long and 7.5-13 cm in diameter, with very thick woody scales. The seed is 2-2.5 cm long, cylindrical, with a short wing which soon becomes detached and remains on the cone-scale when the seed falls. On an average about 2500 seeds weigh 1 kg. The seed is oily, and does not retain its viability long (21).

The seed-crop is an important matter from an economic point of view, and hence trees with broad spreading crowns, even if gnarled and stunted, are of more value than well-shaped trees with narrow crowns.

Table 2. Pinus: phenology of flowering and fruiting

Species	Flowering	Cone ripening dates	Seed dispersal dates	Natural germination dates	Data source
<u>P. gerardiana</u>	May-June	September-October	November	-	7,21
<u>P. halepensis</u>	May-June	September	Fall	-	7,21
<u>P. roxburghii</u>	February-April	January-March	April-May	June-July	7,21
<u>P. wallichiana</u>	April-June	August-September	September-November	June-July (warm areas and September-October (cool areas)	7,21

### P. roxburghii:

Male and female strobili of chir pine emerge from buds during February-April (table 2). The male flowers, 1.3-1.8 cm long when ripening, cylindrical ovoid, are grouped on the axis of the new shoots in spirals of 8x5, the whole inflorescence being 2.5-10 cm long by 3.8-5 cm in diameter. The flowers are yellowish green before ripening, turning light reddish brown after the pollen is shed. The flowers ripen, and pollen showers take place, from

February to April, according to altitude and season. The female flowers of chir pine are pale green or slightly purplish at first, and are found at or near the apices of the new shoots, either solitary or in pairs or in one or two whorls of three each. The female flowers appear in the early part of February at low elevations, and somewhat later at higher elevations. The young cones are erect and ovoid, with scales arranged in spirals of 8x5. Pollination takes place from February to April, depending upon altitude and weather. Shortly after pollination the cone scales close, and the strobili begin a slow development. At the end of the first growing season they are about 1.8-2.5 cm long by 1.5-2 cm in diameter, and turn greyish brown outside, remaining green inside. By this time a light reddish brown bud has formed at the end of the shoot; the cones are at the base of this bud, and are pushed out of their erect position into a more horizontal one. In this stage the cones pass the winter.

At the beginning of the second season the young cones again become active and turn green, the brown portion (the remains of the winter stage) being pushed to the tips of the scales. The growth from this point is very rapid. By June or July the cone has reached full size, but is still green. Towards the beginning of winter the cones gradually turn brown and hard; they are now fully developed, and in this stage they pass the winter.

In the spring of the third season, twenty-four months after the appearance of the female flowers, the cones are light brown, 11.5 to 20.5 cm long and 6 to 9 cm in diameter near the base,

elongate-ovoid, on short stout stalks; the scales are hard, thick, and tightly closed. These cones, solitary or in clusters of two to six, are found at the base of last year's needle-covered shoot.

The cones begin to open as a rule in April or May, but sometimes as early as March. They open only in dry weather, closing up again with rain; given sunny weather, however, complete opening takes place rapidly. The seed does not all fall at once, but may take two or three weeks, or even more, to escape completely; in cool localities and after rainy weather the seed may not be shed until June, while some of it may remain unshed until July. Even in fine weather there is some delay in the escape of seeds owing to the fact that a good shaking by the wind is required to dislodge them all.

The time for which the open cones remain on the tree after shedding their seed depends largely on the weather. Some are blown down during the storms preceding the monsoon, and others in the fall storms. A certain number remain on the tree for a year.

Male inflorescences may follow each other in successive years on the same branch. Female cones may succeed female cones at intervals of one or more years. Male flowers may succeed female flowers on the same shoot at intervals of one or more years; no case has yet been observed of males and females of the same year on the same shoot (21).

The winged seeds lie in pairs at the base of each cone-scale. The seeds, including the wing, are 2.8-4.6 cm long, the wing being 0.8-1 cm wide; without the wing they measure 0.8-1.3 cm by 0.5-0.6

cm. The number of seeds per kg varies from 6,900 to 25,200 with an average of 12,500. The specific gravity of well-formed seed appears to have no relation to its fertility; in tests carried out with the samples in question the lightest seed of all had a fertility of 100 percent., while some of the heavier samples also had a high germinative power (21).

An examination of 284 cones gave an average of 51 seeds per cone, the actual number varying from 31 to 105. The number of malformed seeds averaged less than one to every four cones (21).

Vigorous trees in the open yield large seed crops earlier than trees grown in close stands or suppressed trees. Crown development has an important influence on seed production; trees with full rounded or umbrella-shaped crowns bear a much larger number of cones than those with conical crowns. The selection of seed-bearers from among trees with full crowns is therefore a matter of great importance.

As regards the viability of seed from trees of different sizes, germination tests carried out with seed collected in Rawalpindi division from trees varying from 18.6 to 103 cm in diameter, gave 83 percent viability. Seed from five overmature trees 58 to 103 cm in diameter had a viability varying from 35 to 60 percent (21).

Fair to good seed years occur once every two to three years in P. roxburghii growing in Rawalpindi and Hazara districts (15,21).



**P. wallichiana:**

The male flowers (catkins) ripen and shed their pollen from the end of April to the beginning of June (table 2). This takes place earlier at low elevations and in hot dry seasons. The male catkins are arranged in rather indistinct spirals in a cluster 1.3-5 cm long at the base of the current year's young shoot. The catkins themselves immediately before ripening are 0.75-1 cm long, usually green, but sometimes dark, reddish-purple. They lengthen to 1-2 cm after shedding their pollen, and when ripe are yellow to light brown, and often pink towards the apex. They fall soon after ripening and shedding of pollen.

The young female flowers become visible in April, and are pollinated from the end of April to the beginning of June, according to elevation, locality, and season. The flowers (young cones) are erect and terminal on scale-covered peduncles, solitary or usually two or three together, sometimes more, at the ends of new shoots, forming a whorl round the terminal bud. At the time of pollination the flowers are 1-1.3 cm long and 0.4 cm in diameter, dark reddish purple, with open scales arranged in spirals. After pollination the scales close, and the young cones increase in size to 2.5-5 cm long and 1-1.3 cm in diameter by August, with a glaucous green or purplish colour. They remain in this condition for the remainder of the first season.

Fertilization is not completed until the beginning of the year after pollination. The young cones which appeared in the spring of the previous year begin to grow towards the end of March or during

April of the second year, and growth, once started, is rapid. The growth of the new season's terminal shoot moves the young cones from a terminal into a horizontal position, and as they increase in size and weight, they become pendulous instead of erect. The immature cones of the second season are bluish green and borne in clusters of two or three. They attain full length (15-33cm) from the latter half of June to the early part of August, and the cones gradually turn from green to light brown from the end of August to the early part of October. As they ripen, the scales open and the seeds are shed from the end of September to the early part of November. The length of time from the first appearance of the female flower to the ripening of cone is approximately eighteen months (17,22,23).

The winged seeds lie in pairs at the base of each cone scale. Seeds without wings are 0.6-1 cm long and 0.4-0.5 cm in diameter, dark brown, ovoid, compressed, acute at both ends, and with a hard shell. The wings, light brown streaked with darker brown lines, are 2-2.8 cm long and 0.7-1 cm wide. On an average about 17,000-20,000 seeds weigh 1 kg (7,23).

Blue pine bears seeds at a comparatively early stage, trees ten to twelve years old being occasionally found with well-formed cones on them. As a general rule, cone crops begin to appear regularly at ages fifteen to twenty years.

According to Troup (1921), good seed years are more frequent in blue pine than in any other important Himalayan conifer, and a year seldom occurs in which at least a fair proportion of trees in

a blue pine forest do not bear seed. In good years seed are produced in large quantities, but collection within the natural range of this species during 1972-79 has shown that good seed years may be less frequent than commonly anticipated. Siddiqui (1979) reported that seed production in blue pine follows a cycle of two years of poor seed production followed by 3-4 years of fair to good seed production (17).

**COLLECTION OF FRUITS:** Cones should be collected from trees superior in growth and form characteristics. One year old seedlings of *P. roxburghii*, raised from seed obtained from (a) commercial sources in Pakistan, and (b) selected seed stands, showed a significant difference in average height between a: (16.2 cm) and b: (26.9 cm) (16). Large cones generally contain more seeds than small ones, but normally all cones are collected, except those with obvious disease and insect damage. Widely spaced, dominant trees with full crowns produce the most seeds per cone, provided adequate pollen from other trees is available. When trees are isolated and pollen from other trees is limited, seed yield tends to be low. In dense, young stands most species usually produce few seed.

Ripe cones can be collected from standing trees and from newly felled trees. For most species, cone collections from standing trees should start as soon as the cones are ripe and just cracking, since most seeds are shed promptly from opening cones. For closed-cone species, collection can be delayed without loss of seed, and frequently delay is even desirable. Although seeds may be mature in

the fall, the closed cones are very difficult to open at that time, and additional maturation on the tree facilitates both cone opening and seed extraction (7,23).

To avoid extensive collections of immature or empty seeds, it is advisable to first check ripeness of seeds in small samples of cones from individual trees. A mature seed has a firm white to yellow, or cream coloured "endosperm" and a white to yellow embryo which nearly fills the endosperm cavity.

Ripeness for some species can be estimated by changes in cone colour. Colours of immature and ripe cones of the species are listed in Table 3.

TABLE 3. - Pinus: height at maturity and other data about fruiting

Species	Height at Maturity (meters)	Minimum Seed-Bearing Age (Years)	Interval Between Seed Crops (Years)	Fruit Ripeness Colour Ripe	Fruit Ripeness Colour Preripe
<u>P. gerardiana</u>	15-25	-	-	green	brown
<u>P. halepensis</u>	15-25	15-20	1	green	yellowish brown or reddish brown
<u>P. roxburghii</u>	35-46	15-40	2-4	green to brown	light brown
<u>P. wallichiana</u>	15-46	15-20	1-2	green	light brown

For collection of seed from felled trees, felling operations should be scheduled after the seeds mature. Otherwise there is a risk of harvesting immature seeds.

Good seed trees of chir pine are large and need special climbing equipment. Cones should be harvested when light brown, by cutting off the ends of cone-bearing twigs with long-handled cutters, and allowing them to fall to the ground. Unfortunately, this reduces the next year's crop, but the cone stalks are too

tough to cut on the tree. However, whole branches should not be lopped.

Good seed trees of blue pine and chilgoza pine are easier to climb than chir pine, but special climbing equipment is advisable. Blue pine cones can be picked by hand before they open, when they are just turning brown. It is not necessary to break branch tips. The climber should put the cones directly into a sack while he is up the tree.

Chilgoza pine cone collection is similar to that of chir pine. Mature brown cones should be collected for obtaining seed for raising planting stock. Seeds required for edible purposes are obtained from cones which are still green. Damage to the trees during cone collection should be avoided, so that the next year's seed yield is not affected.

**EXTRACTION AND STORAGE OF SEEDS:** Cones should be dried immediately after collection to avoid mold development and excessive internal heating, which lead to rapid seed deterioration. Drying can be accomplished in 2 to 60 days by immediately spreading the fresh cones in thin layers on a dry surface in the sun. The cones should dry slowly to avoid "case hardening". The fully-opened cones are knocked together to dislodge the seeds. Daily shaking will increase the seed yield. Walking on cones should be avoided, as this may damage the seed. Seeds can also be extracted by placing the opened cones in a large mechanical tumbler or shaker, or in a small manual shaker for small lots.

Serotinous cones of species such as P. brutia or P. halepensis may need special treatment to induce opening. Dipping them in boiling water for 10 to 120 seconds (up to 10 minutes for some especially refractory seed lots), followed by very high temperatures in a drying kiln or oven (75°-80°c), has been effective in some cases. High temperature is needed to melt the resin which forms a strong bonding adhesive between overlapping cone scales (3,7).

Seed-wings are removed either by putting the seeds in a cloth bag and gently rubbing together, then seiving and winnowing, or by machines of various types. Dewinging of a few species can be simplified by first wetting the seeds, then letting them dry; wings are loosened by this method and can then be fanned out. Numbers of cleaned seeds per kg are given for the four Pakistani pine species in Table 4.

The seeds are cleaned by winnowing, or by using mechanical air screen cleaners, fanning mills, or screens, to remove the mixture of broken seed wings, pieces of cone scales, and other impurities. After completing the dewinging and cleaning processes, empty seeds can be separated from the sound seeds by blowing them in aspirators or running them on gravity separators. In Pakistan empty seeds are commonly separated from the sound seeds by blowing them out using a fan.

TABLE 4. - Pinus: cone air drying, cleaned seeds per Kg, and viable periods for seeds in cold storage

Species	Air drying time <sup>1</sup> (Days)	Cleaned Seeds per kg Range (Number)	Cleaned Seeds per kg Average (Number)	Viable period for seeds in cold storage <sup>2</sup> (Years)	Data Source
<u>P. gerardiana</u>	15	2,450-2,900	2,450	-	7,21,23
<u>P. halepensis</u>	3-10	49,000-89,000	62,000	10	7,23
<u>P. roxburghii</u>	-	6,900-25,200	12,500	4+	7,21
<u>P. wallichiana</u>	-	16,000-22,700	20,200	-	7
			16,700	-	21

<sup>1</sup>Air drying times are for a temperature range of 15.5°-37°C.

<sup>2</sup>Period after which at least 50 percent of the seed germinated. Storage temperatures were either -18°-15° or 0.5°-5°C. Seed moisture contents were between 5 and 10 percent.

For most pines, high seed viability can be maintained for long periods of time with proper storage methods. Storage temperature and seed moisture content are the two most important factors affecting the success of seed storage. Siddiqui (1981) reported that germination of blue pine seed is significantly decreased with high storage temperature and that blue pine seed can be stored in dry cold or stratified conditions with no loss in germination (13). Germination of P. gerardiana seeds following storage and stratification indicated that none of the seeds stored at 4°C germinated. Germination of frozen (-10°C) and stratified seeds was 6% compared to 60% for frozen and unstratified seeds (20). As a general rule, seeds should be dried to a moisture content between 5 and 10 percent. This is considerably less than the moisture content of freshly collected seeds. Reduction of moisture content can be achieved in most species by placing the seeds in an ambient atmosphere of relative humidity (RH) of 15-20% for a period

sufficiently long to allow the seeds to reach a moisture content in equilibrium with the RH. Temperatures of  $-18^{\circ}$  to  $-15^{\circ}\text{C}$  are preferred for most species for long-term storage, but a range of  $0.5^{\circ}$ - $5^{\circ}\text{C}$  has also been used. Seeds of P. wallichiana have remained viable for several years at ordinary room temperature (7), but such storage is not recommended. Thoroughly dried seed should be put in a polythene bag, sealed tightly, and placed in a cold store (3,7,11). Some seed lots deteriorate rapidly following removal from cold storage if they are held at room temperature before sowing. Seeds should not be removed from storage more than a week before stratifying the seeds at low temperatures, sowing, or testing (7,23).

**PREGERMINATION TREATMENTS:** Most pines of temperate climates shed their seeds in the fall, and the seeds germinate promptly during the first spring or summer. Pine seeds display highly variable germination behaviour when sown following extraction or storage. The type and degree of dormancy vary among species, geographic sources of the same species, and lots from the same source. Seed dormancy may result from prolonged extraction at excessively high temperatures, and dormancy may increase with prolonged storage (7). Seeds of many species ordinarily germinate satisfactorily without pretreatment, but germination is greatly improved and hastened by first subjecting the seeds to cold stratification, especially when the seeds have been stored.

Stratification is accomplished by first soaking the seeds in water at room temperature or at  $0^{\circ}$ - $5^{\circ}\text{C}$  for 1 or 2 days depending upon the species and then placing them in a moist medium or in a



plastic bag and holding them at a temperature between 0° and 5°C. for a specified period of time. Recommended periods for both fresh and stored seeds are listed in Table 5 for the species growing in Pakistan (6,7,23).

TABLE 5. - *Pinus*: recommended cold stratification periods (0.5°-5°C in a moist medium).

Species	Recommended cold stratification period - fresh seed (days)	Recommended cold stratification period - stored seed (days)	Data source
<i>P. gerardiana</i>	0	0-30	7,23
<i>P. halepensis</i>	0	0	do
<i>P. roxburghii</i>	0	0	do
<i>P. wallichiana</i>	0-15	15-90	do

**GERMINATION TESTS:** For reliable tests of seed viability, seeds should be germinated under optimum conditions of aeration, moisture, temperature, and light. On the basis of extensive experience and experimentation, standardized seed tests for a number of pine species have been established by the Association of Official Seed Analysts (AOSA), and the International Seed Testing Association (ISTA). Some results of seed tests are given for four pine species in Table 6.

TABLE 6. - *Pinus*: germination test conditions and results (7).

Species	Germination test conditions <sup>1</sup>				Germination			
	Daily light period (hours)	Temperature °C	Light Dark °C	Duration (days)	Energy %	Period (days)	Capacity %	Samples (number)
<i>P. gerardiana</i>	0	-	21	-	-	-	47	2
<i>P. halepensis</i>	0	-	20	28	-	-	-	-
	0	-	20-22	30	50-66	20	79	5
	0	-	18-19	30	65-80	16-20	89	12
<i>P. roxburghii</i>	0	-	20-22	30	-	-	83	5
	0	-	-	30	79	10	81	135
<i>P. wallichiana</i>	8	30	20	18	-	-	-	-
	0	-	24-21	60	44	20	64	12

<sup>1</sup>Seeds are germinated without pretreatment on top of one or more layers of an absorbant paper.

Germination of pine can be effectively tested in any medium or container that provides good aeration and holds adequate moisture. For a number of species, light, commonly supplied by a cool, white fluorescent lamp, is required for reliable tests. The usual exposure is 8 hours in each 24-hour period. Different temperatures are employed in seed testing; constant 20°C and alternating 30°/20°C regimes are most common. When alternating temperatures are used, the higher temperature ordinarily is for 8 hours and the lower is for 16. The duration of most tests is from 3 to 4 weeks. Four replications of 100 seeds each should be used for all tests (7).

Cutting tests are commonly used for rough determination of seed quality. Such tests can also provide information on soundness and can be used as an emergency guide in fall sowing of fresh seeds with embryo dormancy. X-radiography can supply good information on soundness. Estimates of viability from these two tests are the most subject to error, since the seeds are not actually germinated (7).

Biochemical methods employing a rapid viability indicator such as one of the tetrazolium compounds can also be used, but are not generally recommended. The results are highly dependent on the analyst's experience, and the age of the seed. The viability estimates often are much higher than the germination capacities obtained from germination tests (7,23).

**NURSERY AND FIELD PRACTICES:** Chir pine can be raised in nursery beds and successfully transplanted bare-rooted, provided due care is taken during and after transplanting. However, for most plantation programmes, containerized seedlings are preferred.

In container production, two seeds should be sown in each polythene bag (size, 18x7.5 cm), covered with fine sand and watered. When germination is almost complete, one seedling from each bag that has two should be removed and replanted in an empty bag. Even if the second seedling is to be thrown away, only one seedling should be left in each pot. If the laboratory germination of the seed is more than 75%, two seeds should be sown in half the pots and one seed in the rest, followed by transplanting of the extra seedlings as above.

If sowing is to be done in nursery beds, the soil should be fertile with good drainage and aeration. Measures should be taken to protect the germinating seeds and seedlings against soil-borne diseases, insects, nematodes, and rodents. Dry seed treatment of P. roxburghii and P. wallichiana seeds with 0.25% ceresan has been reported to give effective control of a large number of seedborne fungi. Hexathir 75 WP at 0.25% level and hot water treatment at 57°C for 10 minutes are also quite effective (10). Seeds should be sown at 10-20 mm depth. Singh, et al. (1973) reported that optimum depth of sowing for P. wallichiana seed is 15 mm (19).

Sowing density used for nursery beds in Nepal aim to produce: chir pine: 1500-2000 seedlings/m<sup>2</sup>, and blue pine: 2500-3000 seedlings/m<sup>2</sup> (12). In the United States seeds are sown in bareroot nurseries at densities selected to produce from 160 to 800 seedlings per square meter. Higher tree survival rates are obtained when medium-to-low sowing densities are used. Most nurseries sow seeds at a slightly higher density if the seedlings are to be

placed in transplant beds for one or more years. A lesser density is desired for 2-0 than 1-0 seedlings. Depending on the species, seed lot, and nursery, sowing densities range from 6 to 90 gms of seed per square meter of bed. Average nursery germination has ranged from 20 to 85 percent of the germination capacities found in laboratory tests. Of the seeds that germinate, as little as 19 and as much as 90 percent produce usable seedlings; the average has been about 55 percent. In many nurseries, fungicides are used to control damping-off, and sprays are used during the season to control insects and other diseases. Chandra, et al. (1975) reported that Captan 0.3%, thiram 0.25% or dithane m-45 0.2% were found the most effective against P. roxburghii seedling damping-off caused by *Fusarium* spp. (1). A nursery experiment near Rome on the relative incidence of damping-off in several coniferous species showed that the susceptibility of P. halepensis was high and that of P. wallichiana was low (8). Generally, transplants (1-1) or older age classes (2-0) are recommended for difficult sites (7).

In Pakistan, pine seedlings are routinely grown in containers (poly-bags/polypots). Partial shade is provided during the germination and seedling establishment phases. These container-grown plants are cultured 1 to 2 years before outplanting. Care must be taken not to grow pine in too small a container for too long a time. Hafeez (1973) reported the performance of conifer seedlings grown in black polythene tubes of different sizes. On the basis of data for seedling height growth after 1-2 years, and costs of the tubes, he concluded that tubes of sizes 15 cm x 5 or

6 cm having 36-45 perforations of 30 mm diameter, are most suitable for raising coniferous planting stock (5). Roots coming out of containers should be pruned periodically. This can be accomplished by air-pruning the roots if containerized plants are grown on a raised wooden or iron frame. All pine species can be vegetatively propagated either by rooting or grafting (7). However, rooting success for most species decreases rapidly when scions are taken from trees older than 5 years. Softwood cuttings of P. roxburghii and semi-hardwood cuttings of P. wallichiana and P. gerardiana set in sand in the chamber (temperature 20-30°C; R.H. 85%) have been reported to give 63.5%, 35% and 0% rooting success respectively (4). Grafting is used to propagate rare material or to clone individual plants, as in seed orchard programmes designed to produce genetically improved forest tree seed (7).

**ILLUSTRATIONS:**

No appropriate illustrations available for correct species.

**Literature Cited:**

1. Chandra, J.P. and Sharma, P. K.  
1975. Effect of fungicides on germination and survival of pine seedlings chir (*Pinus roxburghii* Sargent). *Indian Forester*, 101(8).
2. Dallimore, W. and Jackson, A.B.  
1948. *A handbook of Conifers*. Edward Arnold and Co., Longon.
3. F.A.O.  
1985. *A guide to forest seed handling*. FAO publication No. 20/2. Food and Agricultural Organization of the U.N., Rome.
4. Gupta, M.P. and Chandra, J.P.  
1979. Vegetative propagation of coniferous forest tree species from branch cuttings with the help of mist chamber. *Indian Forester*, 105(6).
5. Hafeez, M.  
1973. Polythene tube size in relation to seedling growth in the nursery. *Pal. Journ. For.*, 23(1).
6. ISTA.  
1991. *Tree and shrub seed handbook*. The International Seed Testing Association, Zurich, Switzerland.
7. Krugman, S.L. and Jenkinson, J.L.  
1974. *Pinus*. In: *Seeds of woody plants in the United States*. Forest Service, USDA, Washington, D.C.
8. Magnani, G.  
1975. The susceptibility of some species of conifers to diseases in seedbeds. II. *Cellulosa e carte*, 26(10).
9. Mitchell, A. F.  
1972. *Conifers in the British Isles*. Forestry Commission booklet No. 33. London.
10. Munjal, R.L. and Sharma, A.D.  
1976. Control of seed mycoflora of some important conifers. *Indian Jour. of Mycology and Plant Pathology*, 6(2).
11. Napier, I.A.  
1987. Seed storage in the nursery (*Prunus*, *Alnus*, and *Pinus* spp.). *Banko Janakari*, 1(1).
12. Napier, I. and Robbins, M.  
1989. *Forest seed and nursery practices in Nepal*. Sahayogi Press (Pvt.) Ltd. Tripureshwor, Kithmandu.
13. Rahman, S., personal communication.  
1982. Pakistan Forest Institute, Peshawar, Pakistan.
14. Sahni, K.C.  
1989. A new variety of blue pine from the eastern Himalaya. *Indian Jour. For.*, 12(1).
15. Siddiqui, K.M.  
1978. Seed production in chir pine, 1978, and future trends. *Pak. Jour. For.*, 28(3).
16. Siddiqui, K.M. and Khan, M.  
1978. A note on the performance of chir pine seedlings raised from seed of selected stands. *Pak. Jour. For.*, 28(4).

17. Siddiqui, K. M. and Parvez, M.  
1979. Seeding periodicity in Blue pine. Pak. Jour. For., 29(2).
18. Siddiqui, K.M. and Parvez, M.  
1981. Seed storage and germination studies in Blue pine. Pak. Joooooour. For. 31(2).
19. Singh, R.V. et al.  
1973. Effect of depth of sowing on germination of Kail (*Pinus wallichiana*) seed. Indian Forester, 99(6).
20. Sprackling, J.A.  
1976. Germination of *Pinus gerardiana* seeds following storage and stratification. Tree Planters Notes, 27(3).
21. Troup, R.S.  
1921. The silviculture of Indian trees. Vol. III. Clarendon Press, Oxford.
22. U.S.D.A.  
1974. Seeds of woody plants in the United States. Forest Service, USDA, Washington, D.C.
23. Young, J.A. and Young, C.G.  
1992. Seeds of woody plants in North America. Dioscorides Press, Portland, Oregon.



# POPULUS

M. KHAN

SALICACEAE - Willow family

POPULUS L.            Poplar

**GROWTH HABIT, OCCURRENCE AND USE:** There are about 30 species of poplar, which are medium to large deciduous trees native in North America, Europe, North Africa and Asia south to the Himalayas (2). The nomenclature, occurrence, and uses of six species and varieties native to Pakistan and of one important exotic species are listed in Table 1.

Poplars are soft-wooded, usually fast growing trees. They are important pulpwood, timber, and veneer species (2,12). In Pakistan, poplar is the principal species used in the match industry. In the United States, poplar timber is used in building construction for rafters, stringers, studding, sheeting, shiplap, flooring, interior panels, mouldings, and trim.

Populus deltoides is used widely in Pakistan for shelterbelt and avenue plantings. P. nigra cv. Italica has also been used in amenity plantings in Hazara, Swat and Northern areas of Pakistan.

Natural hybridization has been reported between almost all sympatric poplar species. The possibility for successful hybridization between species of different taxonomic sections as well as within such sections has been demonstrated by natural and by controlled breeding (2).

In Pakistani poplars, no varieties are recognized but local variations due to elevations and site conditions may occur within the species. Siddiqui (1986) reporting the results of selection trials of P. ciliata, concluded that 2-year-old seedlings produced

from seed collected in xeric habitats outperformed those produced from seed collected in mesic habitats, when both were raised under conditions of high rainfall (3).

**FLOWERING AND FRUITING:** Most poplar species have been classified as dioecious, but P. lasiocarpa has been described as a monocious, self-fertilizing species, and deviations from strict dioecism have been found in individual trees of poplar species (2).

The range in flowering and seed ripening dates for individual species is shown in Table 2. In P. ciliata, the male catkins appear in March immediately before the young leaves. These are 7.5 - 15 cm long, yellow and pendulous. The female catkins are borne on separate trees, are also pendulous, but are somewhat stiffer and greener. The female trees are much commoner than the male. The female catkins elongate to 15-30 cm at ripening in June when the 3- or 4-valved capsules open and permit the minute seeds, covered with silky down, to escape. The seeds are about 13 mm long, light brown, and are covered with minute bristles. A large proportion of the seeds are infertile.

P. nigra rarely flowers in Pakistan. P. euphratica catkins appear in January-February; the male is 2.5-5.0 cm long and the female 5.0-7.5 cm. The fruits ripen in April to June, when the small capsules open into 3 (rarely 2) valves, with the minute seeds, surrounded by silky hairs, being disseminated by the wind (9). P. deltoides flowers appear in March-April, and the fruits ripen during May and August (10).

Table 1. *Populus*: nomenclature, occurrence, and use.

Scientific names and synonyms	Common names	Occurrence	Uses <sup>1</sup>
<i>Populus afghanica</i> (Aitch & Hemsl.) <i>P. nigra</i> L. var <i>afghanica</i> Aitch & Hemsl.	Black poplar	South Waziristan, Dargai, Kurram	-
<i>P. caspica</i> Bornm. <i>P. alba</i> L.	White poplar	Balochistan, South Waziristan, Kurram, Chitral, Swat, Gilgit, Murree, Kashmir	T
<i>P. euphratica</i> Oliv. <i>P. diversifolia</i> Schrenk.	Sindhpoplar, bahan, padar	From Sindh to the upper limits of tree growth	T.F.H.
<i>P. ciliata</i> Wall. <i>P. pyriformis</i> Royle. <i>P. rotundifolia</i> Griff.	Himalayan poplar, Safeda, bagna	Dir, Swat, Chitral, Gilgit, Hazara, Murree, Kashmir	T.E
<i>P. nigra</i> L. Cultivar <i>italica</i> . <i>P. italica</i> (Duroi) Moench. <i>P. pyramidalis</i> Roz.	Black poplar	Balochistan, Swat, Chitral, Gilgit, Kashmir	
<i>P. pamirica</i> Komar. <i>P. suaveolens</i> auct. non Fisch. <i>P. balsamifera</i> Hk. f. non L.	Balsam poplar	North and South Waziristan, Swat, Karakorum, Ladalch.	
<i>P. usbekistanica</i> Kom	-	Gilgit	
<i>P. deltoides</i> Barte. var. <i>deltoides</i>	Eastern Cottonwood	From Quebec to North Dakota, South to Texas and Florida	T.S.E

<sup>1</sup> T: timber, F: fuelwood, H: habitat for wildlife, E: environmental forestry, S: shelterbelt.

Table 2. *Populus*: phenology of flowering and fruiting.

Species	Height at maturity (m)	Flowering dates	Seed ripening and dispersal dates	Data Source
<i>P. alba</i>	15-42	April-May	May-June	1
<i>P. ciliata</i>	37	March	June	9
<i>P. deltoides</i>	24-58	March-April	May-August	1
<i>P. euphratica</i>	15	January-February	April-June	9
<i>P. nigra</i>	18-30	April	Late May	1

Minimum seed-bearing age in poplars shows considerable inter- and intraspecific variation. *P. deltoides* generally reaches flowering age between 10 and 15 years. The reported weights of poplar seeds vary, between and within species, from approximately 312 per gm to more than 15,500 per gm (2).

**COLLECTION, EXTRACTION, AND CLEANING OF SEEDS:** Branches bearing near-mature catkins can be brought into a warm room or greenhouse and placed in water to allow the capsules to open. If catkins are to be picked directly from the trees, a safe criterion for time of collection is when a small percentage of the capsules are beginning to open (4).

If the catkins are permitted to mature on cut branches, the seed can be collected in an upholstery-type vacuum cleaner with a clean cloth bag substituted for the dust bag. Catkins picked directly from the trees (or from cut branches) can be spread out in thin layers in pans or on screens at ordinary room temperature to shed their seed within 1 to 3 days, depending on the ripeness of the fruit (2). The seeds are covered with silky hairs. The removal of these hairs enhances seed germination as reported by Singh (1987) for P. ciliata (7). Poplar seed can be separated from the floss (silky hairs) by rubbing over a wire screen with suitably small mesh, by hand or with a heavy brush, but only about 20 percent of the seed is readily extractable by this method. The most efficient method for freeing poplar seed from the floss is by the use of an air stream. For small quantities of seed this can be done by placing the seed with floss in standard soil screens and applying a stream of air at high velocity to tumble the seed in the upper (covered) screen, permitting the seed to fall to the lower screen containers (2).

**DRYING AND STORAGE OF SEEDS:** Under natural conditions, poplar seeds can remain viable for a period of 2 weeks to a month, varying with the species, the season, and local environmental conditions. With proper drying and cold storage in sealed containers, poplar seed can be stored for several years with little loss of viability. Prestorage drying immediately after collection is an essential prerequisite for successful storage of the seed. Recommendations for drying time varies, e.g., 2 or 3 days at 21°C., 3 to 8 days at 24°-25°C. Viability in storage is improved and with a relatively higher germination if seed moisture content is held at 5 to 8 percent. Cold storage (about 5°C) of fully matured and properly dried seeds can maintain viability for 2 years and in extreme cases as long as 6 (2,12).

**GERMINATION TESTS:** The International Seed Testing Association (1991) specifies the following materials and conditions for the testing of seeds of Populus species: germination on top of one or more layers of moist paper at a temperature regime of 20°-30°C., first counts to be made after 3 days, final count at 14 days; test by using 4 replicates of 100 or replicates of 0-10 gm of seed, weight to nearest mg. The results of four such replicates are added together, averaged and expressed as the number of normal seedlings in the total weight of seed tested (1). For most species, normal germinated seedlings should have well-developed hypocotyl hairs, regular growth, and a geotropic response. Abnormal seedlings would show poor development of the hypocotyl hairs, absence of firm attachment to the substrate, and imperfect

geotropism. Seeds that have been dried and kept in storage may suffer injury from rapid imbibition. Aeration with humid air after storage has been used to solve this problem (12).

**NURSERY PRACTICES:** The production of poplar nursery stock from seed requires an exacting and unique nursery practice. Poplar seed should not be covered nor should it be pressed into the soil of the seedbed (6). The seedlings are extremely susceptible to drying, to washing action of rain or coarse irrigation, and damping-off and other soil fungi. The critical factor for seed germination is a water-saturated seedbed. Continuously favourable conditions (particularly abundant moisture) are required for at least one month for seedling survival and growth (2). Laboratory tests have demonstrated that germination of P. ciliata decreased from 73 to 3% as moisture stress increased from 0 to -3 atmospheres (5).

Fresh seed usually begin to germinate within a few hours on moist seedbeds, and within 12 hours the hypocotyl has begun to grow out of the seedcoat. A circular brush of delicate hairs develops rapidly around the base of the hypocotyl; the hairs become attached to the soil and, as the hypocotyl continues to grow, it straightens and lifts the seed off the ground. From 4 to 6 days after the beginning of germination, the hypocotyl has usually grown straight and upright, and the cotyledons have thrown off the seedcoat. During the period, and until the primary root has become firmly anchored in the soil, irreparable damage may be done by drying of the hairs or by wrenching the seedling from its anchorage by washing or flooding the surface of the soil. About the fifth day,

the primary root begins to grow slowly; after 12 days the root may be only 1.5 mm in length. The growth of the root system continues rather slowly for about 3 weeks to 1 month. The tap roots of one-month old seedlings may be only 2.5 cm. Obviously, irrigation of seedbeds must be with a fine mist or sub-irrigation system. Tests carried out on germination of fresh P. ciliata seed on moist filter paper at 20°C resulted in 88% germination of the seed (7). For P. euphratica, Wang, et al. (1985) reported that 25°-30°C. is the optimum temperature for seed germination (11).

For P. deltoides, about 3 gms of cleaned seed (3,000 seeds) per m<sup>2</sup> for broadcasting and 325 seeds per linear meter of drill row have been suggested as seeding rates. When the seedlings are about 4 weeks old, the beds should be thinned to approximately 215 seedlings per m<sup>2</sup> (2).

Nursery beds may be covered with glass or plastic screens for protection against rain during the first month or two after sowing. Shades and screens help to conserve moisture, but they are needed only if sufficient moisture cannot otherwise be maintained.

To avoid loss due to fungi, poplar nursery beds may be sterilized by steam, and by soil fumigation with methyl bromide and the addition of a thin layer of acid sand, pH 4.5-5.0 (2). In China, Bayleton powder is applied to P. euphratica seed before sowing for the control of rust disease in the nursery beds (8). Softwood and hardwood cuttings of most poplars root readily. Cuttings are usually 25 cm to 30 cm long and taken from dormant one-year-old stems (12).

## ILLUSTRATIONS:

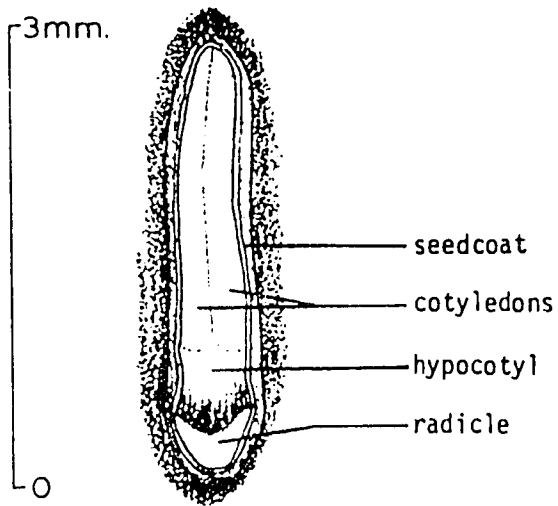


Figure 1. Populus deltoides. Longitudinal section through the embryo of a seed, 20 X. (From 10).



## Literature Cited:

1. ISTA.  
1991. Tree and Shrub Seed Handbook. International Seed Testing Association.
2. Shreiner, E.J.  
1974. Populus. In: Seeds of Woody Plants in the United States. Forest Service, USDA, Washington, D.C.
3. Siddiqui, K.M., et al.  
1986. Selection trials of Populus ciliata Wall. in Pakistan. Pak. Jour. For. 36(1).
4. Singh, R.V. and Singh, V.  
1982. Optimum time for the collection of Populus ciliata seed. Van Vigyan, 1982, 20(3-4).
5. Singh, R.V. and Singh, V.  
1983. Germination of Populus ciliata seed as influences by moisture stress. Indian Forester, 109(6).
6. Singh, R.V., et al.  
1985. Germination of Populus ciliata seed as affected by depth of sowing. Indian Forester, 111(5).
7. Singh, V. and Arya, S.R.  
1987. Populus ciliata - effect of parts of catkins on seed germination. Van Vigyan, 25(1-2).
8. Tian, N.X., et al.  
1984. Experimental control of rust of Populus euphratica at seedling stages with bayleton. Forest Service and Technology (LinYE Keji Tongxun), 1984, (No. 4).
9. Troup, R.S.  
1921. The Silviculture of Indian Trees. Vol. III. Clarendon Press, Oxford.
10. U.S.D.A.  
1974. Seeds of Woody Plants in the United States. Forest Service, USDA, Washington, D.C.
11. Wang, X.L., et al.  
1985. Nursery techniques of seeding Populus euphratica in nursery beds. Forest Science and Technology (LinYE Keji Tongxun), 1985, (No. 1).
12. Young, J.A. and Young, C.G.  
1992. Seeds of Woody Plants in North America. Dioscorides Press, Portland, Oregon.

## PROSOPIS

A. KHAN RAJA

LEGUMINOSAE - Legume family

PROSOPIS, L.

GROWTH HABIT, OCCURRENCE, AND USE: The genus Prosopis belongs to the sub-family mimosaceae of the Leguminosae family. The genus consists of 30-35 species of deciduous, thorny shrubs or small trees. Prosopis species are native to tropical and sub-tropical regions of the Western Hemisphere, Africa and Asia and are well suited to grow in arid and semi-arid conditions (12). They are particularly useful as multipurpose trees having a variety of uses especially as fuelwood and charcoal species. In Pakistan the two major species of Prosopis are P. cineraria (L.) Druce and P. juliflora Swartz Prodr. (mesquite).

P. cineraria:

P. cineraria is a moderately sized, evergreen, thorny tree with a sparse crown and straggling branches armed with conical prickles, native to dry, arid regions of the Indo-Pakistan sub-continent (11). It occurs in Sind, the Punjab plains, Balochistan and drier parts of NWFP, even extending into eastern Iran. It is a principal species on the higher and older alluvium soils (11). It does not ordinarily exceed a height of 12 meters and a diameter of 39 cm. The tree coppices well up to a moderate age and also reproduces freely by root suckers. The tree is a light demander and develops an extremely long tap root that allows extraction of water from deep in the subsoil (9,11).

P. cineraria is an excellent fuel and charcoal species and is used locally for various other purposes. It has a calorific value

of 5,000 k cal per kg of fuel wood (9). P. cineraria foliage is browsed by livestock, and its pods are used as food for cattle (9,11,13). It is a suitable species for dry land afforestation (9,11).

P. juliflora:

P. juliflora is a variable, highly adaptive, and readily hybridizing species (2). It is a deciduous, thorny shrub or small tree which can tolerate highly arid and sub-arid climates (9,12). Mesquite is native to tropical and sub-tropical North and South America and is very abundant in Mexico, Chile and Peru (2,11). It was introduced into the Indo-Pakistan sub-continent in 1877 from seed obtained through Kew gardens (11). It is a useful tree for drier regions but can become a problem in irrigated plantations. It can attain a height of 15 meters and diameter of 19 cm but may also assume a bushy form (9,11,12).

Mesquite is a multipurpose tree species. The wood is good for fuel and charcoal, which burns slowly and evenly and holds heat well (2,11,12,13). The wood is hard and has a beautiful grain and colour that makes it very suitable for parquet flooring and small decorative products (2). The pods make good forage, but sometimes produce ill effects in livestock. Leaves also provide browse, and the flowers supply large quantities of nectar for bees (2,6,11,12,13). The tree is a good soil binder and is recommended for planting in shifting sands and coastal areas (11,13). It is a useful species for planting in saline as well as waterlogged areas or terrain unsuitable to many of man's activities.

**FLOWERING AND FRUITING:** In P. cineraria the spikes of small yellow flowers appear from March to May. The fruit is an indehiscent pod, 10-20 cm long, containing 10-15 seeds which ripen from June to August (11). The ripe fruit is brownish, long, slender, contracted between the seeds and contains a dry sweetish pulp. The seeds are 0.5 - 0.8 cm by 0.4 - 0.5 cm, compressed, ovate, oblong or rhomboidal, brown, smooth, hard, with a moderately hard testa (11). The number of seeds per kg varies from 25,000 to 27,000 (13). The seed remains viable for at least one year in storage under ambient conditions.

In P. juliflora, perfect yellow flowers are borne in spike-like racemes that appear from March through May (2,3). The fruit is an indehiscent pod containing several seeds which ripens in May and June (11,12). The ripe fruits vary in color from straw to reddish brown. The flat, shiny, brown seeds have no endosperm (12).

**COLLECTION, EXTRACTION, AND STORAGE:** The ripe pods of P. cineraria and P. juliflora may be stripped from living trees or picked from the ground. The pods should be dried for several days in the sun or at air temperature to facilitate extraction of seed. Seeds are badly damaged by insects if pods are left for long periods prior to extraction. The seeds can be extracted by manually crushing or beating the pods. They can be cleaned by winnowing or screening and should be treated with an insecticide to prevent attack by insects. Air-dried P. cineraria seeds stored in hessian sacks under ambient conditions retain viability for at least one year

(11). Storage life should be much longer under refrigeration, but no data are available.

In *P. juliflora* the number of seeds per kg varies from 8,000 to 30,000 (13). Seed longevity data are not available but air-dried seeds at ambient temperature remain viable for many years (4,8). Seeds buried in the soil remain viable in nature for several years and continue to germinate year after year. This characteristic of the seed makes it very difficult to eradicate mesquite from irrigated plantations.

**PREGERMINATION TREATMENTS:** Ordinarily the seed of *P. cineraria* will germinate one to two weeks after sowing. Under natural conditions, they germinate at different times during the rainy season, some lying ungerminated until the second season (11). This delayed germination is indicative of dormancy due to hard seed coats. Soaking for 24 hours in cold water and mechanical scarification has been suggested as pregermination treatments (9,13), but more research is needed to determine better scarification methods.

Freshly collected mesquite seeds that have not yet dried may germinate promptly without treatment (3). As seeds dry, their coats become impermeable to water. Successful methods of scarification may include nicking with a knife (3), immersion in absolute ethyl alcohol for 72 hours (1) or treatment with sulfuric acid for 20 to 30 minutes (7,9). Seed coat hardness will vary among lots, so different lengths of treatment time should be tried on small lots (5). Soaking in cold water for 48 hours or immersion

in boiling water have also been suggested (9,13). Germination of treated seed is 80 to 90 percent (9).

**GERMINATION:** Germination of P. cinararia is epigeal. The radicle emerges and the hypocotyl elongates by arching, carrying the cotyledons above ground when it straightens. The testa is carried up over the cotyledons and falls when the cotyledons expand (11).

Germination of P. juliflora is also epigeal (12). The results of scarification by nicking or treatment with sulfuric acid, as given in Table 1 indicates increases in germination of mesquite seed with treatment. Germination of scarified seeds was complete 10 days after exposure to the test conditions (3).

TABLE 1. Prosopis juliflora germination test conditions and results.

Seed Age (Years)	Scarification treatment	Germination medium	Temperature Day Night °F. °F.	Average Germination Capacity (Percent)	Data Source
11	knife nick	wet paper	27 27	98	3
50	--do--	--do--	27 27	60	3
-	none	--do--	27 27	18	3
-	H <sub>2</sub> SO <sub>4</sub>	wet sand	30 20	88	12

**NURSERY AND FIELD PRACTICE:** P. cineraria seeds should be sown in earthen pots or polypots soon after collection, i.e. June to August or during the next spring/summer season. The seeds germinate within one to two weeks and seedlings put on sufficient growth for over-wintering. The leaves of seedlings fall during the cold season (11). The seedlings should be out-planted with a ball of earth preferably when the seedlings are one year old or 30 to 40 cm high. Direct sowing in the field also proves successful if irrigation is available or if seeds are planted in moist places.

P. juliflora plantations can be raised successfully by direct sowing (11). For experimental purposes or for introducing mesquite in problematic areas, nursery seedlings can easily be raised by sowing of treated seeds in polypots. The seedlings can be out-planted when they are one year old.

ILLUSTRATIONS:



Figure 1. Prosopis juliflora. Pod, 1/2 X. (From 12).

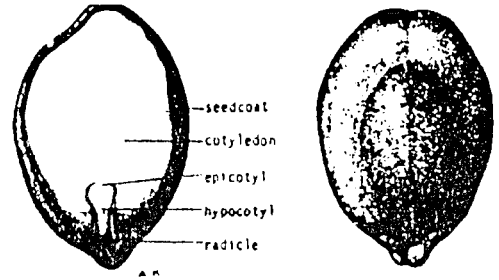


Figure 2. Prosopis juliflora. Longitudinal section through a seed and exterior view, 5 X. (From 12).

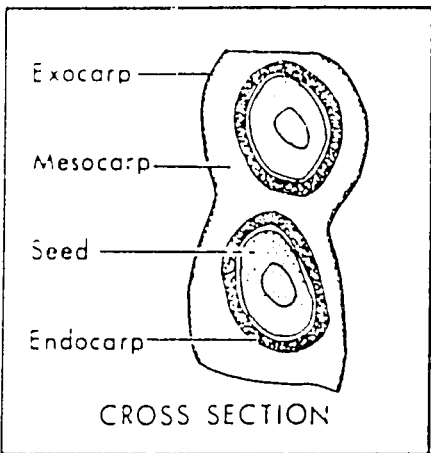
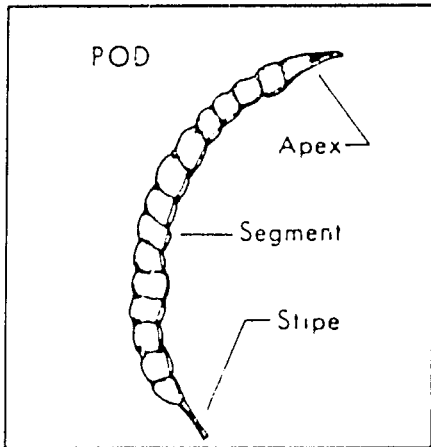


Figure 3. Prosopis juliflora. Drawing of entire pod and cross section of pod segments. (From 12).

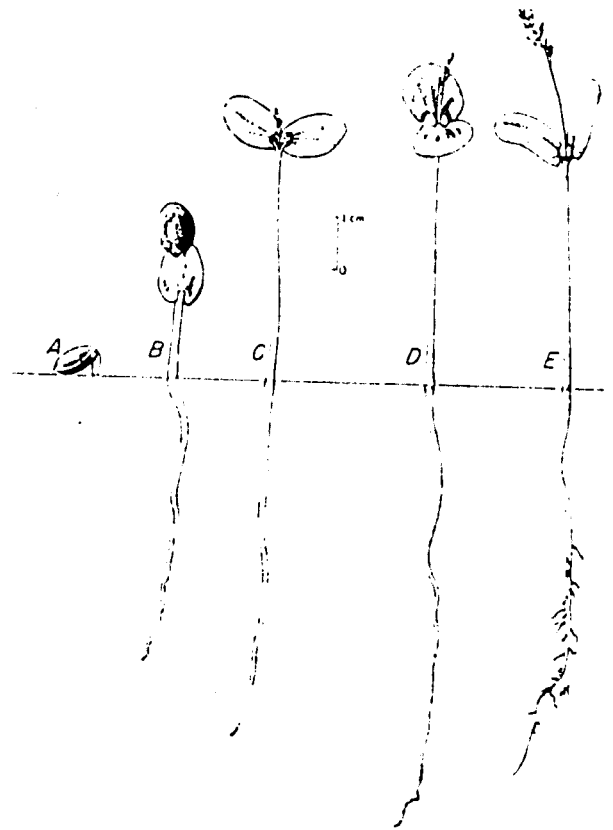


Figure 4. Prosopis juliflora. Seedling development at 1, 2, 5, 10, and 25 days after germination. (From 12).



## LITERATURE CITED:

1. Barton, Lela, V.  
1947. Special studies on seedcoat impermeability. Contrib. Boyce Thompson Inst. 14: 355 p.
2. Folliott, P. F. and Thames, J. L.  
1983. Hand book on taxonomy of *Prosopis* in Mexico, Peru and Chile, FAO Rome 1-8.
3. Glendening, George E., and Paulsen, Harold A., Jr.  
1955. Reproduction and establishment of velvet mesquite, as related to invasion of semi-desert grasslands. U. S. Dep. Agric. Tech. Bull. 1127, 50p.
4. Goor, A. Y., and Barney, C. W.  
1968. Forest tree planting in arid zones. The Roland Press Co., New York. 334 p.
5. Heit, C. E.  
1967. Propagation from seed. Part 6. Hard-seededness--a critical factor. Am. Nurseryman 125 (10): 10-12, 88-96.
6. Kearney, Thomas H., and Peebles, R. H.  
1960. Arizona flora. Ed. 2 with suppl., Univ. Calif. Press, Berkeley and Los Angeles. p. 1085.
7. Khudairi, A. K.  
1956. Breaking the dormancy of *Prosopis* seeds. Physiol. Plant. 9: 452-461.
8. Martin, S. Clark.  
1948. Mesquite seeds remain viable after 44 years. Ecol. 29: 393.
9. National Academy of Sciences. 1980. Firewood crops, National Academy of Sciences. Washington, D.C. 150-153.
10. Stewart, R. R.  
1972. An annotated catalogue of the vascular plants of West Pakistan and Kashamir. Fahkri Printing Press, Karachi 484 p.
11. Troup, R. S.  
1921. The Silviculture of Indian Trees. Oxford at the Claredon Press. 389-402.
12. USDA Forest Service.  
1974. Seeds of woody plants in the United States. U. S. Dept. of Agric. Handbook No. 450. 656 p.
13. VonCarlowitz, P. G.  
1986. Multipurpose Tree and Shrub Seed Directory. ICRAF Nairobi, Kenya. 74-75, 221, 222.

## GLOSSARY

**ABNORMAL SEEDLINGS:**

In seed testing, seedlings which do not possess all normal structures required for growth, nor show the capacity for continued development.

**ABORTIVE:**

Imperfectly or incompletely developed as abortive seed.

**ABSCISSION:**

Natural separation of leaves, flowers and fruits from plants, generally associated with deterioration of a specialized layer of thin-walled cells.

**ABSORPTION:**

Penetration of one substance into the body another, through interpenetration of particles among those already present.

**ACHENE:**

A one-seeded, dry, indehiscent fruit.

**ADSORPTION:**

The taking up of one substance at the surface of another; adhesion of unimolecular layer to surface of solid body.

**AFTER RIPENING:**

Physiological processes which occur in seeds (or bulbs, tubers, and fruits) after harvest or abscission, which occur prior to and are often necessary for germination or resumption of growth under favorable external conditions.

**AGGREGATE FRUIT:**

The fruit formed from the several separate or fused ovaries of a single flower, as in Rubus and Magnolia. Compare multiple fruit or simple fruit.

**ALLELE:**

One of an array of genes possible at a certain position (locus) on a given chromosome. Alternative (Mendelian) effects on the same character are produced by different alleles, e.g., as met in green or albino seedlings. If the array contains more than two genes, the genes are called multiple alleles. Multiple alleles arise by repeated mutations of a gene, each with different effects. No more than two alleles can be present in a given diploid organism.

**AMENT:**

See: Catkin.

**ANGIOSPERMS:**

The botanical name of the group of vascular flowering plants that produce seeds enclosed in the ovary. Includes the hardwoods, bamboos and palms.

**ANTHESIS:**

Stage of full flower expansion and bursting of anthers to release pollen.

**ANTIPODAL NUCLEI:**

Three of the eight nuclei that result from meiosis or sexual cell division in the female organ of seed-bearing plants.

**APOCARPOUS:**

Having separate or partially united carpels.

**APOMIXIS:**

1. All forms of asexual reproduction that tend to replace sexual regeneration.
2. Reproduction from seeds or seedlike organs but without fertilization.

**APOPHYSIS:**

1. An enlargement or swelling of the surface of an organ.
2. Visible portion of a scale in a closed cone.

**ARCHEGONIUM:**

The female germ cell of gymnosperms, within which the ovum is contained.

**ARIL:**

An additional integument or appendage formed on some seeds after fertilization.

**ASEXUAL REPRODUCTION:**

Reproduction by purely vegetative means accomplished in woody plants usually by rooting stem cuttings, air layering, grafting, or budding.

**ASSIMILATION:**

Conversion into protoplasm of ingested and digested nutrient material.

**BERRY:**

Pulpy indehiscent fruit developed from a single pistil and containing one or more seeds but no true stone.

**BISEXUAL:**

Having both stamens and at least one pistil in the same flower; syn. complete flower, perfect flower. Compare unisexual.

- BRACT:**
1. Modified leaf subtending a flower on floral axis.
  2. Modified leaf subtending a scale in female cones.
- BROADCAST SOWING:**  
Scattering seed uniformly over an area; syn. broadcast seeding.
- BROWSE:**  
n. Shoots, twigs, and leaves of trees and shrubs eaten by livestock and wild animals. v.t. to eat such material.
- BUR:**  
Prickly or spiny casing around a fruit; the involucre in Castanea and Fagus.
- CALYX:**  
Outermost group of floral parts; whorl of sepals.
- CAPSULE:**  
Dry, usually many seeded fruit composed of two or more fused carpels that split at maturity to release their seeds as in Populus, Eucalyptus.
- CARABINER:**  
A metal safety clip, used by climbers with ropes, which can be locked in the closed position as an insurance against accidental opening during climbing and fruit harvesting.
- CARPEL:**  
Simple pistil or single member of a compound pistil.
- CARPELLARY:**  
Pertaining to a carpel.
- CARPELLATE:**  
Having carpels.
- CASE-HARDENING:**  
Of cones, the setting of their scales as a result of over-rapid superficial drying, so that they fail to open and discharge their seed.
- CATKIN:**  
Spike of unisexual flowers or fruits with imbricated scaly bracts as in Alnus and Betula. syn. ament. Compare strobile.

**CERTIFIED SEED:**

Seed attested by a recognized certifying agency to be from trees of proven genetic superiority, as defined by that agency, and produced so as to assure genetic identity. syn. elite seed. Compare selected seed and source-identified seed.

**CHAFF:**

In eucalypts, sterile particles derived from infertile or non-fertilized ovules.

**CHILLING:**

See: Prechilling.

**CHROMATID:**

One of the paired microscopic, and usually rod-like, bodies which results from the longitudinal division of a chromosome at mitosis. Each chromatid develops into a chromosome in the daughter cell.

**CHROMOSOME:**

A microscopic, usually rod-like, body present in the cell nucleus and carrying the genes. The number, size and form of the chromosomes are usually constant for each species.

**CLINE:**

A gradual change in a phenotypic characteristic among individuals of a population; usually associated with a gradient in an environmental factor over the range of population.

**CLONE:**

Group of genetically identical plants produced by vegetatively propagating a single plant over one or more vegetative generations; accomplished in woody plants by rooting stem cuttings, budding, grafting, or air layering. Compare ortet, ramet.

**COMBINING ABILITY:**

Capacity of a parent in crosses with other parents to transmit genes for a specific character. Good *general combining ability* (GCA) of a parent signifies high average performance of its progenies in various crosses, as compared to progenies of other parents in the same test. The "breeding value" of a parent is twice its GCA. Good *specific combining ability* (SCA) refers to two parents which, when crossed together, produce progeny better than expected on the basis of the parental GCA values.

**CONE:**

1. One of the reproductive structures of conifers. A female cone consists of a central axis supporting imbricated bracts each of which subtends a scale bearing naked (noncarpellate) seeds. A male cone consists of a central axis supporting spirally arranged microsporophylls each of which bears pollen sacs containing pollen grains. syn. strobilus.
2. Any seed-bearing structure having a conical shape as in Magnolia and Liriodendron.

**CONELET:**

Immature female cone of gymnosperms, sometimes described as flower.

**COROLLA:**

Inner set of floral leaves consisting of separate or fused petals that surround the carpels.

**CORYMB:**

A flat-topped floral cluster as in Rhododendron and Kalmia.

**COTYLEDON:**

Modified leaf or leaves of the embryo or seedling, which may contain the stored food reserves of the seed (= seed leaf). They are formed at the first node or at the upper end of the hypocotyl.

**CUTINISATION:**

The deposition of a waterproof, waxy substance (cutin) on or in the outer layers of cell walls at the surface of seeds, leaves and young stems.

**CYME:**

Flower cluster having main and secondary axes each terminating in a single flower as in Sambucus, Viburnum, and Sorbus.

**DEHISCENCE:**

Splitting open at maturity to discharge contents, as a capsule discharging seed.

**DESORPTION:**

Loss of moisture from a relatively moist hygroscopic material, such as seeds, to a relatively dry atmosphere until the two reach equilibrium.

**DETERMINATE FLOWERING:**

Terminal flowers bloomings slightly in advance of their nearest associates. Compare indeterminate flowering.

**DICHOGAMY:**

Maturation of male and female organs on the same plant at different times.

**DIOECIOUS:**

Having staminate (male) flowers and pistillate (female) flowers borne on different individual plants as in Acer, Fraxinus, and Ilex. Compare monoecious.

**DIPLOID:**

A cell or organism with two basic chromosome sets, symbolized by  $2n$ ; the condition for vegetative tissues of most higher plants.

**DORMANCY:**

A physiological state in which a seed predisposed to germinate does not, even in the presence of favourable environmental conditions.

**DORMANCY, COMBINED:**

Dormancy as a result of two primary factors, such as seedcoat dormancy and embryo dormancy.

**DORMANCY, DEEP:**

Dormancy which requires extensive after-ripening to overcome; usually a double dormancy or a combined dormancy.

**DORMANCY, DOUBLE:**

Dormancy in both the radicle and the epicotyl of the embryo. To overcome it normally requires a warm treatment followed by pre-chilling or two periods of pre-chilling, interrupted by a warm treatment.

**DORMANCY, EMBRYO:**

Dormancy as a result of conditions within the embryo itself: inhibiting substances, incompletely developed embryo. syn. internal dormancy.

**DORMANCY, IMPOSED:**

Dormancy as a result of some action, treatment, or injury to seeds in the course of collecting, handling, or sowing. syn. secondary dormancy, induced dormancy.

**DORMANCY, INDUCED:**

See: Dormancy, Imposed.

**DORMANCY, INTERNAL:**

See: Dormancy, Embryo.

**DORMANCY, PHYSIOLOGICAL:**

A type of embryo dormancy in which germination is prevented by a physiological inhibiting mechanism.

**DORMANCY, SECONDARY:**

See: Dormancy, Imposed.

**DORMANCY, SEEDCOAT:**

Dormancy as a result of seedcoat conditions: impermeability to gasses or moisture or mechanical restrictions.

**DORMANCY, SHALLOW:**

Dormancy which requires little or no afterripening to overcome.

**DRUPE:**

A stone-fruit such as a plum; the pericarp fleshy or leathery, containing a stone with one or more seeds.

**ECOTYPE:**

See: Race.

**EFFECTIVE KILOGRAM:**

The weight of seed of any particular seed lot which can be expected to produce the same number of either viable seeds or plantable plants (according to local usage) as would be produced by one kilogram of standard seed.

**EMBRYO:**

The non-self-supporting immature organism formed from the zygote by cell division and differentiation; the rudimentary plant within the seed.

**EMBRYO SAC:**

The mature female gametophyte in higher plants.

**EMPTY SEED:**

A seed without any content, or without an embryo or embryo cavity if some residual tissue is present; the opposite of filled seed.

**ENDOCARP:**

Inner layer of the pericarp; e.g. the hard, bony part of the fruit of Prunus.

**ENDOGENOUS:**

Developed from a deep-seated layer of tissue. In a seed, developed from, or occurring in, the embryo.

**ENDOSPERM:**

Triploid nutrient storage tissue surrounding the embryo in seeds of angiosperms. The so-called "endosperm" of conifers is haploid, derived from tissue associated with the female gamete.



**ENZYME:**

A catalyst produced by living organisms and acting on one or more specific substrates; a ferment.

**EPICARP:**

See: Exocarp.

**EPICOTYL:**

Portion of the axis of a plant embryo or seedling stem between the cotyledons and the primary leaves.

**EPIGEAL GERMINATION:**

Germination in which the cotyledons are forced above the ground by the elongation of the hypocotyl.

**EXOCARP:**

Outermost layer of pericarp; the skin on fleshy fruits as in Cornus, Malus and Prunus.

**EXOGENOUS:**

Developed from a superficial layer of tissue. In seeds, developed from, or occurring in, the covering of the seed, either seedcoat or pericarp.

**EXTRACTION FACTOR:**

Weight of cleaned seed expressed as a percentage of the weight of the fresh fruit from which the seeds were extracted.

**F 1:**

First filial generation of offspring from a cross between two parents.

**F 2:**

Second filial generation of offspring produced by intercrossing or selfing among the F1 individuals.

**FEMALE CONE:**

See: Cone.

**FEMALE GAMETOPHYTE:**

Haploid nutrient storage tissue in seeds of gymnosperms; often mistakenly called the "endosperm" of seeds of gymnosperms.

**FERMENTATION:**

The process of chemical changes in organic substances caused by the catalytic action of a "ferment", which may be an independent plant such as yeast or bacteria, or an enzyme. May be accompanied by the production of heat and of toxic substances, hence the fermentation of fleshy fruits may adversely affect the seeds which they contain.

**FERTILIZATION:**

Union of the nucleus and other cellular constituents of a male gamete (sperm) with those of a female gamete (egg) to form a zygote. In some species, fertilization may occur months after pollination.

**FILLED SEED:**

A seed with all tissues essential for germination. syn. full seed.

**FLAIL:**

An instrument for threshing cereals by hand, consisting of a wooden staff or handle, at the end of which a stouter and shorter pole or club is so hung as to swing freely.

**FOLLICLE:**

A dry dehiscent fruit formed from a single carpel, dehiscing along the ventral side only.

**FREE RADICAL:**

A group of atoms which usually exists in combination with other atoms, but which may exist independently for shorter or longer periods, e.g. the  $\text{NH}_4$  radical.

**FRUIT:**

Reproductive unit of a seed-bearing plant developed after fertilization by a sperm cell from a pollen grain; fruit includes the ripened ovary and all of its protective covers, appendages, and supporting structures.

**FRUIT WALL:**

Outer layer of fruits in which pericarp is not distinguishable from the seedcoat as in the achenes of Baccharis. Syn: Pericarp.

**FULL SEEDS:**

Those filled with tissue having a normal appearance as distinguished from empty or partially empty seeds. Compare sound seeds.

**FUNICLE:**

The slender stalk of an ovule or seed, attaching it to the ovary placenta.

**GAMETE:**

A male or female reproductive cell, typically the product of meiosis, capable of uniting, in the process of fertilization, with one of the opposite sex.

**GAMETOPHYTE:**

(=Prothallus). The part of the plant that produces gametes or sex cells.

**GAUGE:**

A term used in the UK and elsewhere to define thickness of thin films such as polyethylene. 100 gauge (UK) = 1 mil (USA) and approximately = 25 microns or 0.025 mm.

**GENE:**

The smallest transmissible unit of genetic material consistently associated with a single primary genetic effect. The genes are ultramicroscopic and act as if linearly arranged at fixed places (loci) on a chromosome.

**GENETIC GAIN:**

Average improvement among progeny over the mean for the parents with respect to the characteristics used in selecting the parents.

**GENOTYPE:**

1. An individual's hereditary constitution, with or without phenotypic expression of the one or more characters it underlines. The genotype is determined chiefly from performance of progeny and other relatives. It interacts with the environment to produce the phenotype.
2. Individual(s) characterized by a certain genic constitution.

**GEOGRAPHIC RACE:**

See: Race.

**GERMINATION:**

In general, resumption of active growth in the embryo of a seed as demonstrated by the protrusion of the radicle. In seed testing (ISTA definition), resumption of active growth in an embryo which results in its emergence from the seed and development of those structures essential to normal plant development.

**GERMINATION CAPACITY:**

Proportion of a seed sample that has germinated normally in a specified test period, usually expressed as a percentage. Syn: Germination percentage. It should be noted that in some earlier literature the term "Germination Capacity" has been used to express the total of the seeds which germinate plus the ungerminated but sound seeds (on cutting test), as a percentage of the seeds sown, but this meaning is excluded by the latest IUFRO definition (Bonner 1984 a). cf. Viability percent.

**GERMINATION ENERGY:**

That proportion of germination which has occurred up to the time of peak germination, or the time of maximum germination rate, or up to some pre-selected time, usually 7 test days. (The critical time of measurement can be chosen by several means).

**GERMINATION PERCENTAGE:**

See: Germination Capacity.

**GLABROUS:**

Smooth; without hairs or down.

**GLAUCOUS:**

Having a powdery or waxy coating that gives a frosted appearance and tends to rub off.

**GLOBOSE:**

Approximately or completely spherical; globular.

**GYMNOSPERMS:**

The botanical name of the group of vascular flowering plants that produce seeds not enclosed in an ovary, the most important order of which is the coniferales.

**HAPLOID:**

A cell or organism with one basic chromosome set, symbolized by  $n$ , the normal condition of gametes in plants which are diploid in their vegetative tissues.

**HARD SEEDS:**

Seeds which remain hard and ungerminated at the end of a prescribed test, because they have not absorbed water due to an impermeable seedcoat.

**HAUSTORIA:**

Suckers of parasite plants.

**HEAD:**

Densely packed cluster of stalkless flowers as in Cornus, Baccharis, and Cephalanthus. syn. capitulum.

**HETEROZYGOUS:**

Having one or more sets of unlike alleles, e.g., the dominant with the recessive gene. Thus, an  $Aa$  plant is heterozygous whereas the  $AA$ 's and  $aa$ 's are homozygous. A heterozygote does not generally breed true and is known as a hybrid with respect to the genes in question. Compare homozygous.

**HILUM:**

Scar on a seed marking the point of attachment to the ovary in angiosperms or to the megasporophyll of gymnosperms.

**HOMOZYGOUS:**

Having one or more sets of like alleles, e.g., both dominant ( $AA$ ), or both recessive ( $aa$ ). A homozygote breeds true when mated with the same genotype. Compare heterozygous.

**HUSK:**

Outside envelope of a fruit, especially if coarse, harsh or rough as in the involucre of Carya.

**HYPOCTYL:**

That part of the axis of a germinating embryo which is between the cotyledons and the radicle; in seedlings, the juvenile stem which is between the cotyledons and the root system.

**HYPOGEAL GERMINATION:**

Germination in which the cotyledons remain in the seed below the ground while the epicotyl elongates.

**IMBIBITION:**

The mechanism of initial water uptake by seeds; the taking up of fluid by a colloidal system.

**IMMATURE EMBRYO:**

Condition in which a morphologically immature embryo delays germination.

**INDEHISCENT:**

Refers to dry fruits that normally do not split open at maturity.

**INDETERMINATE FLOWERING:**

Flowers opening progressively from the base of an inflorescence. Compare determinate flowering.

**INFLORESCENCE:**

Floral axis with its appendages; flower cluster.

**INHIBITION:**

A restraining or repression of a function of a seed.

**INTEGUMENT:**

The tissue covering and surrounding the ovule. When the ovule matures, the integument develops into the seedcoat.

**INTERNAL DORMANCY:**

Dormancy maintained by agents or conditions within the mature seed.

**INVOLUCRE:**

One or more whorls of bracts situated below and close to a flower or flower cluster; sometimes enclosing the carpels as in Tectona, Castanea and Fagus.

**KARABINER:**

See: Under Carabiner.

**KERNEL:**

The nucellus of an ovule or of a seed, that is the whole body within the seedcoats.

**KILOGRAM EFFECTIVE FACTOR (KEF):**

The ratio of seedling recovery from standard seed to actual seedling recovery from a given seedlot.

**LEGUME:**

Dry, dehiscent, one celled fruit developed from a simple superior ovary and usually splitting into two equal parts with the seeds attached to the lower edge of each part. The fruit of all genera of the family Leguminosae. syn. pod.

**LIPIDS:**

A group of organic compounds that are esters of fatty acids and are characterized by being insoluble in water but soluble in many organic solvents. Simple lipids include fats and oils and act as one form of storage materials in plants and animals.

**LOCULUS:**

The cavity of an ovary or an anther.

**LACERATE:**

To soften by steeping in a liquid, with or without heat; to wear away or separate the soft parts, by steeping.

**MAST YEAR:**

See: Seed Year.

**MEIOSIS:**

Specialized nuclear division prior to the formation of gametes. In a normal diploid organism meiosis reduces the number of chromosome sets from two ( $2n$ ) to one ( $n$ ).

**MESOCARP:**

Middle layer of the pericarp; the pulp of berries and drupes.

**METABOLISM:**

The chemical changes within a cell that provide the energy required by a plant or animal.

**MICROPYLE:**

Minute opening in the integument of an ovule through which the pollen grain or pollen tube passes to reach the embryo sac; usually closed in the mature seed to form a superficial scar.

**MIL:**

One thousandth of an inch, approximately 25 microns or 0.025 mm. Used in USA to define thickness of thin films such as polyethylene. 1 mil is the equivalent of "100 gauge" (UK).

**MITOSIS:**

Division of a nucleus into two identical daughter nuclei by a process that separates the twin chromatids of each of the paired chromosomes, so maintaining the diploid condition.

**MOISTURE CONTENT:**

The amount of water present in a material e.g. wood, soils or seeds. May be expressed in terms of weight of moisture as a % of the material's oven-dry weight ("dry-weight basis") or, preferably in the case of seeds and fruits, as a % of the material's wet weight including water ("wet-weight" or "fresh-weight basis").

**MONOECIOUS:**

Having staminate and pistillate flowers on the same plant. Compare dioecious.

**MULTILOCLULAR:**

Many-celled, as an ovary.

**MULTIPLE FRUIT:**

Coalesced ripened ovaries of several distinct flowers as in Morus. Compare aggregate fruit and simple fruit.

**NAKED STRATIFICATION:**

Pre-chilling of seeds without the use of a moisture-holding medium.

**NUCELLUS:**

Tissue in the central part of the ovule and inside the integument, within which the embryo sac is embedded.

**NUCLEUS:**

A body of specialized protoplasm found in nearly all cells and containing the chromosomes.

**NUT:**

Dry, indehiscent, one-seeded fruit with a woody or leathery pericarp developing from an inferior compound ovary.

**NUTLET:**

Small nut as in Alnus and Betula; nutlike fruit or seed.

**OBOVOID:**

Inversely egg shaped; ovoid with the broad end toward the apex.

- ORTET:**  
Original plant from which the members of a clone are descended. Compare ramet.
- ORTHODOX:**  
Term used to describe species of which the seeds can be dried down to a low moisture content of around 5% and successfully stores at low or sub-freezing temperatures for long periods.
- OVARY:**  
The part of the pistil that contains the ovule or ovules and ripens to form the fruit or pericarp.
- OVoid:**  
Egg shaped with the broad end toward the point of attachment.
- OVULE:**  
The body within the ovary of the flower that becomes the seed after fertilization and development.
- OVULIFEROUS:**  
Bearing ovules. Applied to the ovule-bearing scales in the cones of conifers (contrast bract scales).
- PANICLE:**  
A compound raceme as in Chionanthus, Fraxinus, and Aesculus.
- PARTHENOCARPY:**  
The development either of seedless fruits or of fruits in which the seeds lack embryos. Results from a failure of pollination, a failure in fertilization, or a failure in embryo development.
- PARTHENOGENESIS:**  
Reproduction from an unfertilized ovule; embryo may be either haploid or diploid. See: Apomixis.
- PEAK GERMINATION:**  
A loose term which describes the point in time when rate of germination is highest; it may be derived in many ways.
- PEDICEL:**  
Stalk of a single flower within a flower cluster.
- PEDUNCLE:**  
Stalk that bears a flower or a flower cluster.



**PERICARP:**

Wall of a ripened ovary that is homogeneous in some genera and in others is composed of three distinct layers: exocarp, mesocarp and endocarp.

**PERIODICITY:**

The tendency, in an individual, stand or species, to produce seed at more or less regular intervals of more than one year.

**PERISPERM:**

Nutritive tissue of a seed derived from the nucellus and deposited external to the embryo sac; diploid in contrast to endosperm which is triploid.

**PHENOLOGY:**

(Study of) relations between seasonal climatic changes and periodic biological phenomena such as flowering and fruiting, leaf flushing and dormancy.

**PHENOTYPE:**

All characteristics of a plant, morphological, anatomical, and physiological, as determined by the interaction between genotype and environment.

**PHYSIOLOGICAL MATURITY:**

A general term for the stage in the life cycle of a seed when development is complete and the biochemical components necessary for all physiological processes are active or ready to be activated.

**PISTIL:**

Ovule-bearing organ of an angiosperm, composed of ovary, style and stigma.

**PISTILLATE:**

Having pistils but no stamens; female. Compare staminate.

**PLACENTA:**

The organ which bears the ovules in an ovary, often the margin of the carpellary leaves.

**PLANTING ZONE:**

Area of reasonably uniform growing conditions in which plants of one or more seed sources are well adapted.

**PLANT PERCENT:**

The %, by number, of seeds which develop into plantable plants (seedlings or transplants) at the end of a given period, generally the end of the nursery period at the time of field planting.

**PLUMULE:**

Primary bud of a plant embryo situated at the apex of the hypocotyl; portion of the seedling axis above the cotyledons, consisting of leaves and an epicotyl, which elongates to form the primary stem.

**POD:**

A superior, one-celled, one- or many-seeded dehiscent fruit of two valves. Resembles the follicle in being dehiscent and formed from a single carpel but differs from it in dehiscing on both sides.

**POLYEMBRYONY:**

Production of two or more embryos from a single ovule and in a single seed.

**POLYGAMO-DIOECIOUS:**

Applied to species that are functionally dioecious, but having a few bisexual flowers on some of the male-flowering plants as well as on some of the female-flowering plants.

**POLYGAMO-MONOECIOUS:**

Pertains to species that are functionally monoecious but having a few bisexual flowers on some individual plants that also bear unisexual flowers of both sexes.

**POLYGAMOUS:**

Having both bisexual and unisexual flowers on the same plant or on different plants of the same species; pertains to species having mostly bisexual flowers.

**POME:**

Many seeded fruit of the apple family consisting of an enlarged fleshy receptacle surrounding the pericarp; pericarp papery and fleshy as in Malus and Pyrus or hard and stony as in Crataegus.

**PRECHILLING:**

Cold moist treatment applied to seeds prior to sowing in soil or germination in the laboratory, and designed to hasten after-ripening or to overcome dormancy.

**PRECURING:**

The deliberate storage and slow air drying under shade of fruits and contained seeds in order to render them more suitable for subsequent operations, e.g. kiln drying, extraction and storage.

**PRETREATMENT:**

Any kind of treatment applied to seeds to overcome dormancy and hasten germination. (See: Chilling, Prechilling, Stratification.)

**PROPAGULE:**

Any part of a plant that may be used to propagate it, either sexually or vegetatively.

**PROVENANCE:**

Fr. (provenience, L) in European usage, the place where seeds were collected; in North America, synonymous with seed source.

**PURE SEED:**

That component of a seed lot which consists of seeds of the designated species. According to ISTA rules, it includes not only mature, undamaged seeds but also undersized, shrivelled, immature and germinated seeds provided they can be positively identified as the designated species, and pieces of seed resulting from breakage which are more than half their original size. Excludes seeds of other species, wings of coniferous seeds, seeds of coniferous or leguminous species with seedcoats entirely removed, broken seed particles less than half the original size and other matter such as stones, twigs and leaves.

**PURITY:**

Proportion of clean, intact seed of the designated species in a seed lot, usually expressed as a percentage by weight.

**PYRENE:**

Stone of a small drupe as in Ilex, Prunus, and Rubus.

**PYRIFORM:**

Pear-shaped.

**QUIESCENT:**

Inactive, resting. Applicable to non-dormant seeds during the interval between maturation on the parent tree and the onset of germination.

**RACE:**

Subdivision of a species distinguished by heritable physiological or morphological characteristics resulting from adaptation to a specific environmental condition and which may be described by geographic location, climate, altitude, soil condition, or other specific environmental factors. syn. ecotype. Compare strain; variety.

**RACEME:**

Elongated inflorescence with flowers on stalks of equal length arising from a main axis as in Prunus, Amelanchier, and Crataegus.

**RACHIS:**

Axis of an inflorescence.

**RADICLE:**

Portion of the axis of an embryo from which the primary root develops.

**RAMET:**

Independent member of a clone.

**RAPHE:**

External ridge on a seed developed from an inverted ovule formed by the part of the funiculus adnate to the ovule.

**RECALCITRANT:**

Term used to describe species of which the seeds cannot survive drying below a relatively high moisture content and cannot be successfully stored for long periods.

**RECEPTACLE:**

End of a flower stalk on which the floral organs are borne.

**ROGUING:**

Systematic removal of undesirable trees i. a population; culling.

**SAMARA:**

Dry, indehiscent, winged fruit , one-seeded as in Fraxinus, Ulmus, or two-seeded as in Acer, Triplochiton.

**SARCOTESTA:**

Soft, fleshy outer layer of a testa.

**SCARIFICATION:**

Disruption of seed coats, usually by mechanical abrasion or by brief chemical treatment in a strong acid, to increase their permeability to water and gases, or to lower their mechanical resistance.

**SEED:**

A fertilized and mature ovule which contains an embryo and nutritive tissue and is enclosed in protective layers of tissue (seed coat).

**SEED CERTIFICATION:**

Guaranty of seed character and quality by a recognized agency, usually evidenced by a certificate including such information as certification category, genuineness of species and variety, year of collection, origin, purity, soundness, and germinative capacity. See also certified seed, selected seed, source-identified seed.

**SEEDCOAT:**

Protective outer layers on a seed derived from the integuments of the ovule; when two coats are present, the thick tough outer coat is the testa and the thin inner coat is the tegmen.

**SEEDCOAT DORMANCY:**

Dormancy imposed on seeds by their own seedcoats through their impermeability to water or gas exchange or mechanical restrictions on growth of the embryo.

**SEED COLLECTION ZONE:**

Area having defined boundaries and altitudinal limits within which soil and climate are sufficiently uniform to indicate high probability for maintaining a single race of seed producing plant; a zone having a distinctive proper name recognized by seed certification agencies and used to designate source collected therein.

**SEED LOT:**

A specified quantity of seed of reasonably uniform origin and quality.

**SEED ORCHARD:**

Plantation of ramets or seedlings from phenotypically superior progenitors on which tests of inheritance or either completed or pending. Area is cultured to minimize pollination by outside sources, to induce abundant seed production at an early age and to facilitate seed collection.

**SEED PRODUCTION AREA:**

Stand of better than average phenotypes upgraded further by periodic removal of the less desirable trees and cultured to induce abundant seed production. syn. plus seed stand.

**SEED SOURCE:**

Geographic location of the original progenitors of trees or shrubs from which a seed lot was collected; synonymous with seed collection zone where seed-producing plants are descended from local progenitors. Compare provenance.

**SEED QUALITY:**

A general term that may refer to the purity, germination capacity or vigour of a seed lot.

**SEED YEAR:**

In respect of any species, particularly trees of irregular or infrequent seed production, a year in which it produces, either as an individual, or a crop, an adequate amount of seed. Many periodic seeders produce heavy ("bumper") seed crops during their seed years.

**SEEDLING RECOVERY:**

The number of plantable plants obtained or expected at the end of the nursery period from one kilogram of seed.

**SELECTED SEED:**

Seed attested by a recognized certifying agency to be from progenitors previously selected as superior phenotypes for one or more characteristics, but on which tests of inheritance are either pending or lacking.

**SEROTINOUS:**

Coming late, particularly applied to plant species or individuals that flower or fruit late in the season and to fruit or cones that remain on the tree without opening for one or more years (e.g. Pinus contorta).

**SHRUB:**

Perennial woody plant branching close to the ground and with no major central stem. Compare tree.

**SIMPLE FRUIT:**

Fruit formed from a single ovary and sometimes including other flower parts; the most common type of fruit. Compare aggregate fruit and multiple fruit.

**SOUND SEED:**

Equivalent to viable seed q.v.

**SOURCE-IDENTIFIED SEED:**

Seed attested by a recognized certifying agency as being from the specified seed source. syn. standard seed.

**SPECIES:**

Category of taxonomic classification below genus rank including individuals with similar morphological characteristics and defined by breeding potential and gene flow. Interbreeding occurs between individuals within a species resulting in gene flow to the next generation. Such interbreeding does not normally occur between individuals of different species.

**SPIKE:**

Elongated inflorescence with sessile flowers on a main axis as in Amorpha and in pistillate flowers of Juqlans and Carya.

**SPERMODERM:**

See: Seed coat.

**SQUASH TEST:**

A simple, indirect test of viability, by which seeds are first allowed to imbibe water and are then squashed with a pair of forceps to reveal the condition of the embryo. The number of seeds appearing fresh and healthy per unit weight of seed plus chaff (in eucalypts) or per 100 (in large seeds) provides a rough estimate of viability.

**STAMEN:**

One of the pollen-bearing organs of a flower in angiosperms consisting of a filament and an anther.

**STAMINATE:**

Having stamens but no pistils; male (from Latin: threadlike).

**STANDARD SEED:**

For a given species, seed with "average" quality characteristics based on previous experience with that species. Used with particular reference to the seedling recovery figures to be expected from 1 kg of standard seed and its relationship to actual seedling recovery from a particular seed lot.

**STIGMA:**

The part of the pistil that receives the pollen.

**STONE:**

Part of a drupe consisting of a seed enclosed in a hard, bony endocarp as in Prunus, Cornus, and Chionanthus.

**STRAIN:**

Group of organisms descended from ancestors previously selected for one or more distinguishing, morphological or physiological characters which are, or which are expected to be, heritable.

**STRATIFICATION:**

Practice of burying seeds in moist medium, often in alternate layers to overcome dormancy; commonly applied to any technique which keeps seeds in a cold moist environment.

**STRIATE:**

Marked with parallel grooves, lines, or ridges.

**STROBILE:**

Spiky pistillate inflorescence or the resulting fruit as in Betula and Alnus; not a true strobilus. (Plural strobiles) syn. female catkin.

**STROBILUS:**

Male or female fruiting body of the gymnosperms. (Plural strobili).

**STYLE:**

The stalk of the pistil between stigma and ovary.

**SUBMITTED SAMPLE:**

The sample of seed submitted to a seed testing station.

**SUBSTRATE:**

Underlayer of soil, sand and other matter. The matter on which a fungus or germinating seedling grows.

**SUTURE:**

1. A junction or seam of union.
2. A line of opening or dehiscence.

**SYNCARP:**

A multiple or fleshy aggregate fruit, as in Morus or Magnolia.

**SYNCARPOUS:**

Composed of two or more united carpels.

**TEGMEN:**

Inner seedcoat, usually thin and delicate.

**TESTA:**

The outer coat of a seed; usually hard or rough, but may be soft in some species (see sarcotesta).

**TREE:**

Perennial woody plant having one well defined central stem with branches forming a crown and attaining a minimum height of 2.44 m. Compare shrub.

**TREE PERCENT:**

Number of trees in a nursery bed at time of lifting expressed as a percentage of the number of viable seeds sown.

**THRESH:**

To separate, by any mechanical means, e.g. rubbing, shaking, trampling, stamping, beating or intermittent pressure, the grains of any cereal from the husks and straw, especially by beating with a flail. Applied also to the separation of other than cereal seeds from their fruits.

**TOLERANCE:**

A permitted deviation (plus or minus) from a standard; in seed testing, the permitted difference between or among replicated measurements beyond which the measurements must be repeated.



**TRIPLOID:**

A cell or organism with three basic chromosome sets, symbolized by 3 n. Applicable to cells of the endosperm in seeds of Angiosperms, which have 3 x the number of chromosomes in the reproductive cells.

**TUMBLING:**

The operation by which cones or fruits are placed in a rotating drum, which rolls and tosses them around to induce the release of the contained seeds.

**UMBEL:**

Inflorescence with flower stalks arising from the apex of the main floral axis and reaching approximately equal lengths as in Rhamnus caroliniana; frequently compound as in the paniculate umbels of Aralia spinosa.

**UNISEXUAL:**

Flowers of one sex either staminate or pistillate. Compare bisexual.

**UNITEGMIC:**

Having only one integument as the ovules of the composite family.

**UTRICLE:**

A bladderly, one seeded, usually indehiscent fruit as in Grayia and Eurotia; consisting of an achene surrounded by bracts.

**VARIETY:**

Subdivision of a species, usually separated geographically from the typical, having one or more heritable, morphological characteristics which differ from the typical even when grown under the same environmental conditions; a morphological variant.

**VERNALIZATION:**

Treatment of seeds, bulbs, or seedlings with low temperatures (0 to 5° C) to hasten flowering of the subsequent plant.

**VIABILITY:**

The state of being capable of germination and subsequent growth and development of the seedling.

**VIABILITY PER CENT:**

At the end of a germination test, the total number of germinated seeds plus ungerminated but sound seeds (on cutting test), expressed as a percentage of the number of seeds sown.

**VIABLE SEED:**

A seed which can germinate under favourable conditions, provided that any dormancy that may be present is removed.

**VIGOUR:**

Those seed properties which determine the potential for rapid, uniform emergence and development of normal seedlings under a wide range of field conditions.

**VIVIPAROUS:**

Germinating while still attached to the parent plant.

**WORKING SAMPLE:**

A reduced seed sample taken from the submitted sample in the laboratory, on which some test of seed quality is made.

**ZYGOTE:**

The fertilized egg.

## G L O S S A R Y

The glossary has been compiled from the following sources:-

1. Seeds of Woody Plants in the United States. Agriculture Handbook No. 450. USDA Forest Service, Washington D.C. 1974.
2. A Guide to Forest Seed Handling. FAO Forestry Paper 20/2. Food and Agriculture Organization of the United Nations, Rome, 1985.
3. Glossary of Seed Germination Terms for Tree Seed Workers. By F.T.Bonner. General Technical Report SO-49. USDA Forest Service, Southern Forest Experiment Station, New Orleans, 1984.