PRODUCING PLANTING STOCK IN FOREST NURSERIES

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Contents

Summary

This chapter discusses issues pertaining to the production of planting material for forestry. Forest nurseries are discussed in reference to their role in integrated forest management. Types of nurseries are identified and their basic features described as well as biological, economic, and management issues of significance to each type of forest nursery. The roles of sexual and asexual reproduction in determining genetic characteristics of planting stock are outlined. Relevant issues of nursery culture are then discussed, for both bareroot and container nurseries, from the preparation for sowing through care and protection of growing plants, to the time the stock is ready to leave the nursery for planting. The significance of beneficial soil organisms to the growth of plants in the nursery, and their role as an alternative to the chemical control of pathogens is also brought up. The quality of planting stock is discussed briefly. The text is largely based on nursery production practices in developed countries of the temperate climate regions because nursery facilities, methods of stock production, and nursery management have reached a considerable sophistication in these countries and can be considered as state of the art. Not everything discussed in this chapter can be directly applied to the management of forest nurseries anywhere in the world. However, many issues can serve as the base from which one can start to look for solutions to locally important problems.

1. Introduction

It is impossible to accurately estimate the number of tree stock produced worldwide for planting forests. In part, this is due to problems with obtaining reliable records but also due to the variation in interpreting as to what constitutes a forest and what does not. The Global Forest Resource Assessment for the year 2000 (FAO, 2001) estimates that there are 187 million ha of plantations worldwide representing about 5% of the global forest area. About 62% of these plantations are in Asia with China and India having the largest proportion of world's plantations. Therefore, plantations are counted as a percentage of world's forests even though many lack the structural characteristics of a natural forest. Apart from plantations, trees are also planted in semi-natural forests, in agroforestry ventures, in public parks, and in urban areas throughout the world and year after year.

These activities require a great number of planting stock and it is produced in huge quantities annually, considering that a single modern nursery can turn out several million plants each year. Unfortunately, tree planting automatically brings to mind the practice of clear falling and replanting of natural forests. This view inadvertently condemns planting as an integral part of devastation of the natural environment and its replacement by an artificially created one. However, planted forests do not have to be monocultures established mainly for wood production. Planting trees can be an alternative or a supplement to the natural method of stand regeneration and a way of introducing or returning forests to areas where they are currently absent. Perhaps the controversy regarding planted forests pertains more to the management of these forests than to the method of their establishment or renewal. Many properly managed forests established by planting successfully fulfil multiple functions. They produce wood, create habitats for wildlife, serve in water and soil conservation, stabilize slopes, protect against winds, and support human enjoyment and recreation. It is important to distinguish between planted forests and tree plantations consisting of fast-growing species grown under intensive culture and short rotations. Many such plantations are monocultures having little in common with real forests and they should not be viewed as forests. It may be taken into account that such plantations help to meet demand for wood and ultimately contribute to the conservation of natural forests, provided they do not replace them.

This chapter reviews topics of relevance to the production of planting stock in forest nurseries. It is largely based on forest nursery practices in developed, temperate climate countries where nursery practices are usually highly sophisticated. However, what is state of the art in one place may not be feasible, practical, or even desirable in another. Readers interested in detailed and specific coverage of topics related to forest nurseries should explore the vast literature available on the subject.

2. The unique character of forestry planting stock

2.1 Nursery-cultured planting stock

The majority of planting stock used in forestry comes from nurseries that specialize in its production. Plants grown from seeds are known as seedlings, but this term has been used liberally, also in reference to plants derived from vegetative propagation**.** Planting stock for forestry is relatively small (especially when compared to the production of ornamental trees or trees for urban planting) and it is produced in large numbers. Small plants take relatively little time and space to grow in a nursery which keeps their unit price low. Small plants are also easier and cheaper to handle, store, transport, and plant than large plants. Essentially, planting stock for forestry is a rootstock from which a tree is expected to grow.

2.2 Wildings

Plants from natural regeneration can be transplanted into the land destined for forest planting. Such plants are called wildings. They are used where inadequate nursery facilities, problems with supply of viable seeds, or some other obstacles prevent raising planting stock of acceptable quality in nurseries. Transplanting wildings has many

limitations. The plants can be injured during excavation, handling, transport, and planting. Tropical and subtropical wildings are usually actively growing and have leaves (leafy wildings) at the time of transplanting. They do not take handling well and must be planted promptly to reduce the "in-transit" period. When plants growing under tree canopies are excavated and planted into open sites, the rapid change in growth conditions may kill the plants. Sometimes, wildings are first transplanted into a nursery for some time where they can be watered and shaded. This allows the plants to gradually adapt to more open growth conditions, and rebuild the root system. Wildings constitute a small percentage of the planting stock used for planting the world's forests.

3. The role of forest nurseries in forest management

Many factors influence the way forests are managed in different parts of the world and the way forest nurseries fit into local forestry operations. The scale and character of forestry operations and the demand for the supply of planting stock are interdependent. Owning a nursery (or nurseries) helps in matching demand with production of planting material and controlling its quality. It creates opportunities for employment and builds local expertise in operating forest nurseries. On the other hand, long-term flexibility is reduced by the weights of investments and commitments made during nursery development. Typically, large forest companies and governments managing forests tend to establish their own nurseries, while small-scale forestry operators tend to purchase the planting stock. Many independently owned nurseries have specialized in production of planting stock for sale only.

4. Does the nursery affect the planting stock?

The so-called nursery effects have been reported and attributed to the modification of the expression of genetic traits by the nursery environment. Different nurseries use different cultural approaches for the production of their crop plants. This affects the morphological and physiological characteristics of the plants produced. The location of the nursery may impact on the phenology of the plants. Local nurseries may supply plants better adapted to the local environment than far-away nurseries, although this may apply little to nurseries using greenhouse culture. Nurseries build their reputation on professional competence, reliability, honesty, and on the performance record of the planting stock they supply. To many clients, the reputation of a nursery is the decisive factor in choosing whom to deal with.

5. Types of nurseries

There are two main types of forest nurseries – barereoot and container nurseries. The planting stock produced by these nurseries is called bareroot and container stock, respectively. In bareroot nurseries, plants grow directly in the nursery soil and the roots are separated from the soil at the time of lifting. The lifted stock is further handled and planted without soil surrounding the roots. In container nurseries, plants are grown with roots in a growing medium held in a container. Roots of lifted plants are covered by the adhering growing medium. Some containers are degradable and do not have to be removed before planting.

5.1 Bareroot nurseries

Plants in bareroot nurseries (Figures 1-2) grow at ambient conditions, which makes these nurseries best for areas of warm climates and long growing seasons. With suitable soil, some species grow better in bareroot culture than in containers. Leafy hardwood species often need appreciable growing space and do well in bareroot culture. Bareroot nurseries require more land than container nurseries.

The land must be suitable for cultivation without costly amendments and its price must not be prohibitive. Ample supply of good quality water is a must. Bareroot nurseries are typically labor demanding. The need for trained labor creates employment opportunities and promotes the involvement of local communities in forestry operations. Although many foresters believe that container stock survives and grows better after planting than bareroot stock, this opinion is not always substantiated.

Many impressive forests that originated from bareroot stock can be found in various parts of the world. Bareroot stock, having exposed roots, is more prone to mishandling than container stock. It must be kept cold during transport and temporary storage and every effort must be made to avoid exposing and drying the roots.

Several water-retaining compounds for application to roots of bareroot stock have been developed to aid in avoiding root drying. Bareroot stock is not bulky; thus it is easy to pack and transport to planting sites and be carried by planters.

Figure 1. Young coniferous seedlings growing in a bareroot nursery in central Europe. The nursery is fenced around the entire perimeter. Irrigation lines visible between nursery beds are supplied with water from a lake located near the nursery.

Figure 2. Broadleaf and coniferous (further in the background) seedlings grow in bareroot beds. Note crop identification markers placed in nursery beds.

5.2 Container nurseries

Container nurseries may be open compounds or they may be greenhouse facilities (Figure 3), where the physical environment is highly controlled. Climatic requirements of the former type are comparable to those of bareroot nurseries because the plants remain at ambient outdoor conditions. Container nurseries with greenhouse culture are best for areas with colder climates and short growing seasons. With controlled environmental conditions, it is possible to accelerate the growth of plants and, if required, have more than one crop rotation each year. The danger of losing the crop due to adverse climatic conditions, especially to frost, can be eliminated. Container nurseries often use artificial growing media rather than the soil (although soil is sometimes used as a part of the mix forming a growing medium). Therefore, the quality of the local soil is of little or no importance to the nursery operations. The protection of the crop against pests, diseases, and weeds is easier in container nurseries, especially in those using sterilized artificial growing media, than in bareroot nurseries. Species with small seeds, those that germinate weakly and grow slowly do better in containers than in bareroot culture. Many coniferous species grow better in containers. Container nurseries are efficient in the use of growing space because of high growing densities and relatively small losses to culling. They use less water for crop irrigation and protection than bareroot nurseries do. Usually, lifting and sorting the plants are the times of peak demand for labor while only few employees are needed most of the time. Container seedlings are more tolerant of handling and suffer less transplant shock than bareroot seedlings. This is mainly the result of the root protection by the adhering growing medium (sometimes also by the container). On the other hand, container seedlings are bulky and take much space in storage and transport.

Figure 3. A modern container nursery in Canada has automated heating, venting, watering, and fertilizing systems as well as computerized control of environmental conditions. The roof and side covers of transparent plastic can be removed during hot weather.

5.3 A combination of container and bareroot nursery culture

This combination increases the flexibility of nursery operations and the ability to adjust to tentative changes in the demand for planting stock. When larger planting stock is needed, it is often started in small, densely spaced containers, then transplanted into bareroot beds at greater spacing. Such planting stock is called container transplants. The first step, usually carried out under greenhouse culture, improves the efficiency of seed use by reducing losses in germination and early growth of the plants, compared to sowing directly into bareroot beds. Planting stock from vegetative propagation started in containers can also be transplanted into bareroot beds. The transplanting provides spacing as needed while freeing up the more costly space of the greenhouse. Surplus container stock or stock that failed to develop to the required specifications within the expected time frame can be transplanted to a bareroot bed for further growth.

6. Establishing a new nursery

6.1 Economic and logistical considerations

There is a sizable literature offering advice on how to start a new nursery, what kind, and how to evaluate the probability of its success as a business venture. Much of this literature reflects the realities of its place of origin. The literature from countries with free-market economy emphasizes the importance of market analysis, evaluation of profit margins compared to alternative investment of the capital, and other considerations characteristic of this type of economy. Under different circumstances, for instance, where forestry is run by the state or when it is monopolized, factors such as competition

for business or recent trends in the world's stock markets may be of little, if any, importance.

It goes without saying that the investment in the development of a nursery should be economically justified in any situation. Various issues need to be considered when deciding the appropriate type of nursery. These are: the demand for particular types of planting stock, the cost of the land, the necessity of constructing support facilities, availability and cost of required equipment, and (for greenhouse culture) the availability of cheap energy. It must be evaluated how the nursery products will fit in to the existing planting practices, and if changes to these practices are likely in the near future. It is logical to produce planting stock that matches the tools or machines used for planting. Sometimes, certain kinds of planting stock are simply preferred over others. The suitability of the land for agricultural purposes is extremely important to bareroot nurseries, but is of no issue to container nurseries because the plants will not be grown in the nursery soil. The preparation of the land for a bareroot nursery may be costly. The land for a container nursery usually needs minimal preparation. The cost of the land is an issue for any nursery type but other expenses depend greatly on the size (or production capacity) and the degree of sophistication of nursery operations. In both bareroot and container nurseries, there is great variation in the degree of mechanization of operations, the cost, and the complexity of the supporting infrastructure.

6.2 Choosing a site for a nursery

A team of specialists including experienced growers should survey several potential nursery sites. Issues of importance when evaluating alternative sites for a nursery can be roughly divided into two groups – issues of biological importance and those of logistical significance.

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Bibliography

Appleton B.L. (1995). Nursery production methods for improving tree roots - an update. *J. Arboriculture* **21 (6)**, 265-270. [Methods for reducing root circling in container-grown nursery stock are presented]

Balsari P.; Airoldi G., Facciotto G. (1997). Mechanized harvesting in a poplar nursery. *Sherwood - Foreste-ed-Alberi-Oggi* **3 (7)**, 41-46 [This paper describes an efficient technique for harvesting poplar whips. In Italian with English summary].

Bergmann B.A.; Whetten, R. (1998). *In vitro* rooting and early greenhouse growth of micropropagated *Paulownia elongata* shoots. New-Forests **15(2)**, 127-138. [Improvements to tissue culture of this species and transferring the rooted shoots from culture conditions to the greenhouse are presented]

Carey W.A., and Kelley W.D. (1993). Seedling production trends and fusiform rust control practices at southern nurseries, 1981-1991. *South. J.Appl. For*. **17 (4)**, 207-211. [Some chemical options for fusiform rust (*Cronartium quercuum* f.sp. *fusiforme* [*C. fusiforme*]) control are summarized]

Dhiman R.C., Shailender Kumar, Devagiri G.M., Vinod A., Kumar S. and Arya V. (1996). Recent developments in containerized tree seedlings production. *Advances in Forestry Research in India*. **15**, 155-167. [This paper describes the modernization of seedling production in India including the choice of container types and growing media for forest nurseries]

Dogra P.D., Dhiman R.C and Sunil P. (1998). Reproductive biology of forest trees and its application in tree improvement. Tree-improvement: applied research and technology transfer. p.69-79. Science Publishers, Inc.; Enfield; USA. [This paper discusses the asexual and sexual methods employed in tree improvement programs in India]

Dunn G.M., Huth J.R. and Lewty M.J. (1997). Coating nursery containers with copper carbonate improves root morphology of five native Australian tree species used in agroforestry systems. *Agroforestry Systems*. **37 (2)**, 143-155 [One of many recent papers showing that chemical root pruning works well for many tree species]

Edwards D.G.W., and El-Kassaby Y.A. (1996). The biology and management of coniferous forest seeds: genetic perspectives. *Forestry-Chronicle* **72 (5)**, 481-484. [This is an overview of the influence of tree reproductive processes and management practices used in seed orchards and forest nurseries on the genetic composition of the seedling crop]

Giorcelli A., and Allegro G. (1998). Treatments for the proper protection of poplar forest nurseries. Sherwood Foreste ed Alberi Oggi **4 (9)**, 31-37 (This summarizes information on weeds, pests, and diseases of *Populus* spp. in Italian nurseries and on methods of their control. In Italian with English summary]

Harrington J.T. and Glass P.A. (1997). Determining the number of seeds to sow per cell: an application of the geometric distribution. Tree-Planters'-Notes **48(1-2),** 28-32. . [This paper provides a programming language for a spreadsheet program determining the sowing rates]

Hendromono S.O. (1994). *Eucalyptus deglupta* Blume seedling quality and growth in various medium types and moisture potentials. *Bul. Penelitian Hutan* **562**, 17-27 [This presents result of research on different growing media and moisture regimes in the culture of eucalyptus. In Indonesian with English summary).

Johansson G., Hulten H., Stenstrom E., Lindelow A., Lindstrom A., Hagberg J., Skogh B., Torneus C., Graberg M., and Hannerz M. (1996). Seedling production and seedling damage. Conference Proc., Uppsala, 30 January 1996. Redogorelse -SkogForsk. No. 3, 58 pp. SkogsForsk (Forestry Research Institute of Sweden); Uppsala; Sweden. [Nine papers cover issues pertinent to the management of forest nurseries and crop protection in the cold climate of northern Europe]

Keever G.J. (1995). Plant growth regulators: potential uses in the nursery industry. Southern Region. Comb. Proc. Nineteenth Annual Meeting, Athens, Georgia, USA, 6-9 Nov., 1994. *International Plant Propagators' Society* **44**, 474-477. [Results of research on the use of plant growth regulators to manipulate the growth and development of ornamental woody species but potentially useful in the production of forest tree seedlings]

Landis T.D., Tinus R.W., McDonald S.E., and Barnett J.P. (1990). The container tree nursery manual. Vol. 1-5. Agriculture Handbook (Washington) No. 674, USDA Forest Service; Washington; USA [This provides a broad and detailed coverage of various aspects of seedling production in containers and the management of container nurseries in temperate climates]

Linderman R, Dixon W., Fraedrich S., and Smith R.S. Jr. (1994). Alternatives to methyl bromide: assessment of research needs and priorities for forestry, nursery, and ornamental crops. *Tree-Planters'-Notes* **45 (2)**, 43-46. [A summary of a workshop on the alternatives to the use of methyl bromide as a soil fumigant]

Ludwig A: (1996). Treating plants with browse protectants in the nursery. *AFZ Der Wald, Allgemeine Forst Zeitschrift fur Waldwirtschaft und Umweltvorsorge.* **51 (26)**, 1453-1454 [This paper, in German only, shows the economic and technical advantages of spraying rather than individually treating nursery plants with chemical browse repellants.]

Maynard A.A. (1998). Utilization of MSW compost in nursery stock production. *Compost Science and Utilization*. **6 (4),** 38-44. [This is a study made in the eastern USA evaluating the municipal solid waste (MSW) compost as a soil amendment or weed-suppressing mulch in a bareroot nursery]

Mayr L. (1992). Biological pest control in tree nurseries. *Gartenbau-Magazin* **1 (6)**, 58-59 [A brief overiew of the topic in German with English summary]

Menzies M.I. (1995). Propagation of radiata pine plants for plantation forestry. New Zealand Region. Twenty-third Annual Meeting, Rotorua, New Zealand, 13-16 October 1994. International-Plant-Propagators'-Society: Combined-Proceedings **44**, 382-388. [This presentation reviews vegetative methods of propagation of *Pinus radiata* for fast-growing tree plantations]

Mexal J.G, Phillips R., and Landis T.D. (1996). "Jellyrolling" may reduce media use and transportation costs of polybag-grown seedlings. Tree-Planters'-Notes **47 (3)**, 105-109. [Positive and negative aspects of the use of a hydrophilic polymer for root protection are discussed in the context of their implications to polybag nurseries]

Miller J.H., and Jones N. (1995). Organic and compost-based growing media for tree seedling nurseries. World Bank Tech. Pap. No. 264, xiii + 75 pp. Washington; USA [A review on potting media characteristics and components, compost, and compost production. Useful to growers in tropical and temperate regions]

Mohammed G.H., Colombo S.J, and Noland T.L. (1997). New-Forests. (special issue). Making the grade: Proc. International Symposium on Planting Stock Performance and Quality Assessment, Sault Ste Marie, Ontario, Canada, September 11-15, 1994. [Many papers on stock quality, its assessment, and post-planting performance]

Mohit G., Neelu G., Srivastava R.L., Gera, M.and Gera N. (1997). Practical handbook on nursery and plantation technology. TFRI: 12, (iv) 37 pp. Tropical Forest Research Institute (Indian Council of Forestry Research & Education ICFRE); Jabalpur; India. [A practical overview of various aspects of nursery production in India – stock production from seed and vegetative propagation as well as planting techniques are covered]

Mohit Gera, Neelu G., Bhandari A.S., Gera M., and Gera N. (1996). Some new equipment for improved nursery practices. *Indian-Forester* **122 (8)**, 696-705. [Specifications are given for a variety of tools and equipment developed in India for use in bareroot and container nurseries producing planting stock from seeds and by vegetative propagation]

Molina M.P., Barros, R.D., Ipinza, C.R. (1992). Analysis of different containers for the production of *Eucalyptus globulus* plants. *Ciencia e Investigacion Forestal* **6 (2),** 169-193 [In Spanish with English summary].

Monteuuis O., Vallauri D., Poupard C., Hazard L., Yousof Y.; Wahap L.A.; Garcia C., Chauviere M., and Abd-Wahap L. (1995). Mass clonal propagation of mature teak trees (*Tectona grandis*) by rooted cuttings. *Bois-et-Forets-des-Tropiques* **243**, 25-39 [Results of research on various techniques for propagation of teak from rooted cuttings are presented and discussed in reference to clonal forestry of teak. In French with extended Engish summary].

Parvinder K., Bhupender D., and Diwan S. (1996). UHF-IUFRO International Conference on Nursery and Establishment Operations for Difficult Sites, 6-12 October 1996, Nauni, Solan, H.P. India. Proceedings: Volume 1, Abstracts. 73 pp. PB: Dr Y.S. Parmar University of Horticulture and Forestry; Nauni, Solan; India. [Abstracts of almost 80 papers are organized by theme. Topics include nursery establishment and

operations in intemperate climates and stock production for harsh sites. A good source of names and affiliations to contact regarding specific issues]

Penuelas .JL., Carrasco I., Herrero N., and Nicolas J.L., Ocana, L. Dominguez, S. (1995). Control of weed competition in a forestry nursery by chemical methods. Proc.of the 1995 Congress of the Spanish Weed Science Society, Huesca, Spain, 14-16 November 1995, p. 273-276. Sociedad Espanola de Malherbologia; Madrid; Spain (An evaluation of the effectiveness and side effects of several pre-emergence herbicides in provided in Spanish with English summary)

Rao GM; Rao AR, Acharyulu VSN, and Prasad N.S. (1998). Improvement of planting stock through culling in root trainer nursery. *Indian Forester* **124 (9)**, 739-742 [This paper describes the effects of culling criteria on stock quality released form a container nursery]

Rose R., Haase D.L., and Boyer, D. (1995). *Organic matter management in forest tree nurseries: theory and practice*. Oregon State University, Nursery Technology Cooperative; Corvallis; USA, 67 pp. [A general reference for the addition of organic amendments to forest nursery soils discussing their effects on soil properties, benefits, and side effects of their application.]

Rose R., and Haase D.L. (1996). Irrigation for frost protection in forest nurseries: room for improvement. *Western J.Appl.For*. **11 (1)**, 16-19. [This is a literature review and a summary of surveys from nurseries in the northwestern USA regarding the use of irrigation for protecting nursery crop against frost injury]

Sadiq R., Stock M., Wenny D, and Robberecht R . 1998. An expert system for forest nursery management. *AI-Applications* **12 (1-3)**, 41-50. [A description of an interactive, multimedia computer program with an educational and advisory role in management of container nurseries in the Inland Northwest of the USA]

Schaefer-Wildenberg B. (1994). Mycorrhiza inoculation at time of sowing. *Allgemeine Forst Zeitschrift* **49 (18)**, 984. [A method of inoculating seedlings of Douglas-fir and three hardwood species is briefly described in German].

Schwartz M. (1993). Germination math: calculating the number of seeds necessary per cavity for a given number of live seedlings. *Tree-Planters'-Notes*. **44**: (1), 19-20. [This shows how to use a calculator and a simple mathematical formula to get a maximum number of germinates from a fixed number of seeds.]

Shukla A.N. (1996). Management of diseases in the forest nurseries in India. Van Vigyan. (1995 publ. 1996) **33**, 3-4.

Smith A.E. (1995). Handbook of weed management systems. Books in Soils, Plants and the Environment Series. Marcel Dekker Inc., New York; USA. ix + 741 pp [This book presents a broad overview of the basic knowledge required for the development of weed management strategies for major crops, including those of forest nurseries, grown in the USA.]

South D.B. (1996). Top-pruning bareroot hardwoods: a review of the literature. *Tree-Planters'-Notes* **47 (1)**, 34-40. [This reviews the economic and performance-related aspects of top pruning of hardwoods].

Sutherland J.R., Glover S.G. (eds.) (1991). Proc. The First Meeting of IUFRO Working Party S2.07-09 (Diseases and Insects in Forest Nurseries): Victoria, British Columbia, Canada, August 22-30, 1990. Information Report Pacific Forestry Centre, Canadian Forest Service, No. BC-X-331, vii + 298 pp.

Tinus R.W. (1995). A new greenhouse photoperiod lighting system for prevention of seedling dormancy. *Tree-Planters'-Notes* **46 (1)**, 11-14. [This shows how an oscillating light source coupled with an oscillating parabolic mirror can prevent the onset of bud dormancy]

Varma R.V. (1996). Some destructive nursery diseases and their management. Impact of diseases and insect pests in tropical forests. Proc. IUFRO Symposium, Peechi, India, 23-26 November 1993. :Mehrotra M.D., Nair, K.S.S, Sharma, J.K. (eds.); 143-152. [Results of disease surveys, damage evaluation, and

methods of controlling economically important diseases in the northern areas of India are presented. Also, see other topical papers in the Symposium Proceedings]

Wilhoit J.H., Kutz L.J. and Vandiver W.A. (1997). Machine vision system for quality control assessment of bareroot pine seedlings. *South. J. Appl. For*. **21 (2)**, 90-96. [Results of testing a camera/computer software – based system for measuring seedlings is described]

Yapa A.C. (ed.) (1996). Proceedings: International Symposium on Recent Advances in Tropical Tree Seed Technology and Planting Stock Production, 12-14 June, 1995, Haad Yai, Thailand. v + 232 pp. ASEAN Forest Tree Seed Centre Project; Saraburi; Thailand PY [Thirty research papers and 10 posters from the conference focused on reforestation of degraded and denuded lands in South East Asia. A range of topics is covered from seed quality, collecting, and processing through various aspects of nursery production planting stock from seeds and vegetative propagation]

Zhao J.P., Gu-Zheng Ping, Z.J.P., and Gu Z.P. (1998). A study on mechanism of dielectric separation of tree seeds. *J.Beijing For. Univ*. **20 (4)**, 80-86. (Chinese with English summary)

Biographical Sketch

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