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Seed Technology:
A Challenge for Tropical Forestry

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About one million hectares (2.47 million acres) in the Tropics are planted in tree seedlings each year, but only a small portion of these seedlings are indigenous species. A common barrier to the use of indigenous species is the unavailability of high-quality seeds arising from the lack of seed technology information. Seed problems of tropical forest trees that need more study include phenology of flowering and fruiting, collection, cleaning, storage, and pretreatment for germination. A number of capable research centers around the world are working to find the answers. Tree Planters' Notes 43(4):142-145; 1992.

Deforestation of tropical regions is a well-documented problem that has raised international concerns from many quarters. Almost daily we are bombarded by print and visual media presentations on the many benefits of tropical forests and how we must arrest and reverse their destruction. While environmental problems (global warming, flooding, biological diversity, etc.) are often foremost in the public eye, there is also widespread concern for the 1.5 to 2 billion people who depend on trees for livestock fodder, fruits, local construction, and cooking and heating fuel. A simple, yet effective, solution for these problems is to plant more trees. To plant more trees, reliable sources of high-quality seeds are needed. Some might say that we have an abundance of tree seeds, but are these seeds from the proper species for the Tropics?

Tropical forestry plantations have been estimated to total about 6.9 million ha in 1975, 11.5 million in 1980, and 17.0 million in 1985 (Willan 1985). If this rate of planting (slightly more than 1 million ha, or 2.47 million acres, per year) has been maintained, then there should be about 25 million ha of plantations in 1992. On the basis of surveys made in the 1980's (Greathouse 1982, Keipi 1987, Turnbull and Doran 1992), one must conclude that approximately 90% of this total is in industrial plantations of fast-growing species *(Eucalyptus, Pinus, Gmelina,* etc.). Very little planting has been done with indigenous species.

In the latter half of the last decade, however, interest shifted somewhat from large industrial plantations, especially exotics, to smaller plantings of indigenous multipurpose species. This change in interest has been accelerated by the awareness of germplasm conservation needs, as many multipurpose trees are on lists of endangered species-41 fuelwood species in Africa alone (Palmberg 1981). Many donor agencies now favor social forestry/ agroforestry projects over industrial plantations. These conditions have created a larger demand for seeds of indigenous species, a demand that is difficult to meet because of the lack of basic seed information on these species. For example, the International Council for Research in Agroforestry (ICRAF) published a directory of multipurpose trees that totaled 1400 species (Von Carlowitz 1980). Only 196 of these species are listed in the current Rules for Testing Seeds (International Seed Testing Association 1985), and that number includes 169 species that are listed generically under *Acacia* and *Eucalyptus.* There are many gaps in our understanding of tropical seeds, and seed testing is only one of them.

Deforestation will continue in the Tropics, for economics is a strong driving force. Environmental and social impacts can be ameliorated, of course, by replanting these areas. Exotics may dominate planting programs for a while yet, but the best indigenous species should emerge to be important components of sustainable forestry systems. One step in this direction should be the development of strong national seed programs. The objectives of such programs should include choosing the best species, determining the best seed sources, and developing appropriate seed and nursery technology.

A good example of this approach is currently underway in Costa Rica under the auspices of the Organization of Tropical Studies. Originally funded by a grant from the MacArthur Foundation, this study is evaluating indigenous species for their ability to survive and grow in abandoned pastures that are being replanted to trees. In the early stages, several native species are outperforming the more common exotics. This program could pay big dividends to forestry in Costa Rica and serve as a model for other tropical countries. Numerous problems in seed technology exist, however, and must be solved before optimum utilization of these species can proceed.

Major Seed Problems

One major seed problem in the Tropics is the lack of definitive information on the phenology of flowering and maturation of fruits and seeds. In moist tropical forests in particular, extensive phenological observations of many species have been recorded in recent years, yet predictive models for flowering are lacking (Bawa et al. 1990). Flowering and fruiting of some species seem related to wet season-dry season cycles (Whitmore 1983, Wright and Cornejo 1990), and these patterns are not difficult to predict. Even where good data exist, all is not easy. Unlike most temperate zone species, many tropical trees flower over a period of many months, so that multiple stages of seed maturity may be present at any one time on the same tree. This condition complicates seed collection, for there is no single definable period of seed maturation within a species or even among trees of the same species.

Other collection problems are presented by the spatial distribution or size of trees in natural stands. Low distribution frequencies of species in tropical forests are common (Gentry 1988). If only a few fruits are available from individual trees, then collection costs soar quickly. Plantations and/ or seed orchards would solve this dilemma, but they are almost nonexistent for these species. In moist tropical forests, fruit-bearing limbs of desirable trees may be as much as 35 meters above the forest floor. Unless seeds can be collected from the ground after natural seedfall, climbing is the only practical option.

Predators present another major problem in the Tropics. Birds, monkeys, and bats eat fruits and seeds before natural seedfall (Howe 1990). Animals are natural seed dispersal mechanisms in tropical ecosystems, but they complicate things for human seed collectors. And when seeds are dispersed on the ground, numerous birds, rodents, and insects are there to eat them. Timely collections are needed to avoid these losses, but incomplete knowledge about fruiting phenology and wide spatial distribution of trees combine to make this difficult.

Extraction and cleaning are areas of seed technology that have not been emphasized for tropical species. As long as collections are limited and seed lots are small, hand labor is sufficient for most jobs. If collections grow in size for reforestation efforts (as surely they will), then mechanized extraction and cleaning will be needed. Is the seed extraction and cleaning equipment that is currently used for temperate species suitable for tropical tree seeds? Until the equipment has been tested, no one can say for sure. This subject has good potential for applied research; modest efforts could produce significant gains.

In contrast to the common image of rapid germination in tropical forests, there are many species that exhibit seed dormancy. While many species germinate promptly when dispersed, others exhibit long delays in germination. Seed dormancy is most common among leguminous species and species of dry tropical forests. Numerous species (including non-legumes) have seed coats hard enough to survive in the litter in moist forests for at least 3 years (Whitmore 1983). Seed coat dormancy, the most common cause, is easily overcome with scarification, but other, more complex dormancies may be encountered. On the forest floor, for example, spectral quality of light is often the key to timely germination (Vázquez-Yanes and Orozco-Segovia 1990).

The most challenging problem for seed science in the Tropics is storage of **recalcitrant seeds.** Seeds are described as recalcitrant if they are killed by desiccation below moisture contents of 20 to 30% (Chin and Roberts 1980). If seeds can be dried to 10% moisture, they can be stored at subfreezing temperatures. Such seeds are described as orthodox, and their number includes most important temperate zone timber species. The recalcitrant group can be divided further into temperate recalcitrants, seeds that tolerate temperatures down to freezing, and tropical recalcitrants, seeds that are killed by temperatures below 15 to 20 °C. (Bonner 1990).

The intolerance of tropical recalcitrant seeds to both low moisture content and low temperature prevents the use of these conditions for storage. Temperate recalcitrant seeds fare better in storage because low temperatures can be used, but both groups have short storage lives (table 1). Solution of the storage problem for one of the recalcitrant

Table 1—*Storage test results for some recalcitrant tree seeds*

Species	Test conditions: Temp. (°C)	Test conditions: Seed moisture (%)	Test results: Time (month)	Test results: Viability loss (%)
Temperate recalcitrant				
Acer saccharinum	−3	50	18	8
Quercus falcata var. *pagodaefolia*	3	35	30	6
Q. robur	−1	40–45	29	31–61
Q. rubra	−1 to −3	38–45	17	18–46
Q. virginiana	2	—	12	35
Tropical recalcitrant				
Araucaria hunsteinii	2	30	12	82
A. hunsteinii	19	25–30	2	±30
Azadirachta indica	26	10–18	2	65
Hopea helferi	15	47	1	2
Shorea robusta	13.5	40–50	1	60
S. roxburghii	16	40	9	±30

Source: Adapted from Bonner (1990).

seed groups should benefit the other group as well.

Current Efforts

There are plenty of challenges in seed technology of tropical species, and much can be done without massive expenditures for laboratories and equipment. Most of the research suggested in this article must be done on-site in the Tropics, not in the comfort of well-equipped temperate-zone laboratories. There are many competent seed researchers and institutions in tropical regions around the world (table 2). This is not a complete list, by any means, and new programs seem to be continually coming on line. While seed research is not the primary focus of some of these institutions, they all have the capability to solve their respective problems.

Some of these research centers, such as the ASEAN Tree Seed Center of Thailand; CONIF of Columbia, and the University of Campeche of Mexico, publish their own series of seed research bulletins. Silvical characteristics of tropical species, including seed data, are highlighted in leaflets published by the USDA Forest Service's International Institute of Tropical Forestry in Puerto Rico, CATIE in Costa Rica, and the North American Forestry Commission's Tropical Silviculture Study Group.

Research papers on tropical tree seeds appear now in scientific journals at an ever increasing rate, which is evidence of two trends. One is that many more researchers from the temperate zone are working on tropical seed problems these days, and the second is that the capabilities of research staffs and institutions in tropical countries are increasing. In the long run, it will be the scientists from the tropical countries who contribute the most to meeting the challenges of tree seed technology in tropical forestry.

Table 2—*Some forestry research centers with expertise in tropical tree seed technology and/or physiology*

Region	Institution and location
Africa	Kenya Forest Research Institute (Nairobi, Kenya)
	Centre National de Semences Forestieres (Ouagadougou, Burkina Faso)
Asia	ASEAN-Canada Forest Tree Seed Center (Mauk-lek, Saraburi, Thailand)
	Kerala Agricultural University (Trichur, India)
	Australian Tree Seed Centre, CSIRO Division of Forestry & Forest Products (Canberra, ACT, Australia)
Latin America	Instituto Nacional de Pesquisas da Amazonia (Manaus, Brazil)
	Corporacion Nacional de Investigacion y Fomento Forestal (CONIF) (Bogota, Colombia)
	Centro de Investigaciones en Bosque Tropicales, Universidad Autonoma de Campeche (Campeche, Mexico)
	Centro de Ecologia, Universidad Nacional Autonoma de Mexico (Los Tuxtlas, Mexico)
Europe	Royal Botanic Gardens (Kew, Sussex, UK)
United States	Forestry Sciences Laboratory, USDA Forest Service, & Mississippi State University (Starkville, Mississippi)

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