



Demonstrationsanlæg vedrørende reduceret sprøjtning mod ukrudt samt kombinationer af herbicidanvendelse og andres renholdelsessystemer

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INTRODUCTION

by

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1.1 Trends and Development in Tropical and Subtropical Forestry and Their Influence on Seed Demand

The forest cover in most tropical countries is declining at an alarming speed. In a recent account of the world's forests, FAO (1997) shows that with the exception of India, where there has been a small improvement, all tropical countries have lost forest cover during the period 1990-95. The deforestation rate is highest in Central America and SE Asia where it ranges between 1.2 and 1.7 % annually. In West Africa the deforestation rate is on average about 1 % annually, while in most other parts of Africa plus in South America it is between 0.5 and 0.8 % annually. In some countries like the Philippines and some Central American countries it is as high as 3-3.5 %. In many countries the deforestation rate has declined during the last decades only because there is little left to destroy.

Most countries are aware of the danger of loss of forests, and large afforestation programmes have been launched all over the tropics both by forest departments, private companies and donor-supported projects. However, as the figures indicate, plantation activities have rarely been able to keep pace with deforestation, not to mention replacement of what has been lost during the past.

Deforestation influences countries and their people in many ways. Shortage of wood products influences the daily life of millions of people in rural and urban communities; shortage of construction timber influences house building; shortage of fuelwood influences cooking habits and the time women (mainly) spend with their children or in agriculture production etc. Environmental degradation is often closely linked to deforestation. Soil degradation, siltation of waterways, occasional floodings etc. are all immediate or long-term effects of deforestation that affect millions of people in the tropics today.

Substitutes for wood energy, like oil, coal and gas, which basically solved the deforestation problem in the temperate region during the last century, are beyond reach for most rural communities in the tropics. So are alternatives to construction and household implements (concrete, plastic etc.) at least in the rural areas. Hence, there is only one answer to the deforestation problem: new trees and forests must be raised. To reverse deforestation and reclaim land degraded by deforestation is an enormous challenge and will require large numbers of plants, which in turn implies an increased seed demand.

Afforestation is no longer a matter for forest departments alone. The character of forest planting has changed over the years in accordance with the broader spectrum of demand. Whereas most plantation activities during the first half of this century and up to about 1980 were concentrated on large-scale industrial plantations, focussed on a handful of plantation species like pines, eucalypts and to a lesser extent teak and mahoganies, they have now changed to a much broader front. Community forestry or social forestry with components of agroforestry, shelterbelt plantation, village woodlots etc. now makes up a major share of the total planting activities: tree planting has become a natural component of tropical land management. Further, land rehabilitation and watershed management by forest planting are often important parts of countries' forest policy.



Figure 1.1. Fuelwood collection in Malawi. Fuelwood is the principal source of energy in rural areas in most of the tropics, and fuelwood supply makes up a major challenge of plantation forestry today.



Figure 1.2. *Leucaena leucocephala*, an example of a multipurpose tree, widely used in e.g. agroforestry programmes. From an ICRAF experiment, Kenya.

Forest plantations may not be able to create the diversity of plants and wildlife that has been lost. Yet, large-scale plantations are still necessary both directly in order to provide the essential industrial wood, and indirectly to relieve the pressure on the remaining natural forests. Even in industrial plantations there has been a shift in forest policy in many countries. During the last decades many governments have put much more emphasis on the use of local species, where exotic species formerly dominated in plantations. This trend, together with the above-mentioned wider planting activities, has increased the demand for a much wider diversity of species, including primarily local and little known species.

Plantation area, species selection and plantation types are all factors that influence seed demand and hence seed supply. Simultaneously with seed supply, appropriate technology for many new species must be developed.

1.2 Important Tree Families and Genera

Despite the trend towards greater species diversity in planting programmes, the majority of cultivated forests are based on a handful of important genera and families. Among the gymnosperms, pines make up the vast majority with *Pinus caribaea*, *P. patula* and *P. oocarpa* as by far the most widely used species in plantations. Araucarias and *Podocarpus* spp. are important plantation species locally but the plantation area is small compared to pines.

Tropical hardwoods (angiosperms) are dominated, both in area and number of species planted, by the mostly Australian family Myrtaceae, of which *Eucalyptus* and in particular *E. camaldulensis* have gained ground worldwide. Meliaceae count a number of very popular forest species with the mahoganies as the most popular, but both neem and cedrelas are also widely planted.

Leguminosae have by far the largest species diversity among cultivated forest trees, which accords with the number of species in the family and their distribution throughout the tropical area. Legume trees are especially popular in agroforestry and for rehabilitation of degraded land because most of them have nitrogen-fixing ability. Also, several Casuarinaceae have become popular for environmental planting especially as shelterbelts in coastal areas, but also to some extent in plantations.

Verbenaceae make up a relatively small family in terms of species number, but contain some very important species of which teak (*Tectona grandis*) has a long history as a plantation species; *Gmelina* and several *Vitex* species are also widely planted albeit these mostly within their natural area of distribution. Dipterocarpaceae, which make up the major component of the South East Asian tropical rainforests, is an example of a family where seed problems (recalcitrant seeds) are a major constraint in cultivation.

Many of the new species in planting programmes belong to these families although other families also contain many species of actual and potential interest.

Figure 1.3
Leucaena leucocephala, an example of a multipurpose tree, widely used in e.g. agroforestry programmes. From an ICRAF experiment, Kenya.



1.3 Regeneration and Propagation by Seed

Plants regenerate and multiply in two ways: 1. asexually (= vegetatively) and 2. sexually by the formation of seeds. Vegetative regeneration, for example via root suckers, is important for short-range regeneration of some species (e.g. *Populus* spp. and *Casuarina* spp.), and some species like *Populus* and *Salix* have traditionally been propagated vegetatively by rooting of cuttings. During the last decades vegetative propagation techniques have gained ground for mass propagation of improved genetic material, e.g. clonal plantations of hybrid pines in Australia (Walker and Haines 1996). Vegetative propagation has also become increasingly popular for the propagation of trees with difficult seeds such as some of the dipterocarps (Kantarli 1993). Yet, seed propagation remains the principal mode of propagation in silviculture in the temperate as well as in the tropical region. Seeds are unique in natural regeneration and propagation because:

1. Seeds constitute unique genetic compositions, resulting from mixing parental genetic material (by crossing over between chromosomes during meiosis in ovules and pollen and the random combination of gametes during fertilization). The result is genetic variation of the offspring, which in turn enhances ecological adaptability.
2. Seeds are usually produced in large numbers and are readily available each year or at longer intervals.
3. Seeds are (usually) small concentrated packages of plants-to-be, containing nutrients for the establishment of the plant and, excepting recalcitrant seeds, usually much more resistant to damage and environmental stress than vegetative propagules.
4. Many seeds can be stored for long periods under cold dry conditions.

The science of seed biology encompasses development and physiology of seeds until they finally germinate or fail to do so. Knowledge of seed biology is crucial for proper management of seed sources as well as the handling of seeds themselves.

Considering that in a regenerational context only one successful seed (or two if the species is dioecious) is necessary to replace the parent tree(s), the production of seeds during the lifetime of a tree is exorbitant. A full grown *Eucalyptus camaldulensis* tree may produce a million or more seeds per year and may live and produce seeds for a century. Each year's production could afforest several hundred hectares. Although seed production is smaller in most other species, it is probably never a limiting factor in natural regeneration. Each seed contains the potential for becoming a full grown tree, but in nature most of the seed production will succumb, - from failed dispersal, predation, infestation, natural deterioration, germination failure etc.

In forest seed handling we want as much as possible of the collected seed to survive and germinate. The objective of seed handling is to achieve a high survival rate of the seed. Seed handling encompasses a series of procedures beginning with selection of the best quality of seed source, through collection, processing, storage, pretreatment

to germination. Each link of this chain implies a potential risk of losing seed, and any link in the process is of equal importance (though not necessarily equally sensitive). If a seed dies due to careless handling during collection or processing, even the best storage, pretreatment or germination conditions will not bring it back to life. If a seed dies during a handling procedure, the whole preceding effort is wasted. However, some handling procedures become unacceptably expensive if a certain loss is not tolerated during the process. In some cases it is more economical to collect excess seed, some of which is lost, rather than trying to save everything. This balance must be weighed in each situation.

The whole process of seed handling begins with collection of good quality seeds, both physiologically and genetically. Although this book will mainly deal with the physiological aspects, genetic aspects should not be ignored. The genetic quality of seed will affect a plantation for years ahead, and since the operational cost of seed handling is almost the same regardless of genetic history, expensive handling will pay better when applied to a good quality seed lot. Referring to the genetic quality of seeds, the Australian Tree Seed Centre has adopted the slogan: 'Good seed does not cost - it pays' (Midgley 1996), meaning that the small investment in obtaining the best seed source is minor compared to the potentially better growth of the progeny.

1.4 Seed Problems - Limiting Factors in Tree Propagation and Afforestation

Problems of seed procurement and technology often limit the use of particular species. Nurseries may tend to raise species whose seeds are readily available and which are easy to raise from seeds, since the additional work imposed by more problematic species does not pay. It may be difficult to increase seedling prices sufficiently to cover additional nursery costs; seedlings often tend to be sold at a fairly uniform price no matter how much effort was involved in raising them (Pedersen 1994). No doubt one reason for eucalypts being so popular is their easy seed collection and low nursery costs.

For several species, shortage of seed, difficulties in collection, short viability and/or problems of extraction, dormancy or other handling difficulties limit their use in plantation programmes. For example, collection of seeds from mature trees of *Alnus nepalensis*, *Catha edulis* and *Grevillea robusta* is very difficult because the seeds are borne on thin and inaccessible branches at great height and are easily lost during collection. In *Agathis* spp. seed production is often low and collection is difficult because the single-seeded fruits are scattered all over the crown, which makes collection very labour intensive.

Unfortunately, the genetically desirable growth habit of tall, straight, branchless trees is often inversely correlated with ease of collection. It is then tempting to collect from specimens with relatively low and more easily accessible branches, e.g. the so-called wolf-trees which often also have a higher seed production, but may be of poorer genetic quality. *Araucaria cunninghamii* is an Australian species with excellent wood properties but with unreliable and often low seed production; a time lapse of 8-10 years between good seed crops is common. Although the seeds store well at low temperature, storage between two seed crops is expensive since the seeds are fairly large and temperature must be kept under 5°C to maintain their viability.

1.5 Advances in Research and Technology in Handling of Tropical Forest Seed

Many tropical humid-zone species like khayas and dipterocarps have the dual problem of seed availability: short seed viability combined with long intervals between seed crops. In others, limitations in seed viability (whether caused by inert seed physiology or limitations in storage technology) make immediate sowing necessary, sometimes at times not optimal for seedling survival during the nursery stage. An example is neem (*Azadirachta indica*), which sometimes must be kept as small seedlings in the nursery through the dry season. Extraction and dormancy problems make seed handling of some species very difficult, and thereby limit their use. Examples are *Pterocarpus* species and some species from fire-prone areas.

Seed viability often restricts the distance seeds can be used away from their parent source. On the international scale species with short viability are prone to deterioration during transport and transit even with an efficient transport system. Such problems not only affect introduction of a species into a new area but also exchange of germplasm between countries.

As these examples illustrate, solution of technical problems in seed handling may for many species be a key to wider use.

Much progress **has** been made in tropical forest seed handling. Problems of seed coat dormancy have largely been overcome although pretreatments need adjustment for many species. Storage problems for recalcitrant seeds have not been (and may never be) overcome, but recent research has shown that recalcitrance is a more complex character than previously envisaged: some problems previously considered related to recalcitrance may be difficult orthodoxy, some relating to maturity problems. For some species, appropriate measures e.g. correct collection time and good storage conditions can prolong storage life. Seed physiology and other characteristics are well known and documented for many species, including many from the tropics and subtropics. These include many types of dormancy and their related pretreatments.

Research in tropical forest tree seed is currently being undertaken by a number of research institutions, forest seed centres and projects worldwide. Research results are often published in one of the three major international seed research publications viz. Seed Science and Technology (ISTA), Seed Science Research (CAB-international) and Journal of Seed Technology (AOSA), the latter though with relatively little published from the tropical region. Local research on tropical species is often published in general forestry magazines like *The Indian Forester* and *The Malaysian Forester*. Only a few publications have seed research and technology as their major or only topic. However, in Central America the publication '*Arboles y Semillas del Neotropico (Museo Nacional de Costa Rica)*' deals especially with seed and reproductive ecology of local tree species. In SE Asia local research results on indigenous species carried out by ASEAN Forest Tree Seed Centre have been published in the centre's own publication 'The Embryon'. In addition many forest seed centres publish technical papers on specific topics.

Several symposia and workshops have been held on tropical forest seed, e.g. IUFRO/ACIAR in Australia in 1989 (ACIAR 1990), two

IUFRO symposia in 1992 and 1995 in Burkina Faso and Tanzania respectively (IUFRO 1993, IUFRO 1996), an IPGRI/Danida Forest Seed Centre international workshop on intermediate/recalcitrant tropical forest tree seeds (IPGRI 1996), and a symposium in Nicaragua in 1995 (CATIE 1995). Proceedings from these workshops and symposia contain research results on various aspects of the handling of tropical forest tree seed.

A few general seed-handling handbooks have been published since 'A Guide to Forest Seed Handling' in 1985. Bonner et al. (1994) published general guidelines on seed handling in connection with their training courses. Most other books were written for particular geographical regions: two Indian books (Prasad and Kandya 1992; Khullar et al. 1991) deal with the topic under Indian conditions. From Australia, Langkamp (1987) contains chapters on seed collection and handling, and Kenya Forestry Research Institute has published general seed handling guidelines (Albrecht 1993).

Specific topics of seed handling have been dealt with in various publications e.g. the ISTA 'tropical and subtropical tree and shrub seed handbook' (Poulsen et al. 1998) which deals specifically with seed testing. This topic has also been dealt with in several publications from the ASEAN Forest Tree Seed Centre (references given in chapter 11 on seed testing). A number of Lecture Notes and Technical Notes published by Danida Forest Seed Centre cover various aspects of seed handling. These and other major publications are mentioned under the particular topics of the individual chapters in this book. The above sources plus several others have been used extensively during the compilation of this book.

Despite new findings and the more extensive documentation on tropical species, the practical seed handler still faces real problems of adjusting methods and procedures to particular species and conditions. This implies a thorough knowledge of the species in question and options for overcoming particular problems. Seed handling cannot be carried out according to a simple 'cookbook'. It is therefore important to know not only optional methods but also why these methods may work or not work.

The outline of this book basically follows that of the predecessor 'A Guide to Forest Seed Handling' by R.L. Willan (1985). After an introduction to seed biology in chapter 2, the following chapters follow the chronological order of seed handling, starting with planning of seed collection, then collection, processing, storage etc. until germination. The chapter on seed testing has been reduced mainly because several detailed guidelines already exist. Since seed testing laboratories normally carry out seed testing, the practical seed handler usually needs an explanation of what is measured during seed testing rather than how to carry out the tests. Although the book mainly deals with the physiological quality of seed, a chapter has been included on the possible influence of seed handling on the genetic quality of seed. In relation to nursery operation, a chapter on microsymbiont management is included. This is in view of the fact that microsymbionts are often collected and handled by those who collect and supply seeds. With increasing acknowledgement of the importance of these symbionts, a description of their nature and their handling was considered relevant.

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