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STORAGE CONDITIONS AND PRE-GERMINATION METHODS FOR SEED OF SELECTED TROPICAL TREE SPECIES

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SECID/AUBURN AGROFORESTRY REPORT NO. 20

STORAGE CONDITIONS AND PRE-GERMINATION METHODS FOR SEED OF SELECTED TROPICAL TREE SPECIES.

EXECUTIVE SUMMARY

This document summarizes tree seed storage conditions and pre-germination methods of major species utilized in Agroforestry II, a USAID funded agroforestry project in Haiti.

The study is not meant to be an exhaustive review of the subject, and is designed to provide the practitioner with the necessary information to store and germinate tree seed optimally.

It is likely that the species list be expanded in the future. However, the information contained in this document is generally appropriate for most species, and serves as a base for experimentation of other tropical and sub-tropical species.

The data is summarized from responses to a request for information from 10 institutions and 9 countries. Many of the experts from these institutions have extensive experience and research in the area of seed technology that is contained in this document. Literature references are provided to guide the reader to more detailed and comprehensive coverage of the topics.

LIST OF ACRONYMS

ASEAN	Association of Southeast Asian Nations
ATSC	Australian Tree Seed Centre
CFDD	Community Forestry Development Division
ESNACIFOR	Escuela Nacional de Ciencias Forestales
FAO	Food and Agriculture Organization (United Nations)
IBPGR	International Board for Plant Genetic Resources
ISAR	Institut des Sciences Agronomiques du Rwanda
ISTA	International Seed Testing Association
KFRI	Kenya Forestry Seed Centre
ODH	Operation Double Harvest
OFI	Oxford Forestry Institute
PADF	Pan American Development Foundation
SE	Seed Export
SECID	South-east Consortium for International Development
USAID	United States Agency for International Development

REZIME

Rapó sa bay kondisyon sa yo ki ta pemet nou estoke semans pye bwa yo pi byen. Infomasyon ki bay nan rapó sa-a dwe ogmante sa nou jwenn nan Gid Pepinyeris, chapit 3 ki ekri pa PADF.

Gen twa kondisyon nou kapab kontwole pi fasil. Se 1) kalite sache kap estoke semans la; 2) nivo tanperati nan kote nou estoke semans la; 3) kantite dlo nou kite nan semans-lan pandan yo estoke pou plizye mwa. Nou bay infomasyon pou tanperati estoakj ak imidite semans pou chak kalite bwa nou etidye nan Table I.

Ankó, semans ki soti nan kek kalite bwa mande yon tretman avan nou seme yo nan pepinye. Pou chak kalite bwa, nou bay infomasyon sa-a nan Table II.

KONSEY

1. PADF e CARE dwe kontwole mwa yo kapab konseve semans chak kalite bwa nan kondisyon yo gen kounye-a. Sa ki pi enpotan se tanperati e kantite dlo ki nan semans kap estoke. SECID dwe kompare kondisyon ke lot peyi ap rekomande ak sa PADF ou CARE ap fe. Eske diferan kondisyon pou chak kalite bwa impotan pou nou konseve semans yo?

2. Nou dwe mete plis impotans nan rechech pou kalite bwa yo ki bay semans yon sel fwa pa ane, oubyen ki konn bay move rekolt semans tanzantan. Sa dwe fet paske nap oblije estoke semans pou le pepinye bezwen semans la, pa selman tel kalite bwa ap bay yon bon rekolt. Kalite bwa ki bay grenn nimpot le, ou bay anpil grenn ki pa pouri fasil, pa mande nou fe anpil rechech.

3. Kalite bwa ki bay semans ki frajil ou ki pap viv lontan mande nou fe rechech nan lot jan pou leve bwa yo. Tout kalite bwa pa mande nou konseve yo kom semans. Si gen pwoblem estokaj, nou dwe we ki jan nou ka motive moun yo pou yo ta pran ti pye bwa ki leve anba maman bwa yo oubyen seme semans yo direkteman nan platban bo lakou pou yo ka plante nan bon sezon lapli. Nou ka fe sa pou nim, frenn, mango, kajou, zoranj, sitron, chadek, e plizie lot kalite ki bay pwoblem stokaj.

4. Tretman semans ki fet avan yo seme nan pepinye dwe fe tout semans leve mem le e anko, li fe yo leve pli vit. Li bon paske sa fe tout plantil yo rive menm wote ansam. Si gen plizye tretman pou yon kalite semans, nou dwe chwazi sa ki pli fasil e ki bay nou bon rezilta.

5. Kote PADF e CARE ap estoke semans an gran kantite, nou oblije instale yon delko ki mache tout tan lé EDH pa bay kouran. Delko sa-a dwe komanse e rete otomatik, pou moun pa bezwen okipe li tout tan. Konsa, tout ekipman ki anplas pou estoke semans yo nan bon kondisyon pap rete mache.

6. Tout rechech laboratwa oblije swiv reg yo ki ekri nan ISTA (1985). Nou dwe swiv dokiman sa jiska li pa bon anko, oubyen gen lot pi bon konsey sou teknik pou egzamine semans yo.

INTRODUCTION

Seed storage and pretreatment is critical in any forestry project. Seed of most economically important tree species remain the principal means by which germplasm is maintained, transported and propagated for reforestation purposes throughout the world.

In the tropics, the storage of forestry tree seed is not as precisely documented as temperate species. (The exception is tropical cash crops e.g. *Theobroma cacao, Coffea arabica, Citrus* spp.) Several reasons exist for this state of affairs: the higher species diversity (and seed type diversity), the lag in scientific research by tropical countries in the area of seed technology, and the fact that information is scattered and not readily available in the refereed literature. Furthermore, as research develops, the seed of many tropical species considered recalcitrant are being accepted as orthodox. (Orthodox seed can be defined as seed which can be dried down to a low moisture content of around 5% (wet basis) and successfully stored at low or sub-freezing temperatures for long periods (Roberts 1973). Thus, the storage temperature and seed moisture contents considered optimal may change over time simply due to new findings or verification that improper methods were utilized to conduct the storage experiments.

This report is not meant to be an exhaustive review on the topic of tree seed storage and pre-germination treatments. These are provided in such documents as FAO (1985) and Justice and Bass (1978). The selected list of species treated in this report represent many of the principal species in demand by the USAID funded Agroforestry II project in Haiti, though the same species may play a minor role in forestry or agroforestry projects in other tropical countries. More extensive treatment of tropical fruit species can be found in Bass (1975), King et al. (1981), King and Roberts (1979), and Riley (1987). Literature citations for the genera and species reviewed are reported if known.

The document can be divided into storage conditions and seed pre-treatment. These are factors in seed longevity and germinative capacity that can be easily controlled. Seed handling, from seed collection to storage, obviously affects seed viability, but is not elaborated in this report. It suffices to say that this period is a potentially dangerous time for most species in terms of seed longevity.

METHODOLOGY

In an attempt to summarize the knowledge that exists at seed centers and research laboratories working with tropical tree seed, a request for information on the seed storage conditions and pre-germination treatments of 22 genera was sent to 16 experts in 14 countries (Appendix). These genera represent a sample of the major species outplanted by the USAID Agroforestry II project in Haiti. In due course, this list will be expanded to include other important tree species in Haiti. The data contained in this report was gathered from 10 responses to the request. This information was summarized to supplement information that is in the literature. It should be noted that most of the response information is based on operational protocol. The utility of such an approach is justified to short-cut unnecessary research time by the tropical forester and offer a summary of what leading institutions are practicing to store tree seed from the tropics.

RESULTS

Seed Storage Conditions

Containers

Unless otherwise noted, all storage is in airtight containers, usually plastic bags, plastic bottles or metal containers. Though the respondents often did not indicate thickness, a 4-5 mil (100-125 microns) polyethylene plastic is considered adequate to prevent passage of water vapor (Robbins 1983). Oxford Forestry Institute (OFI) seals plastic bags that are placed within sealed metal boxes. Escuela Nacional de Ciencias Forestales (ESNACIFOR) stores seed in sealed 5 mil plastic bags. Both OFI and ESNACIFOR store their containers in a cool room without humidity control. A review of packing materials for seed is given in FAO (1985), Freire and Mumford (1986) and Warham (1986).

Seed Maturity.

OFI stressed the seed maturity problem that naturally affects storage life:

" A basic rule that has been borne out for most of our species is the need to collect really ripe seed to ensure good storage viability. Seed that is collected before peak ripeness and ripened artificially appears to lose viability much more rapidly than ripe seed."

This is supported by Stein et al. (1974) and Harrington (1970).

Initial Viability.

Seed lots with high initial viability and germinative capacity have a higher longevity in storage than those with low initial viability (FAO 1985).

Chemical Treatments.

Though fungicidal treatment cannot be generally recommended for seed storage (Magini 1962), insecticide is useful to control pests that may be contained in the seeds prior to storage, particularly the legumes. Only Seed Export indicated a pesticide treatment prior to cool storage: 4% Malathion at 125 grams/100 kg seed and Captan (Orthocide) at 60 grams/100 kg seed.

Storage temperature and seed moisture content.

In orthodox seeds, loss of seed viability is largely governed by the rate of respiration. Any measures which reduce the rate of respiration without otherwise damaging the seed are likely to be effective in extending longevity during storage (FAO 1985).

Two of the most important factors in this respect are temperature and moisture content. Table I summarizes the information by species. A moisture content (wet basis) of 4-8% is considered safe for most orthodox species; 5% is recommended for long-term storage for genetic conservation (IBPGR 1976). It appears from the data that a storage temperature of 3-4 °C is optimal unless sub-

freezing temperatures do not cause any damage. Species for which no information on storage temperature and moisture content was made available from the respondents were: *Simarouba glauca*, *Calaphyllum calaba*, *Cinnamomum montanum* and *Zanthophyllum martinicense*. In the case of *Cinnamomum zeylanicum*, a species considered recalcitrant, viability decreased from 80% after one week to 52% after two weeks when partially dried and stored at ambient temperature in India (Kanna and Balakrishnon, 1967). Storage conditions for many of the native fruit species occurring in Haiti are summarized in King and Roberts (1980) and Riley (1987).

For several species, notable differences in storage temperature and seed moisture content were recommended by the respondents. The effects of these differences on longevity of a given seed lot is largely unknown. They may not be significant for many of the orthodox seeds. However, variation in storage life is also affected by differences in state of maturity, parental and provenance effects, seasonal and annual effects and seed handling procedures. No doubt many of these factors are different for each of the institutions represented in this study.

A problem in the past has been that seed moisture content has not always been determined according to international standards, even for orthodox seeds. The International Seed Testing Association (1985) rules state:

"For leguminous and tree seeds coarse grinding is necessary; at least 50% of the ground material shall pass through a sieve with meshes of 4.00 mm."

It has not been verified that these guidelines were followed in determining the moisture contents reported in this document.

Table I. Recommended seed storage moisture content and temperature of selected tropical tree species.

SPECIES: *Acacia auriculiformis* A. Cunn. ex Benth.

INSTITUTION	STORAGE MOISTURE CONTENT (% WW BASIS)	STORAGE TEMPERATURE (CELSIUS)	DURATION (MONTHS)
KFRI	5-7	3	> 60
KEW*	5-7	16	NA
ATSC	8-12	3-20	> 84
ASEAN	5-10	2-4	> 60
PADF	NA	25	NA

* Unless it is confirmed that seed can be frozen at 5-7% moisture content without damage. See Doran et al. (1983).

SPECIES: *Alnus acuminata* H.B.K.

INSTITUTION	STORAGE MOISTURE CONTENT (% WW BASIS)	STORAGE TEMPERATURE (CELSIUS)	DURATION (MONTHS)
KEW*	5-7	16	NA
SE	8-9	0-4	10
OFI	7-8	4	NA

* If it is orthodox seed, in which case freezing may be possible.

SPECIES: *Azadirachta indica* A. Juss.

INSTITUTION	STORAGE MOISTURE CONTENT (% WW BASIS)	STORAGE TEMPERATURE (CELSIUS)	DURATION (MONTHS)
KFRI*	15	>16	4
KEW	3	2 or -20	>36
CFDD	9	4	NA
ASEAN*	40-50	15	4
PADF*	NA	25	NA

* Ventilated container such as cotton or sisal bag. See Chaisurisi et al. (1986); Ezumah (1986).

Table I (cont.)

SPECIES: *Cassia siamea* Lam.

INSTITUTION	STORAGE MOISTURE CONTENT (% WW BASIS)	STORAGE TEMPERATURE (CELSIUS)	DURATION (MONTHS)
KFRI	5-7	3	>60
KEW	5-7	16	NA
ESNACIFOR	7.5	4	60
PADF	NA	25	NA

SPECIES: *Casuarina equisetifolia* L. ex J.R. & G. Forst., *C. glauca* Sieber ex K. Spreng.

INSTITUTION	STORAGE MOISTURE CONTENT (% WW BASIS)	STORAGE TEMPERATURE (CELSIUS)	DURATION (MONTHS)
KFRI	8	3	>24
ESNACIFOR	11	4	36
ATSC	8-12	3-5	>60
SE	8-9	0-4	24
ASEAN	5-10	2-4	>24
PADF	NA	4	NA
ISAR	NA	4	8

See Liengsiri and Hellum (1984).

SPECIES: *Catalpa longissima* (Jacq.) Sims

INSTITUTION	STORAGE MOISTURE CONTENT (% WW BASIS)	STORAGE TEMPERATURE (CELSIUS)	DURATION (MONTHS)
KEW*	5-7	16	NA
PADF	NA	4	NA

* If the seed is orthodox.

Table I (cont.)

SPECIES: *Cedrela odorata* L.

INSTITUTION	STORAGE MOISTURE CONTENT (% WW BASIS)	STORAGE TEMPERATURE (CELSIUS)	DURATION (MONTHS)
ESNACIFOR	14	4	48
SE	8-9	0-4	72
OFI	7-8	4	120
PADF	NA	4	NA

See Lamprecht (1956).

SPECIES: *Cordia alliodora* (Ruiz & Pav.) Oken

INSTITUTION	STORAGE MOISTURE CONTENT (% WW BASIS)	STORAGE TEMPERATURE (CELSIUS)	DURATION (MONTHS)
ESNACIFOR	10	4	36
SE*	6-8	0-4	6.5
OFI	7-10	4	100

* "*Cordia alliodora* seed has to be collected when naturally felling to the ground and fumigated immediately"

SPECIES: *Colubrina arborescens* (Mill.) Sarg.

INSTITUTION	STORAGE MOISTURE CONTENT (% WW BASIS)	STORAGE TEMPERATURE (CELSIUS)	DURATION (MONTHS)
ESNACIFOR	8	4	NA
PADF	NA	25	NA

Table I (cont.)

SPECIES: *Citrus maxima* (Burm.) Merr.

INSTITUTION	STORAGE MOISTURE CONTENT (% WW BASIS)	STORAGE TEMPERATURE (CELSIUS)	DURATION (MONTHS)
KEW*	5-7	16	NA
PADF	NA	25	NA

* If the seed is orthodox. See King and Roberts (1980); King et al. (1981); Riley (1987).

NB Riley (1987) recommends for *Citrus maxima* to soak seed for 24 hours; pack the seed with moist sterile material; store for 30-60 days at 4 °C. Germination period is between 14-21 days.

SPECIES: *Eucalyptus camaldulensis* Dehnh., *E. tereticornis* Sm.

INSTITUTION	STORAGE MOISTURE CONTENT (% WW BASIS)	STORAGE TEMPERATURE (CELSIUS)	DURATION (MONTHS)
KFRI	6-8	3	>60
ESNACIFOR	11	4	36
ATSC	8-12	3-5	>60
SE	6-8	0-4	134
ASEAN	5-10	2-4	>36
PADF	NA	4	NA

See Turnbull (1975); Doran et al. (1987); Yap and Wong (1983).

SPECIES: *Gliricidia sepium* (Jacq.) Kunth ex Walp.

INSTITUTION	STORAGE MOISTURE CONTENT (% WW BASIS)	STORAGE TEMPERATURE (CELSIUS)	DURATION (MONTHS)
KFRI	5-7	3	>60
ESNACIFOR	9	4	24
SE	6-8	0-4	10
ASEAN	5-10	2-4	>36
OFI	7-10	4	48-60
PADF	NA	4	NA

Table I (cont.)

SPECIES: *Grevillea robusta* A. Cunn.

INSTITUTION	STORAGE MOISTURE CONTENT (% WW BASIS)	STORAGE TEMPERATURE (CELSIUS)	DURATION (MONTHS)
KFRI	8	3	>24
ESNACIFOR	10	4	NA
ATSC	8-12	3-5	>24
CFDD	9	4	12
SE	7-8	0-4	3
PADF	NA	4	NA

SPECIES: *Hibiscus elatus* Sw.

INSTITUTION	STORAGE MOISTURE CONTENT (% WW BASIS)	STORAGE TEMPERATURE (CELSIUS)	DURATION (MONTHS)
KEW*	5-7	16	NA
PADF	NA	25	NA

* If the seed is orthodox.

SPECIES: *Lysiloma sabicu* Benth.

INSTITUTION	STORAGE MOISTURE CONTENT (% WW BASIS)	STORAGE TEMPERATURE (CELSIUS)	DURATION (MONTHS)
OFI	7-8	4	50
PADF	NA	25	NA

Table I (cont.)

SPECIES: *Leucaena* spp.

INSTITUTION	STORAGE MOISTURE CONTENT (% WW BASIS)	STORAGE TEMPERATURE (CELSIUS)	DURATION (MONTHS)
KFRI	5-7	3	>60
KEW	5-7	16	NA
ESNACIFOR	10	4	60
CFDD	8-9	4	>48
SE	8-10	0-4	12
ASEAN	5-10	2-4	>60
OFI	7-8	4	96
PADF	NA	25	NA

SPECIES: *Swietenia* spp.

INSTITUTION	STORAGE MOISTURE CONTENT (% WW BASIS)	STORAGE TEMPERATURE (CELSIUS)	DURATION (MONTHS)
KEW	3	2 or -20	>36
ESNACIFOR	7-8	4	24
SE	8-10	0-4	4
ASEAN	5	10	12
OFI	7-10	4	NA
PADF*	NA	25	NA

* Ventilated container. See King and Roberts (1980).

SPECIES: *Tectona grandis* L.f.

INSTITUTION	STORAGE MOISTURE CONTENT (% WW BASIS)	STORAGE TEMPERATURE (CELSIUS)	DURATION (MONTHS)
KFRI	10	3	12-60
ESANCIFOR	8	4	36
PADF	25	NA	NA

See Yap and Wong (1983); King and Roberts (1980).

PRE-GERMINATION METHODS

Pre-germination methods are important for many species, particularly for the hard coated species. Basically, these methods break dormancy, which includes hard seediness that is common in legumes. These methods vary and have been summarized in Table II for each of the species for which pre-germination was determined as necessary or at least optimal. *Citrus maxima*, *Cinnamomum montanum* and *Zanthophyllum martinicense* were either not handled or no information was given. A review of pre-germination treatments is given in FAO (1985) and Kariuki and Rode (1987).

In the case of *Azadirachta indica*, it may not be viability that is problematic as much as it is changes in properties of the seed coat as a result of drying. If the germination-inhibiting chemicals in the seed coat are removed or neutralized, germination of neem proceeds normally (Fagoonee, 1983). Seedcoat dormancy may even be combined with embryo dormancy if seed of certain species are stored. This may be the factor in *Simarouba glauca*. Seed that has been tested by OFI to be 70% viable by the tetrazolium test still germinated poorly (C.E.Hughes, personal communication). It is in question how many of the native species in Haiti exhibit this problem, though it appears true for *Zanthophyllum martinicense* and *Colubrina arborescens*. Until many of the seed dormancy problems are solved, the storage of seed is of little value. This places a limitation of using many native species if fresh seed is not available or logistical problems between seed collection and propagation are not efficient.

It is clear that several methods may be appropriate for a given species, particularly to overcome seed coat dormancy. The method applied is usually a tradeoff between maximum germination and efficiency of conducting the treatment. For this reason, manual scarification (such as clipping or cracking) and acid treatments are less appropriate than immersion in water at varying temperatures and soaking, if the same germination results are achieved.

Table II. Recommended pre-germination treatments of tropical tree seed for species included in this study.
NR = No treatment required.

SPECIES	INSTITUTION	PRE-GERMINATION TREATMENT
Acacia auriculiformis	ATSC	1. Immersion in boiling water for 1 minute, drain off water and soak for 24 hours
	ASEAN	2. Conc. sulfuric acid for 30 min.
	PADF	3. Immersion in boiling water for 10 min and let soak for 24 hours

See Doran et al. (1983); Acoba (1987); Kiriuki and Rode (1987).

Table II (cont.)

Alnus acuminata	OFI	1. NR Short-lived
	SE	2. NR Loses germination beginning 200 days
	ISAR	3. NR
Azadirachta indica	KEW	1. Cracking
	CFDD	2. NR
	ASEAN	3. NR
	PADF	4. Soak in cold water.
	ISAR	5. Soak in cold water 1-2 days.
	See Fagoonnee (1983).	
Cassia siamea	KFRI	1. Pour boiling water over seed and let cool for 12 hours
	ESNACIFOR	2. Small longitudinal cut
	ASEAN	3. Conc. sulfuric acid for 15-45 minutes
	PADF	4. Immerse in 80 °C water and soak for 24 hours
	See Kobmoo and Hellum (1984); Kariuki (1987).	
Casuarina equisetifolia, *C. glauca*	KFRI	1. NR
	ASEAN	2. NR
	SE	3. NR No significant loss in germination
	PADF	4. NR
	ISAR	5. NR
Calophyllum calaba	ODH	1. Remove hard seed coat
	See Seeber and Agpaoa (1976).	
Catalpa longissima	PADF	1. NR
Cedrela odorata	OFI	1. NR
	KFRI	2. NR
	SE	3. NR Loses around 5% germination per year
	ESNACIFOR	4. NR
	PADF	5. NR

Table II (cont.)

Colubrina arborescens	PADF	1. Immersion in 80 °C water and let soak for 24 hrs.
	ODH	2. Soak 24 hrs and rinse. Repeat this 3-4 days until hard seed coat cracks
Cordia alliodora	OFI	1. NR
	SE	2. NR
	ESNACIFOR	3. NR Loses germination quickly
	ISAR	4. NR
Eucalytpus camaldulensis	KFRI	1. NR
E. tereticornis	ASEAN	2. NR
	SE	3. NR No significant germination loss in 11 years.
	ESNACIFOR	4. NR
	PADF	5. NR
	ISAR	6. NR
Gliricidia sepium	ESNACIFOR	1. Longitudinal cut
	OFI	2. NR
	ASEAN	3. NR
	SE	4. NR Keeps good germination in 11 days
	KFRI	5. NR
Grevillea robusta	SE	1. NR Keeps good germination
	ATSC	2. NR Mould can be a problem
	KFRI	3. NR
	CFDD	4. NR
	PADF	5. NR
	ISAR	6. NR
Hibiscus elatus	PADF	1. NR

Table II (cont.)

Leucaena spp.	OFI*	1. See footnote
	ESNACIFOR	2. Small longitudinal cut
	KFRI	3. Nipping; immersion in 80 °C water for 5 min.
	ASEAN	4. Conc. sulfuric acid for 30 min.
	CFDD	5. Immerse 2-3 min. boiling water and 24 hrs. cold water
	SE	6. Scarification. Looses germination from 300-360 days
	PADF	7. Immersion in 80 °C water and let soak for 24 hrs.
	ISAR	8. Immersion in 80 °C for 2 min.
Simarouba glauca	ESNACIFOR	1. NR Loses germination quickly
	PADF	2. Cracking
Swietenia spp.	ESNACIFOR	1. NR
	SE	2. NR Loses around 50% germination in one year
	ASEAN	3. NR Half-winged seed
	OFI	4. NR
	ISAR	5. NR

See Alvarez-Racelis and Bagaloyos (1977); Ponoy et al.(1984); Kiriuki and Rode (1987).

* "Seed pretreatment for *Leucaena leucocephala* has been well studied. Experiments are under way on the complete range of *Leucaena* species to define suitable pretreatment methods. At this stage it is clear that the standard hot water pretreatment method for *L. leucocephala* is not suitable for all the species, some requiring more severe treatment and some no pretreatment at all. Results of this study will be published in due course."

Table II (cont.)

Tectona grandis		
	ASEAN	1. Soak in water and allow to dry for 3 days, repeat this 6 times (ISTA, 1985)*
	KFRI	2. Soak in cold water for 48 hours. Poor results so far
	ESNACIFOR	3. Oven at 45 °C during 5 days watering daily. Very good germination

See Bryndum (1966); Wood (1967).

* Not appropriate as shown by non-uniform germination and heterogenous seed content per fruit.

RECOMMENDATIONS

1. The longevity of seed under current storage conditions at PADF and CARE facilities in Haiti should be determined. At least one of the recommended temperature and seed moisture content combinations for storage in this report should be compared to examine differences in the effect on seed storage life.

2. Species should be prioritized according to timely availability of seed harvests in Haiti. Those species with significant seasonal and annual differences in seed quality and quantity would take a priority over species that are prolific seeders or bear seed at periodic times sufficient for nursery demands.

3. Species for which seed is hard to store should be carefully studied to find alternative means of propagation and germplasm multiplication. Not all species have to be stored as seeds. Sowing of fresh seed and storing the germplasm as a live seedling in the shade has merit since it simulates natural conditions better than storage as a seed. This would seem appropriate for *Azadirachta indica, Cinnamomum montanum, Simarouba glauca, Swietenia* spp., *Alnus acuminata, Citrus maxima* and most of the recalcitrant species.

4. Seed pre-treatments to break dormancy should also increase uniformity and velocity in seed germination. This is a major objective of any pre-treatment method. The choice of the pre-treatment takes into account ease of handling, costs of treatment, and effect on germinative capacity of the seed.

5. The major seed storage and testing facilities of PADF and CARE must have an uninterrupted power supply to run properly. The current unstable supply of electricity in Haiti should be backed up by either a diesel generator or a solar driven power supply complete with sensor and disconnect switches, to guarantee automatic transfer of power sources.

6. All seed testing in Haiti is to follow the ISTA (1985) rules until further recommendations by experts in the field of tropical seed technology and seed testing.

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APPENDIX

January 31, 1990

Dear Sir,

We are investigating the storage of tropical tree seed in Haiti. As you well appreciate, much of the information is obscure and unavailable. Prior to conducting our own research, we would like to gather as much information on storage and germination protocols at your facility. This way we have an idea of what is practical for our seed testing and storage facility in Haiti.

For each species on the attached list, please indicate the optimal temperature (or temperature range), moisture content (or moisture content range) and container to maintain viability. Please note pre-germination treatments, if necessary. Any other relevant information concerning this area of research on a per species basis would be much appreciated.

I acknowledge the fact that you will not have any information for several of the species. Mark "NA" in the appropriate spaces. Furthermore, there may be someone else who has more information. Please pass on the request for data.

Thank you very much for your anticipated cooperation. This information will be very useful to our implementing sound research and the management of our seed testing and storage facility.

Sincerely yours,

Joel Timyan
Seed and Germplasm Specialist

cc: Scott Josiah/PADF
Peter Welle/CARE

APPENDIX (CONT)
ATTACHMENT I

SPECIES	STORAGE MOISTURE CONTENT (% WW BASIS)	STORAGE TEMPERATURE (CELSIUS)	STORAGE CONTAINER	DURATION (DAYS)
Swietenia spp.				
Cedrela odorata				
Simarouba glauca				
Catalpa longissima				
Colubrina arborescens				
Grevillea robusta				
Azadirachta indica				
Hibiscus elatus				
Eucalyptus camaldulensis				
Eucalyptus tereticornis				
Alnus acuminata				
Casuarina equisetifolia				
Casuarina glauca				
Gliricidia sepium				
Cassia siamea				
Citrus maxima				
Lysiloma latisiliqua				
Leucaena spp.				
Acacia auriculiformis				
Cordia alliodora				
Tectona grandis				
Calophyllum calaba				

APPENDIX (CONT)
ATTACHMENT I

CONT

SPECIES	STORAGE MOISTURE CONTENT (% WW BASIS)	STORAGE TEMPERATURE (CELSIUS)	STORAGE CONTAINER	DURATION (DAYS)
Cinnamomum montanum				
Zanthoxylum martinicense				

ATTACHMENT II

SPECIES	PRE-GERMINATION TREATMENT	COMMENTS
Swietenia spp.		
Cedrela odorata		
Simarouba glauca		
Catalpa longissima		
Colubrina arborescens		
Grevillea robusta		
Azadirachta indica		
Hibiscus elatus		
Eucalyptus camaldulensis		
Eucalyptus tereticornis		
Alnus acuminata		
Casuarina equisetifolia		
Casuarina glauca		
Gliricidia sepium		
Cassia siamea		

SPECIES	PRE-GERMINATION TREATMENT	COMMENTS
Citrus maxima		
Lysiloma latisiliqua		
Leucaena spp.		
Acacia auriculiformis		
Cordia alliodora		
Tectona grandis		
Calophyllum calaba		
Cinnamomum montanum		
Zanthoxylum martinicense		

Respondents of letter dated 31 January 1990 requesting information on seed storage and pre-treatment protocols.

1. Ing. J.A. Lewald Capoulliez
   Seed Export,
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   Guatemala City, Guatemala

2. Ing. Oscar Ochoa Mendoza
   Banco de Semillas,
   Corporacion Hondurena de Desarollo Forestal,
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   Siguatepeque, Honduras

3. Mr. Chr. Schaefer
   Kenya Forest Seed Centre,
   Kenya Forestry Research Institute,
   P.O. Box 20412,
   Nairobi, Kenya

4. Mr. N.R. Shrestha
   Community Forestry Development Division,
   Ministry of Forest and Soil Conservation,
   Hattisar, Kathmandu, Nepal

5. Mr. Michel Ndeze
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6. Mr. Somyos Kijkar
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7. B.V. Gunn,
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