Seed health problems in tropical forest tree seeds and their impact on seedling production

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Recently, studies were undertaken to standardize the seed technology of tropical forestry seeds under the World Bank aided Forestry Projects and data were generated on seed technology of 88 broad-leaved forestry species in the Kerala State. In the present paper, seed health problems in *Tectona grandis*, *Albizia lebbeck* and *Dalbergia sissoides* are dealt with. Sample trees were selected in different seed zones in the State and phenological data were collected. Seed crop assessment was carried out and seeds/fruits samples were collected during 1998–2001 and seed/fruit characteristics were studied. To overcome the seed coat dormancy and to enhance the seed germination potential, cold and hot water treatments, and acid (H_2SO_4) treatment were carried out. Seed microflora was assessed by employing standard techniques (ISTA) and identification of spermoplane microorganisms was made. Seedling growth, vigour and seedling diseases were studied in seedbed and root trainer nurseries. The causal agents from diseased seedlings were isolated and identified. Seed dressing fungicides, Hexathir, Hexacap and Carbendazim were screened for their efficacy under seed storage. Results showed that seeds of all the three forestry species harboured large number of fungi. These fungi play a role in causing seed rot and poor germination. Even though, storage molds like *Aspergillus, Penicillium* and *Trichoderma* were the predominant ones, field fungi like *Colletotrichum, Bipolaris, Phomopsis* and *Phoma* were also encountered. Treatments to break the seed coat dormancy in seeds of all the three tree species increased percent seedling emergence as well as reduced the spermoplane fungal flora and thereby the risk of rot caused by them. Seed treatment with fungicides was effective in reducing the spermoplane fungal flora.

Introduction

Despite the advances in seed technology over the past several years, little effort has been made of them in India to improve the quality of tree seeds and thereby the planting stock. Teak (*Tectona grandis* L.), the prime forestry species in the country, has been raised extensively in plantation since 1850s. Germinability of teak seed is usually found to be low (<50%) which is largely attributed to emptiness (Troup 1921, Murty 1973, Ghosh 1977); the percentage of emptiness in teak fruits varies from area to area (Gupta and Kumar 1976). Although, several studies have been conducted, the factors responsible for low percent germination is not fully revealed. For the causes of poor seed germination, so far, studies have been directed towards seed maturity, seed dormancy, size, etc. (Dabral 1976, Gupta and Pattanath 1975, Joshi and Kelkar 1971), however, little attention has been paid to study the deterioration of seed quality by microorganisms.

With the increasing demand on indigenous species over exotics (eucalypts and acacias) to reforest the degraded areas, many lesser exploited tree species are being tried under various planting schemes. *Albizia lebbeck* (L.) Willd. and *Dalbergia sissoides* Grah. are among those species, however, information on their phenology, fruit/seed characteristics, seed health problems and seed pre-treatment requirements is meager. The present study was taken up to investigate the seed health parameters and standardize technology to raise quality seedlings in nursery.

Materials and methods

Selection of trees and collection of seeds

Stands of *Tectona grandis*, *Albizia lebbeck* and *Dalbergia sissoides* in various localities belonging to different agro-climatic zones in the State (Prasad and Kandya 1992) were selected for the study. Ten trees of respective species were selected in each stand, marked and observations on flowering, fruiting and seed maturation were recorded and seed crop assessment carried out. Seeds/fruits were collected during 1998 and 1999 seeding seasons from the selected stands of respective tree species. Seeds collected from individual trees in a locality were mixed together and composite samples made. Seed/fruit characteristics, pod size, seed size, number per pod and number of locules were studied. Seed samples were brought to the laboratory, extracted, purified and seed weight and moisture level were assessed. Seeds were sun or air dried to reduce the moisture content to 10–15% and stored. Composite samples of each tree species from each localities were stored separately in cloth bags at 25±2 °C.

Working sample from each composite sample was drawn and seeds were further categorized into different groups of apparently healthy, discoloured, deformed and biodeteriorated. Status of fungal and insect infestations was assessed by dry seed examination method using sterioscopic binoculars. The percentage of discoloured, poorly filled, shrunken and deteriorated seeds in each sample was assessed separately. Seed moisture content was measured by oven drying method. Weight of seeds from each category as well as from pooled sample was determined separately (ISTA 1985).

Seed pre-treatment

To overcome the seed coat dormancy and thereby enhancing the germination potential of seeds, various treatments were carried out. These include: i) cold water soak - soaking the seeds in water at room temperature for 24 hours; ii) hot water soak - soaking the seeds in boiling water and keeping them until the water cools down; iii) acid treatment - soaking the seeds in concentrated sulphuric acid for 5 to 20 min and washing thoroughly with water.

Seed health testing

Spermoplane microflora was assessed by employing standard blotter technique (ISTA 1985). Both sterilized and non-sterilized seeds were screened. Agar plate method (ISTA 1993) was employed to detect the seed borne fungus and bacteria. Working sample of 200 to 400 seeds of each species was drawn from each composite sample and tested. Seeds were plated at equal distance in sterile plastic dishes (Ø 90–140 mm) lined with three moistened germination paper discs (blotter). Both surface sterilized and non-sterilized seeds were tested. Surface sterilization

was carried out with 0.01% mercuric chloride for 2 min and thoroughly washed with sterile water. The number of seeds incubated per Petri dish varied with the size of the seeds. The set ups were incubated at 25±2 °C in a Seed germinator fitted with fluorescent lights adjusted at 12 hr dark and light cycle. The incubated Petri dishes were removed from the Seed germinator after 12 days and observations on germination, microbial association and infection on emerging seedlings recorded. Potato dextrose agar medium was used for assessing the spermoplane microflora by agar plate method. Seeds surface sterilized with 0.01% mercuric chloride and then washed with sterile water were plated on PDA medium in petri dishes and incubated for 7 to 10 days. Microbial colonies developing from the seeds were isolated, purified and identified. Identification of spermoplane microorganism was attempted up to generic level or species level in certain cases and percent incidence of each microorganism was deduced.

To assess the effect of spermoplane microorganisms, some of which may also be seed-borne, on the germinability of seeds, growing on test was carried out. Steam sterilized perlite was used as the growing medium. Plastic trays (60 x 30 x 20 cm) were filled with sterilized perlite and the seeds of respective tree species were sown, watered and maintained. Observations on seedlings emergence, incidence of disease on seedlings etc. were recorded up to 30 to 45 days of emergence. The diseased parts from the seedlings were plated aseptically on PDA medium and causal organism isolated and identified.

Fungicidal seed dressing

Fungicides, thiride (Hexathir), bavistin (Carbendazim) and captan (Hexacap), were evaluated for their efficacy as seed dressing chemicals. Cleaned seeds of each species were treated with fungicides at the rate of 2 g/kg of seeds in polythene bags (18 x 12 cm) and stored for three weeks. The treated seeds were tested employing blotter method.

Results and discussion

Phenology and fruit/seed characteristics

Tectona grandis

Teak trees generally flowers during June to August-September and fruits ripen from November to January. However, early flowering from May to July was also observed in all the three localities in the State (Table 1). Fruits were available till March in Wayanad and Nilambur, while in Chinnar, fruits were available for collection during May also. Fruits characteristics vary from locality to

Table 1. Fruit characteristics of teak from different localities.

Locality	Seed sub-zone	Fruit without calyx, cm		Mean no. of locule/fruit	Empty locule/fruit	Sound seeds/fruit
		Length	Breadth			
Kuppadi	Wayanad	1.54 (0.04)	1.42 (0.03)	3.50 (0.84)	1.64 (1.67)	1.20 (1.03)
Nedunkayam	Nilambur	1.24 (0.15)	0.94 (0.07)	3.40 (0.69)	1.60 (1.50)	0.70 (0.67)
Churulipetty	Chinnar	1.13 (0.01)	1.09 (0.09)	3.81 (0.40)	2.52 (1.34)	0.90 (0.94)

Figures in parenthesis are SE of mean value.

locality (Table 1). In teak seeds, number of locules varied from 2 to 4 and sound seeds varied from 0 to 2. Seed lot from Wayanad showed the highest number of sound seeds.

Teak fruits collected from Wayanad, Nilambur and Chinnar were severely infested by insects which made tunnels in the mesocarp and endocarp from the pedicel part of the fruit. Insect infestation ranged from 9 to 18.5 percent and the highest per cent insect attack was observed on seeds from Wayanad. Fungal hyphae, fructifications and sclerotia were also observed on the fruits. Discolouration and shriveling was associated with about 12.5% of the fruits from Chinnar. Results on extraction of seeds from teak fruits revealed that emptiness is very common in teak fruits from Chinnar (Table 1). Moreover, ill-filled and shriveled seeds were more in seed samples from Chinnar than from the other two localities. Seeds inside the locules were also found deteriorated and covered with fungal mycelium.

Dalbergia sissoides

D. sissoides trees generally flowers during December to January and up to February in Dhoni and Wayanad. Seeds are available for collection in February. At Chinnar, mature fruits are available in May. Fruits characteristics showed variation in seedlots from different localities (Table 2). Seeds were found moderately affected with spermoplane microorganisms and insects. The seeds from each locality could be categorized into apparently healthy, discoloured, and deformed seeds. The percentage of seeds belonging to such categories was 78, 13 and 9 respectively in seedlot from Chinnar, 67, 21 and 12 respectively in seedlot from Dhoni, 74, 17 and 9 respectively in seedlot from Wayanad.

Table 2. Caharacteristics of seeds of D. sissoides.

Seed characteristics	Localities		
	Chinnar	Dhoni	Wayanad
Length of pod (cm)	6.16	6.30	5.80
Width of pod (cm)	1.42	1.68	1.78
No. of locules per pod	3.50	4.40	5.00
No. of seeds per pod	3.20	4.00	4.60
% discoloured and deformed seeds	22.00	33.00	26.00
Wt. of 100 seeds (g)	3.00	3.25	3.07
% MC	16.66	15.00	20.00

Albizia lebbeck

A. lebbeck trees flower mostly during January to March. But in Chinnar and Palakkad flowering occurs during August to September also. Pod collection period is from November to March. The fruit characteristics length and width of pod, number of locules per pod, and number of seeds per pod varied considerably (Table 3). Percent moisture content of seeds collected from different localities ranged from 10.62 to 12.15. *A. lebbeck* seeds collected from the three localities Chinnar, Kuzhalmannam and Palakkad were found severely affected with microorganisms. The percentage of discoloured and deformed seeds was very high and it ranged from 50 to 60 (Table 3). Severe infection of seeds inside the pod as well as germination of intact seeds were also noticed. The weight of 100 seeds from the pooled samples from the three localities ranged from 11.2 to 12.0 g. Dry seed examination revealed fungal mycelial mats, fructifications, as well as insect infestations. Comparatively deformed, shriveled and infested seeds were high in seedlot from Chinnar than those from other two localities.

Table 3. Pod/seed characteristics *A. lebbeck*.

Seed/fruit characteristic	Localities		
	Chinnar	Kuzhalmannam	Palakkad
Length of pod (cm)	19.76	23.75	21.72
Width of pod (cm)	3.79	4.53	4.08
No. of locules per pod	6.50	11.80	9.00
No. of seeds per pod	6.00	10.60	8.40
Length of seed (cm)	0.95	0.91	1.10
Width of seed (cm)	0.78	0.64	0.66
Thickness of seed (cm)	0.20	0.22	0.22
% discoloured and deformed seeds	50.00	52.00	60.00
Wt. of 100 seeds (g)	12.00	11.20	11.90
Wt. of 100 discoloured seeds (g)	5.79	9.50	9.80
% MC	12.12	11.00	19.62

Seed microflora

Tectona grandis

A rich microflora comprising a total of 18 fungal genera, together with mycelia sterilia (black and white), bacteria and actinomycetes was detected on seeds of *T. grandis* from different localities. Of these seed lot from Wayanad harboured more number of microorganisms and showed their highest frequency of occurrence (Table 4). The most frequent fungal genera were *Aspergillus*, *Botryodiplodia*, *Fusarium* and *Trichoderma.* Though, bacteria were found in all the three seed lots tested, their highest frequency (33%) was observed in seed lot from Wayanad. As expected, number of microorganisms and their percent incidence were higher in non-surface sterilized seeds (NSS) than surface sterilized (SS), and acid pre-treated (A) seeds. By surface sterilization, most spermoplane microflora except bacteria was excluded. Sulfuric acid treatment was also equally

Table 4. Spermoplane microorganisms detected on *T. grandis* (Wayanad seedlot).

Sl. No.	Microorganism	Blotter method, % incidence			Agar plate method
		NSS	SS	A	% incidence
1	*Alternaria alternata*	2			2
2	*Aspergillus* spp.	1			
3	*Aspergillus niger*	16	1	4	4
4	*Botryodiplodia theobromae*	2			4
5	*Chaetomium* sp.	3			
6	*Colletotrichum gloeosporioides*	6			
7	*Curvularia* sp.				4
8	*Drechslera* sp.	1			
9	*Fusarium* sp.	20			12
10	*Mucor* sp.			14	
11	*Paecilomyces* sp.	8			
12	*Penicillium* sp.	7			
13	*Pestalotia* sp.	4			
14	*Phoma* sp.	5	4		
15	*Trichoderma* sp.	12	4	4	
16	*Verticillium* sp.	3			
17	Sterile mycelium (black)		8	8	2
18	Sterile mycelium (white)	2			
19	Bacteria	33	10	6	8
20	Actinomycetes	1			

NSS = non-surface sterilized; SS = surface sterilized; A = sulphuric acid treatment.

effective in reducing the seed microflora substantially and increasing the percent germinability of the seeds. Emerging seedlings in these treatments were found very healthy and showed any sign of seedling infection from storage fungi.

Seed health test by agar plate method, where extracted seeds were used, revealed association of field fungi like *Botryodiplodia theobromae* Pat., *Fusarium moniliforme* J. Sheld., *Curvularia lunata* (Wakker) Boedijn, *Phoma* sp., *Colletotrichum gloeosporioides* (Penz. & Sacc.) C., etc. in all the three seed lots tested. Of these, many are capable of causing seedling rot and foliage infection. The high level of infestation of the teak seeds by these field fungi clearly indicates the possibility of infection by the pathogen during the early developmental phase of the fruits.

Dalbergia sissoides

A rich microflora comprising of 16 fungal genera, together with mycelia sterilia, bacteria and actinomycetes were detected on seeds of *D. sissoides* collected from different localities (Table 5).

Table 5. Spermoplane microorganisms detected on seeds of *D. sissoides* (Chinnar 1998 seedlot).

Sl. No.	Microorganism	Blotter method, % incidence					Agar plate method % incidence
		NSS	SS	HW	CW	A	
1	*Alternaria* sp.						8
2	*Aspergillus* sp.	12					
3	*Aspergillus niger*	16	10	6	8	10	18
4	*Chaetomium* sp.	3					
5	*Curvularia* sp.						8
6	*Fusarium* sp.	3	6				14
7	*Paecilomyces* sp.	1					
8	*Penicillium* sp.	6					
9	*Trichoderma* sp.	3	2	4	8		8
10	*Verticillium* sp.	1					
11	Sterile mycelium (black)			14			14
12	Bacteria	9	16	8	8	8	22
13	Actinomycetes				6	4	4

NSS = non-surface sterilized; SS = surface sterilized; HW = hot water treatment; CW = cold water treatment; A = sulphuric acid treatment.

Most microorganisms were encountered on non-surface sterilized seeds in blotter tests. Among the seedlots, those from Wayanad and Dhoni harboured more number of spermoplane microbes than the seeds from Chinnar. The spermoplane microbes detected include the common storage fungi, field fungi, bacteria and actinomycetes. Among the storage fungi, *Aspergillus* spp., *Penicilium* spp. and *Chaetomium* sp. were the predominant ones. The incidence of these storage fungi ranged from 38 to 69%. However, the occurrence of field fungi like *Alternaria* sp., *Curvularia* sp., *Drechslera* sp., *Bipolaris* sp., *Fusarium* spp., *Pestalotia* sp., *Phoma* sp., etc. in all the three lots ranged from 4–41%. Seeds from Wayanad and Dhoni were found infested with large number of field fungi and their percentage was 41 and 34 respectively. While seeds from Chinnar recorded only a few field fungi and their per cent incidence was less than five (Table 5). As expected, the fungal genera, their frequency of occurrence as well as intensity of infestation were more in non-surface sterilized seeds from all the three localities. Surface sterilization of the seeds with 0.01% mercuric chloride considerably reduced the occurrence of the fungal genera to 1–3 and also the percent incidence to 6–10. Even though, bacteria were detected on seeds from all the three localities, their incidence was substantially reduced by surface sterilization and also by other seed pre-

treatments. Cold water, hot water, and acid treatments carried out to enhance the seed germinability, were also effective in excluding most of the spermoplane microflora. Seed health test employing agar plate method could detect a large number of field fungi like *C. gloeosporioides, Curvularia* sp., *Fusarium pallidoroseum* (Cooke) Sacc., *Phoma* sp., *Pestalotia* sp., etc. Of these *C. gloeosporioides* was encountered in high frequency on seeds from Wayanad (25%) and Dhoni (10%). The percent incidence of *Fusarium* (mostly *F. pallidorosum*) was also ranged from 6–18 in all the seedlots. Many of these field fungi are potential pathogens of *Dalbergia sissoides* seedlings in nurseries. The results indicate that at least a few of these fungi which are possibly seed-borne may play a role in deterioration of seeds in storage as well as incidence of seedling diseases in nurseries.

Albizia lebbeck

A rich microflora comprising of 19 fungal genera, together with unidentified mycelia sterilia, bacteria and actinomycetes were encountered on seeds of *A. lebbeck* collected from the three different agroclimatic sub-zones of the State (Table 6). Seed health test by blotter method revealed

Table 6. Microorganisms detected on seeds of *A. lebbeck* (Palakkad 1998 seedlot).

Sl. No.	Microorganisms	Blotter method, % incidence			
		NSS	SS	HW	A
1	*Aspergillus* spp.	10.0	5.0	13.0	7.0
2	*Aspergillus niger*	0.5			
3	*Beltrania* sp.	8.0	8.0	12.0	
4	*Chaetomium* sp.	2.0	4.0	1.0	3.0
5	*Colletotrichum gloeosporioides*	0.5			
6	*Fusarium* sp.	1.0	4.0		
7	*Paecilomyces* sp.	0.8		1.0	
8	*Penicillium* sp.	16.0	3.0	6.0	
9	*Rhizopus* sp.	2.3	2.0		
10	*Trichoderma* sp.		2.0	2.5	3.0
11	Sterile mycelium (black)	0.5	1.5	1.0	
12	Sterile mycelium (white)	1.0	0.5		2.0
13	Bacteria	17.0	11.0	32.0	4.0
14	Actinomycetes	5.5	1.0		3.0

NSS = non-surface sterilized; SS = surface sterilized; HW = hot water treatment; A = sulphuric acid treatment.

a large number of spermoplane microbes on non-surface sterilized seeds. Among the seedlots tested, those from Palakkad recorded more number of spermoplane microbes which include common storage moulds, field fungi, bacteria and actinomycetes. Among the storage moulds, *Aspergillus spp., Chaetomium* sp., *Rhizopus* sp., *Penicillium* sp., etc. were the predominant fungi. Their frequency of occurrence ranged from 21–48%. Among the field fungi recorded on seeds, *Beltrania* sp., *C. gloeosporioides*, *Fusarium* sp. and *Phoma* sp. are the important ones and their per cent incidence in the seed samples from the three localities ranged from 7 to 21. Seeds from Chinnar recorded the least number and per cent incidence of field fungi, while the seeds from Palakkad yielded more number of field fungi as well as their per cent incidence. Incidence of bacteria in seeds ranged from 7 to 19% in non-surface sterilized seed samples. Bacteria were found mostly associated with the discoloured and deformed seeds and such seeds become completely rotten with heavy bacterial ooze. Though surface sterilization with 0.01% mercuric chloride reduced the per cent incidence of the bacteria, both hot water and acid treatment increased the per cent incidence. A high per cent (32%) incidence of bacteria was recorded in hot water treatment of seedlots from Chinnar and Kuzhalmannam. However, in general, hot water and acid

treatments to break the seed dormancy and to enhance the seed germination, also reduced the number of spermoplane microflora and their intensity.

Growing-on test

T. grandis: Seedling emergence started four to six days after sowing in the sterile perlite medium and continued up to 21 days. However, a large number of them emerged within 8 to 12 days of sowing. Percentage germination was slightly higher (51%) than that obtained in blotters. Seedling infection, damping-off, collar rot and cotyledon rot were observed on the emergents and isolations made from the diseased specimens yielded *F. moniliforme, F. oxysporum* Schlect. and *C. lunata*.

D. sissoides: Seedling emergence started 5 to 7 days after sowing in the sterile perlite medium and continued up to 16 days. Most seedlings emerged within 10 to 12 days of sowing. Percentage germination (56%) was found lower than that obtained by blotter method. Seedling infections, collar rot caused by *Fusarium* sp. and leaf spot caused by *Colletotrichum gloeosporioides* were recorded.

A. lebbeck: Seeds from Palakkad were used for the growing-on test. Emergence of seedlings started 4 to 5 days after sowing in sterile perlite medium and continued up to 9 days. Most seedlings emerged within 5 to 7 days of sowing. Percentage germination (73%) was found lower than that obtained by blotter method. Seedling infection, cotyledon infection (bacterial), rot of radicle and plumule (bacterial) and leaf spot caused by *Fusarium* sp. and *Colletotrichum gloeosporioides* were observed.

Seed pre-treatment

T. grandis: The percent germination of seeds from different localities, ranged from 36 to 48 in blotter test. Soaking the seeds in concentrated sulphuric acid for 20 min gave higher percent germination (Table 7); highest germination of 78% was obtained for seed lot from Nilambur, followed by seed lot from Chinnar (74%).

Table 7. Effect of seed pre-treatments on percent germination of *T. grandis* seeds.

			Percent seed germination		
Locality	Zone	Sub zone	NSS	SS	A
Wayanad	KL3	c	46	40	64
Chinnar	KL2	b	48	34	74
Nilambur	KL3	c	39	36	78

NSS = non surface sterilized; SS = surface sterilized; A = sulphuric acid treatment.

D. sissoides: Pre-treatments of seeds, soaking in cold water for 24 hr dipping in hot water and then soaking in cold water for 24 hr were equally effective in increasing the germinability of seeds of *D. sissoides* (Table 8). Highest per cent germination of 96 was observed in cold water treatment of seeds from Dhoni.

Table 8. Effect of various seed pre-treatments on percent germination of *D. sissoides* seeds.

Locality	Zone	Subzone	Per cent germination			
			NSS	SS	HW	CW
Dhoni	KL3	b	38	47	82	96
Chinnar	KL2	b	4	14	20	38
Wayanad	KL3	c	54	64	94	80

NSS = non-surface sterilized; SS = surface sterilized; HW = hot water treatment; CW = cold water treatment.

A. lebbeck: Seed pre-treatments, hot water soaking and conc. sulphuric acid treatment (5 min) were equally effective (Table 9). In hotwater treatment, seedlot from Palakkad gave higher per cent germination (92), while seedlot from Kuzhalmannam recorded only 60% germination. Seedlots from all the three localities gave a high percent germination which ranged from 94–95%. The results indicate that acid treatment has to be carried out to get a maximum per cent germination.

Table 9. Effect of seed pre-treatments on germination of seeds of *A. lebbeck.*

Locality	Zone	Sub zone	Per cent germination			
			NSS	SS	HW	A
Kuzhalmannam	KL3	Palakkad	7.5	34.5	60.0	94.0
Palakkad	KL3	Palakkad	60.0	51.5	92.0	95.0
Chinnar	KL2	Munnar	26.5	63.0	80.0	94.0

NSS = non-surface sterilized; SS = surface sterilized; HW = hot water treatment; A = acid treatment.

Discussion

Most of the tropical trees exhibit irregular phenology depending on the local climatic conditions. Due to high variation in period of seed/fruit maturity in a particular tree species in different localities, collection of seeds from trees becomes difficult. Hence, seeds are usually collected from the forest floor after the seed fall which often get infected by decay organisms. In general, tropical seeds harbour rich microflora and thereby cause seed decay and affect the seed germination. Earlier, Mohanan and Sharma (1991) reviewed the status of seed pathology of 63 tropical and 13 temperate forest tree species in India. The present study shows that apart from common storage moulds, teak fruits harbour a few potential fungi like *Phoma* sp., *C. gloeosporioides* and *Fusarium* sp., which are also known to be seed-borne in various crops. Earlier, *Cercospora* sp. and *Fusarium* sp. have been recorded as possible seed-borne fungi in teak (Sharma and Mohanan 1997). Although, enclosed in stony endocarp, teak seeds are found to be invaded by fungi and caused shriveling and decay of seeds in the locules. Teak fruits infested by insects which made extensive tunnels in mesocarp and endocarp were found colonized by both field and storage fungi. The role of these fungi in seed deterioration, seed abortion and locule emptiness cannot be ruled out. Growing-on test using extracted seeds also revealed infection on emerging seedlings by fungi like *Fusarium* spp. and *C. lunata* which were also recorded in blotter and agar tests. The poor germinability of teak seeds is usually attributed to seed dormancy due to stony impermeable endocarp (Unnikrishnan

and Rajeev 1990). The physiological conditions in the form of nutrient imbalance has also been reported as an important factor for low germinability (Gupta and Pattanath 1975). The present study confirms the results of Murty (1973) and Ghosh (1977) on seed emptiness as one of the major factors for the low germinabilty. However, the present study reveals that locule emptiness due to seed abortion, possibly be caused by seed-borne fungi, rather than the unknown sterility factor operating in Verbanaceae family, may be the leading factor for low germinability of teak seeds.

So far, no information is available on spermoplane microflora as well as on seed technology of *D. sissoides*. Recently, Chacko and Mohanan (2002) have generated data on seed health and seed technology of this indigenous species. The percent study also shows incidence of many field fungi on seeds and a few of these potential fungi may possibly play a role in deterioration of seeds in storage as well as incidence of seedling diseases in nurseries. To safe guard the seeds against spermoplane microflora, and also to check the seedling diseases in nursery, seed dressing with fungicide like thiride or captan 2g/kg of seeds is desirable.

From *A. lebbeck* seeds only a few species of *Aspergillus, Penicillium, Fusarium* and *Rhizopus* have earlier been reported (Mittal and Sharma 1979, Tiwari and Sharma 1981). In the present study, seed lots from different localities revealed many spermoplane organisms including field fungi like *Drechslera* sp., *Phoma,* sp., *F. solani*, *C. gloeosporioides*, etc. *C. gloeosporioides* and *Fusarium* sp. are suspected to be seed-borne as both the fungi caused seedling infection in nurseries. However, seed rot caused by bacteria (*Pseudomonas* sp.) was the major seed health problem encountered in most of the seed lots. The bacterial infection occurs on pods and spread to the developing seeds. Rainfall during the seed maturation period may possibly enhance the bacterial rot. As both hot water and acid treatments enhanced the per cent seed germination, any of the seed pre-treatment can be practiced. Since, *A. lebbeck* seeds are available in plenty, long-term seed storage is not required, however, seed dressing with fungicide like thiride or captan 2g/kg of seeds can reduce the spermoplane microflora and thereby the possible seed decay.

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References

Chacko, K.C. & Mohanan, C. 2002. Development of technology for collection, processing and testing seeds of important tree species of Kerala. Final Technical Report (ICFRE). Kerala Forest Research Institute, Peechi, Kerala, India.

Dabral, S.L. 1976. Extraction of teak seeds from fruits, their storage and germination. Indian Forester 102: 648–658.

Ghosh, R.C. 1977. Handbook on Afforestation Techniques. Controller of Publication, Government of India, New Delhi.

Gupta, B.N. & Kumar, A. 1976. Estimation of potential germinability of teak (*Tectona grandis* L.f.) fruits from twenty three Indian sources by cutting test. Indian Forester 102: 808–813.

Gupta, B.N. & Pattanath, P.G. 1975. Factors affecting germination behaviour of teak seeds of eighteen Indian origin. Indian Forester 101: 584.

International Seed Testing Association. 1985. International rules for seed testing. Seed Science and

Technology 13: 299–355
International Seed Testing Association. 1993. International rules for seed testing. Seed Science and Technology 21: 1–259.
Joshi, M.D. & Kelkar, S.P. 1971. Germination of seed in dry teak (*Tectona grandis* L.) 1. Preliminary studies on fruit development and seed dormancy. Indian Forester 97: 210–215.
Mittal, R.K. & Sharma, M.R. 1979. Seed microflora of *Albizzia lebbeck* Benth. (Abst.). Proc. 66th Indian Science Congress Part III Sec.IV. (Bot).
Mohanan, C. & Sharma, J.K. 1991. Seed pathology of forest tree species in India: present status, practical problems and future prospects. Commonwealth Forestry Review 70 (3): 133–151.
Murty, A.V.R.G. 1973. Problems of teak seeds 2. Germination studies. In: Proc. IUFRO Int. Seed Symp., Bergen, Vol II. Paper No. 21.
Prasad, R. & Kandya, A.K. 1992. Handling of forestry seeds in India. Associate Publishing Company, New Delhi, India. 420 p.
Sharma, J.K. & Mohanan, C. 1997. Seed microflora of teak and its effect on seed germination and seedling growth. In: Teak (eds. S. Chand Basha, C. Mohanan and S. Sankar), Proc. Int. Teak Symp., Kerala Forest Research Institute, Peechi, Kerala. p. 113–117.
Tiwari, B.K. & Sharma, G.D. 1981. Seed mycoflora of eleven tree species of north-eastern India. Indian Phytopathology 34: 83.
Troup, R.S. 1921. The Silviculture of Indian Trees. Vol. II, The Clarendon Press, Oxford.
Unnikrishnan, K. & Rajeev, K.P. 1990. On germination of Indian teak (*Tectona grandis*). Indian Forester 116: 992–993.