SUMMARY
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In forestry, availability of healthy seeds is an important factor in raising planting stock. Initial seed health and storage conditions are the major factors governing the germinability of seeds. Like seeds of agricultural and horticultural crops, forest tree seeds are also liable to be affected by micro-organisms during storage, which affects the germination, and reduces the viability. Further introduction of seed-borne diseases into newly sown crops/areas on account of using unhealthy seeds is also not ruled out. Availability of healthy stock of seedlings is intrinsic for raising plantations and to meet this requirement elimination of nursery diseases by appropriate chemicals is of prime importance. As exotic tree species may become susceptible to various native pathogens, it is generally considered better to select indigenous tree species for large scale plantations as they are well adapted to local environment. However, before taking up large scale afforestation programme involving any indigenous tree species, it is essential to have knowledge about seed disorders and seedling diseases and their management. With a view to select appropriate tree species with fewer seed disorders and seedling disease problems for use in further plantation programme, four indigenous tree species such as *Albizia odoratissima* (L.f) Benth., *Lagerstroemia microcarpa* Wt.,
*Pterocarpus marsupium* Roxb. and *Xylica xylocarpa* (Roxb.) Taub. were evaluated to meet the above parameters.

The results of the study are presented in two parts. The seed pathology constitutes the first part, while the seedling diseases and their management form the second part. Seed health testing methods, seed microflora and their significance, management of seed microflora, seed storage and its influence on seed germination and seedling growth were carried out under seed pathological studies. The occurrence of various seedling diseases, their symptomatology, causal organisms and pathogenicity tests, *in vitro* evaluation of fungicides and disease control measures in the nursery are included in the second part.

1. **SEED PATHOLOGICAL STUDIES**

1.1. Seed health testing methods

The main objective of this study was to ascertain the most suitable seed health testing method for forestry tree species. Five seed health testing methods viz., standard blotter (SB), 2,4-D, deep freeze (DF), potato-dextrose agar (PDA) and malt extract agar (MEA) using both surface sterilised and non-surface sterilised seeds were evaluated to obtain maximum information on seed microflora.
In Albizia odoratissima, of the fifteen microorganisms recorded on non-surface sterilised seeds, except actinomycetes, all were detected in SB method; actinomycetes were detected only in 2,4-D and DF methods. Low incidence of Fusarium solani (Mart.) Sacc. was observed only in SB method. Surface sterilization with 0.1% HgCl₂ reduced the incidence of many micro-organisms except a Gram (-) bacterium.

In Lagerstroemia microcarpa PDA, DF and SB methods were equally effective as most of the micro-organisms grew well. Alternaria alternata (Fr.) Keissler was detected only in PDA and DF methods and a Gram (-) bacterium had significantly higher incidence in SB method as compared with others. Surface sterilisation reduced the incidence of certain micro-organisms and eliminated a few others.

In Pterocarpus marsupium, 15 micro-organisms were recorded with varying intensities in SB method followed by other methods. Actinomycetes did not appear in MEA method. Alternaria infectoria E. Simmons Botryodiplodia theobromae Pat. and Myrothecium roridum Tode: Fr. grew well in SB, MEA and DF methods respectively. Surface sterilisation brought down the percent incidence, as well as the number of micro-organisms in all the methods.
*Xylica xylocarpa* recorded a total of 11 micro-organisms in SB method. *Fusarium pallidoroseum* (Cooke.) Sacc. and *Cladosporium herbarum* (Pers.) Link ex Gray were detected mainly on non-surface sterilized seeds. Surface sterilisation of seeds reduced the incidence of a number of storage fungi and to a lesser extent the field fungi.

1.2. Seed microflora and their significance

The studies were mainly taken up with a view to generate data on micro-organisms associated with the seeds of four tree species and ascertain how do they affect the quality of seeds, which consequently may affect/influence the seedling vigour.

Macroscopic examination revealed the occurrence of apparently healthy, discoloured and discoloured and deformed seeds in *A. odoratissima*. The incidence of seed microflora was higher in deformed seeds as compared to other categories. The germination percentage was lower viz., 6% in deformed seeds whereas it was 21% in apparently healthy seeds, indicating the superiority of selecting apparently healthy seeds for sowing.

Of the 15 micro-organisms detected by different methods in *A. odoratissima* viz. *Actinomycetes*¹, *Aspergillus flavus* Link.², *A. niger* van Tieghem³, *A. stellatus* Curzi.⁴, *A. versicolor*⁵ (Vuill.) Tiraboschi *Cladosporium herbarum* (Pers.) Link ex
Gray, Colletotrichum gloeosporioides (Penz.) Penz & Sacc.

Fusarium moniliforme Sheld., F. solani (Mart.) Sacc., Myrothecium roridum Tode, Penicillium citrinum Thom, Rhizopus oryzae Went & Prinsen Geerligs, Trichurus spiralis Hasselbr., sterile hyphae and a bacterium Gram (-)

except 1, 5, 10 and 14, all were tested for their pathogenicity. Fusarium moniliforme, F. solani, C. herbarum, A. stellatus, T. spiralis and R. oryzae affected the seed germination and growth of seedlings. Vigour index was the lowest in treatments involving both the species of Fusarium followed by Cladosporium herbarum, A. flavus, A. stellatus, T. spiralis and R. oryzae.

In Lagerstroemia microcarpa also apparently healthy, discoloured and discoloured and broken seeds were encountered. The incidence of various micro-organisms was higher in the latter two categories as compared with apparently healthy seeds. Twelve micro-organisms viz., Alternaria alternata, Aspergillus flavus, A. niger, Curvularia lunata (Wakker) Boedijn, Fusarium solani, Memnoniella echinata (Riv.), Galloway, Phomopsis sp., Penicillium citrinum, Rhizopus oryzae sterile hyphae (black), sterile hyphae (white), and a bacterium Gram (-) were recorded by different methods on the seeds of L. microcarpa. Except 10 and 11, all were
checked for their pathogenicity. *F. solani* was found to be highly pathogenic since it reduced the germination (5%) as compared with control (13%). The vigour index was the lowest in *F. solani* (226) followed by *A. niger* (292), while the untreated control recorded a vigour index of 595.

Dry examination of seeds in *Pterocarpus marsupium* also revealed three categories of seeds. The number of microorganisms was lower in apparently healthy seeds as compared with other categories. Surface sterilisation greatly reduced the incidence of micro-organisms and improved germination percentage. The micro-organisms recorded by different methods were *Actinomycetes*¹, *Alternaria infectoria*², *Aspergillus candidus*³ Link ex Link, *A. flavus*⁴, *A. niger*⁵, *A. ochraceus* Wilhelm.⁶, *A. versicolor*⁷ *Botryodiplodia theobromae*⁸, *Cladosporium herbarum*⁹, *Chaetomium globosum* Kunze.¹⁰, *Fusarium moniliforme* Sheldon var. *intermedium* Neish & Leggett.¹¹, *Mennoniella echinata*¹², *Marasmius sp.*¹³, *Myrothecium roridum*¹⁴, *Penicillium citrinum*¹⁵, *Trichothecium roseum* (Pers.) Link ex Gray¹⁶, *Trichurus spiralis*¹⁷ *Rhizopus oryzae*¹⁸ and sterile hyphae (black)¹⁹ of which 2, 4, 5, 6, 8, 9, 11, 14, 12, 17 and 18 were tried for pathogenicity. *A. flavus*, *B. theobromae* and *F. moniliforme* var. *intermedium* caused reduced germination; in addition the latter also caused decay of seeds (2%). The
vigour index was the lowest in the case of seeds treated with B. theobromae, A. flavus and F. moniliforme var. intermedium indicating that they are pathogenic to seeds of P. marsupium.

In Xyilia xylocarpa also apparently healthy, discolored and discolored and shrivelled seeds were encountered. The incidence of various micro-organisms was higher in the latter two categories as compared with apparently healthy seeds. Actinomycetes, Aspergillus flavus, A. niger, A. ochraceus, A. versicolor, Chaetomium globosum, Cladosporium herbarum, Fusarium pallidoroseum, Penicillium citrinum, Rhizopus oryzae, Trichoderma sp., Trichothecium roseum, sterile hyphae (white) and a bacterium Gram (-) were recorded. Pathogenicity of only 2, 3, 7, 8, 9, 10 and 14 were tested. A. flavus reduced the seed germination considerably. Bacterium C. herbarum and F. pallidoroseum caused distortion of seedlings. Vigour index was the lowest in seeds treated with A. flavus, C. herbarum, F. pallidoroseum and R. oryzae.

1.3. Management of seed microflora

Various methods such as hot water treatment and fungicidal seed dressing were evaluated for their efficacy in reducing the seed-borne micro-organisms and consequently improve the seedling vigour. The efficacy of hot water treatment was evaluated at 50°C and 60°C for 15 and 30 min. In the chemical
control experiment, commonly available seed dressers viz., captafol, captan, carbendazim, carboxin, mancozeb, MEMC (Methoxy ethyl mercuric chloride), PCNB (Penta chloro nitro benzene), and thiram were tested

In general, hot water treatment was effective in Albizia odoratissima as higher vigour index was achieved over control in all the treatments. The number of micro-organisms also reduced from 12 in control to 6 - 9 in other treatments; M. echinata and C. globosum were the new fungi recorded after hot water treatment. Captan was the best fungicide as far as the seed germination and shoot length were concerned followed by carboxin, mancozeb, and carbendazim. On the contrary, MEMC, captafol and thiram appeared to be harmful as there was reduction in the germination percentage.

In the case L. microcarpa, though the number of micro-organisms was reduced, the hot water treatment was not at all effective as the seed germination was completely inhibited in 60° and 50°C-30 min. treatments. In treated seeds, Curvularia lunata and C. herbarum were completely eliminated and incidence of F. solani was significantly reduced. Curiously, high incidence of P. citrinum was recorded on the treated seeds. Chemical treatment with mancozeb was most
effective followed by carboxin, MEMC, carbendazim and captan. Captafol and PCNB were not effective.

The hot water treatment was not effective in the case of *P. marsupium* also. Although germination of seeds of *P. marsupium* was greatly reduced in 50° and 60°C-30 min. treatments, at 15 min. exposure it remained unaffected. Root length was greatly enhanced at 50°C and 60°C - 30 min. while shoot length did not change appreciably. However, the number of micro-organisms reduced from 13 in control to 5-10 after hot water treatment. In chemical control studies, captan was the most effective fungicide in respect of seedling vigour, followed by thiram, captafol, MEMC and carboxin. In none of the treatments germination was affected. All the fungicides were effective in reducing the number of micro-organisms; MEMC completely inhibited the growth of all the micro-organisms.

In *Xylia xylocarpa* hot water treatment was not effective as it reduced the seed germination except for treatment at 50°C-15 min. The number of micro-organisms also reduced from 9 in control to 2-4 in various treatments. Interestingly, *A. flavus* and *R. oryzae* recorded higher incidence in most of the treatments as compared with control. Thiram was most effective as a seed dresser followed by mancozeb and carbendazim. Though, the germination was enhanced in these
treatments the shoot length did not change appreciably. Seeds treated with captan, carboxin, MEMC and mancozeb were completely free from micro-organisms.

1.4. Storage and its influence on microflora, seed germination and seedling growth

Seeds of all the four tree species were stored separately in plastic containers and cloth bags for one year in the laboratory. Other treatments included fungicidal seed dressing, storage of seeds in a desiccator over calcium chloride at room temperature and at 4°C. The number of micro-organisms were enumerated at Day-1, Day-90, Day-180 and Day-365 following SB method. At each sampling the germination percent and vigour index were also worked out for all the treatments.

In A. odoratissima, most storage fungi recorded initially continued their presence till the end of the storage period. However, seeds stored under dehumidified conditions recorded less number of micro-organisms as compared with laboratory storage. Field fungi like F. moniliforme and F. solani were not observed after 90 days of storage under dehumidified conditions. The germination and vigour index gradually decreased as the period of storage increased. In seeds stored under dehumidified conditions at 4°C, the germination percentage reduced from 24% to 11% after 1 year.
Similar results were obtained for the seeds of *L. micr-
ocarpa*. Most storage fungi continued to appear till the end
of storage period. The number of micro-organisms was less on
seeds stored under dehumidified conditions. The seed germina-
tion showed a reduction from 10% to 4% in control untreated
seeds while it varied from 10% to 7% in seeds stored at 4°C
under dehumidified conditions.

In *P. marsupium*, the incidence of field fungi like
*Myrothecium roridum* and *F. moniliforme var. intermedium* were
either reduced or they were completely eliminated during the
period of storage. Seeds treated with fungicides recorded only
storage fungi. The number of micro-organisms was less in
seeds stored under dehumidified conditions as compared with
other treatments. The vigour index gradually decreased as the
storage period increased. Storage of seeds at 4°C under
dehumidified condition was effective as the reduction in ger-
mination was only from 23% to 14% over 1-year of storage as
compared with 24% to 4% in control.

*X. xylocarpa* also yielded similar results. The number
of micro-organisms was less on seeds stored under dehumidified
condition at room temperature and 4°C as compared with con-
trol. Storage of seeds treated with fungicides was not effec-
tive as the germination was completely lost over 1 year period
of storage. In dehumidified conditions at room temperature and 4°C, germination percentage showed a reduction from 55 at Day-1 to 17-26 at Day-365, respectively.

2. SEEDLING DISEASES AND THEIR MANAGEMENT

In nurseries no seedling diseases were recorded from Albizia odoratissima indicating that it is virtually free from seedling diseases.

From L. microcarpa, two seedling diseases viz., damping-off and root rot were recorded of which the former was a serious disease, caused by Rhizoctonia solani Kuhn. Evaluation of fungicides against R. solani using poisoned food method (PFM) indicated that only carbendazim, MEMC, carboxin, PCNB and thiram were the most effective ones. However, in soil fungicide screening method (SFSM), carbendazim and MEMC only gave 100% inhibition over control at the highest concentration of 0.2% and 0.0125% (a.i.) respectively. Small scale nursery trials indicated that pre-sowing soil drenching with MEMC (0.006% a.i.) gave adequate control of damping-off. Root rot disease was not found to be a serious one as only < 1% container seedlings were affected. In vitro evaluation of fungicides against Pythium middletonii Sparrow. using PFM indicated MEMC
and thiram as the most effective fungicides inhibiting the pathogen at all the three concentrations tested.

*Pterocarpus marsupium* recorded two seedling diseases viz., collar rot caused by *R. solani* and seedling blight caused by *Sclerotium rolfsii* Sacc. Collar rot did not appear to be a serious disease as it occurred in low incidence. High incidence (ca. 32%) of seedling blight was observed during monsoon period (June - September). *In vitro* evaluation indicated the superiority of MEMC against *R. solani* followed by carboxin, and to a lesser extent carbendazim. Other fungicides were not effective. Against *S. rolfsii* carboxin and thiram were found effective in all concentrations tested in PFM, while MEMC and captan brought about inhibition only at higher concentrations. A pilot scale nursery trial indicated that pre-sowing soil drenching of carboxin or thiram (0.2% a.i.) or MEMC (0.0125% a.i.) was most effective in controlling seedling blight completely.

*X. xylocarpa* recorded no seedling disease in nurseries except an economically unimportant seedling blight disease caused by *R. solani* in a few container seedlings. *In vitro* evaluation of fungicides using PFM indicated that carbendazim
and MEMC were the most effective ones followed by PONB, carboxin and thiram while these gave promising results only at the highest concentration tested in SFSM.

From the study, it may be concluded that the seeds of four indigenous tree species harboured rich seed microflora as in the case of agricultural crops with storage or saprophytic fungi as the predominant ones. Although a few field fungi recorded in the study did not cause any seed-borne diseases in nurseries. Besides, the tree species tested have a few common seed microbes as well as some microbes exclusively associated showing substrate preference. In general, SB method was superior to others as more micro-organisms were recorded and surface sterilisation of seeds reduced the micro-organisms both qualitatively and quantitatively. Dry examination of seeds revealed the presence of apparently healthy, discolored and shrivelled and deformed seeds and the incidence of micro-organisms in the former category was less as compared with the others. Hot water treatment was not at all effective for the four forestry species tested. However, fungicidal seed dressing was effective as it reduced the incidence of many micro-organisms as well improved the seedling vigour. Storage of seeds treated with fungicides was not found effective in maintaining the viability of seeds; however, storage of seeds
under dehumidified conditions can be tried in special circumstances. Very few seedling diseases were found to be associated with the four indigenous tree species and this support the generally held view that indigenous tree species rarely suffer from serious disease problems.