SEED DORMANCY AND GERMINATION IN *ALBIZIA FALCATARIA* AND *ALBIZIA PROCERA*

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SAJEEVUKUMAR, B., SUDHAKARA, K., ASHOKAN, P.K. & GOPIKUMAR, K. 1995. Seed dormancy and germination in *Albizia falcataria* and *Albizia procera*. Twenty-two different pre-treatments were tested on *Albizia falcataria* and *A. procera* seeds in order to speed germination. The study showed that, in addition to the presence of an impermeable seedcoat and micropylar plug, dormancy in these two species is due to a water soluble inhibitor present in the seedcoat. The possibility of difference in the solubility and/or quantity of the inhibitor present in these two species was indicated; the inhibitor in *A. procera* may be less in quantity and/or less water soluble. Though treatments such as manual nicking and acid scarification improved the germination percentage, the most effective and practical method of pre-treatment to obtain quicker and higher germination in *Albizia* was physical scarification followed by soaking in flowing water for 24 hours.

Key words: Seed dormancy - germination - inhibitor - *Albizia falcataria* - *Albizia procera*

SAJEEVUKUMAR, B., SUDHAKARA, K., ASHOKAN, P.K. & GOPIKUMAR, K. 1995. Kedormanan biji benih dan percambahan *Albizia falcataria* dan *Albizia procera*. Dua puluh dua pra-rawatan yang berbeza diuji pada biji benih *Albizia falcataria* dan *A. procera* untuk mempercepatkan percambahan. Kajian ini menunjukkan bahawa kedormanan dalam dua spesies ini disebabkan oleh kehadiran lapisan biji yang tak tertelapkan dan plug mikropila serta perencat larut air yang terkandung dalam selaput biji. Kemungkinan perbezaan dalam kelarutan dan/atau jumlah perencat yang terdapat dalam dua spesies ini ditunjukkan; jumlah perencat dalam *A. procera* mungkin kurang dan/atau kurang larut air. Walaupun rawatan seperti torehan dan pelelasan asid memperbaiki peratus percambahan, kaedah pra-rawatan yang paling efektif dan praktikal untuk memperolehi percambahan *Albizia* yang lebih banyak dan lebih cepat ialah pelelasan fizikal diikuti dengan rendaman di dalam air yang mengalir selama 24 jam.

Introduction

Albizia species have enormous potential as multipurpose trees in forestry and agroforestry practices throughout the tropics. Among the fourteen Indian species of this genus, all of which are trees (Troup 1921), *Albizia falcataria* (L.) Fosberg (Syn. *Paraserianthes falcataria* (L.) Nielson) and *Albizia procera* (Roxb.) Benth. (Syn. *Mimosa procera* Roxb., Vern. White Siris) are the most prominent.

Regeneration from seed remains the most common method of propagation in these species. However, delayed and irregular germination is a serious constraint in the large scale propagation of *Albizia* (Msanga & Maghembe 1986).

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The problem of seed dormancy and its adverse effect on nursery management has been emphasized by Bonner *et al.* (1974). Much research has therefore gone into examining the cause of dormancy and devising effective treatments to remove it. Clemens *et al.* (1977) observed that seeds of most tropical leguminous trees are dormant due to impermeability of the seedcoat. Several workers have shown that germination without pre-treatment was very poor in *Albizia* species (Rai 1978, Gogue & Emino 1979, Halos & Fabian 1981, Babeley *et al.* 1986).

Dormancy due to a hard seedcoat has been reported in *Albizia* spp. and various methods like soaking the seed in cold or hot water (Kumar & Purkayastha 1972, Valencia 1973, Kemp 1975, Halos & Fabian 1981, Koffa 1983), mechanical scarification like puncturing of the seedcoat (Khan & Tripathi 1987), filing and rubbing of the seedcoat (Babeley *et al.* 1986), hot wire scarification (Sandiford 1988) and acid scarification (Rai 1978, Babeley *et al.* 1986, Rai *et al.* 1986) have been recommended to overcome dormancy. The present study was conducted to find factors involved in the dormancy, other than seedcoat impermeability, and to develop an easy and effective method of seed treatment to maximise germination in *A. falcataria* and *A. procera.*

Materials and methods

Mature pods of *A. falcataria* and *A. procera* were collected directly from the crown of healthy middle-aged trees (two trees/species) growing at the Kerala Agricultural University Main Campus (10° 32' N, 76° 10' at an altitude of 22 - 25 m a.s.l.) and Peechi Reserve Forest (10° 32' N, 76° 32' at an altitude of 100 m a.s.l.) in Thrissur respectively. Pods were collected by means of a pole and hook during the last week of January and second week of May 1991 respectively. Length and width of the pod as well as number of sound seeds per pod were determined from representative samples of 25 pods in four replications. Pods were dried in the sun and beaten with a stick to extract the seeds. Thousand-seed weight and seed moisture contents were determined (ISTA 1985). Cleaned seeds were mixed thoroughly, packed in sealed polythene bags and stored at 5 °C until the tests were carried out.

Experiment 1

The following seed treatments for the removal of seed dormancy in *A. falcataria* and *A. procera* were tested. Four replications of 25 seeds were used for each pre-treatment.

Water soaking

One litre of hot water of temperatures of 40, 60, 70, 80, or 100 °C were taken in different containers. The seed lots were placed in the water and the whole (seeds + water) were allowed to cool to ambient temperature for 24 h (T2, T3, T4, T5 and T6 respectively). Seeds soaked in water at ambient temperature (22.7 to 31.5 °C) for 24 h served as the control (T1).

Dry heat or fire

Seeds were allowed to slide for 7 seconds over a hot plate at a temperature of 350 °C (T7) or subjected to straw fire, where the seeds were spread uniformly on a concrete floor and covered with a single layer of dry rice straw (116 g m^{-2}) which was then set on fire (T8). Immediately after the dry heat or straw fire treatments, the seeds were soaked in water at ambient temperature for 24 h.

Physical methods

A small portion of the seed coat was removed using nail cutter from the end opposite the hilum (nicking) and soaked in still water (T9) or in flowing water (T10) at ambient temperature for 24 h. In another treatment, nicked seeds were soaked in still water for 24 h, followed by complete removal of the seedcoat (T11).

Chemical methods

Seeds were scarified with 100 ml conc. H_2SO_4 for 10 min, washed thoroughly in running water and soaked in water at ambient temperature for 24 h (T12); or seeds were soaked at ambient temperature for 24 h in 100 ml of 6 (T13) or 30% (T14) H_2O_2 solution.

Experiment 2

Results of the physical treatments tried in Experiment 1 led us to suspect that water-soluble germination inhibitors might be present in the seed coats. In order to confirm this, a second experiment was conducted. Nicked seeds of *A. falcataria* or *A. procera* received the following treatments: (a) soaking in 100 ml of seedcoat extract of either *A. procera* (T15) or *A. falcataria* (T16) for 24 h; (b) soaking as above, then complete removal of seedcoats (T17 and T18 respectively), (c) soaking in flowing water for 24 h, then in *A. procera* or *A. falcataria* seed coat extract for 1h (T19 and T20 respectively). In order to determine if the inhibiting substance was present on the outer or inner surfaces of the seedcoat, two additional treatments were tried: (d) soaking the intact, untreated seeds in flowing water for 24 h (T21) or sowing the intact, untreated seeds in nursery bed (T22). Soaking was done in ambient conditions where the day and night temperature varied from 31.5 to 22.7 °C.

Seedcoat extract

Seeds of *A. procera* and *A. falcataria* were crushed separately in a grinder and the seedcoat material was separated by sieving. Ten gram of the crushed seedcoat was soaked in 400 ml of distilled water with intermittent stirring for 24 h. The whole

suspension was considered as the seedcoat extract. The same seedcoat extract that was used for soaking the seeds was also used for moistening the substratum.

Experiment 3

Seedcoat extracts of *A. falcataria* and *A. procera* were also tested for their inhibitory effects on the germination of cowpea (*Vigna unguiculata*) (var. Kanakamani) seeds. Four replications of 25 seeds each were soaked for 24 h in cold water (T23) or in seedcoat extract of either *A. falcataria* (T24) or *A. procera* (T25).

Germination methods

Twenty-five seeds were placed for germination on filter paper in separate petri dishes (9 cm diameter) kept at room temperature where the temperature varied from 31.5 to 22.7°C. The filter paper was moistened with distilled water daily in the case of all treatments except those involving seedcoat extracts (T15, T16, T19, T20 and T22). These treatments received the respective seedcoat extracts for moistening the filter paper. The petri dishes were covered and kept in plastic trays containing water to prevent ant infestation and then placed on open racks. In the case of field nursery bed sowing (T22), seeds were sown in July during the Southwest Monsoon season.

Assessment

Germination was observed daily. A seed was considered germinated when its radicle was one cm long and the green hypocotyl was visible. All the germinated seeds were counted and removed at each assessment to prevent double counting. At the end of the tests, cumulative germination percentages were calculated for each treatment. Vigour parameters were calculated for *Albizia* species using the germination value, final mean daily germination and peak value (Czabator 1962).

Statistical analysis

Standard deviation and coefficients of variation were calculated for pod characteristics of both *Albizia* species and for germination percentage of cowpea seeds. In the case of *Albizia* species, treatment means for cumulative germination percentage after transforming them to arcsin square root of the proportion, final mean daily germination, peak value and germination value were analysed using analysis of variance. Differences among means were tested at $p \leq 0.01$ using least significant difference (L.S.D.).

Results

Characteristics of pods and seeds

Albizia falcataria pods were smaller than those of *A. procera*, but the number of sound seeds per pod was more in *A. falcataria*. Moisture contents and 1000-seed weights were significantly higher in *A. procera* (Table 1).

Table 1. Physical characteristics of the pods and seeds of *Albizia falcataria* and *A.procera*

Physical characteristic	Species	
	A. falcataria	*A. procera*
Mean pod length (cm)	9.5a	5.6b
Mean pod width (cm)	1.9a	2.2b
Mean no. of seeds/pod	12.0a	9.0b
1000 seed weight (g)	29.0a	38.1b
Moisture per cent (wet weight basis)	5.5a	6.7b

Values in the same row with the same alphabet do not differ significantly ($p < 0.05$).

Cumulative germination percentage

Scarification with concentrated H_2SO_4 for 10 min (T12), soaking the nicked seeds in flowing water (T10), and complete removal of the seedcoat (T11) resulted in significantly higher germination percentages than did the control (T1) in both species (Table 2). Among the various hot water treatments, temperatures of 40 °C (T2), 60 °C (T3), 70 °C (T4) and 80 °C (T5) resulted in significantly higher germination in *A. falcataria* only. In both these species, boiling water (T6), dry heat (T7), straw fire (T8) and H_2O_2 (T13, T14) treatments resulted in complete failure of germination.

Soaking nicked seeds of *A. falcataria* and *A. procera* in either seedcoat extract (T15, T16) resulted in complete failure of germination. The seeds so soaked failed to germinate even after the removal of seedcoats (T17, T18). Soaking nicked seeds in flowing water followed by soaking in seedcoat extract of *A. procera* (T19) resulted in 75.8 and 74.1 % germination respectively whereas soaking in seedcoat extract of *A. falcataria* (T20) resulted in 47.9 and 65.3 % germination respectively as compared to 10.5 and 39.6 % observed in the control treatments (Table 3). Soaking intact seeds of *A. falcataria* and *A. procera* in flowing water before sowing (T21) showed only 5.2 and 26.6 % germination respectively and sowing of *A. procera* in the nursery bed (T22) did not improve germination any further. However, seeds of *A. falcataria* sown without any treatment in the nursery bed (T22) gave significanlty higher germination compared to the control, and seeds of *A. procera* were not affected by nursery sowing.

Table 2. Cumulative germination percentage and number of days taken to complete germination in *Albizia falcataria* and *A. procera* seeds as affected by different pre-treatments

Pre-treatment	*A. falcataria*		*A. procera*	
	Cumulative germination percentage	No. of days taken for germination	Cumulative germination percentage	No. of days taken for germination
A. Water soaking				
T1 Control	10.5a	8	39.6a	3
T2 40 °C	44.8b	3	44.5a	4
T3 60 °C	94.3c	4	48.8a	4
T4 70 °C	90.5c	4	37.9a	4
T5 80 °C	93.8c	4	58.2b	4
T6 100 °C	12.5a	4	20.5a	4
C. Physical methods (nicking followed by soaking in -)				
T9 still water	54.0b	3	48.1a	3
T10 flowing water	96.0c	2	91.7c	2
T11 still water followed by seedcoat removal	83.2c	2	89.2c	2
D. Chemical methods				
T12 H_2SO_4	97.0c	3	93.5c	2

Values in the same column with the same alphabet do not differ significantly ($p < 0.01$).

Table 3. Cumulative germination percentage and number of days taken to complete germination by *Albizia falcataria* and *A. procera* seeds as affected by inhibitors

Pre-treatment	*A. falcataria*		*A. procera*	
	Cumulative germination percentage	No. of days taken for germination	Cumulative germination percentage	No. of days taken for germination
T1 Control	10.5a	8	39.6a	3
T19 *A. procera* extract	75.8c	3	74.1b	3
T20 *A. falcataria* extract	47.9b	3	65.3b	3
T21 Seed soaked in flowing water	5.2a	2	26.6a	2
T22 Sowing in nursery bed	42.9b	5	30.0a	5

Values in the same column with the same alphabet do not differ significantly ($p < 0.01$).

Seedcoat extracts of both the species inhibited germination of cowpea seeds. Cowpea seeds soaked in *A. falcataria* seedcoat extract (T24) failed to germinate, whereas those soaked in *A. procera* seedcoat extract (T25) showed only 17% germination. The control lots (T23), which were soaked in cold water, recorded 65% germination (Table 4).

Table 4. Cumulative germination percentage of cowpea seeds (*Vigna unguiculata*) (var.Kanakamani) as affected by the seedcoat extracts of *Albizia* spp.

Pre-treatment	Cumulative germination (%)	Coefficient of variation (%)
T23 Cowpea soaked in cold water	65a	16.9
T24 — in *A. falcataria* extract	nil	nil
T25 — in *A. procera* extract	17b	64.8

Values in the same column with the same alphabet do not differ significantly ($p < 0.01$).

Vigour parameters

Soaking nicked seeds in flowing water (T10) and complete removal of seedcoats (T11) resulted in the highest mean daily germination (MDG) in *A. procera* and *A. falcataria* respectively (Figure 1). However, MDG after soaking nicked seeds in still water (T9) was equal to that of the control samples. In the case of *A. procera*, scarifying the seeds in H_2SO_4 (T12) also resulted in a high MDG.

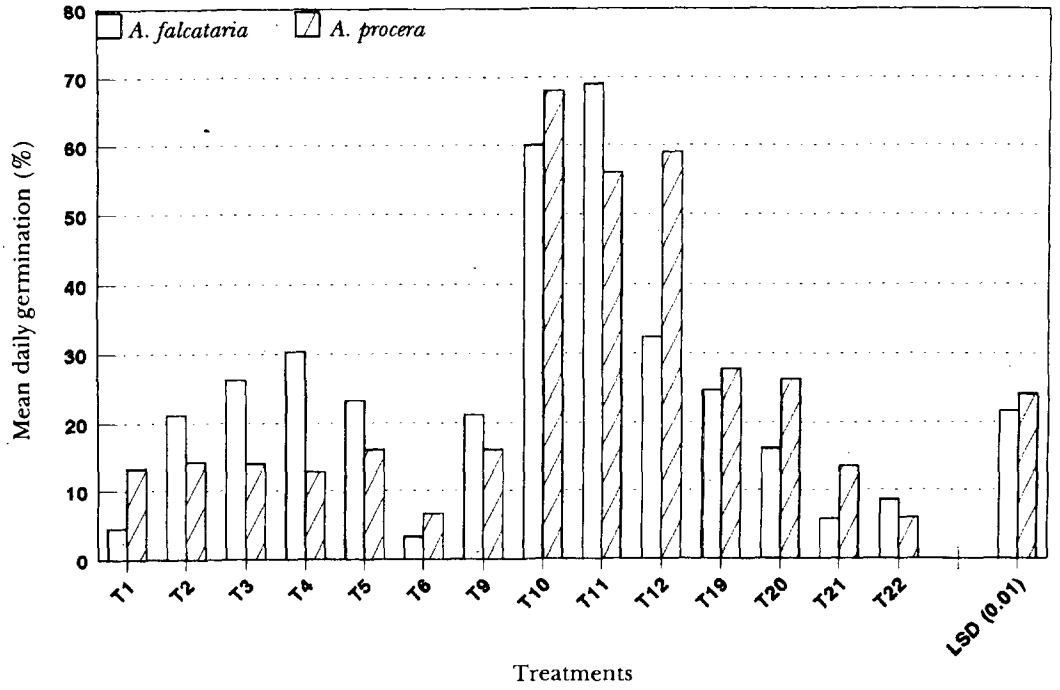

Figure 1. Effect of pre-treatments and seedcoat extracts on mean daily germination of *Albizia falcataria* and *A. procera* seeds

Soaking nicked seeds in flowing water (T10), and complete removal of seedcoats (T11) resulted in the highest peak value (PV) in *A. falcataria* (Figure 2). In the case of *A. procera*, H_2SO_4 treatment (T12) also resulted in a very high PV. Even though hot water treatments at 40, 60, 70 and 80 °C, soaking the nicked seeds in still water, and H_2SO_4 scarification (T2, T3, T4, T5, T9 and T12 respectively) resulted in significantly higher PV compared to the control, they were significantly inferior to soaking nicked seeds in flowing water (T10) and complete removal of seedcoat (T11) in *A. falcataria*. Complete removal of seedcoats (T11) and soaking nicked seeds in flowing water (T10) resulted in high germination value (GV) in both species (Figure 3). In *A. procera* acid scarification (T12) also resulted in high GV. None of the other treatments significantly improved GV.

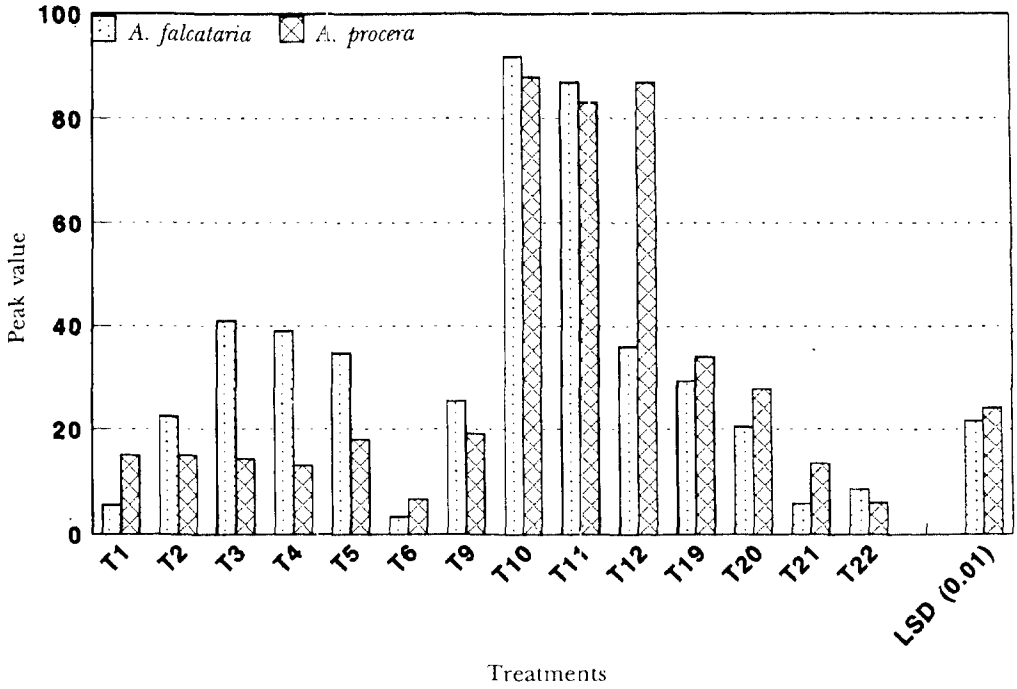

Figure 2. Effect of pre-treatments and seedcoat extracts on peak value of *Albizia falcataria* and *A. procera* seeds

Soaking nicked seeds of *A. falcataria* in flowing water followed by soaking in *A. procera* seedcoat extract (T19) resulted in a final MDG of 24 (Figure 1). When *A. falcataria* seedcoat extract was used (T20), a much lower value was obtained. Soaking intact seeds in flowing water (T21) and also sowing in nursery beds (T22) did not have any influence on final MDG. Similar results were obtained in the case of PV and GV (Figures 2 and 3).

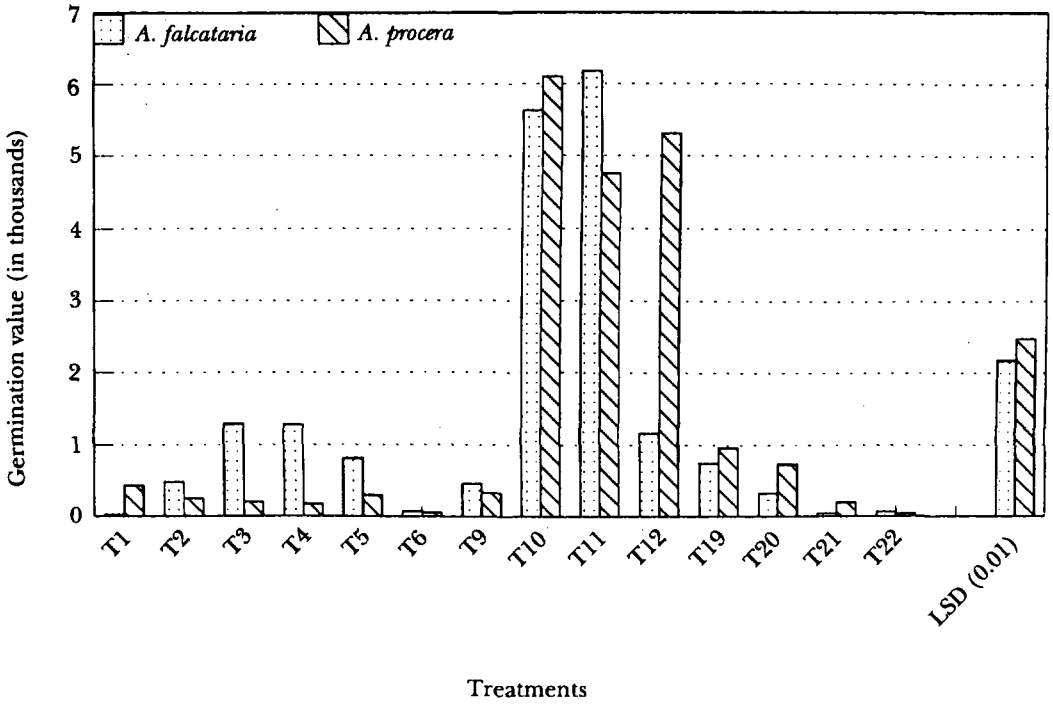

Figure 3. Effect of pre-treatments and seedcoat extracts on germination value of *Albizia falcataria* and *A. procera* seeds

Discussion

The poor germination of seeds of *Albizia* spp. has been attributed to two reasons. One is the slow imbibition caused by the thick impermeable seedcoat (Jones 1963, Hendry & Staden 1982, Khan & Tripathi 1987, Sniezko & Gwaze 1987), the other is the presence of a micropylar plug (Dell 1980). Differential germination responses were observed for the various treatments in this study. Acid scarification using H_2SO_4 resulted in highest germination percentage in both species. The ability of the acid to break the exogenous dormancy in several tree seeds including that of some *Albizia* species has been documented (Hatano & Asakawa 1964, Babeley *et al.* 1986, Rai *et al.* 1986, Sur *et al.* 1987). Acid scarification has been reported to disintegrate the seedcoat material or micropylar plug in *Cassia fistula* seeds (Bhattacharya & Saha 1990). The advantage of H_2SO_4 scarification in *A. procera* seeds has been observed for the first time in this study.

Hot water treatments of 40, 60, 70 and 80°C significantly increased germination only in *A. falcataria.* Similar results have been obtained by several workers (Bowen & Eusebio 1981, Koffa 1983, Diangana 1985). This may be attributed to the discharge of micropylar plug during wet heat (Dell 1980). Hot water treatment at 40 and 100°C resulted in significantly lower germination

percentage compared to other temperature treatments. The temperature of 40 °C may be insufficient to break the impermeability of the seedcoat as evidenced by poor imbibition. On the other hand, imbibition was almost complete at 60 °C and higher temperatures. Boiling water treatment was too severe as evidenced by very poor germination. Poor germination response due to boiling water treatment may be due to the sensitivity of the embryo to higher temperatures (Kandya 1990).

Complete removal of the seedcoat (T11) or soaking the nicked seeds in flowing water (T10) was the most promising method of seed treatment. Soaking the nicked seeds in still water (T9) failed to improve germination despite unhindered imbibition. These results lead us to suspect the presence of some water soluble inhibitor in the seedcoat. Nicked seeds when placed in the seedcoat extract of either species (T15 and T16) and soaking nicked seeds in seedcoat extracts followed by complete removal of the seedcoat (T17 and T18) also failed to give any germination. Soaking nicked seeds in flowing water initiated germination within 24 h as evidenced by the emergence of radicle. When these seeds were soaked for 1 h in seedcoat extracts (T19 and T20), the subsequent germination sequence was significantly arrested. The germination percentage and speed of germination as indicated by GV obtained due to *A. falcataria* seedcoat extract treatment (T20) was lower than that of *A. procera* seedcoat extract treatment (T19). This may be due to the greater inhibiting action or greater amount of inhibitor in the seedcoat of *A. falcataria*.

These results demonstrate that seedcoat dormancy in *A. falcataria* and *A. procera* is determined not only by the impermeability of the seedcoat, but also by the presence of a water-soluble inhibitor in the seedcoat. The inhibitory effect of the seedcoat extracts of both these species on the germination of cowpea seeds corroborates this view. Fairlamb and Davidson (1976) found that an aqueous extract from *Tectona grandis* fruits inhibited germination of cress seed. Similar results have been reported in the case of *Pinus pinea* (Martinez-Honduvilla & Santos-Ruiz 1978) and *Terminalia ivorensis* (Brookman-Amissah 1976). Significantly higher germination percentage was observed in the case of soaking nicked seeds in flowing water (T10) compared to soaking intact seeds in flowing water (T21) or nursery bed sowing (T22). This suggests that the inhibitor is present inside the seedcoat and when the seedcoat was nicked and soaked in flowing water, the inhibitor present in the seedcoat might have been washed away whereas, in intact seeds the inhibitor might have remained in the seedcoat even after soaking so as to inhibit the germination.

Seedcoat extract of *A. falcataria* (T24) resulted in complete inhibition of germination of cowpea seeds whereas that of *A. procera* (T25) reduced the germination percentage only. This again demonstrates the greater inhibiting action or greater amount of inhibitor in the seedcoat of *A. falcataria*. Conc. H_2SO_4 acid scarification (T12) significantly improved the germination percentage and speed of germination in *A. procera*, but could not improve the speed of germination in *A. falcataria*. Moreover, soaking the nicked seeds in flowing water and further soaking in seedcoat extracts also shows that seedcoat extract of *A. falcataria* (T20) reduced all the germination parameters compared to seedcoat extract of *A. procera*

(T19). Significant difference in germination observed between species in field nursery sowing (T22), H_2SO_4 scarification (T12), hot water treatment (T2 to T6) and the seedcoat extract treatment (T19, T20, T24 and T25) indicates that the nature and/or the quantity of the inhibitors present in these two species are different; *A. procera* seedcoat has much less of the inhibitor or this inhibitor is not completely soluble in cold water. Further studies are needed to confirm this.

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References

BABELEY, G. S., GAUTAM, S. P. & KANDYA, A.K. 1986. Pre-treatment of *Albizia lebeck* (Benth.) seeds to obtain better germination and vigour. *Journal of Tropical Forestry* 2 : 105 - 113.

BHATTACHARYA, A. & SAHA, P.K. 1990. Ultrastructure of seedcoat and water uptake pattern of seeds during germination in *Cassia* spp. *Seed Science and Technology* 18 : 97 - 103.

BONNER, F.T., McLEMORE, B.F. & BARNETT, J. P. 1974. Pre-sowing treatment of seed to speed germination. Pp. 126 - 135 in *Seeds of Woody Plants in the United States.* Agriculture Handbook No. 450. Forest Service, United States Department of Agriculture, Washington, D.C.

BOWEN M. R. & EUSEBIO, T.V. 1981. *Albizia falcataria. Information on Seed Collection, Handling and Germination Testing.* Occasional Technical and Scientific Notes, Seed Series No. 4, Forest Research Centre, Sabah.

BROOKMAN-AMISSAH, J. 1976. Coumarin-like substance in the fruit of *Terminalia ivorensis* A. Chev. inhibits its germination. Pp. 33 - 46 in *Proceedings of the Second International Symposium on Physiology of Seed Germination.* International Union of Forestry Research Organisations, Fuji, Japan.

CLEMENS, J., JONES, P.G. & GILBERT, N.H. 1977. Effect of seed treatments on germination in *Acacia. Australian Journal of Botany* 25 : 269 - 276.

CZABATOR, F.J. 1962. Germination value: an index combining speed and completeness of pine seed germination. *Forest Science* 8 : 386 - 396.

DELL, B. 1980. Structure and function of the strophiolar plug in seeds of *Albizia lophantha. American Journal of Botany* 4 : 556 - 563.

DIANGANA, D. 1985. Treatment to accelerate germination of *Acacia mangium, Albizia falcataria, Calliandra calothyrsus* and *Leucaena leucocephala. Nitrogen Fixing Trees Research Report* 3 : 2 - 3.

FAIRLAMB, J. & DAVIDSON, J. 1976. Germination of teak seed - preliminary evidence of a chemical germination inhibitor. Pp. 73 - 80 in *Proceedings of the Second International Symposium on Physiology of Seed Germination.* International Union of Forestry Research Organisations, Fuji, Japan.

GOGUE, G.J. & EMINO, E.R. 1979. Seedcoat scarification of *Albizia julibrissin* (Durazz.) by natural mechanisms. *Journal of American Society of Horticultural Science* 104 : 421 - 423.

HALOS, S.C. & FABIAN, V.I. Jr. 1981. A quick, simple method of improving the germination of stored *Albizia procera* (Roxb.) (Benth.). *Sylvatrop* 6 : 85 - 90.

HATANO, K. & ASAKAWA, S. 1964. Physiological processes in forest tree seeds during maturation, storage and germination. Pp. 279 - 232 in Romberger, J. A. & Mikola, P. (Eds.) *International Review of Forest Research* . Academic Press, New York.

HENDRY, N.S. & STADEN, J. VAN. 1982. Seed germination and the potential for control of *Acacia mearnsii* as a weed. *South African Journal of Science* 78 : 206 - 207.

INTERNATIONAL SEED TESTING ASSOCIATION (ISTA). 1985. International rules for seed testing - annexes 1985. *Seed Science and Technology* 13 : 356 - 513.

JONES, R. M. 1963. Studies in the autecology of the Australian *Acacias* in South Africa. IV. Preliminary studies of germination of seed of *Acacia cyclops* and *Acacia cyanophylla*. *South African Journal of Science* 59 : 296 - 298.

KANDYA, S. 1990. Enhancing germination in *Cassia siamea* seeds. *Journal of Tropical Forestry* 6 : 28 - 35.

KEMP, R.H. 1975. Seed pre-treatment and principles of nursery handling. In *Report on FAO/DANIDA Training Course on Forest Seed Collection and Handling.* Volume 2. Food and Agriculture Organisation, Rome.

KHAN, M.L. & TRIPATHI, R.S. 1987. Ecology of forest trees of Meghalaya: seed germination and survival and growth of *Albizia lebbeck* seedlings in nature. *Indian Journal of Forestry* 10 : 38 - 43.

KOFFA, S. N. 1983. Temperature: its effect on the pre-germination of *Albizia falcataria*. *Canopy International* 9 : 5.

KUMAR, P. & PURKAYASTHA, B. K. 1972. Note on germination of the seeds of lac hosts. *Indian Journal of Agricultural Science* 42 : 430 - 431.

MARTINEZ-HONDUVILLA, C.J. & SANTOS-RUIZ, A. 1978. Germination inhibitors in the pine seedcoat. *Planta* 141 : 141 - 144.

MSANGA, H.P. & MAGHEMBE, J.A. 1986. Effect of hot water and chemical treatments on the germination of *Albizia schimperana* seed. *Forest Ecology and Management* 17: 137 - 140.

RAI, S.N. 1978. Pre-treatment of seeds of *Albizia falcata, Albizia chinensis* and *Albizia richardiana*. *Myforest* 14 : 241 - 245.

RAI, S. N., NAGAVENI, H. C. & PADMANABHA, H. S. A. 1986. Germination and viability of some tree seeds. *Van Vigyan* 24 : 8 - 12.

SANDIFORD, M. 1988. Burnt offerings: an evaluation of the hot wire seed scarifier. *Commonwealth Forestry Review* 67 : 285 - 292.

SNIEZKO, R. A., & GWAZE, D.P. 1987. Effect of seed treatments on germination of *Acacia albida* (Del.). Pp. 325 - 333 in Kamra, S.K. & Ayling, R.D. (Eds.) *Proceedings of the International Symposium on Forest Seed Problems in Africa.* Harare, Zimbawe, Aug. 23 - Sept. 2, 1987. Department of Forest Genetics and Plant Physiology, Swedish University of Agrcultural Sciences, S-90183, Umea, Sweden.

SUR, K., LAHIRI, A. K. & BASU, R. N. 1987. Improvement of germinability of some forest tree seeds by acid scarification and hydration dehydration treatments. *Indian Agriculturist* 31 : 115 - 122.

TROUP, R. S. 1921. *The Silviculture of Indian Trees.* Volume 2. International Book Distributors, Dehra Dun : 466 - 484.

VALENCIA, A. R. 1973. *Germination of Moluccan sau (Albizia falcata) Seeds Soaked in Hot Water.* Occasional Paper 50, Bureau of Forestry, Philippines.