

Enhancing Germination of four Australian *Acacia* Species through Seed Treatments Overcoming Coat-Imposed Dormancy

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1 Introduction

Rising desertification rates, population increases, and fuel and fodder shortages are major factors driving the need for propagation and dissemination of highly tolerant and beneficial trees and shrubs. A prominent source of potential fuelwood and foliage species is the genus *Acacia*, since it embodies many desired attributes (DORAN *et al.*, 1983) and is thus the focal point of afforestation projects. The species under consideration are widely distributed in the sand dunes and drylands of Australia (HALL, 1972), where they are used for fencing, the manufacture of ornamental items, and as a source of forage (HUXLEY *et al.*, 1992). They are drought tolerant, thus making them of special importance to arid and semi-arid areas of the tropics and subtropics (FAO, 1983). However, the seed coat of most *Acacia* species is impermeable to water and oxygen (KHASA, 1993) and those of *A. aneura*, *A. farnesiana*, *A. saligna* and *A. victoriae* are no exception; natural seed germination may require months or years (ACOBA, 1987). Therefore, for successful seed germination in the nursery, it is necessary to apply some form of pre-sowing treatment to ensure not only a high final germination percentage, but also a rapid and uniform germination pattern. Sur *et al.* (1987) reported enhanced germination in seeds of *A. auriculiformis* and *A. nilotica* after acid scarification with H_2SO_4 for 30 minutes, whereas ACOBA (1987) found that nicking the seed coat or immersion in hot water gave superior results in regard to germination.

HARTMANN *et al.* (1990) also recommended scarification and soaking treatments for *A. cyanophylla*, and *A. koa*. Jerlin and Vadivelu (1994) used sand scarification to treat *A. mellifera* seeds and obtained germination percentages three times higher than untreated seeds. The effect of seed treatments on the species *A. aneura*, *A. farnesiana*, *A. saligna* and *A. victoriae* have not been well documented and vegetative propagation of the species is not efficient enough to replace the use of seeds (OMARI, 1992). This paper describes seed treatment methods to maximize germination percentage and speed of the mentioned species under four incubation temperatures.

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2 Materials and Methods

Seeds of *A. aneura* F. Muell of Wedge Yuendumu (Australian Northern Territory), *A. farnesiana* L. Will. of Dier Alla (Jordan Valley), *A. saligna* Lindl. of the Kamalia district (Salt Province, Jordan) and *A. victoriae* Benth. of Nitadowns (Western Australia) were obtained from the Australian Tree Seed Centre and the Jordanian Forest Seed Centre, for Australian and Jordanian accessions, respectively. Seed characteristics are shown in Table 1.

Table 1. Seed lot characteristics of *A. aneura*, *A. farnesiana*, *A. saligna* and *A. victoriae*

Species	Seed Coat/Embryo Ratio	No. of Seeds/ Kg	Viability (%) (Tetrazolium Test)
<i>A. aneura</i>	4.0	50000	88.3
<i>A. farnesiana</i>	20.0	9090	90.0
<i>A. saligna</i>	3.0	58800	86.7
<i>A. victoriae</i>	4.2	5560	88.4

Seeds were subjected to the following treatments: Soaking in tap water (EC 0.7 mmho cm⁻¹, pH 6.8) for 24 hours (hereafter termed W), acid scarification by soaking in concentrated (98%) sulphuric acid (H₂SO₄) for 40 minutes (A), acid scarification followed by soaking in tap water for 24 hours (A-W), acid scarification followed by soaking in hot (100°C) water (off the heat source) up to cooling down (to 25°C; aprox. 3 hours) (A-HW), or soaking in hot water up to cooling down (HW). Untreated seeds formed the dry control (DC). All seeds were surface dried at 25°C for 4 hours before being sown.

The experiment was arranged within the framework of a randomized complete block design, and the experimental units arranged in a split-split block design. Species were used as the main plots, treatments as subplots and temperatures as sub-sub plots. Seeds were sown in polythene trays between pleated filter paper at a rate of 100 seeds/tray. Each treatment was replicated four times for each species at each temperature regime. Seeds were incubated at one of four temperature regimes, namely 15, 20, 25 or 30°C in the dark.

Germination assessment was made daily for a two month period. Germinating seeds were recorded and removed. Seeds were considered as germinated when approximately 3 mm of the radicle and cotyledons had emerged followed by further development of shoots and roots. Non-germinating seeds were left in trays till termination of the experiment to be assessed for viability, while seedlings were classified as normal and abnormal (ISTA, 1993). Data were exposed to an analysis of variance (ANOVA) procedure. Mean separation was conducted using Duncan's Multiple Range Test ($p \leq 0.05$) applied through the SAS® statistical package (SAS, 1991).

A separate lot of seeds was treated in the same manner as above, surface dried and exposed to a deformation test. The deformation test was carried out using a universal testing machine equipped with a hydraulic pressure system and a digital load meter unit. Individual seeds were placed on a 4 kg steel cylinder 10 cm in height and 5 cm in diameter with a cylindrical cap applying pressure from the top. The load meter would take a reading at the first occurrence of deformation of the seed, thus showing seed-coat resistance to cracking; a measure of seed-hardiness. Tests were applied to ten separate seeds for each treatment combination and the mean was taken. Data for the deformation test were not statistically analyzed due to lack of replication.

3 Results and Discussion

The soaking of *Acacia* seeds in any one of the five solution combinations significantly increased their percentage of final germination (Fig. 1). Pooled over all four species and four temperature regimes, dry, untreated seeds germinated at a mere 5.7 %. By soaking in sulphuric acid (A), this rate rose to 65.6 %. A-treated seeds gave the highest germination percentages followed by A-W, A-HW and HW (Fig. 1). The time needed to initiate and end germination, on the other hand, was not clearly improved by seed treatment, nor was the mean germination time (Fig. 2), since untreated seeds had similar germination rates as treated counterparts.

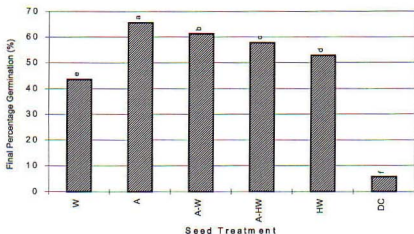


Fig. 1: Effect of seed treatments pooled over species and incubation temperatures on the final percentage of germination of *Acacia* seeds (W: Water, A: Acid, A-W: Acid + Water, A-HW: Acid + Hot Water, HW: Hot Water, DC: Dry Control). Bars with the same letters are not significantly different according to Duncan's Multiple Range Test (5% probability)

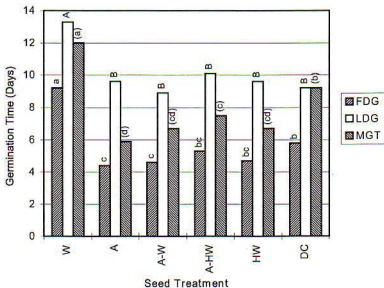


Fig. 2: Effect of seed treatments on the first day of germination (FDG), last day of germination (LDG) and mean germination time (MGT) of four *Acacia* species. Bars in the same category (small-lettered, capital-lettered or with letters in parentheses) with the same letter are not significantly different according to Duncan's Multiple Range Test (5% probability)

Interactive analysis of seed treatment and species confirmed the results of pooled effects: A-treated seeds gave the highest germination percentages reaching values of 90% compared to percentages lower than 35% for untreated seeds of *A. aneura* and *A. farnesiana* (Fig. 3). A difference in the response to treatments also appeared between species. *A. aneura* and *A. farnesiana* responded more positively to A-treatments than *A. saligna* and *A. victoriae* in terms of the final germination they attained. *A. saligna* also responded well to AW and HW treatments. This was not reflected in the mean germination time, where treatments did not improve this parameter except in the case of *A. victoriae* (Fig. 4).

The effect of incubation temperatures on the germination percentage of the four species is shown in Fig. 5. The 20°C regime appeared to be the most favorable for *A. aneura*, *A. saligna* and *A. victoriae*. *A. farnesiana*, on the other hand, responded to rises in temperature by reducing the final germination percentage. It exhibited a stepwise reaction to temperature with germination percentages of 65.0, 47.5, 36.6 and 26.6% under temperatures of 15, 20, 25 and 30°C, respectively (Fig. 5). The fastest germination (lowest mean germination time) was achieved in *A. farnesiana* at 20°C, however (Fig. 6). From Fig. 6 it can also be seen that species varied in their speed of germination.

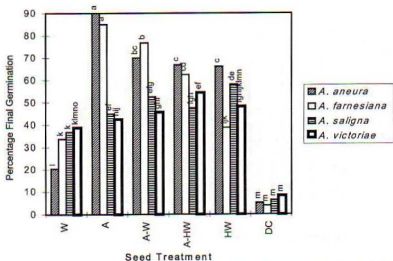


Fig. 3: Interactive effects of seed treatment and species on the percentage of final germination of *Acacia* (W: Water, A: Acid, A-W: Acid + Water, A-HW: Acid + Hot Water, HW: Hot Water, DC: Dry Control). Bars with the same letters are not significantly different according to Duncan's Multiple Range Test (5% probability)

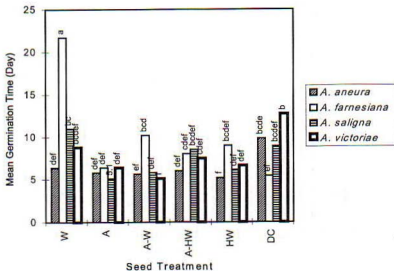


Fig. 4: Interactive effects of seed treatment and species on the mean germination time of *Acacia*. Bars with the same letters are not significantly different according to Duncan's Multiple Range Test (5% probability)

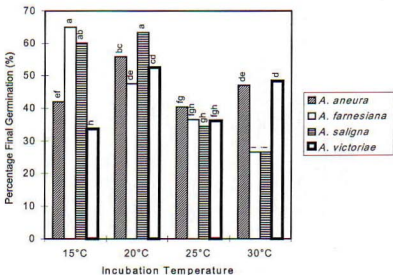


Fig. 5: Interactive effects of incubation temperature and species on the percentage of final germination of *Acacia*. Bars with the same letters are not significantly different according to Duncan's Multiple Range Test (5% probability)

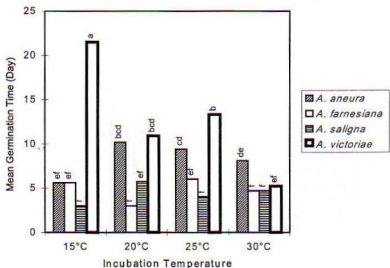


Fig. 6: Interactive effects of incubation temperature and species on the mean germination time of *Acacia*. Bars with the same letters are not significantly different according to Duncan's Multiple Range Test (5% probability)

A. victoriae took a longer time to germinate than the other species. This is also confirmed by comparing DC seeds in Fig. 4. Otherwise, 20°C was better than 15°C for *A. aneura* and *A. saligna* in respect to the MGT. *A. farnesiana* did not show a clear response to temperature reacting positively to 15 and 25°C by reducing the MGT, but not to 20 and 30°C.

From these results it may be possible to draw a number of conclusions regarding the seed treatment of the four species. First, it is clear that all five soaking and scarification treatments positively influenced seed germination percentages. A water soak after scarification, be it cold or hot, seems not to advance this effect further since A-W and A-HW treatments gave higher germination than DC but not higher than A-treated seeds when pooled over species and temperatures (Fig. 1). This implies that acid scarification alone is effective in breaking seed-coat-imposed dormancy of the four species. We speculate that acid scarification caused a wearing-off of the seed coat resulting in embryo accessibility to water and oxygen, both of which are essential to germination (BEWLEY AND BLACK, 1978). Hartmann *et al* (1990) have recommended scarification and soaking treatments for *A. synophylla* and *A. koa*. They explained the need for such treatments on the basis of seed-coat weathering. While Palma *et al.* (1995) explained increased germination of acid-treated *A. senegal* seeds through a rise in water imbibition rates. Indeed, the fracture force deformation test, in spite of its non-statistical nature, showed that the weakest seed coats existed in A-treated seeds and the strongest in DCs (Fig. 7). Also, differences between species were detected *A. saligna* generally having weaker seed coats and *A. farnesiana* tougher ones in comparison to the other two species as seen from Fig. 7. This may have had something to do with the corresponding seed coat/embryo ratio or the 1000 seed weight of the species (Table 1). *A. farnesiana* had a ratio of 20 compared to 3 for *A. saligna*. This implies a larger fraction of the seed is composed of coat in the former, an attribute raising seed-hardiness.

Water soaking may also cause dilution and/or leaching of chemical inhibitors within the seed coat of a number of *Acacia* species including *A. lasiocarpon*, *A. drummondii* and *A. lateriticola* (MURRAY *et al.*, 1983). The species *A. aneura* and *A. farnesiana* seem not to follow the same line of effects since water soaking following scarification did not advance germination further than acid scarification alone. The presence of inhibitors in the seed coats of *A. saligna* and *A. victoriae* may not be ruled out, however, due to positive effects of water soaking after acid treatment. This may imply that the coat forms a mechanical and/or chemical restriction to germination in these species.

That 20°C was more advantageous to germination of *A. aneura*, *A. saligna* and *A. victoriae* may reflect the habitat of these three species. *A. aneura* and *A. saligna* seeds originate from areas with an annual air temperature of 22.6 and 20.0°C, respectively. *A. victoriae* came from a 21.0°C region, while *A. farnesiana* had an annual temperature region of 17.5°C (personal communication, Australian and Jordanian Tree and Forest Seed Centres, respectively). This is probably why *A. farnesiana* responded to increases in temperature by reducing germination, since optimum germination temperature usu-

ally reflects the plant's temperature cycle within its natural habitat (EL-SHEIKH, 1984). Otherwise, and in contrast to our results, temperature elevations between 10 and 25°C have been found to have positive effects on *Acacia* species such as *A. cyclops* and *A. albida* (Fox, 1985). Our data is in line with the work of Abulfatih (1995) who attributed differences in *Acacia* seed response to temperature to variation in location.

The evidence from the results presented herein suggest that soaking seeds of *A. aneura*, *A. farnesiana*, *A. saligna* and *A. victoriae* in concentrated sulphuric acid for 40 minutes greatly improves the final germination of seeds. It does not speed up the germination process, however. Seeds should be sown at 20°C for *A. aneura*, *A. saligna* and *A. victoriae*, and at 15°C for *A. farnesiana*. From a practical standpoint this may help nurseries to propagate and distribute seedlings with less seed loss and higher success rates. This is especially desirable due to the fact that seed is usually tediously collected by hand.

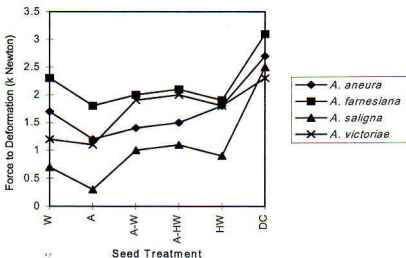


Fig. 7: Interactive effects of seed treatment and species on the force needed to deform seed coats of *Acacia* (W: Water, A: Acid, A-W: Acid + Water, A-HW: Acid + Hot Water, HW: Hot Water, DC: Dry Control) (data not statistically analysed)

4 Summary

Germination of the *Acacia* species *A. aneura*, *A. farnesiana*, *A. saligna* and *A. victoriae* is usually low due to impermeable seed coats causing dormancy. Propagation and distribution of the species for afforestation and reforestation projects requires higher germination and establishment rates. A number of pre-sowing seed treatments were examined

with the goal of breaking seed-coat-imposed dormancy. Both concentrated sulphuric acid (H_2SO_4) and water treatments were applied to *Acacia* seeds in various combinations at 15, 20, 25 or 30°C. Results revealed that soaking seeds in concentrated H_2SO_4 or in water significantly increased germination percentage of treated seeds. Response to temperature followed a line reflecting habitat annual temperature for the four species. It is concluded that H_2SO_4 or water may be used to treat seeds of the four species to improve germination percentages.

Verbesserung der Keimung von vier australischen *Acacia* Arten durch keimruhebrechende Saatgutbehandlungen

Zusammenfassung

Die geringe Keimung der *Acacia* Arten *A. aneura*, *A. farnesiana*, *A. saligna* und *A. victoriae* wird hauptsächlich durch die Impermeabilität der Samenschale verursacht. Für die Vermehrung dieser Bäume für Aufforstungsprojekte ist von daher eine höhere Keimungsrate notwendig. Mit dem Ziel, die Keimruhe zu durchbrechen, wurden in diesem Versuch verschiedene Saatgutbehandlungen getestet. Die Samen wurden sowohl mit Wasser als auch mit H_2SO_4 behandelt. Während die Geschwindigkeit der Keimung nicht von der Behandlung beeinflusst wurde, reagierten die verschiedenen Arten je nach Habitat, unterschiedlich auf die Temperatur.

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