

# Effects of Soil Type and Different Pre-sowing Treatments on Seedling Emergence and Vigour of *Acacia sieberana*

Innocent Pahla<sup>1,\*</sup>, Tavagwisa Muziri<sup>1</sup>, Tiniel Chinyise<sup>1</sup>, Simbarashe Muzemu<sup>1</sup>, James Chitamba<sup>2</sup>

<sup>1</sup>Department of Horticulture, Faculty of Natural Resources Management and Agriculture, Midlands State University, P. Bag 9055, Gweru, Zimbabwe

<sup>2</sup>Department of Agronomy, Faculty of Natural Resources Management and Agriculture, Midlands State University, P. Bag 9055, Gweru, Zimbabwe

**Abstract** An experiment was carried out at Midlands State University to determine the effect of soil type and different seed treatments on seed emergence and seedling vigour of *Acacia sieberana*. The experiment was arranged as a 2×5 factorial treatment structure laid out in a completely randomized design with three replications. Soil type had two levels (sand and clay) while seed treatments had five levels (98% H<sub>2</sub>SO<sub>4</sub> for 60 minutes, 98% H<sub>2</sub>SO<sub>4</sub> for 90 minutes, hot water only, hot and cold water, and straight sowing (control)). Results showed that soil type and seed treatment significantly affected seed emergence ( $p<0.05$ ) of *A. sieberana*. Seeds subjected to 98% H<sub>2</sub>SO<sub>4</sub> for 60 minutes and then sown in sand soil gave the highest emergence percentage of 80%, followed by those that were hot water treated and sown in sand soil with 53%. Soil type and seed treatment significantly affected days to emergence ( $p<0.05$ ) of the *A. sieberana*. Seeds treated with 98% H<sub>2</sub>SO<sub>4</sub> for 60 minutes and then sown in sand soil had the shortest period to emergence (6 days). Straight sown seeds recorded the longest time to emergence (18 days). It was concluded that subjecting seeds to 98% H<sub>2</sub>SO<sub>4</sub> for 60 minutes and sowing them in sandy soils can improve emergence percentage and also reduce time taken to emergence of *A. sieberana* seeds.

**Keywords** *Acacia sieberana*, Soil Type, Seed Pre-treatment, Germination, Emergence

## 1. Introduction

*Acacia sieberana* is an important tree species for social forestry and agroforestry program due to its rapid growth and capability of nitrogen fixation. The genus *Acacia* has more than 500 species found throughout the world, with most being native to Australia. However, some of the most attractive of these trees and shrubs are native both to Zimbabwe and South Africa [1]. There are several species within this genus of *acacia* and these include *Acacia albida*; *A. galpinii*; *A. polyacantha*; *Acacia karoo*; *Acacia nitotica*; *Acacia tortilis* and *A. sieberana*. *A. sieberana* is flat topped and can grow up to 9 m high with a spread of approximately 15 m.

*A. sieberana* pods and leaves can be used to feed livestock and game; stem and branches as bush fencing. The tree also has some aesthetic and practical value as shade around homesteads as well as the bark having some medicinal properties [1]. The fact that *A. sieberana* is deciduous means that it can bring different forms and impacts in the garden during the different seasons in the year. Van Vyck *et al.* [2] noted that a leafless tree is best able

to express its form. The tree casts a dappled shade which permits a lawn to grow beneath the canopy and also tolerates drought. Moreover, the tree has some soil improving properties and can live up to 100 years, can coppice easily, thus making it a suitable landscape plant for degraded environments [3].

However, all species of *acacia* are propagated from a seed with an extremely hard seed coat, which under natural conditions would take a long time to germinate [4]. The factors which affect the germination of *Acacia* species in a given micro-environment are soil type, seed dormancy and water availability [5, 6]. Substantial reduction in seed germination has been shown in many species [7]. The situation is exacerbated by the fact that seeds are the only means of propagation of *Acacia* species [8] hence seed dormancy could present a serious problem for seed germination of *A. sieberana* thereby affecting establishment of this agroforestry tree species.

Germination of *A. sieberana* is very poor as the seeds are dormant hence they will not germinate promptly when subjected to conditions which are normally regarded as suitable for germination. Therefore, the seeds must be artificially subjected to some physical and chemical pre-sowing treatment so as to cope up with dormancy and obtain uniform, rapid and synchronous germination [9, 10]. External stimuli to promote seed coat rupture of hard seeded species like *A. sieberana* is thus required [11].

\* Corresponding author:

ipahla2008@gmail.com (Innocent Pahla)

Published online at <http://journal.sapub.org/plant>

Copyright © 2014 Scientific & Academic Publishing. All Rights Reserved

The fact that *A. sieberana* is propagated from a hard coated seed reduces the scope of its use as a landscape plant. This is in spite of the fact that the tree is capable of providing obvious aesthetic and ornamental values in the landscape environment. However, the most limiting factor to its use in landscapes is its lack of readiness to germinate. Yet, problems of low germination rates for several tropical agroforestry tree species are still caused by dormancy, partly because of lack of general knowledge of their seed physiology, and partly because of variation in dormancy rate [12]. The effect of different pre-treatment methods on seed germination of some tree species has been reported [10, 13, 14]. However, there are few publications on the effect of different soil types and pre-sowing treatment of *A. sieberana* hence intensive plantation of the crop in Agroforestry and home garden is restricted due to poor seed germination and delayed initial establishment in the nursery [13, 15].

Therefore, the main objective of the present study was to determine the best possible soil type and pre-sowing treatment method that maximizes the seed germination and initial seedling growth of *A. sieberana* in the nursery.

## 2. Materials and Methods

The experiment was carried at the Midlands State University, which is located in the Midlands Province in Zimbabwe, the area is in agro-ecological region III. It is at an altitude of 1428 m, latitude of 19°E and longitude of 29°85'. The area receives an average annual rainfall of between 550 and 600 mm. Its mean temperature is 22°C.

The experiment was carried out as a 2×5 factorial experiment laid in a completely randomized design (CRD). The experiment had two factors, soil type with two levels (clay and sand) and seed treatment with five levels (98% H<sub>2</sub>SO<sub>4</sub> for 60 minutes (HSC1), 98% H<sub>2</sub>SO<sub>4</sub> for 90 minutes (HSC2), hot water only (HT), hot and cold water (HC), and straight sowing (SS) (control)).

Thirty seeds were placed in 98% H<sub>2</sub>SO<sub>4</sub> for 60 minutes and another Thirty for 90 minutes and then washed repeatedly and thoroughly in cold water.

For the hot water treatment, thirty seeds were put in hot water, left in the water till the water cooled down. For the hot and cold water treatment, thirty seeds were placed briefly (2 minutes) in hot water, and then transferred immediately into cold water. After being subjected to treatments the seeds (including the direct sowing were further soaked in cold water for 30 minutes, after that the water was drained and seeds were allowed to dry for 60 minutes.

Black polythene bags that were 10 cm wide by 25 cm long were filled with equal amounts of growing medium, that is, sand and red clay. Fifteen polythene bags were used for each soil type; equal amount of soil was applied in the bags after which planting holes of 2 cm deep were made. Ten seeds (subjected to treatments) were sown in each polythene bag and covered with soil. Watering was done to field capacity to

initiate germination and this was done on the same day for all treatments.

The number of days taken to 30 % germination was noted. The germination percentage was determined after 14 days from planting day. It was determined using the following formula:

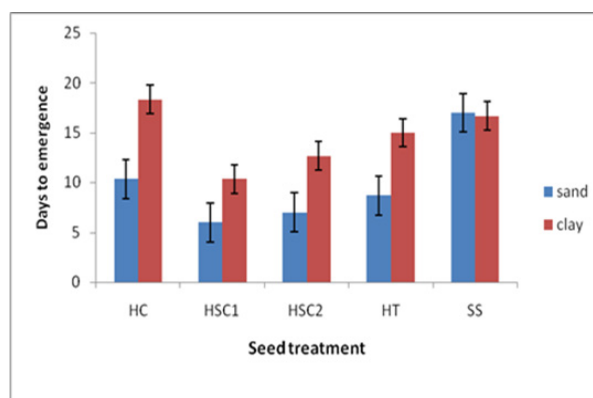
$$\text{Emergence \%} = \frac{\text{Number of seeds emerged}}{\text{Total number of seeds sown}} \times 100$$

Height of seedlings was measured at 21 days after emergence of the first seedling.

The data was subjected to analysis of variance using GenStat statistical package version 7.22 and the least significant difference (LSD) was used for separation of treatment means at 5% significance level.

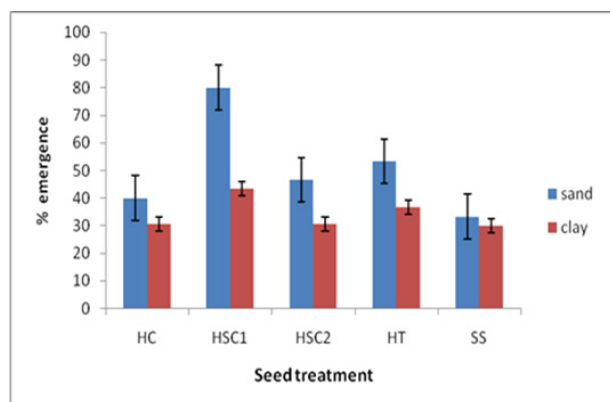
## 3. Results

There was a significant interaction ( $p < 0.05$ ) between soil type and seed treatment on the number of days to 30% germination. Seeds that had been exposed to H<sub>2</sub>SO<sub>4</sub> for 60 minutes and planted in sand soil took 6 days to emerge, whilst seeds exposed to hot and cold water treatment and planted in clay soil took the longest time to emerge (18 days) (Figure 1). Seeds that were treated with hot/cold water, hot water, 98% H<sub>2</sub>SO<sub>4</sub> for 60 minutes and 98% H<sub>2</sub>SO<sub>4</sub> for 90 minutes and planted in sand soil recorded lower number of days to emergence compared to the seeds exposed to the same treatments but planted in a clay soil (Figure 1).



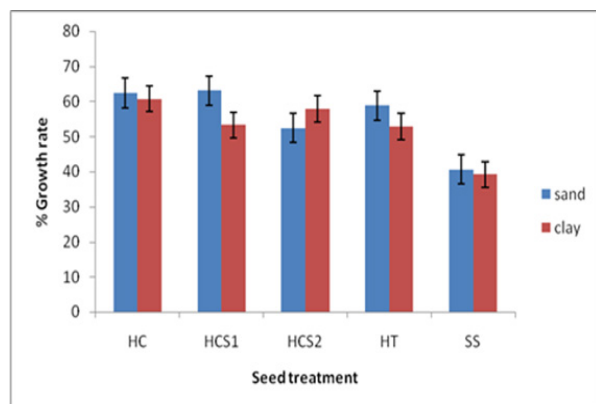
**Figure 1.** Effect of soil type and pre-sowing seed treatment on days to 30% seedling emergence

There was a significant interaction between soil type and seed treatment ( $p < 0.05$ ) on the emergence percentage of the *A. sieberana* seeds that were sown in different soil types and different pre-sowing seed treatments. Seeds sown in sand soil after being treated with H<sub>2</sub>SO<sub>4</sub> for one 60 minutes had the highest emergence percentage of 80% ( $p < 0.05$ ) (Figure 2). Seeds sown in clay soil had generally the lowest emergence percentage irrespective of the treatment rendered as compared to the same treatments under a sand soil. However, seeds sown in sand and clay but receiving no pre-sowing treatment had no significant difference in their emergence percentages (Figure 2).



**Figure 2.** Effect of soil type and pre-sowing seed treatment on emergence percentage

Straight sown seeds in both soil types had a significantly reduced initial seedling growth of *A. sieberana* while those pre-treated with  $H_2SO_4$  for 60 minutes had the highest growth rate in terms of plant height (Figure 3)



**Figure 3.** Effect of soil type and seed treatment on seedling shoot height

## 4. Discussion

Soil type had a significant effect on days to emergence with the sand soil planted seeds taking the shortest time to emerge across all seed treatments as compared to clay planted seeds. This could be because of the physical and chemical characteristics of clay. Dey [16] highlighted that clay can pose a major challenge to germination and emergence due to its poor drainage, and it tends to clod easily. An ideal propagation media must be sufficiently porous so that excess water drains away, permitting adequate penetration of oxygen to the seed, of which all these attributes are lacking in clay soils. All containers used as propagation potting plants produce a perched water table that creates a zone of saturated growing medium at the bottom of the container, more so, if the soil has poor drainage like clay [17].

Seeds treated with  $H_2SO_4$  took the shortest time to emergence in both soils. However the best results were recorded where seeds were subjected to 98%  $H_2SO_4$  for 60 minutes and then sown in sand soil. Baskin [18] noted that the whole idea behind treating the seeds is to either

completely remove the germination impeding seed coat or to reduce its thickness so that the seed could emerge. Removal or reduction in thickness of the seed coat allows the seed to take up water and respiratory gases thus the germination process can be initiated. It is highly probable that treating seeds with  $H_2SO_4$  reduced the thickness of the seed coat compared to the other scarification techniques. Exposing the seeds to concentrated levels of sulphuric acid can also have a negative effect as it can end up damaging the seed, when the acid can penetrate into the seed via its exposed micropyle [19]. This could possibly explain why seeds that were exposed to 98%  $H_2SO_4$  for a longer period of 90 minutes recorded a lower emergence rate as compared to those exposed for 60 minutes in the same concentration.

Seeds sown in sand soil performed better than those sown in clay soils across all treatments. The results are similar to Okello and Young [20] who observed that *A. drepanolobium* seed germination was higher in red sandy soils than in clay loams. Sand has loosely aggregated particles that allow free exchange of gases between the germination medium and the embryo. Oxygen is essential for respiratory purposes in germinating seeds and oxygen uptake is proportional to the amount of metabolic activity taking place [17]. Sand soil is the most suitable germination medium for tropical tree seed germination due to its availability, low cost, capacity to hold moisture and suitability for large tree seeds [21].

Poorly drained soils like clay have their pore spaces filled with water so that little oxygen is available to seeds, where the amount of oxygen in the medium is affected by its low solubility in water and its ability to diffuse in the medium [22]. Landis *et al.* [23] noted that gaseous exchange between the germination medium and the atmosphere, where oxygen concentration is 20%, is reduced significantly by hard crust on the surface which can limit oxygen diffusion. This coupled with treating seeds with sulphuric acid for one hour could have aided an increase in germination percentage in seeds treated with  $H_2SO_4$  for 1 hour and then sown in sand soil, since this treatment recorded the highest percentage germination of 80%. Acid can effectively reduce the seed coat thickness, allowing the seed to take in oxygen and water through the micropyle [24]. This is consistent with Niranjana *et al.* [9] who reported that pregermination treatments like  $H_2SO_4$  will destroy the integrity of impermeable cover and so permit the imbibition of the embryo. On the other hand, because clay particles are closely packed together and remain saturated with moisture for long periods of time, they are therefore slow to warm up, thus temperatures for germination are not attainable easily.

Hot water treatment also showed a significantly high germination percentage as compared to control because it simulates the effect of veld fires on the seed where the seed coat is burnt and reduced in thickness, allowing the seed to take in oxygen and water, thus breaking its dormancy [25]. Leaving the seed soaked in water has the possibility of leaching out metabolites that inhibit germination [26]. However, the findings are inconsistent with Azad *et al.* [13]

who reported highest germination (52%) in hot water treatment in *A. lebbeck*. This may be due to the variation of seed coat thickness of the species used in the latter and the present study. Moreover, Schmidt [12] reported that hot water overcomes physical dormancy in leguminous plants like *A. sieberana* by creating tension which consequently causes cracking of the macrosclerid layer or by affecting the strophilar plug.

Soil type and seed treatment had no significant effect on the subsequent seedling height in the twenty one days of observation from planting. This could be because during this period, all the seedlings that had germinated were still drawing their nutrients from the seed endosperm, thus eliminating the effect of soil on their growth rate [26]. Moreover, all the seed treatments did not have any effect on the endosperm, thus giving a shoot height that is not significantly different from each other.

## 5. Conclusions

Basing on these research findings, it could be concluded that treating seeds with  $H_2SO_4$  for an hour and then planting them in sand soil is the most ideal pre-sowing treatment and propagation media respectively for *A. sieberana* seed. This treatment the least number of days to emergence and gave comparatively highest germination percentages. Treating seed in hot water and then planting in sand soil proved to be a competent and superb alternative propagation combination. It could be recommended that for the propagation of *A. sieberana* by seed, sand soil combined with  $H_2SO_4$  pre-sowing treatment for one hour can be used.

## ACKNOWLEDGEMENTS

The authors would like to acknowledge the management and staff of Midlands State University for provision of expertise and necessary materials/resources for the experiment to be successfully carried out.

## REFERENCES

- [1] Steyn, M. 1994. Southern African Acacias Identification Guide. Polokwane, South Africa. Page 14.
- [2] van Wyk, D, Braam, C and Piet, S. 2003. Field Guide to Trees of Southern Africa. Windhoek, Namibia Pages 222-231.
- [3] Thomas P. 2001. Trees: Their natural history. Cambridge, United Kingdom. Page 43.
- [4] Srivastava, H.S. 2004. Plant physiology and biochemistry. New Delhi, India. Pages 435-438.
- [5] Clark, D.B., D.A. Clark and P.M. Rich, 1993. Comparative analysis of microhabitat utilization by samplings of nine tree species in neotropical rain Forest. Biotropica., 25: 397-407.
- [6] Al-Khateeb, S.A., 2005. Germination response of *Acacia tortilis* to seed treatments and incubation temperatures. Alexandria Journal of Agricultural Research, 50 (1): 33-40.
- [7] Miller ME. 1995. *Acacia* seed survival, seed germination and seedling growth followed pod consumption by large herbivores and seed chewing by rodents. Afr. J. Ecol., 33: 194-210.
- [8] Ahmed, M.A.J. 2008. Effect of Bruchid beetles (*Burchidius arabicus* Decelle) infestation on the germination of *Acacia tortilis* (Forssk.) seeds. American Journal of Environmental Sciences 4 (4): 285-288, 2008.
- [9] Niranjana HG, Ramesh BHN, Rajeshwari N and Sudeer S. 2010. Effect of presowing treatments on the germination and vigour of stored accessions of *Jatropha curcas* L. collected from different places of Karnataka. Research and Reviews in Biomedicine and Biotechnology, 1(2): 94-100.
- [10] Azad MS, Manik MR, Hasan MS, Matin MA. 2011. Effect of different pre-sowing treatments on seed germination percentage and growth performance of *Acacia auriculiformis*. Journal of Forestry Research, 22(2): 183-188.
- [11] Islam AKMA, Anuar N, Yaakob Z. 2009. Effect of genotypes and pre-sowing treatments on seed germination behavior of *Jatropha*. Asian Journal of Plant Science, 8(6): 433-439.
- [12] Schmidt, L. 2000. Dormancy and pretreatment. In: Schmidt, L. 2000. Guide to Handling of Tropical and Subtropical Forest Seed. Danida Forest Seed Centre.
- [13] Azad MS, Matin MA, Islam MW, Musa ZA. 2006. Effect of pre-sowing treatment on seed germination of Lohakath (*Xylia kerrii* Craib & Hutch.). Khulna University Studies, 7(2): 33-36.
- [14] Azad MS, Musa ZA, Matin A. 2010. Effect of pre-sowing treatments on seed germination of *Melia azedarach*. Journal of Forestry Research, 21(2): 193-196.
- [15] Alamgir M, Hossain MK. 2005. Effect of pre-sowing treatments on germination and initial seedling development of *Albizia saman* in the nursery. Journal of Forestry Research, 16(3): 200-204.
- [16] Dey, S.C. 2001. Complete Home Gardening, New Delhi, India. Pages 21-9.
- [17] Hartmann, H.T., Dale, E. Kester, Fred, T. Davies, Jr and Geneve, R.L. 2007. Plant Propagation: Principles and Practices: New Delhi, India. Page 32-3.
- [18] Baskin, C. 1998. Seeds: Ecology, biogeography and evolution of dormancy and germination: New York Times Academic Press, USA. Pages 13-17.
- [19] Ellis, J.E. 1963, reprinted 2006. The influence of treating tomato seed with nutrient solution on emergence rate and seedling growth: American Society of Horticultural Science. Texas, USA. Page 6.
- [20] Okello BD and Young TP. 2000. Effects of fire, bruchid beetles and soil type on germination and seedling establishment of *Acacia drepanolobium*. African Journal of Range and Forage Science, March 2000: 46-51.
- [21] Spicer N, Barnes R and Timberlake J. 2004. *Acacia* handbook: growing and managing *Acacia* in Southern and Central Africa. CBC Publishing, Zimbabwe. Pp. 1-144.

- [22] Marshall, C and Grace J. 2008. Fruit and seed production: Aspects of development, environment, physiology and ecology: Society for Experimental Biology Seminar Series 47. Pp. 19-22.
- [23] Landis, T.D., Tinus, R.W., McDonald, S.E and Barnet, J.P. 1993. Containers and growing media: The container tree nursery manual, volume 2. Agricultural Handbook. Washington. D.C. USA. Page 33.
- [24] Iqbal, M. 1994. Growth patterns of vascular plants. Portland, Oregon State, USA. Page 13-32.
- [25] Johnson, D. 1993. Gardening with Indigenous Trees and Shrubs. Pretoria, South Africa. Pages 17-22.
- [26] Bewley, J.D and Black, M. 1994. Seeds: Physiology of development and germination. New York. USA. Pages 12-18.