

Optimizing germination: the effect of temperature and chemical scarification on *Acacia saligna* (Labill.) seeds¹

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Abstract

Seed dormancy in plants can be caused by various factors, with the seed coat (tegument) being a significant barrier, especially in species like *Acacia*. Our study aims to find the optimal conditions for germination of *Acacia saligna* seeds, where these seeds were subjected to two periods of scarification with 96% concentrated sulfuric acid plus control which make three groups (the first group control, the second group 20 min, the last group 60 min of scarification) the seeds were then divided into two groups to germinate at two different temperatures: 15°C and 25°C. Germination was followed in lab for 20 days. Then we performed measurements of germination performance parameters (germination rate, vigor index, median germination time). Our results showed that the best germination rate and speed of *Acacia saligna* seeds was seed subject chemical scarification for 60 min and germinated at 15 ° C, whereas, the seeds that managed to germinate at 25 ° C showed greater root elongation. Finally, we were able to conclude that *A. saligna* prefers coolness for germination and higher temperatures for growth.

Keywords: *Acacia saligna*, scarification, temperature, germination, tegument.

Optimisation de la germination : l'effet de la température et de la scarification chimique sur les graines d'*Acacia saligna* (Labill.)

Résumé

La dormance des graines chez les plantes peut être causée par divers facteurs, le tégument étant une barrière importante, notamment chez les espèces comme *Acacia*. Notre étude vise à déterminer les conditions optimales pour la germination des graines d'*Acacia saligna*, soumises à deux périodes de scarification avec de l'acide sulfurique concentré à 96 % et un groupe témoin sans scarification. Cela a formé trois groupes : le premier étant le groupe témoin, le deuxième groupe a subi une scarification chimique de 20 minutes et le dernier de 60 minutes. Ensuite, chaque groupe a été divisé en deux sous-groupes pour une germination à deux températures différentes : 15°C et 25°C. La germination a été suivie en laboratoire pendant 20 jours. Nous avons mesuré divers paramètres de performance germinative (taux de germination, indice de vigueur, temps médian de germination). Nos résultats montrent que les graines d'*Acacia saligna* soumises à une scarification chimique de 60 minutes ont présenté les meilleurs taux de germination à 15°C, tandis que celles qui ont germé à 25°C ont montré une plus grande elongation des racines. En conclusion, nous avons pu déterminer que *A. saligna* préfère une température plus basse pour la germination et des températures plus élevées pour la croissance.

Mots clés: *Acacia saligna*, scarification, température, germination, tégument.

¹ This research is extracted from the thesis of the lead author presented to the Graduate Program in Plant improvement, University Amar Telidji Laghouat, defended on 2020

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INTRODUCTION

Plants are often exposed to various biotic and abiotic environmental stresses. (AbuQamar et al., 2009) One such stress, seed dormancy, can be described as the blocking of germination of an intact viable seed under favorable conditions, but previous reviews have concluded that this is one of the least understood phenomena in seed biology (Hilhorst, 1995).

Dormancy and seed germination are complex adaptive traits in higher plants influenced by many genes and environmental factors (koornneef et al., 2002). Understanding these traits are particularly important for species with ecological and economic significance, such as those within the *Acacia* genus.

Globally, there are more than 1,350 species of *Acacias*. The *Acacia* is the largest genus of woody plants in Australia with nearly 1000 species currently known (Maslin 2001). The classification of this widely distributed genus is under review. *Acacia* is categorized into three main subgenera: *Acacia*, with 161 species; *Aculeiferum*, containing 235 species; and *Phyllodineae*, comprising 960 species. (Maslin et al, 2003). Many *Acacia* species possess a waterproof seed coat, which contributes to their diverse uses, including as fuelwood, paper pulp, human food, animal feed, and land rehabilitation efforts.

One notable species is *Acacia saligna*, a highly polymorphic species native to western Australia (Maslin,1974), it plays a critical role

in stabilizing coastal and inland sand dunes, controlling gully erosion, and rehabilitation of mined areas (Midgley and Turnbull, 2003), currently circumscribed by four to five informal subspecies (Millar et al., 2010). Distinguished by a combination of 203 morphological differences, including the appearance of the phyllode, the shape of the inflorescence bud, the length of the racemes and the diameter, color and number of flower heads (Millar et al. 2011).

Acacia saligna holds significant social and environmental benefits due to its resistance to drought, and ability to fix nitrogen (Cunningham et al 2014) Furthermore, it offers beneficial multi-uses for fuel wood, lumber, livestock fodder, and even high-protein seeds for chickens and human consumption (Kassa et al., 2014).

Acacia saligna is widely used in reforestation and land rehabilitation efforts, but its hard seed coat poses challenges for germination, current knowledge on optimal scarification duration and temperature conditions for this species remains limited (Ghassali et al,2012) here comes the interest of this study which is to determinate the optimal conditions of germination along with its characteristics in certain temperature with and without the seed tegument obstacle of *Acacia saligna* and its value as a potential species for reforestation efforts aimed at combating desertification in arid and semi-arid regions.

MATERIAL AND METHODS

1. Seeds collection

Seeds of *Acacia saligna*, also known as Bluish *Acacia* were collected

manually by cutting pods directly from the trees that, while not overly aged, are in excellent health and good condition, in the

region of Laghouat, Algeria. The experiment was conducted at the laboratory of the Department of agronomy of Laghouat University.

2. Scarification treatments

Three groups of seeds two of them were dipped in concentrated sulfuric acid (96%) for 20 minutes and 60 minutes plus (control) non scarified. Scarification durations were selected based on the findings of Kheloufi et al (2019), which identified a range of 30 to 120 minutes of scarification duration in sulfuric acid 96% for *Acacia* species including *Acacia saligna*.

3. Disinfection and placement

Following scarification, seeds were rinsed thoroughly, soaked in distilled water for 15 minutes, and disinfected with 20% sodium hypochlorite for 30 minutes, a final rinse in distilled water preceded placement in Petri dishes lined with double layer of damp absorbent paper a total of 1200 seed of *Acacia saligna* were used 50 seeds per petri dish moistened as needed with 5ml of water.

4. Temperature

The petri dishes were divided equally between two temperature regimes: 15 C° and 25 C° (in controlled incubators), with 12 petri dishes assigned to each temperature. The choice of temperature 25C° was based on the alignment with room temperature, commonly used in germination experiments, including studies on *Acacia* species by Sánchez-Bayo and King (1994). The 15C° temperature was selected to assess the seeds' tolerance to cooler conditions. Each scarification treatment (0, 20, and 60 minutes) was replicated four times at both

temperatures. Germination was monitored daily during 20 days.

5. The parameters measured

The parameters used to assess the behavior of the seeds during germination were:

5.1. Germination rate (GR %)

After 20 days of incubation, the experiment was terminated, and the germination percentage for each petri dish was calculated. A seed was considered germinated if it developed a radicle (emergence of the germ). The germination rate was expressed as the ratio of the number of germinated seeds to the total number of seeds in each dish (Côme, 1970).

$$GR\% = \frac{\text{Number of germinated seeds}}{\text{Total numberr of seeds}} \times 100$$

5.2. Germination kinetics

Germination kinetics was analyzed by plotting the daily cumulative germination rate over the 20-day period. This was calculated based on the number of newly germinated seeds recorded during each observation (Hajlaoui et al., 2010).

5.3 Median germination duration

The median germination duration was calculated as the mean germination time representing the time required for 50% of the germinated seeds to emerge (Côme, 1970).

5.4 Seedling vigor index (SVI)

The seedling vigor index was determined using the formula proposed by to Abdul-Baki (1973):

$$(SVI) = (L_r + L_s) \times GP$$

With:

L_r : Root length (cm). L_s : Shoot length (cm). GP : Germination percentage.

5.5 Statistical analysis

Data were analyzed using Minitab 17 software. The Tukey test was applied to compare means and determine the statistical groupings. Due to the small sample size (less than 30 replicates) the Shapiro-Wilk test was used to assess normality.

RESULTS AND DISCUSSION

The germination dynamics of *Acacia saligna* seeds were significantly influenced by the concentration of sulfuric acid and the temperature treatments applied during the experiment. These factors collectively determined the germination capacity, offering insights into the optimal conditions necessary to enhance germination rates and seedling performance.

1. Germination Kinetics and Germination Rate

The analysis of germination kinetics (Figure 1) showed that non-scarified seeds did not germinate at either 15°C or 25°C the effects of different scarification durations on germination parameters are summarized in Table 1.

Table 1: Effect of scarification time on germination parameters (during 20 days)

Factor	Scarification		
	Non scarified	Scarified 1H	Scarified 20 min
GR%	0,250 ^b ± 0,707	59,5 ^a ± 35,0	17,50 ^b ± 16,27
SVI	0,006 ^c ± 0,017	2,71 ^a ± 0,53	0,525 ^b ± 0,427
Median duration	0,000 ^b ± 0,000	4,42 ^a ± 1,72	3,80 ^a ± 3,56

GR%: germination rate, **SVI:** seedling vigor index, values are means of 4 replicates of germination parameters. Letters in the same column indicate significant difference at 5% of probability.

Seeds scarified for one hour at 15°C had the best performance, reaching over 50% germination by day 4, with a final germination rate exceeding 90%. In comparison, seeds scarified for 20 minutes at 15°C had a final

germination rate of 32%, and those scarified for one hour at 25°C had a germination rate of 27%. Seeds scarified for 20 minutes at 25°C had minimal germination, below 2%

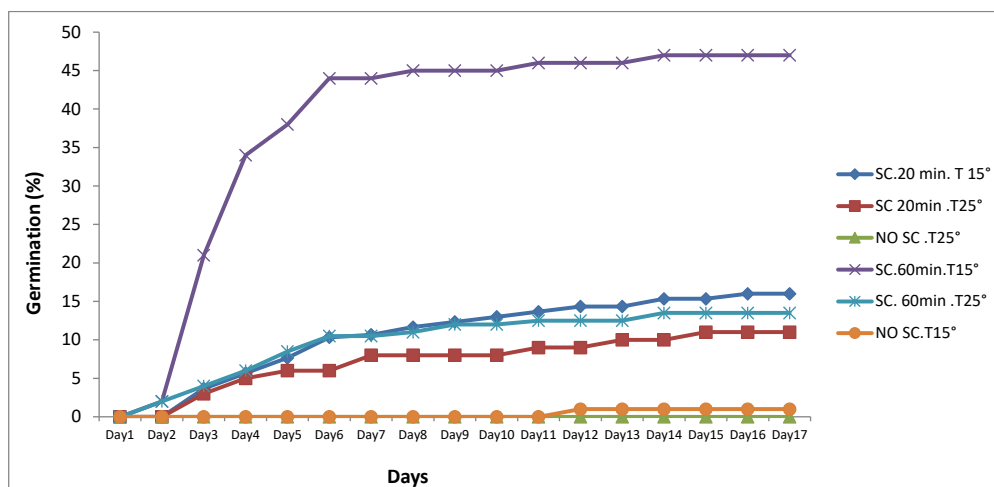


Figure 1: Germination kinetics of *Acacia saligna* seeds under different temperatures and scarification durations.

The analysis of the collected data revealed significant differences in the germination rates of *Acacia saligna* seeds, with

the optimal germination temperature at 15°C Table 2 presents the germination performance under different temperature conditions.

Table 2: Effect of Temperature time on germination parameters (during 20 days)

Factor	Temperature	
	T15C°	T25C°
GR%	41 ^a ± 39,7	9,83 ^b ± 13,11
SVI	1,021 ^a ± 0,978	1,144 ^a ± 1,531
Median duration	2,818 ^a ± 2,347	2,66 ^a ± 3,57

GR%: germination rate, **SVI:** seedling vigor index, values are means of 4 replicates of germination parameters. Letters in the same column indicate significant difference at 5% of probability.

This findings support earlier studies, such as those by Allen and Meyer (1990), who demonstrated that other spices including *Penstemon*, also achieve optimal germination at 15°C , with notable reductions at higher temperatures. These similarities suggest a broader adaption of certain species to cooler germination conditions.

Seeds that were not scarified failed to germinate at either temperature highlighting the critical role of overcoming the physical dormancy imposed by the seed coat. This observation aligns with previous reports on the

depressive effect of the seed coat in many Fabaceae species, such as *Acacia tortilis* (El-Aziz et al., 2013) and *Retama raetam* (Abdellaoui et al., 2018).

Chemical scarification with sulfuric acid proved beneficial, particularly with 60 minute duration, aligning with the findings of Kheloufi et al. (2019). what we can add to this study, that the lower temperature of 15°C and 60 minutes of scarification were comparable to those obtained at 25°C and 120 minutes which mean the germination rates increases with longer scarification durations at 15°C. Similar

results were found by Tigabu and Odén (2001) on *Albizia gummifera*, another species in the *Fabaceae* family. Their study revealed that the seeds treated with sulfuric acid for a longer period of time showed the best germination rates, with the greatest results obtained at 60 minutes in concentrated sulfuric acid. Our findings indicate that scarification for 60 minutes at a temperature of 15°C is an ideal

condition for achieving high average germination capacity in *Acacia saligna* seeds in contrast with the findings of Patil et al (2012) related to a species of same genus *Acacia mangium* revealed that only 10 minutes of scarification in concentrated sulfuric acid led to 90.67% of germination rate while optimal temperature was 32 C° resulting 97.33 % germination rate.

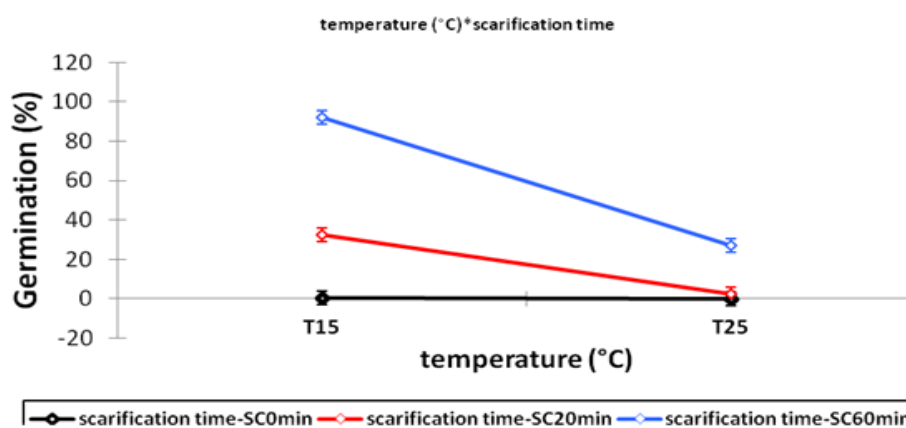


Figure 2: Final germination rate of *Acacia saligna* seeds under different temperatures and scarification time.

2. Seedling Vigor Index (SVI)

The seedling vigor index (SVI) varied significantly with scarification time but not with temperature. The highest SVI (3.52) was observed for seeds scarified for one hour at

25°C, while the lowest SVI (0.049) was noted for non-scarified seeds at 15°C (Figure 3). The ANOVA test confirmed highly significant differences in SVI between scarification times but not temperatures.

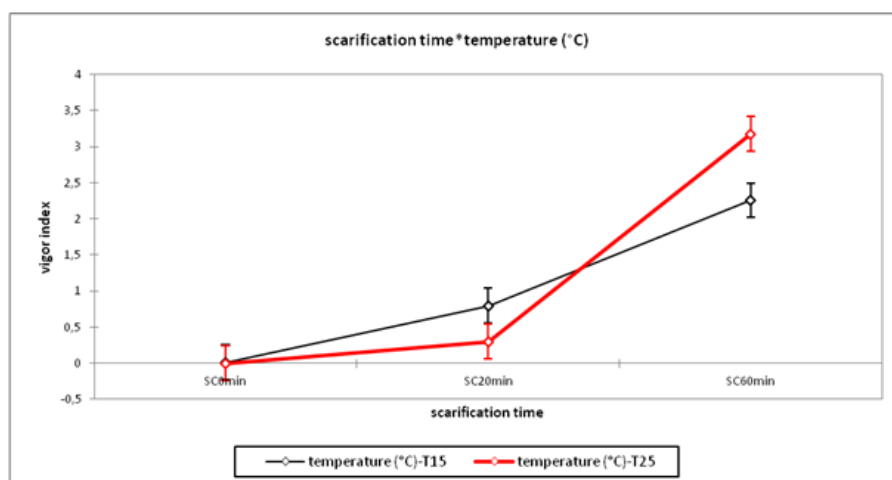


Figure 3: Seedling vigor index of *Acacia saligna* seeds under different temperatures and scarification times.

Our findings indicate no significant difference in the vigor index between seeds scarified for 20 minutes at 15°C and those scarified for 60 minutes at 25°C. This result corroborates the work of Maccioni et al. (2019), who reported less than a 50% germination rate for *Acacia saligna* seeds scarified for shorter durations and germinated at 15°C, emphasizing the need for longer scarification times

The seedling elongation has shown to increase with longer scarification periods as . According to Buriro et al. (2011), the vigor index is an indicator of quick germination and rapid growth. The seeds scarified for 60 minutes demonstrated significant radicle and aerial part elongation, unlike those scarified for 20 minutes, agreeing with Karaguzel et al. (2004) on *Lupinus varius* seeds, though the optimal scarification duration varied by species. While longer periods benefited *Lupinus varius*, The use of chemical scarification such as sulfuric acid can lift integumentary constraints and allow the penetration of air and water (Benadjaoud, 2004) and Devi et al. (2012), which facilitates the quick emergence of the radicle (Oukara et al., 2017). Temperature did not significantly affect the vigor index meanwhile Buriro et al. (2011) and Barpete et al. (2015), found that higher temperatures positively impacted the

vigor index for wheat and *Gossypium hirsutum* L

Acacia saligna germinated better under cold conditions, with temperature having minor effect on seedling emergence and growth, similarly, Alves et al. (2016) found that temperature had little effect on the vigor index of *Platymiscium floribundum*, which was more influenced by light. This reinforces the species-specific nature of responses to scarification and environmental factors

3. Median Germination Duration

The shortest median germination time (2.7 days) was observed for seeds scarified for one hour at 15°C, while the longest (9.5 days) was recorded for seeds scarified for 20 minutes at 25°C. The ANOVA test showed that scarification duration significantly impacted germination speed, while temperature did not ($P = 0.02$).

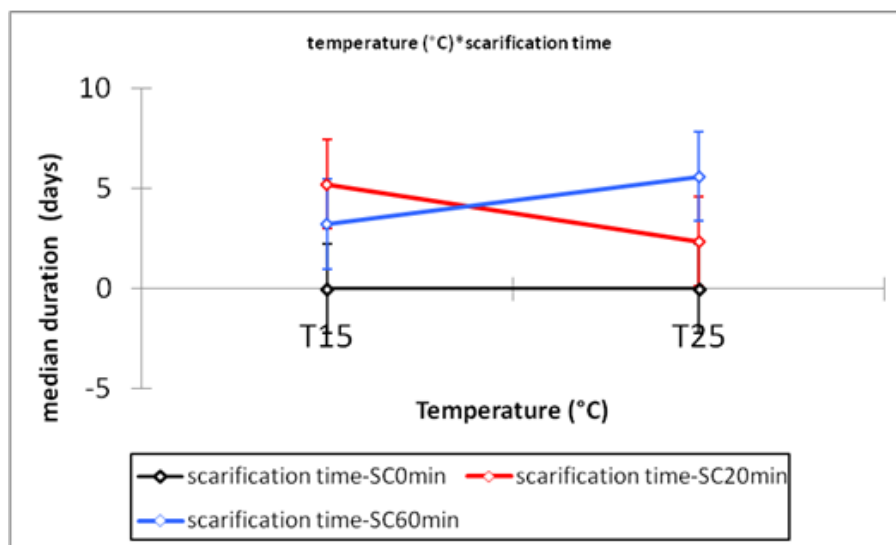


Figure 4: Median duration of germination of *Acacia saligna* seeds under different temperatures and scarification times.

According to the variance analysis the median germination duration showed that the scarification duration is the factor that directly influences the germination speed, since the longer the duration of scarification, the shorter the median germination duration, this can be seen in 60-minute-scarified seeds, which had the shortest median germination time. On the other hand the variance analysis showed that the temperature factor did not significantly

affect the median germination duration. In a study by Lachiheb *et al.* (2004) on some halophyte species showed that, with the exception of *Juncus maritimus*, which had zero germination capacity under all the temperatures tested, all the other species showed more or less different responses to temperature.

CONCLUSION

This study highlights the pivotal roles of scarification duration and temperature in enhancing the germination success of *Acacia saligna* seeds, a species renowned for its potential in ecological restoration. Chemical scarification for 60 minutes proved highly effective, significantly improving germination rates, with optimal germination occurring at 15°C, root elongation and seedling vigor were notably higher at 25°C, suggesting that different temperature conditions may favor distinct growth stages.

These findings have far-reaching ecological implications, particularly for

reforestation and land rehabilitation in arid and semi-arid regions where *Acacia saligna* plays a crucial role in combating desertification, stabilizing soils, and providing habitats. By identifying the optimal scarification and germination conditions, this research contributes to addressing the challenge of low germination rates associated with hard-coated seeds, a common limitation in restoration projects.

This research emphasizes the importance of tailored approaches to seed treatment in maximizing germination efficiency, which could significantly enhance the success rates of

large-scale planting initiatives. Moreover, these results provide valuable guidance for policymakers and land managers in planning reforestation programs in areas with variable temperature conditions.

Future research could extend this work by examining germination responses to temperatures below 15°C, which may simulate colder environments.

Additionally, investigating alternative cost-effective scarification techniques such as

mechanical or biological methods could further facilitate the widespread adoption of *Acacia saligna* as a cornerstone species in environmental restoration projects.

Such advancements would strengthen its application as a sustainable solution to land degradation and biodiversity loss on a global scale.

ACKNOWLEDGEMENTS

We would like to sincerely thank the Department of Agronomy at the University of Amar Telidji, Laghouat, for providing the necessary facilities and resources for this research. Special appreciation goes to the

laboratory staff for their assistance in supplying the chemicals and equipment, and for their technical support throughout the experiment.

REFERENCES

- Barpete, S., Ca, M., Anayol, E., Ahmed, H. A., & Khawar, K. M. (2015). Effect of temperature on germination, seed vigor index, and seedling growth of five Turkish cotton (*Gossypium hirsutum* L.) cultivars. *Fresenius Environmental Bulletin*, 24(8), 2561-2566.
- Abdellaoui, R., Boughalleb, F., Zayoud, D., Neffati, M., & Bakhshandeh, E. (2019). Quantification of *Retama raetam* seed germination response to temperature and water potential using hydrothermal time concept. *Environmental and Experimental Botany*, 157, 211–216.
<https://doi.org/10.1016/j.envexpbot.2018.10.014>
- Abdul-Baki, A. A., & Anderson, J. D. (1970). Viability and Leaching of Sugars from Germinating Barley 1. *Crop Science*, 10(1), 31–34.
<https://doi.org/10.2135/cropsci1970.0011183X001000010012x>
- AbuQamar, S., Luo, H., Laluk, K., Mickelbart, M. V., & Mengiste, T. (2009). Crosstalk between biotic and abiotic stress responses in tomato is mediated by the AIM1 transcription factor. *The Plant Journal*, 58(2), 347–360.
<https://doi.org/10.1111/j.1365-3113.2008.03783.x>
- Allen, P. S., & Meyer, S. E. (1990). Temperature Requirements for Seed Germination of Three Penstemon Species'. *HortScience*, 25(2), 191–193.
<https://doi.org/10.21273/HORTSCI.25.2.191>
- Alves, M. M., Alves, E. U., & Rodrigues, C. M. (2016). Germination of seeds of *Platymiscium floribundum* VOG. (fabaceae) under the influence of temperatures and light. *Ciência Florestal*, 26(3), 971-978.
- Benadjaoud, A., & Aïd, F. (2004). Effets de quelques traitements physico-chimiques et de la température sur la faculté germinative des graines de *Parkinsonia aculeata* L. *Annales de l'Institut National Agronomique El Harrach*, 12(25), 19-30.
- Buriro, M., Oad, F. C., Keerio, M. I., Tunio, S., Gandahi, A. W., & Hassan, S. W. U. (2011).

- Wheat seed germination under the influence of temperature regimes. *Sahad journal of agriculture*, 27(4), 539-543.
- Côme, D. (1970). Les obstacles à la germination (monographie et physiologie végétale). Masson et Cie, Ed. Paris, 162p.
 - Cunningham, P., Mezgebe, K., Kassa, H., & Hagazi, N. (2014). SECTION A: Use of *Acacia saligna* in agroforestry systems: The potential for *Acacia saligna* agroforestry farming systems in Tigray, Ethiopia. *Agroforestry Consultant*, World Vision Australia, Melbourne, Australia, 10-22.
 - El-Azazi, E.-S., Sourour, M. M., Belal, A. H., & Khalifa, E. A. (2013). Improving *Acacia tortilis* seeds germination by breaking dormancy treatments. *International Journal of Advanced Biological Research*, 3(1), 103-109.
 - Hajlaoui, H., Mighri, H., Noumi, E., Snoussi, M., Trabelsi, N., Ksouri, R., & Bakhrouf, A. (2010). Chemical composition and biological activities of Tunisian *Cuminum cyminum* L. essential oil: A high effectiveness against *Vibrio* spp. strains. *Food and Chemical Toxicology*, 48(8-9), 2186-2192. <https://doi.org/10.1016/j.fct.2010.05.044>
 - Hilhorst, H. W. M. (1995). A critical update on seed dormancy. I. Primary dormancy. *Seed Science Research*, 5(2), 61-73. <https://doi.org/10.1017/S0960258500002634>
 - Karaguzel, O., Cakmakci, S., Ortacesme, V., & Aydinoglu, B. (2004.). Influence of seed coat treatments on germination and early seedling growth of lupinus varius L. *Pakistan journal of botany*, 36(1), 65-74.
 - Kassa, H., Mezgebe, K., Hagazi, N., Gebremeskel, G., & Darcha, G. (2014). Population distribution and structure of *Acacia saligna* trees in eastern Tigray, Ethiopia. *Tigray Agricultural Research Institute, Mekelle Agricultural Research Centre*, 43-49.
 - Koornneef, M., Bentsink, L., & Hilhorst, H. (2002). Seed dormancy and germination. *Current Opinion in Plant Biology*, 5(1), 33-36. [https://doi.org/10.1016/S1369-5266\(01\)00219-9](https://doi.org/10.1016/S1369-5266(01)00219-9)
 - Lachiheb, K., Neffati, M., Zid, E. (2004) Aptitudes germinatives de certaines graminées halophytes spontanées de la Tunisie méridionale. *Cahiers Options Méditerranéennes*, 62, 89-93
 - Maccioni, A., Santo, A., Falconieri, D., Piras, A., Manconi, M., Maxia, A., & Bacchetta, G. (2019). Inhibitory effect of rosemary essential oil, loaded in liposomes, on seed germination of *Acacia saligna*, an invasive species in Mediterranean ecosystems. *Botany*, 97(5), 283-291. <https://doi.org/10.1139/cjb-2018-0212>.
 - Maslin, B. R. (1974). Studies in the genus *Acacia*. 2. Miscellaneous new phyllodinous species. *Nuytsia-The Journal of the Western Australian Herbarium*, 1(4), 315-331. <https://doi.org/10.58828/nuy00018>
 - Maslin, B. R. (2001). Wattle: *Acacias* of Australia. ABRS ; CALM.
 - Maslin, B. R., Miller, J. T., & Seigler, D. S. (2003). Overview of the generic status of *Acacia* (Leguminosae: Mimosoideae). *Australian Systematic Botany*, 16(1), 1-18. <https://doi.org/10.1071/SB02008>
 - Midgley, S. J., & Turnbull, J. W. (2003). Domestication and use of Australian acacias: Case studies of five important species. *Australian Systematic Botany*, 16(1), 89-102. <https://doi.org/10.1071/SB01038>
 - Millar, M. A., Byrne, M., & O'Sullivan, W. (2011). Corrigendum to: Defining entities in the *Acacia saligna* (Fabaceae) species complex using a population genetics approach. *Australian Journal of Botany*, 59(5), 507. https://doi.org/10.1071/BT10327_CO
 - Millar, M. A., Byrne, M., Nuberg, I. K., & Sedgley, M. (2012). High Levels of Genetic Contamination in Remnant Populations of *Acacia saligna* from a Genetically Divergent Planted Stand. *Restoration Ecology*, 20(2),

- 260–267. <https://doi.org/10.1111/j.1526-100X.2010.00758.x>
- Oukara, F. Z., Salem, K., Chaouch, F. Z., & Benrebiha, F. Z. (2017). Effect of pretreatments on the germination of Atlas pistachio seeds (*Pistacia atlantica*). *African Journal of Agricultural Research*, 12(9), 750-755.
 - Patil, G., Naugraiya, M. N., & Kumar, S. (2012). Effect of scarification, temperature and moisture stress on seed germination and seedling growth in *acacia mangium*. *J. Trop. Biodiv*, 20(2), 181–188.
 - Ghassali, F., Salkini, A. K., Petersen, S. L., Niane, A. A., & Louhaichi, M. (2012). Germination dynamics of Acacia species under different seed treatments. *Range Management and Agroforestry*, 33(1), 37–42.
 - Kheloufi, A., Boukhatem, Z. F., Mansouri, L. M., & Djelilate, M. (2019). Maximizing seed germination in five species of the genus Acacia (Fabaceae). *Reforesta*, 7, 15-23. <https://doi.org/10.21750/REFOR.7.02.64>
 - Sánchez-Bayo, F., & King, G. W. (1994). Imbibition and germination of seeds of three Acacia species from Ethiopia. *South African Journal of Plant and Soil*, 11(1), 20–25.
 - Subhashini Devi, P., Satyanarayana, B., Arundhati, A., & Raghava Rao, T. (2012). Effect of storage temperature and dormancy-breaking treatments on seed germination, moisture content and seed vigor in gum karaya (*Sterculia urens* Roxb.). *Forest Science and Technology*, 8(1), 11–15. <https://doi.org/10.1080/21580103.2012.658235>
 - Tigabu, M., & Odén, P. C. (2001). Effect of scarification, gibberellic acid, and temperature on seed germination of two multipurpose Albizia species from Ethiopia. *Seed Science and Technology*, 29, 11-20.