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Optimization of Seed Germination of Selected Legumes that Grow in Dry Lateritic Soil in Purulia and Adjoining Districts of West Bengal, India

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ABSTRACT

The germination process is considered the most crucial factor in a plant's life cycle as it seriously affects the successful execution of afforestation and reforestation programs. The successful plantation programme on wastelands requires a basic knowledge of some key factors that influence seed germination. The seeds of most leguminous plants are not able to germinate properly, while the potentiality of a plant and its growth depends much on seed germination. In the recent observation, five plant species namely Acacia mangium Willd., Albizia procera (Roxb.) Benth, Bauhinia acuminata Linn., Millettia pinnata (L.) and Peltophorum pterocarpum (DC.) K.Heyne, were taken as plant materials to determine the rate of germination percentage. Plant seeds are sown in Petri dishes on Whatman no. 1 filter paper moistened with distilled water under room temperature. Under controlled conditions, seed germination percentage is very low except for B. acuminata. Pretreatment with phytohormones (250 µg ml-1 of IAA and GA) and nitrogenous substances (2.5 mM of potassium nitrate and Thiourea) results in some improvement in the germination percentage in all five tree legumes.

Keywords: *seed germination, legume, pretreatment, plant hormones, nitrogenous substances*

Introduction

The process by which a seed is activated from dormancy to an active state of growth and development into a plant is called germination. Many seed psychologists consider seed germination to be a process that begins with water imbibitions and ends with the emergence of the radical [1]. The manifestation of germination is increased water absorption by the seed, followed by the appearance of a radicle (2 mm long). Most legume seeds face difficulty to germinate, and the success of the plant (which can be determined by germination and establishment) depends largely on seed germination. The seeds of some legume species, such as *Cassia, Albizia*, *Acacia* and *Leucaena*, have a hard seed coat [2,3,4,5,6], mainly due to the accumulation of lignin, suberin or cutin on the seed coat as well as on mature endosperm [7,8,9,10]. Seed dormancy is a major problem in tropical forests due to the lack of penetration of the seed coat [11]. Some methods to promote germination in a few tropical plant seeds have been standardized till now [12,13]. Little is known about the mechanisms of breaking seed dormancy in trees such as *Acacia*, *Cassia,* and *Leucaena* [14,15].

Pretreatment, broadly defined, refers to the processes that seeds must go through before being sown. The utility of priming has also been reported for many field crops such as wheat, maize, sugar beet, soyabean, and sunflower [17,18]. We know that light plays a vital role in the regulation of germination [19]. It has been demonstrated that the mechanism of light sensitivity in seeds is related to the phytochrome pigment, which is widely dispersed in plants and photochemically reactive [20].The most popular method of treating legumes is hot water pretreatment, which successfully reduces the hard seededness and improves seed permeability [21,22,34]. As per several studies [23,24,25,26] gibberellins are now widely acknowledged to be strong promoters of seed germination.

Applying IAA to *Alstonia scholaris* [27], *Saussurea costus* [28], and red sanders [29] was also found to increase the percentage of seed germination. Hormones also have a well-established role in reviving the dormancy of forest tree seeds [30,31]. To disrupt the physiological dormancy of hard seed coat species, exogenous treatments of GA3 have been widely used [32]. Use of GA as a growth promoter has been established in pennycress [35,36]. Potassium nitrate has been reported to enhance seedling growth by improving nutrient uptake and promoting robust root and shoot development [37,40]. Application of thiourea has shown promise in breaking dormancy and speeding up germination, especially for seeds with hard or impermeable seed coats [38]. In legumes, such as chickpea and soybean, thiourea has been found to promote faster germination and higher seedling vigor [39].

Materials and Methods

In the recent study, five plant species (*Acacia mangium* Willd., *Albizia procera* (Roxb.) Benth, *Bauhinia acuminata* Linn., *Millettia pinnata (L.)* and *Peltophorum pterocarpum* (DC.) K.Heyne were taken as plant material to determine germination percentage. These plants grow abundantly in and around Purulia, westernmost district of West Bengal, India. Purulia is located between 23.33^0 North and 86.36 East longitudes. The soil of Purulia is of lateritic type. The temperature ranges from 26-45°C during summer season while from 11-24°C during winter.

Healthy seeds of five plants were taken and they were surface sterilized by using 1% sodium hydrochlorite solution for 5 minutes, washed thoroughly with purified water and dried on tissue paper. Seeds were then sown in covered petridishes on the layers of filter paper soaked with distilled water. Light was provided 8 hours daily for light treatment.

While in hot water pretreatment, seeds were immersed in warm water (85 ºC) for 5 min. followed by washing several times with water before incubation. For pretreatment with Phytohormones and nitrogenous substances, seeds were pre-incubated in test solution of phytohormones (250 µg ml^{-1} of GA and IAA) or nitrogenous substances (2.5 mM of potassium nitrate and thiourea) for a day before germination. Emergence of radicle by 2 mm was taken as the criterion of germination. In case of each species, the percentage of seed germination was calculated at 24h intervals up to 15 days of incubation period. The values were expressed as seed germination percentage of total number of seeds. Every experiment was repeated three times with three replicates in each time and the mean values were presented.

Result

Seed germination behaviors of *Acacia mangium* represented in the figure 1. In present study, germination percentage of *A. mangium* was only 55% under control condition. Slight increase in rate of germination (60%) indicates light may have a positive effect. Hot water pretreatment greatly enhance seed germination (84%). IAA pretreatment has a positive but moderate effect on rate of germination (62%). GA slightly increases germination rate upto to 64%. KNO_3 appears to be slightly more effective than IAA and GA and it is 65%. Thiourea shows 64% germination like that of GA.

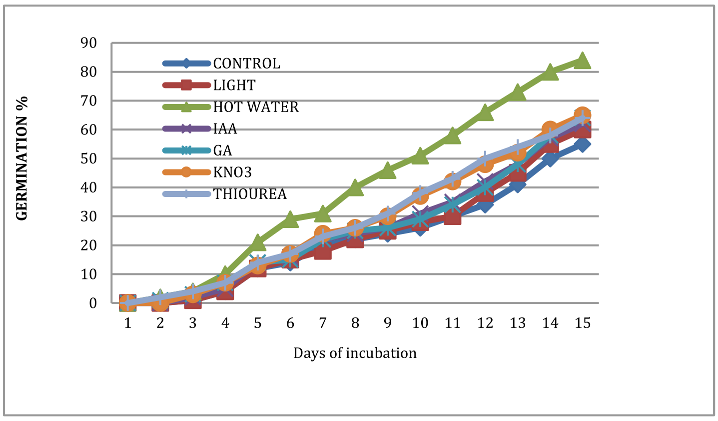

Figure1: Various pre treatment effects on seed germination rate of Acacia mangium.

Figure 2 - shows germination behavior of *A. procera*. In *A. procera*, seed germination percentage was 60% and that is second highest among the plants studied, under control condition. Minor improvement with light treatment leads to 64%. Substantial increase to 82% indicates hot water is highly effective. Pretreatment with IAA and GA are as effective as light treatment and they shows 62% and 64% germination respectively. Potassium nitrate appears to be slightly better (66%), suggesting a beneficial effect. Thiourea shows the best result among chemical treatments with 70% germination.

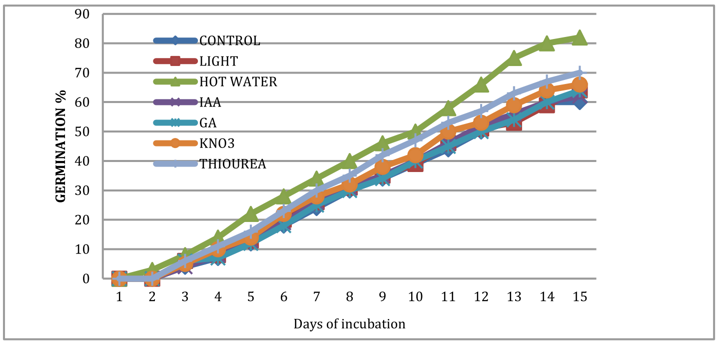

Figure 2. Various pre treatment effects on seed germination rate of A. procera.

In all cases *B. acuminate* shows 100% germination, pretreatments reduced the number of days to achieve final percentage. *B. acuminata* seed shows 100 percent seed germination in 12 days under control condition while in hot water pretreatment it takes only 9 days. In case of pretreatment with IAA it took only 11 days for complete germination. Pretreatment with nitrogenous substances (both potassium nitrate and thiourea) 100% germination achieved on day 10. Seed germination behaviors of *B. acuminata* have been shown in the figure 3.

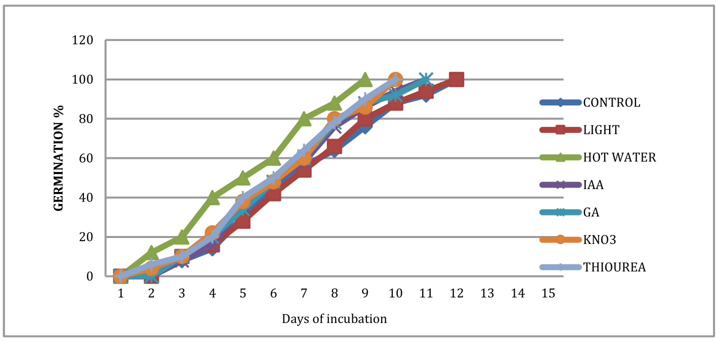

Figure 3. Various pre treatment effects on seed germination rate of B. acuminata

Seed germination behaviours of *M. pinnata,* have been shown in the figure 4. Under control condition germination was only 43% in *M. pinnata.* Seeds under daily light cycle increased germination rate up to 49%. Light pretreatment helps marginal increase of seed germination and it is 49%. Hot water pretreatment is extremely effective in this species and germination rate get increased up-to 98%. Improvement of seed germination up to 52% with IAA and in case of GA it is 56%. Potassium nitrate also shows 56% germination like that of GA. Thiourea shows highest germination (61%) among all other chemical pretreatments.

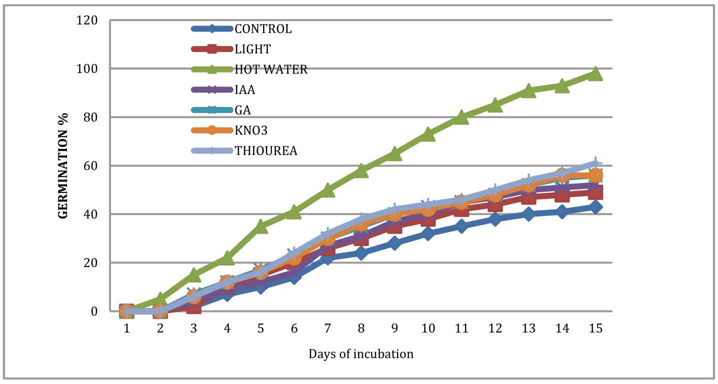

Figure 4: Various pre treatment effects on seed germination rate of M. pinnata.

Seed germination behaviors of *P. pterocarpum* was represented in the figure 5. In *P. pterocarpum*, germination percentage was only 40% under control condition. Hot water pretreatment shows a remarkable increase in seed germination (84%), showing hot water's effectiveness in this plant. Pretreatment with phytohormones like indole-3-acetic acid and gibberellic acid showed an increase in final germination percentage (52% with indole-3-acetic acid and 48% with gibberellic acid). While, pretreatment with both potassium nitrate and thiourea showed an increase in final germination percentage (58% with potassium nitrate and 55% with thiourea).

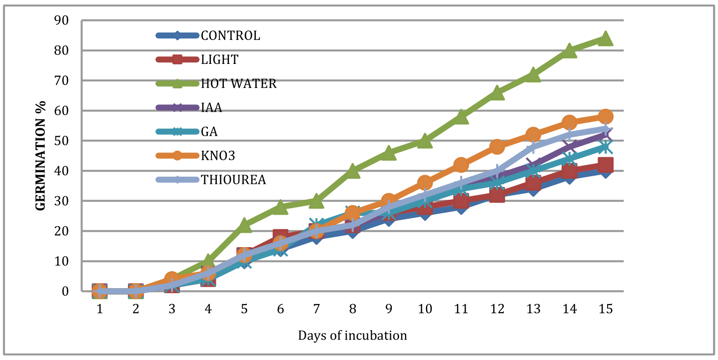

Figure 5. Various pre treatment effects on seed germination rate of P. pterocarpum.

Discussion

In summary, hot water treatment significantly enhances germination for most species. Chemical treatments like indole-3-acetic acid, gibberellic acid, potassium nitrate, and thiourea generally show positive effects on germination compared to the control, with varying degrees of effectiveness across different species. *B. acuminata* seeds are notably good, in which 100% germination was observed under control conditions. The data suggests that species-specific responses to pre-treatments are crucial to consider in seed germination studies. Germination rates were counted at 24-hour intervals up to 15 days, providing a comprehensive view of the germination process over time. This detailed analysis can help in understanding the optimal conditions for seed germination of these species.

Conclusion

Finally considering the effects of different pre-treatments to improve seed germination percentage of five plants, it can be concluded that hot water pre-treatment might have increased water permeability of the seed coat and thus the rate of germination. Pre-treatments with phytohormones and nitrogenous substances also increased the germination rate which indicates that some metabolic barrier may be present which limiting germination potential. The outcome of the experiment will be beneficial for improvement of seed germination of the above mentioned tree species. Large scale plantation of these multipurpose legume trees for environmental and commercial purpose can be possible with the insight of this research. The outcome of the present investigation will help plantation of tree legumes in dry lateritic wastelands as a part of agroforestry as well as afforestation and reforestation programme.

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Conflict of Interest

The authors declare that there is no conflict of interest.

References

1. Bewley, J. D. and Black, M. (1978). Physiology and Biochemistry of Seeds in Relation to Germination. Vol. 1, Development, Germination and Growth. Springer-Verlag, Berlin.
2. Bewley, J. D. and Black, M. (1994). Seeds: Physiology of Development and Germination. Second Edition, Plenum Press, New York.
3. Mayer, A. M. and Poljakoff-Mayber, A. (1989). The Germination of Seeds. Fourth Edition. Pergamon Press, London.
4. Kelly, K. M., Van Staden, J. and Bell, W. E. (1992). Seed coat structure and dormancy. *Plant Growth Regul.*, 11, 201-209.
5. Hartmann, R. B., Kester, D. E., Davis jr., F. T. and Geneve, R. L. (1997). Plant Propagation Principles and Practices. Sixth Edition. Prentice- hall of India private limited, New Delhi, pp. 194-210.
6. Kundu, M. and Kachari, J. (2001). Effect of accelerated ageing on moisture content, germination percentage and electrolyte leachate of seeds of Cassia fistula Linn. *Seed Research*, 29(1), 215-218.
7. Rolston, M. P. (1978). Water impermeable seed dormancy. *Bot. Rev.*, 44: 365-396.
8. Egley, G. H. (1989). Water-impermeable seed coverings as barriers to germination. In: Recent Advances in the Development and Germination of Seeds (ed. Taylorson, R. B.). Plenum press, New York, pp. 207-224.
9. Kelly, K. M., Van Staden, J. and Bell, W. E. (1992). Seed coat structure and dormancy. *Plant Growth Regul.*, 11, 201-209.
10. Bedell, P. E. (1998). Seed Science and Technology (Indian Forestry Species). Allied Publishers, India, pp. 346-354.
11. Brown, N. C. A. and Booysen, P. (1969). Seed coat impermeability in several Acacia species. *Agroplantae*, 1, 51-60.
12. Gupta, B. N., Pattanath, P. G., Adorsh Kumar, Thapliyal, R. C. and Ratori, A. S. (1975). Rules for germination tests of tree seeds for certifications. *Ind. For.*, 101(5), 264-272.
13. Gupta, B. N. and Pattanath, P. G. (1976). Germination response of some forest tree seeds under controlled conditions. *Ind. For.*, 102(5), 264- 272.
14. Biradar, B. B., Mahadevappa, M. and Munegowda, M. K. (1988). Seed scarification studies in subabul. *Seed Research*, 16, 238-240.
15. Sinhababu, A., Banerjee, A. and Kar, R.K. (2007). Seed germination and seedling growth in some selected fast growing fuel wood plants. *Indian Forester*. 133, 534-546.
16. Sadeghian, S. Y. and Yavari, N. (2004). Effect of Water Deficit Stress on Germination and Early Seedling Growth in Sugar Beet. *J. Agron. Crop Sci.*, 190, 138-144.
17. Mehmet, D., Okcu, KG., Atak, M., Cikili, Y. and Kolsarici, O. (2006). Seed treatment to overcome salt and drought stress during germination in sunflower (*Helianthus annus* L.). *European Journal of Agronomy*, 3, 291-295.
18. Bajehbaj, AA. (2010). The effects of NaCl priming on salt tolerance in sunflower germination and seedling grown under salinity conditions. *African Journal of Biotechnology*, 9(12), 1764-1770

19. Crocker, W. (1930). Effect of the visible spectrum upon the germination of seeds and fruits. In: Biological Effects of Radiation. McGraw-Hill, New York, pp. 791-828.

20. Bewley, J. D. and Black, M. (1985). Seeds: Physiology of Development and Germination. First Edition, Plenum Press, New York.

21. Gray, S. G. (1962). Hot water treatment for Leucaena leucocephala (L.) Benth. Aust. *J. Exp. Agric. Anim. Husb*., 2, 178-180.

22. Akinola, J. O., Afolayan, R. A. and Olorunju, S. A. S. (1991). Effect of storage tests colour and scarification method on seed germination of *Desmodium velutimum* (Willd.) D. C. *Seed Sci. Technol*., 19, 159-166.

23. Chen Shepley, S. C. and Varner, J. E. (1973). Hormones and seed dormancy. *Seed Sci. Technol.*, 1: 325-338.

24. Karssen, C. M., Brinkhorst-Van der Swan, D. L. C., Breekland, A. E. and Koornneef, M. (1983). Induction of dormancy during seed development by endogenous abscisic acid different genotypes of Arabidopsis thaliana (L.) Heynh. *Planta*, 157, 158-165.

25. Mayer, A. M. and Poljakoff-Mayber, A. (1989). The Germination of Seeds. Fourth Edition. Pergamon Press, London.

26. Takahashi, N., Phinney, B. O. and MacMillan, J. (1992). Gibberellins. Springer-Verlag, Berlin.

27. Singh, D. V., Srivastava, G. C. and Abdin, M. Z. (2000). Effect of benzyladenine and ascorbic acid and abscisic acid content and other metabolites in sena (*Cassia angustifolia* VAHL.) under water stress conditions. *Indian J. Plant Physiol*., 5(2), 127-131.

28. Kundu, M., Sharma, P., Kachari, J. and Sett, R. (1997). Effect on pretreatment on seed germination and seedling vigour in *Alistonia scholaris*. *Seed Research*, 25(1), 16-18.

29. Chauhan, J. S., Tomar, Y. K. and Vashist, D. P. (1998). Effect of various levels of IAA on the seed germination of *Saussurea costus* (Falk.) Lipschitz. (S. lappa (Decne.) Sch.-BIP. *J. Indian Bot. Soc*., 77, 175- 177.

30. Naidu, C. V. (2001). Improvement of seed germination in red sanders (*Pterocarpus santalinus* Linn. F.) by plant growth regulators. *Indian J. Plant Physiol*., 6(2), 205-207.

31. Ahmadloo, F., Kochaksaraei, M.T., Azadi, P., Hamidi, A. and Beiramizadeh, E. (2015). Effects of pectinase, BAP and dry storage on dormancy breaking and emergence rate of *Crataegus pseudoheterophylla* Pojark. *New Forest*., 46(3),373–386.

32. Daneshvar, A., Tigabu, M., Karimidoost, A. and Oden, P.C. (2016). Stimulation of germination in dormant seeds of Juniperus polycarpos by stratification and hormone treatments. *New Forest.*, 47(5), 751–761.

33. Yao, W.F., Shen, Y.B. and Shi, F.H. (2015). Germination of Tilia miqueliana seeds following cold stratification and pretreatment with GA3 and magnetically-treated water. *Seed Sci Technol*., 43(3), 554–558.

34. Mala Seng and Eun Ju Cheong (2020) Comparative study of various pretreatment on seed germination of *Dalbergia cochinchinensis*, Forest Science and Technology, 16:2, 68-74.

35. Ott, M.A., Gardner, G., Rai, K.M., Wyse, D.L., Marks, M.D. and Chopra, R. (2021). Transparent testa 2 allele confers major reduction in pennycress (*Thlaspi arvense* L.) seed dormancy. *Industrial Crops and Products*, 174, 214-216.

36. Koirala, N., Barker, D., Helfer, C., Phippen, W.B., Heller, N., Hard, A.W., Wells, S. and Lindsey, A.J. (2022). A process to enhance germination of a wild pennycress variety. *Seed Science and Technology*, 50, 195-205.

37. Choudhury, S. R., Das, S. and Ghosh, P. (2020). Effect of potassium nitrate on seed germination and seedling growth in various crops. *Plant Growth Regulation*, 91(2), 135-144.

38. Zhang, Y., Tang, Q. and Lu, Y. (2020). Effects of thiourea on germination, seedling growth, and stress tolerance in wheat. *Agricultural Science and Technology*, 21(1), 54-62.

39. Sharma, P., Gill, S. S. and Reddy, M. S. (2018). Role of thiourea in seed germination and growth regulation under stress. *Environmental and Experimental Botany*, 146, 109-118.

40. Natarajan, S., Thirugnanam, T. and Kandasamy, K. (2017). Synergistic effect of KNO3 and thiourea on seed germination and growth of tomato (*Solanum lycopersicum* L.). *Journal of Applied Horticulture*, 19(2), 121-126.