Original Research Article
Improvement in Seed Germination through Pre-sowing Treatments in*Cinnamomum glaucescens* (Nees) Hand.-Mazz., A Native Tree of Eastern Himalaya, India

ABSTRACT
Cinnamomum glaucescens (Nees) Hand.-Mazz. belongs to family Lauraceae, is an aromatic evergreen tree, prizedfor its scented timber and fruits which is rich in essential oil commercially. Indiscriminate collection methods of fruit and its poor germination being the challenges for establishment in forest. Sixteen different pre-sowing seed treatments were applied to analyse the effect of germination responseand was arranged in a randomized complete block design in nursery bed.Depulped seeds dipped in 4% hydrogen peroxide in dark for 12 hours significantly (P<.05) enhanced the germination percentage (66.67 %), peak value (0.55), germination value (0.31), germination speed (0.66) followed by seeds treated in 8% H_2O_2 with 60.56%germination, as compared to others. Therefore, it is suggested to use 4% hydrogen peroxide to promote seed germination rates,that could be useful to propagate*C. glaucescens*seedlings to satisfy the demands of planting stock.

Keywords: Cinnamomum glaucescens, pre-sowing treatment, hydrogenperoxide, germination.

1. INTRODUCTION
The genus *Cinnamomum*Schaeff. comprises about 250 species, widely distributed throughout tropical and subtropical Asia, South America, Australia and the Pacific [1,2, 3, 4, 5]. *Cinnamomum glaucescens* (Nees) Hand.-Mazz. (syn. *C. cecidodaphne*) recognized as large-sized evergreen tree belonging to the family Lauraceaeand also known by the vernacular name Sugandhakokila, Malagiri(Nep.), Gonorai (Manip.), Gonsorai (Ass.) native to the Eastern Himalayan regions of India from Sikkim eastward, Assam, Manipur, Mizoram, Meghalayaascending up to an altitude of 1330m[6, 7, 8, 9, 10,11, 12]. The tree seed at intervals of 2-3 years, in October-November[13] so the production of seeds is also very limited. The fragrant fruits are about 3 cm long, surrounded by an enlarged perianth at the base enclosed in a cup 10-12 mm across[10, 14]. When young, seeds are usually dark green and turn black as they ripen. *C. glaucescens* produces high-quality scented timberwhich is valued for furniture, wardrobes, boxes or cabinet making [10].The wood oil has a persistent camphoraceous odour and resistant to insect attack. The timber in Assam is considered to be first-class for furniture and boat-building [7]. The wood on distillationyields about 1 to 1.25% of essential oilwith a good source of safrole [8, 11, 15]. The aromatic fruit is highly prized commercially which is rich in essential oilswith insecticidal,antifungal, antibacterial, antiaflatoxin, antioxidantactivities have been reported [16,17, 18, 19, 20, 21, 22]. Natural germination of this species is typically lowin the forests[23], although over-exploitation and indiscriminate collection methods of aromatic fruit for market demand make it challenging to proliferateand stands at therisk of existence in nature [24, 25, 26,27]. Seeds of *C. glaucescens*lose their viability within two months [14, 31].As seed dormancy occurs in many tropical tree species to varying degrees with some mechanism for delaying germination after seed has been dispersed while at the same time seed viability being a crucial factor for successful germination [28, 29, 30].The specific conditions required to break dormancy and initiate germination can vary significantly among species or within a species [32].Proper nursery growing techniques are not available for *C. glaucescens*and thegermination is reported just over 30% in nursery conditions [33]. There are challenges involved in establishing this species and special attention need through nursery production to promote cultivation and consequently enhancing conservation initiatives[27].Hence, the experiment was thus conducted to find out the appropriate pre-sowing treatments that maximize total germinationresponse of *C. glaucescens.*

2.MATERIALS AND METHODS

The study was performed in the research field, Department of Silvicultural and Agroforestry, College of Horticulture and Forestry, Central Agricultural University (I), Pasighat, Arunachal Pradesh (elevation: 153masl, latitude: N28°04'43" and longitude: E95°19' 26"). Mature fruits of *Cinnamomum glaucescens* (Nees)Hand.-Mazz.,were collected from healthy mother trees(avg. ht.27 m and dbh of 25.50cm) during the month of November 2022, from Gopur (26°52'48.2772"N, 93°36'29.9880"E), Sonitpur District, Assam (India). The fruits were brought to the laboratory and were depulped, dried in shade for 1 day, and finally some external anomaly and damaged seeds were discarded. Selected seeds were subjected to sixteen pre-sowing treatment combinations and were denoted as follows: T_1-control (with pericarp); T_2-soaking in water for 24h at ambient temperature; T_3-nicking micropylar and soaking in water for 24h at ambient temperature; T_4-dipping in lukewarm water, (4 times volume of water of seed) and left to cool at ambient temperature 12h; T_5-dipping in warm water (45°C), (4 times volume of water of seed) and left to cool at ambient temperature 12h; T_6-dipping in warm water (75°C), (4 times volume of water of seed) and left to cool at ambient temperature 12h; T_7-dipping in 4% hydrogen peroxide in dark for 12hrs; T_8-dipping in 8% hydrogen peroxide in dark for 12hrs; T_9-15 days cold stratification at 5°C in moist cotton; T_{10}-15 days cold stratification at 5°C in moist cotton and, followed bydipping in 15% hydrogen peroxide in dark for 30 minutes; T_{11}-dipping in gibberellic acid (0.05%) for 12h; T_{12}-dipping in gibberellic acid (0.01%) for 12h; T_{13}-dipping in indole-3 Acetic Acid (500 ppm) for 12h; T_{14}-dipping in indole-3 Acetic Acid (1000 ppm) for 12h; T_{15}-dipping kinetin 25 mg/L for 12h; T_{16}-dipping kinetin 50 mg/Lfor 12h; and sowed in raised bed (upper layer prepared with soil, sandand FYM planting mixture of ratio 2:1:1 respectively) arranged in Randomized Complete Block Design with four replications consisting of 100 seeds per replication. The germinated seeds were recorded on daily basis starting from the 8^{th} day until the 23^{rd} day. Germination was defined as emergence of plumule on nursery bed. The following germination parameters were evaluated:

(i) Germination percentage was calculated using the formulae asISTA [34].

$$\text{Germination percentage} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds sown}} \times 100$$

(ii) Peak value was calculated as the maximum mean daily germination (MDG) reached at any time during the period of test.

(iii) Viability loss (expressed in percent/arcsine)was calculated as: total number of seeds sown-total number of seeds germinated.

(iv) Germination value is a composite value combining both germination speed and total germination providing an objective means of evaluating the results of germination test was calculated using the formula of Czabator[35].

Germination Value = Final DGS x Peak value; where DGS is (Daily Germination Speed)

(v) Germination Speed = $N_1/d_1+N_2/d_2+N_3/d_3+ \ldots\ldots\ldots\ldots + N_n/d_n$

Where, N- number of germinated seeds, d- number of days.

(vi) Germination energy and energy period: Germination energy (GE) was calculated on the basis of percentage of total number of seed that had germinated when germination reached its peak, and the Energy Period was taken up to the day of peak germination [48].

$$GE = \frac{\text{Number of seed germinated upto the time of peak germination}}{\text{Total number of seeds sown}} \times 100$$

Data analysis: The experimental layout arranged in Randomized Complete Block Design (RCBD) was adopted for nursery conditions. Significance of the treatments was determined by analysis of variance (ANOVA) and the differences between the means were compared by Fisher's least significant difference (LSD) test at 0.05 level following the model suggested by Panse and Sukhatme[36]. Statistical significance was set at $P<.05$. Results were subjected to analysis of variance ANOVA and the means were compared by Ducan's Multiple Range Test[37]. Result data (in percent) were transformed by arcsine prior to analysisin order to unify the variances as per the standard rules.

3. RESULTS AND DISCUSSION

The comparative effect of various pre-sowing treatments on germination parameters have been given in Table 1. The germination parameters under different treatments showed significant variations.

Maximum germination percent (66.67) was noticedin T_7i.e. seeds dipped in 4%hydrogen peroxide for 12h in dark andT_8(60.56%), dipped in 8% hydrogen peroxide for 12h in dark followed by T_4 (45.83%), T_2 (43.61%) and other treatments (T_3>T_{14}>T_9>T_{13}>T_{12}>T_{15}>T_6>T_{10}>T_5>T_{16}>T_{11}) ranging between 23.06 - 38.33 percentand lowest in T_1-control (22.22%). However, this significant difference (*P*<.05) in germination rate with 4-8% use of H_2O_2as compared to rest of other pretreatment was reported to be more pronounced,and this may be characterised by its highly oxidative reactivity.Presently, the findings of enhanced germination with application of H_2O_2 could not be supported enough with available literature but similar research are in accordance with Ching [38] (*Pseudotsutgamenziesii*); Ogawa *et* al. [39]in *Zinnia elegans*;Ghildiyal *et* al. [40]in *Pinus roxbughii*; Joseph *et* al. [41] in *Garcinia* spp.;Omokhua*et* al. [42]in *Maesobotryabarteri*;Chen *et* al.[43]in *Cinnamomum migao*;Rinaldi *et* al. [44] in *Michelia champaca*;Lorenzo-Barrera [45] in *Eysenhardtiapolystachya*andPuwein*et* al. [46]in *Canarium strictum*.

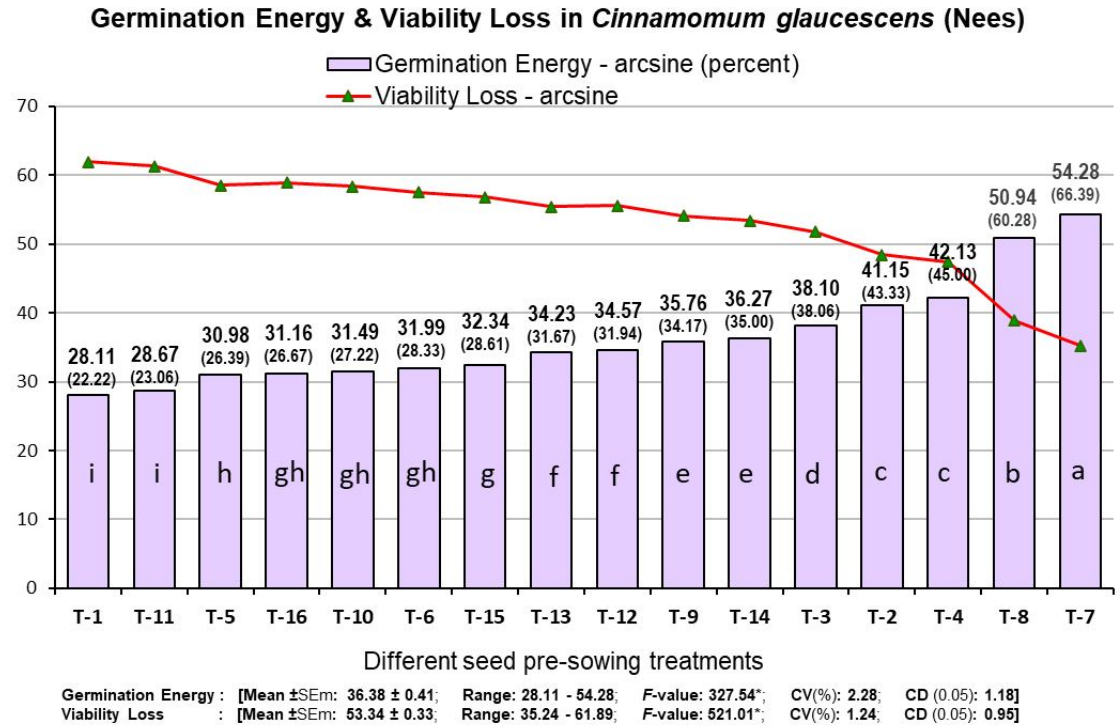
Table 1. Effect of seed pre-sowing treatment on germination parameters of sixteen treatments under nursery conditions.

Treatments	**Germination %** arcsine (percentage)	**Peak value**	**Germination value**	**Germination speed**	**Energy Period** (days)
T_1	28.11^{k} (22.22)	0.20^{l}	0.04^{l}	0.22^{l}	109.25^{bc}
T_2	41.31^{d} (43.61)	0.39^{c}	0.15^{c}	0.43^{d}	111.25^{b}
T_3	38.26^{e} (38.33)	0.40^{c}	0.16^{c}	0.42^{d}	95.75^{i}
T_4	42.60^{c} (45.83)	0.45^{b}	0.20^{b}	0.49^{c}	100.75^{fgh}
T_5	31.47^{j} (27.22)	0.28^{f}	0.07^{gh}	0.29^{g}	95.25^{i}
T_6	32.52^{hi} (28.89)	0.27^{fg}	0.07^{gh}	0.30^{g}	103.75^{ef}
T_7	54.75^{a} (66.67)	0.55^{a}	0.31^{a}	0.66^{a}	120.00^{a}
T_8	51.10^{b} (60.56)	0.54^{a}	0.30^{a}	0.61^{b}	110.25^{bc}
T_9	35.92^{f} (34.44)	0.34^{d}	0.11^{d}	0.37^{e}	99.75^{gh}
T_{10}	31.64^{ij} (27.50)	0.28^{f}	0.08^{fg}	0.29^{g}	98.00^{hi}
T_{11}	28.67^{k} (23.06)	0.24^{h}	0.06^{h}	0.26^{h}	95.75^{i}
T_{12}	34.40^{g} (31.94)	0.33^{d}	0.11^{d}	0.35^{e}	97.25^{hi}
T_{13}	34.57^{g} (32.22)	0.31^{e}	0.09^{ef}	0.33^{f}	104.50^{de}
T_{14}	36.60^{f} (35.56)	0.33^{d}	0.10^{de}	0.36^{e}	107.50^{cd}
T_{15}	33.21^{h} (30.00)	0.28^{f}	0.08^{fg}	0.31^{g}	102.00^{efg}
T_{16}	31.11^{j} (26.67)	0.26^{g}	0.07^{gh}	0.26^{h}	102.75^{efg}
Mean ± SEm (Range)	36.63 ± 4.04 (28.11 - 54.75)	0.34 ± 0.06 (0.20 - 0.55)	0.13 ± 0.005 (0.04 - 0.30)	0.37 ± 0.007 (0.22 - 0.66)	103.36 ± 1.19 (95.25 - 120)
CV (%)	1.85	3.50	7.70	3.57	2.29
F- value	496.85*	286.49*	275.91*	342.11*	33.66*
CD ($p \leq 0.05$)	0.967	0.017	0.014	0.019	3.39

Note: Value denoted with the same letter(s) are not significantly different at *P*<.05according to Duncan's Multiple Range Test (DMRT). Values with (*) are significantly different at *P*<.05probability level.

Plate 1. Ripened fruit of adult *Cinnamomum glaucescens*(Nees)(a), fruit collection with pericarp (b), depulped fruit ready for pre-treatments (c), pre-sowing treatment: hydrogen peroxide (d), hypogeal germination stages (e) seedling in polybag (f).

The germination value captures the speed and completeness of seed germination [47, 35]also varied significantly amongst different treatments, the highest value was recorded in T_7(0.31) and T_8 (0.30) followed by T_4(0.20) and the other treatments showing decreasing trends.It was also observed that maximum germination speed observed in T_7 and T_8 making hydrogen peroxide suitable therapy for triggering seed germination of *C. glaucescens*.The lowest energy period (95.25 days) was recorded for the seeds subjected to T_5withan ascending sequence ofT_3>T_{11}>T_{12}>T_{10}>T_9>T_4>T_{15}>T_{16}>T_6>T_{13}>T_{14}>T_1>T_8>$T_2$and reaching maximum duration in T_7 (120 days), contrariwise representingenhanced germination percentage and reduced duration. Peak value indicates the maximum germination rate in a particular day, and the highest peak was recorded in T_7 (0.55) and T_8 (0.54) was at par, although this trend was more or less similar to the germination energy andthe highest value (66.39%) was calculated for T_7 followed by T_8 (60.28%)were significantly better than other pre-treatments. The viability loss inversely varied with respect to germination energy as demonstrated in figure 1, and showed maximum energy percentage could maintain their viability for anextended period of time indicating higher germinationenergy resulted in lower viability loss, though the germination energywith high values depicted the germination potential and vigourness of the seeds[48].As compared to 16 pretreatments examined in our experiment, 4% H_2O_2 acts bestandmaycontribute in ‘vigouration’benefits for seedling productions in forest nurseries. There may be few indication in reverence to the unfavourableeffects of hydrogen peroxide treatments to tree seeds, while this elevated germination responded due to H_2O_2 has been noted in many investigations ontree species in understanding the germination expressions beyond the sanitation benefits viz., *Pinus elliottii* (1%) [49]; *Pseudotsuga menziesii*, *Pinus ponderosa*, *P. lambertiana* (1%) [50];*Cinnamomum camphora*(15%)[51]; *Tectona grandis* (0.5 to 5%) [52];*Pinus Palustris* (30% & 3%) [53] and*Fagus orientalis* (1%, 2%, 5% and 30%) [54].



Note: Bars with same letter(s) for germination energy are not significantly different at *P*<.05 according to Duncan's Multiple Range Test (DMRT).Values with (*) are significantly different at *P*<.05; ±SEm, standard error of the mean; *F*-value, ratio of variances (*Fisher* analysis of variance); CV, coffiecient of variation; CD, critical difference at 0.05 level. Bars (ascending) and graphical line (descending) depicts arcsine value.

Fig.1.Germination energy and viability lossof different pre-sowing treatment of *Cinnamomum glaucescens* (Nees) under nursery conditions.

4. CONCLUSION

Suitable pretreatment applied to dormant seeds ensures successful propagation to get additional level of seed germination. The findings of the experiment concluded that seeds dipped in 4% hydrogen peroxide for 12h in dark (T_7) significantly enhanced the germination percentage among differentpre-sowing treatments sowed in nursery conditions. Hence, this treatment can be recommended for large scale production of nursery seedlings of *C. glaucescens* for promoting commercial plantation and support conservation efforts. The mechanism of seed breaking dormancy of this species also needs further study.

REFERENCES

1. Li X, Bai P. Flora Reipublicae Popularis Sinicae. Science Press, Tomus. 1982;31:509.
2. Kostermans AJGH. *Cinnamomum.* In: Dassanayake MD,editor. A Revised Handbook to the Flora of Ceylon. Amerind Publishing Co., New Delhi. 1995;9:112-129.
3. Mabberley DJ. Mabberley's plant-book: A portable dictionary of plants, their classifications and uses, third edition. Cambridge University Press, UK. 2008;188-496
4. Shu Z, Xiwen L, Jie L, Van der Werff H. *Cinnamomum* Schaeffer, Bot. Exped. 74. 1760, nom. cons. Flora of China. 2008;7:166-187.
5. Yang Z, Liu B, Yang Y, Ferguson DK. Phylogeny and taxonomy of *Cinnamomum* (Lauraceae). Ecology and Evolution. 2022;12(10):1-19. DOI:https://doi.org/10.1002/ece3.9378.
6. Hooker JD. The Flora of British India. Vol-V. L. Reeve & Co., Brook, Ashford, Kent, London. 1885;135.
7. Bor NL. Manual of Indian Forest Botany. Geoffrey Cumberlege Oxford University Press. Bombay. 1953;53.

8. Gamble JS. A Manual of Indian Timbers. Sampson Low, Marston & Company Ltd. London. 1902;563.
9. Brandis D. Indian Trees. Archibald Constable & C. Ltd. Butler & Tanner, The Selwood Printing Works. London. 1906;534.
10. Kanjilal UN, Kanjilal PC, De RN, Das A. Flora of Assam.Vol–IV. Assam Govt. Press, Shillong.1940;58.
11. Anonymous. The Wealth of India, Raw materials, Vol. III (Revised), CSIR, New Delhi.1992;578-579.
12. Rani A, Pandey C, Tiwari G, Patni K. A Review of Aroma Profile of *Cinnamomum* species in Northern and North East India*.* World Journal of Pharmaceutical Research. 2017; 6(11):200-221.
13. Troup RS. The Silviculture of Indian Trees. *Lauraceae* to *Coniferae*. Vol. III. Clarendon Press, Oxford, UK. 1921;789.
14. Jackson JK. Manual of Afforestation in Nepal. Forest Research and Survey Center, Ministry of Forests and Soil Conservation, Kathmandu, Nepal. 1994;2:471.
15. Ravindran PN, Babu K, Shylaja M, editors.*Cinnamon* and *Cassia*. The genus Cinnamomum, CRC Press, Boca Raton, Florida, USA. 2004;361.
16. Adhikary SR, Tuladhar BS, Sheak A, van Beek TA, Posthumus MA, Lelyveld GP. Investigation of Nepalese Essential Oils. I. The Oil of *Cinnamomum glaucescen*s (Sugandha Kokila). Journal of Essential Oil Research. 1992;4:151-159.
17. Baruah A, Nath SC. Leaf essential oils of *Cinnamomum glanduliferum*(Wall) Meissn and *Cinnamomum glaucescens*(Nees) Meissn. Journal of Essential Oil Research. 2006; 18:200-202.
18. Chinh HV, Luong NX, Thin DB, Dai DN, Hoi TM, Ogunwande IA. Essential Oils Leaf of *Cinnamomum glaucescens* and *Cinnamomum verum* from Vietnam. American Journal of Plant Sciences. 2017;8:2712-2721.
19. DPR. Plants of Nepal:Fact Sheet.Government of Nepal, Ministry of Forest and Soil Conservation, Department of Plant Resource, Thapathali, Kathmandu, Nepal. 2012;56.
20. Prakash B, Singh P, Yadav S, Singh SC, Dubey NK. Safety profile assessment and efficacy of chemically characterized *Cinnamomum glaucescens*essential oil against storage fungi, insect, aflatoxin secretion and as antioxidant. Food and Chemical Toxicology. 2013;53:160-167.
21. Rajendra G, Jyoti B, Shiksha A, Esha P, Udaya LP, Ranjana P, et al. Antibacterial and cytotoxic activities of high altitude essential oils from Nepalese Himalaya. Journal of Medicinal Plant Research. 2013;7:738-743.
22. Satyal P, Paudel P, Poudel A, Dosoky NS, Pokharel KK, Setzer WN. Bioactivities and compositional analyses of *Cinnamomum* essential oils from Nepal: *C. camphora, C. tamala* and *C. glaucescens*. Natural Product Communications. 2013;12:1777-1784.
23. Sharma P, Acharya KR. Economics of *Cinnamomum glaucescens*(Nees.) Drury in Western Terai Region of Nepal: A Value Chain Perspective. Forestry Journal of Institute of Forestry. 2020;17:102-117. DOI: https://doi.org/10.3126/forestry.v17i0.33625*1 Tribhuvan*
24. Rawal RB. Commercialization of aromatic and medicinal plants in Nepal.In: Durst PB, Bishop A,editors. Beyond timber: Social, economic and cultural dimensions of non-wood forest products in Asia and the Pacific, Regional Office for Asia and the Pacific (RAP), FAO/RAP. 1995;49-155
25. Handa SS, Rakesh DD, Vasisht K. Compendium of Medicinal and Aromatic Plants-Asia. Earth, Environmental and Marine Sciences and Technologies. ICS-UNIDO, Italy. 2006;2:295.
26. Maraseni TN. Selection of non-timber forest species for community and private plantations in the high and low altitude areas of Makawanpur District, Nepal. Small-Scale Forestry. 2008;7(2):151-161.
27. de Kok R. *Cinnamomum glaucescens*. The IUCN Red List of Threatened Species.2022. [Accessed 10 August 2024]. DOI:https://dx.doi.org/10.2305/IUCN.UK.2022-1.RLTS.T145309203A145416036.en.
28. Nwoboshi LC. Tropical Silviculture: principles and techniques. Ibadan University press, Nigeria. 1982;333.
29. Baskin CC, Baskin JM. Seeds: ecology, biogeography, and evolution of dormancy and germination. Academic Press, San Diego, CA, USA. 1998;666.
30. Abayechaw D, Wulchafo K. The Concept and Process of Seed Germination - A Review. International Journal of Current Research and Academic Review.2020;8(5):100-112.
31. Luna RK. Plantation Trees. International Book Distributors, Dehra Dun.1996;975.

32. Luna T, Wilkinson K, Dumroese RK. Seed germination and sowing options. In: Dumroese RK, Luna T, Landis TD, editors. Nursery manual for native plants: A guide for tribal nurseries - Volume 1: Nursery management. Agriculture Handbook 730. Washington, D.C.: U.S. Department of Agriculture, Forest Service. 2009;8:133-151.
33. Roy B, Bhandary SBR. Propagation and field trials of sugandhakokila (*Cinnamomum glaucescens*). Banko Janakari. 1989;2(1):117-118.
34. ISTA. Agricultural, Vegetable and Horticultural Species. In: Leist N, Kramer S,Jonitz A,Basserdorf,editors.ISTA Working Sheets on Tetrazolium Testing Vol. I. CH-Switzerland. 2003; 200.
35. Czabator FJ. Germination value: an index combining speed and completeness of pine seed germination. Forest Sciences. 1962;8(4):386-396.
36. Panse VG, Sukhatme PV. Statistical methods for agricultural workers. 4th ed. The Indian Council of Agricultural Research, New Delhi, India. 1985;1-381.
37. Duncan DB. Multiple ranges and multiple F-tests. Biometrics. 1955;11(1):1-42.
38. Ching TM. Activation of germination in Douglas Fir seed by hydrogen peroxide. Plant Physiology. 1959;34(5):557-563.
39. Ogawa K, Iwabuchi MA. Mechanism for promoting the germination of *Zinnia elegans* seeds by Hydrogen peroxide. Plant Cell Physiology. 2001;42(3):286-291.
40. Ghildiyal SK, Sharma CM, Khanduri VP. Improvement in germination of chirpine (*Pinus roxburghii*) by a presowing treatment with hydrogen peroxide. Journal of Tropical Forest Science. 2007;19(2):113-118.
41. Joseph A, Satheeshan KN, Jomy TG. Seed germination studies in *Garcinia* spp. Journal of Spices and Aromatic Crops. 2007;16(2):118-121.
42. Omokhua GE, Aigbe HI, Uko IJ. Effect of pre-treatments on germination and early seedling growth of *Maesobotryabarteri*. International Journal of Scientific & Engineering Research. 2015; 6(3): 921-925.
43. Chen J, Huang X, Xiao X, Liu J, Liao X, Sun Q,et al. Seed dormancy release and germination requirements of *Cinnamomum migao*, an endangered and rare woody plant in Southwest China. Frontiers in Plant Science. 2022;13:1-14.
44. Rinaldi N, Singh B, Alice AK. Influence of pre-sowing treatments on seed germination of *Michelia champaca* Linn. Under Eastern Himalayas, India. The Pharma Innovation Journal. 2022;SP-11(9):173-176.
45. Lorenzo-Barrera NA, Andrade-Rodríguez M, Villegas-Torres O, Sotelo-Nava H. Pre-germination treatments on kidneywood (*Eysenhardtiapolystachya*) seeds. RevistaCiênciaAgronômica. 2024;55:1-8.
46. Puwein F, Singh B, Tatan T. Influence of pre-sowing treatments on germination of *Canarium strictum*Roxb. International Journal of Current Microbiology and Applied Sciences. 2022;11(01):301-307
47. Diavanshir K, Pourbeik H. Germination value a new formula. SilvaeGenetica. 1976;25: 79-83.
48. Willan RL. A Guide to Forest Seed Handling: With Special Reference to the Tropics. Food and Agriculture Organization of the United Nations, Rome. FAO Forestry paper. 1985;20/2. Available: https://www.fao.org/4/AD232E/AD232E00.htm
49. Forrest WG. The effect of pretreatment on germination of slash pine seed. Forestry Commission of New South Wales. Research Note. 1964;No.14:10-11.
50. Stein WI. A field test of Douglas-fir, ponderosa pine and sugar pine seeds treated with hydrogen peroxide. Tree Planters' Notes. 1965;71:25-29.
51. Chien C, Lin TP. Mechanism of hydrogen peroxide in improving the germination of *Cinnamomum camphora*seed. Seed Science and Technology. 1994;22(2):231–236.
52. Masilamani P, Dharmalingam C. Effect of seed treatment with hydrogen peroxide on germination and seedling vigour on teak (*Tectona grandis* Linn.f). Tropical Agricultural Research and Extension. 1999;2(1):26-29.
53. Barnett JP, Varela S. A review of chemical treatments to improve germination of longleaf pine seeds. Native Plants Journal. 2004;5(1):18-24. DOI: https://doi.org/10.2979/NPJ.2004.5.1.18
54. Rezaei A, Yazdian F, Nasery B, Haghverdi K, Hedayati MA. A study of hydrogen peroxide effects on oriental beech (*Fagus orientalis)* nuts germination stimulation. Annals of Biological Research. 2012;10:4728-4733.