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Variation in seed germination behavior of *Santalum album* based on pre sowing treatment enhancer

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Abstract
Sandalwood (*Santalum Album* L.) is a commercially important indigenous tropical tree belongs to the family Santalaceae. The species is being raised as large scale plantation in both forest and outside forest areas. The main source of these plantations through its seeds which is difficult to germinate and needs special chemical treatment. But due to its hard seed coat limits seed germination. Seed encapsulation technique has a significant impact on germination and seedling quality in forestry crops. So far experiment was conducted at Agroforestry experimental area of Tropical Forest Research Institute, Jabalpur (MP) in the year 2021 with an aim to find best pre-sowing treatments to enhance germination of Sandalwood (*Santalum album* L.). Seeds were collected from three different locations *viz*. Seoni (MP), Marayoor (Kerala) and TFRI campus, Jabalpur (Madhya Pradesh) and treated with different treatments which includes growth regulators (G_3 500 ppm and 1000 ppm), Cow urine (100% concentrated), Normal Water (24 hrs) and untreated seeds as control. Among all the treatments seeds treated with GA_3 (1000 ppm) recorded maximum germination percentage (55%) followed by Cow urine (48%) as compared to control of TFRI location, Similarly Seoni source also showed maximum seeds germination 44% was recorded with GA_3) 1000 ppm (treatment followed by GA_3, 500 ppm (37%) and minimum germination 4.66% was recorded in untreated seeds. Seeds procured from Marayoor Kerala registered similar findings i.e. maximum germination with GA_3, 1000 ppm (51.33%) followed by GA_3, 500 ppm (50.66%) and minimum 21.33% in Untreated seeds. The variations in germination percentage within treatment not correlated with geographic locations and soil conditions.

Keywords: *Santalum album*, pre-sowing treatments, dormancy, germination percentage, gibberalic acid (GA_3)

Introduction
Santalum album L. (Sandalwood) belongs to the Family Santalace and perform best under various agroforesty system. It is related to Indian faith and culture considering the fact that historical period in spite of the Sandalwood has been distributed everywhere in the country, 90% of the populace of sandalwood located only in Karnataka, Tamil Nadu and Kerala protecting approximately an area of 8300 square kms (Arun Kumar *et al*. 2016) [3]. Sandalwood oil is the one of the valuable source for perfume industry and the usage of variety of merchandise cleaning soap enterprise and Incense sticks, additionally useful in cosmetic industry. The crude oil of sandalwood is used for pores and skin problems like acne, prickly warmness, pores, skin eruptions, itching, swelling and rashes ,aside from its medicinal uses, its softwood is generally used for carving and making articles. Many products like rosary from seeds, soaps, perfumes, incense stick and powder and so for (Subasinghe, 2013)] [18] .[It has also an vital area in Hindu religious ceremonies. In India, the herbal plantations of sandalwood is regularly diminishing due to adjustments within the land use, habitat destruction, illegal felling and theft of plantations (Arun Kumar *et al*., 2012) [2] .Other natural factorslike fire, drought, floods and biotic factors human interference, over grazing of the seed by animals also causes a rapid decline in its natural population and also creating hurdles for its germination. (Doran *et al.*, 2005) [6].
Das and Tah, 2013 reported that seeds of sandalwood are impermeable to water which causes poor germination. Various other physiological factors mechanically resistant seed coats, rudimentary and physiological immature embryo, morphologically mature and physiological immature embryos also causes seed dormancy.
Polaiah *et. al.* (2020) [15], conducted a study to examine the impact of GA_3, cow urine, cow dung slurry and chemicals including HNO_3, KNO_3, Thiourea and H_2SO_4on seed germination and morphological parameters of sandalwood at ICAR-Directorate of Medicinal and fragrant plant life studies Anand, Gujarat.

Material and Methods

Experimental site

The study was conducted in lab condition of Agroforestry division of Tropical Forest Research Institute, Jabalpur (with geographic location N 23.09 E 79.98 and N 23.10, E 79.98) during year 2021. The climate of the study area is semiarid, received 1350 mm rainfall during the period. The mean monthly minimum temperature varies between 5.3 to 6.1 °C during December to January, and maximum temperature varies between 40 to 42 °C during May to June, respectively, soil condition of experimented area was sandy soil with low nutrient availability.

Treatment details of field experiment

The seeds of Sandalwood were collected in the month of March and September 2021 from selected CPTs at TFRI campus and forest areas of Seoni districtusing agro-net for dust and moisture free collection and also seeds were procured from Marayoor Kerala. Seeds were graded, de-pulped and dried before pre sowing treatment. For sowing, raised seed bed of size10 m x1 mwas filled with mixture of sand, soil and well rotten FYM with ratio of 1:2:1 respectively. After seed treatment, seed was dibbled at 1 cm depth and then covered with a thin layer of soilin seed bed . Seed treatment details are given below.

Table 1: Pre seed sowing treatments of Sandalwood

Treatment details (TFRI, Seoni and Marayoor
T_1 – Untreated seeds (Control)
T_2 – Cow urine for 24 hours
T_3 – GA_3 (500 ppm), for 24 hours
T_4 – GA_3 (1000 ppm) for 24 hours
T_5 – Water soaking

Observations on germination parameters were recorded each day up to one month till its final germination obtained.

Seed Moisture Content

The seeds were tested for moisture content material on fresh weight foundation by way of oven dry approach (ISTA, 1999) [10], approximately 5 g of seed samples had been taken in triplicates and determined the exact moist weights. The seeds were dried in a warm air oven at 100 °C for 17 hours. The sample seeds had been then cooled in desiccators and the dry weight was recorded. The moisture content material became calculated using the following formula:

$$\text{Moisture Content (\%)} = \frac{\text{(Initial weight – Dry weight) g X 100}}{\text{Initial weight (g)}}$$

Seed Vigour Index

Seed vigour Index is calculated with the aid of figuring out the manufactured from germination percentage and seedling length of the identical seed lot. The seed lot displaying the better seed vigour index is taken into consideration to be greater full of life (Abdul-Baki and Anderson, 1973) [1].

Germination Test: Germination test was carried out as per ISTA policies (1999) [10]. Seed germination percentage was determined by using sowing one hundred seeds in five replications in sand beds with regular watering once a day. The germination check was finished on the 20th day of the test starting from appearance of first sprout.

Germination percentage: The number of normal seedlings produced in each treatment was counted and average was expressed in percent (ISTA, 2003).

$$\text{Moisture Content (\%)} = \frac{\text{(Initial weight – Dry weight) g X 100}}{\text{Initial weight (g)}}$$

Statistical analysis: The test was carried out in Randomized complete Block design. Data were analysed statistically by analysis of variance (ANOVA) to detect significant variations among mean (Sheoran *et al*. 1998) [16], significantly differing mean have been tested based on F check value at 0.05 probability degree. Variance in data has been expressed as mean ± standard errors.

Results and Discussion

The significant results were recorded for Germination percentage and Germination powerby different pre-sowing seed treatments and the results were shown in Table 1 and fig 1**,** Table 2, and Fig. 2and Table 3 and Fig. 3.

Effect on seed germination

The significant effect of various pre-sowing seed treatments on seed germination of sandalwood was recorded**.** Among the treatments, it was observed that the seeds treated with GA_3 1000 ppm showed significantly highest germination percentage (55%) followed by Cow urine **(**48 %) whereas the lowest germination percentage was noticed where the seeds were untreated (5.66 %) in case of seed colected from Seoni district maximum germination found in $GA_3$1000 ppm showed significantly highest germination percentage (44.33%) followed by GA_3 500 ppm **(**37 %) whereas the lowest germination percentage was noticed where the seeds were untreated (4.66 %). In seeds procured from Marayoor Kerala maximum germination recorded in GA_3, 1000 ppm (51.33%) followed by GA_3, 500 ppm (50.66%) and minimum germination was recorded in untreated seeds (21.33%), same result was obtainted by Polaiah *et al.* 2020 **[15]** and Berry *et al.* 2021 **[4]** on *Gmelina arborea.* GA_3 releases the seeds from dormancy via promoting protein synthesis, elongation of coleoptiles and manufacturing of ethylene (Stewart and Freebairn, 1969) [17]. The same consequences had been mentioned through Nagaveni et al. (1989) [12] that the sandalwood seeds treated with specific growth hormones and determined that GA3 treated seeds exhibited high germination percentage under subject circumstance. Subsequently, GA3 had a enormous impact on breaking the seed dormancy and the germination of the seed.

Sutheesh *et al.* (2016) [19] and Polaiah *et al.* (2020) [15] also reported the same result where GA_3 1000 ppm has highest germination percentage for sandalwood. Palani *et al.*, (1996) [13] also stated the outcomes of pre-sowing remedies in Albizia lebbeck. The outcomes had been in keeping with Muruganandam *et al.* (2019) [11] mentioned a high percentage of germination (56.55%) of the *Gloriosa superba* seeds treated with the GA_3 and that they determined at lower concentration 200 ppm as compared excursion examine. The consequences of our work are similar to Hussain and Jha (2014) [9] who found that progressed seed germination percent in *Rauvolfia serpentina* (48.65%) and *R. tetraphylla* (56.66%) seeds dealt with the GA_3.

Table 1: Germination percentage of various pre sowing treatments in *Santalum album* L. of TFRI, Jabalpur (Madhya Pradesh)

Treatments	Germination Percentage (%)
T_1– Untreated seeds (Control)	5.667
T_2– Cow urine (soaked for 24 hours)	48.333
T_3– GA_3 (500 ppm), (soaked for 24 hours)	37.667
T_4– GA_3 (1000 ppm), (soaked for 24 hours)	55.000
T_5– Normal Water (soaked for 24 hours)	8.000
C.D.	4.793
S.E(m)	1.447
S.E(d)	2.047
C.V.	8.103

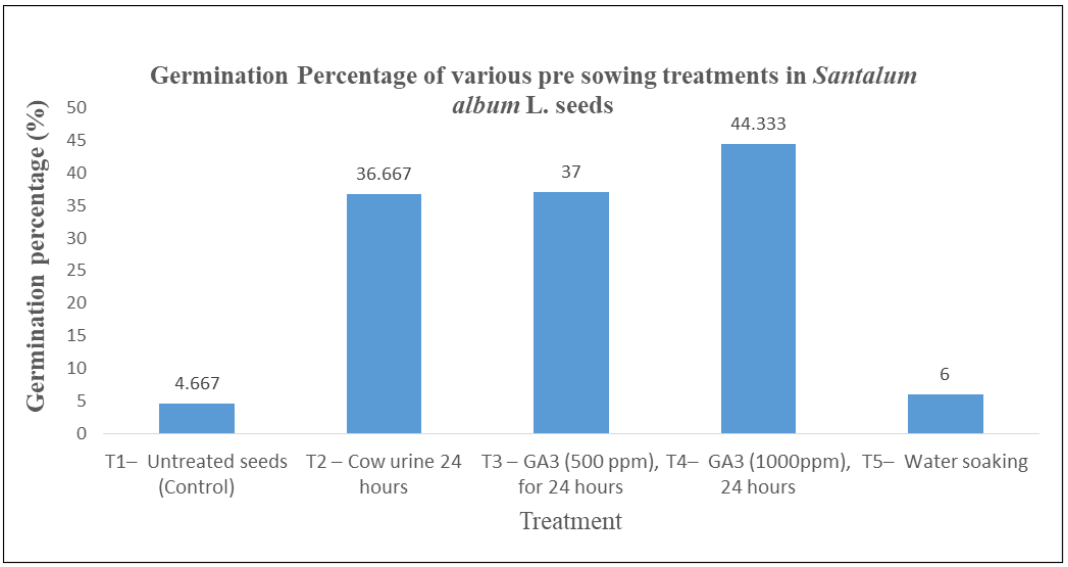

Fig 1: Germination percentage of various pre sowing treatments of *Santalum album* L.

Table 2: Germination percentage of various pre sowing treatments in *Santalum album* L. of Seoni District, Madhya Pradesh.

Treatments	Germination Percentage (%)
T_1– Untreated seeds (Control)	4.667
T_2– Cow urine (soaked for 24 hours)	36.667
T_3– GA_3 (500 ppm), (soaked for 24 hours)	37.000
T_4– GA_3 (1000 ppm), (soaked for 24 hours)	44.333
T_5– Normal Water (soaked for 24 hours)	6.000
C.D.	10.452
S.E(m)	3.156
S.E(d)	4.463
C.V.	21.243

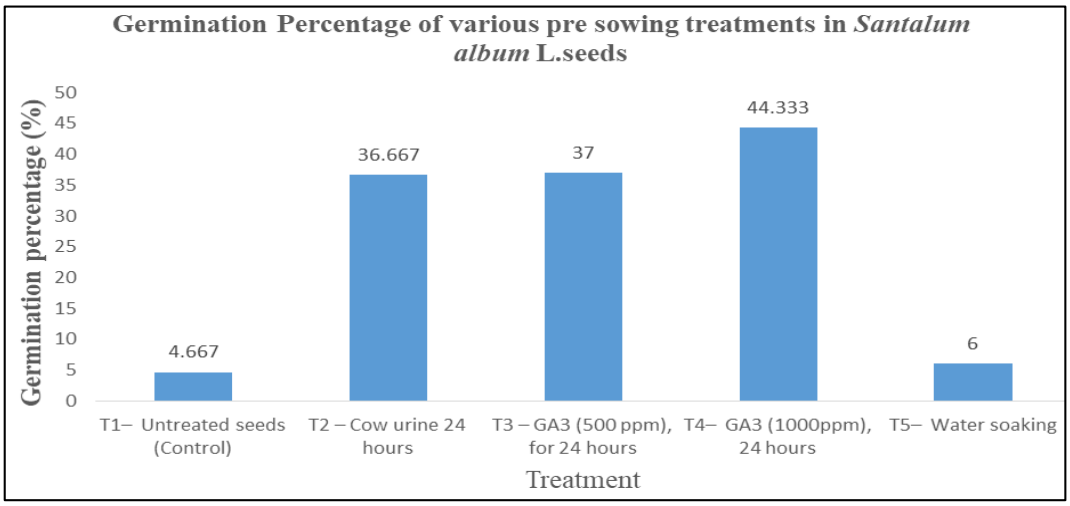

Fig 2: Germination percentage of various pre sowing treatments *Santalum album* L.

Table 3: Germination percentage of various pre sowing treatments in *Santalum album* L. of Marayoor, Kerala**.**

Treatments	Germination Percentage (%)
T_1– Untreated seeds (Control)	21.330
T_2– Cow urine (soaked for 24 hours)	29.250
T_3– GA_3 (500 ppm), (soaked for 24 hours)	50.660
T_4– GA_3 (1000 ppm), (soaked for 24 hours)	51.33
T_5– Normal Water (soaked for 24 hours)	7.000
C.D.	3.534
S.E(m)	1.067
S.E(d)	1.509
C.V.	5.792

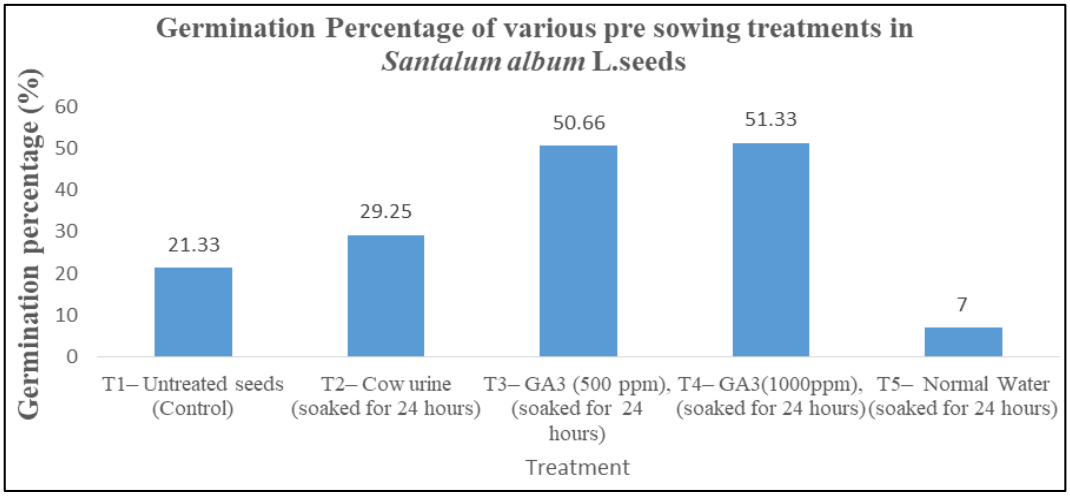

Fig 3: Germination percentage of various pre sowing treatments *Santalum album* L.

Conclusion

From the studyit could be concluded that the sandalwood seeds were treated with GA3 1000 ppm germinated quicker and additionally gave better boom performances. As a result, it could be recommended that GA3 1000 ppm is appropriate dose to break the seed dormancy because it gave the maximum seed germination percent and seedling growth to supply best planting substances for the sandalwood farming.

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