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Effect of different pre-sowing treatments on germination of Red sanders (*Pterocarpus santalinus* L. f.) in Net house condition

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Abstract
The present investigation entitled "Effect of different pre-sowing treatments and growing conditions on germination of Red Sanders (*Pterocarpus santalinus* L. f.)" was carried out in the year 2015-16 at Department of Silviculture and Agroforestry, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari (Gujarat). The experiment comprised of eleven pre-sowing treatments *viz.*, T_1 (Tap water for 4 days), T_2 (Tap water for 8 days),T_3 (Lukewarm water for 4 days), T_4 (Lukewarm water for 8 days), T_5 (GA_3 @ 250ppm for 1 day), T_6 (GA_3 @ 500ppm for 1 day), T_7 (10 % sulphuric acid for 1day), T_8 (10 % hydrochloric acid for 1day), T_9 (10 % nitric acid for 1day), T_{10} (Separating seeds from pods with a sharp knife or scalpel and sown directly) and T_{11} (Control) and grown in net house condition with Completely Randomized Design having three repetitions. The treated plants were kept in net house for further study. Among different pre-sowing treatments, seed pre-treated with T_6 (GA_3 @ 500ppm for 1 day) registered earlier sprouting (7.67) and higher germination percentage (66.67 %), collar diameter (5.65 mm), plant height (41.20 cm), number of leaves per plant (20.44), root length (30.57 cm), fresh of plant (31.58 g/plant), dry weight of plant (24.77 g/plant) and survival percentage (63.33 %). The next best pre-sowing treatments are T_5 (GA_3 @ 250 ppm for 1 day) and T_{10} (Separating seeds from pods with a sharp knife or scalpel and sown directly). The seeds which were no treated (T_{11}: control) found poorest for all parameters under study.

Keywords: *Pterocarpus santalinus* L. f., Red sanders, GA_3, net house, seed germination, pods

1. Introduction
Red Sanders (*Pterocarpus santalinus* L. f.) is an endangered and endemic tree species that occurs in Southern parts of Eastern Ghats of India. Being a commercially important tree of Indian forests, commonly termed in the trade as "Red Sanders" and locally considered as the "Pride of India" and the "State Tree of Andhra Pradesh". Due to prevailing dry and hot conditions in its natural habitat, the pollination ecology is vulnerable. As an endemic species, for its continuous survival, Red Sanders has devised cross pollination as the main system exhibiting xenogamous breeding though geitonogamy exists a bit (Rao and Raju, 2002) [14]. The matured reddish brown coloured winged pods are formed after eleven months of flowering and have one or two seeds (Dayanand, 1988) [4]. Heartwood of Red Sanders has high demand in domestic as well as international market and the wavy grained wood is valued. It was found that seedlings raised from wavy grained trees were slow growing compared to that of straight grained trees. The seedlings had short internodes, smaller and greener leaves, petioles and more compact crown and concluded that these traits were distinct and can be used for segregating the seedlings.
The macro and micro propagation protocol have been developed; further refinement is required for mass propagation. The poor seed germination was reported by Kalimuthu and Lakshmanan (1995) [7]. Seed germination has been advocated as one of the most viable tools for the ex situ conservation of threatened germplasm (Rao, 2004) [13]. Considering the wood demand, restricted distribution, slow regeneration, illegal harvest, trade and habitat destruction and various limitations in propagation of Red Sanders by natural means are prolonged dormancy, low germinability and poor viability of seeds.

2. Materials and Methods

The pods of Red Sanders (*Pterocarpus santalinus* L. f.) were brought from Bengaluru, Karnataka and pods were sown directly into the polythene bag in the Net house. In one polythene bag one pod is sown at the depth of 2 cm. One pod of Red Sanders contains two seeds. The pods were treated with the following treatments *viz.*, T_1: Pods of Red Sanders were kept in Tape water and allowed soaking for 4 days. Water was regularly changed once in 24 hours time period for the leach out of the phenolic compounds present in the pods; T_2: Pods of Red Sanders were kept in Tape water and allowed soaking for 8 days. Water was regularly changed once in 24 hours time period for the leach out of the phenolic compounds present in the pods; T_3: Pods of Red Sanders were kept in lukewarm water and allowed soaking for 4 days. Water was regularly changed once in 24 hours for leach out of the chemicals present in the pods; T_4: Pods of Red Sanders were kept in lukewarm water and allowed soaking for 8 days. Water was regularly changed once in 24 hours for leach out of the chemicals present in the pods; T_5: GA_3 @ 250 ppm for 24 hours; T_6: GA_3 @ 500 ppm of solution for 24 hours; T_7: 10 % H_2SO_4 solution for 20 minutes and then after placed in water for 24 hours; T_8: 10 % HCl solution for 20 minutes and then after placed in water for 24 hours; T_9: 10 % H_2SO_4 solution for 20 minutes and then after placed in water for 24 hours; T_{10}: Seeds were separated from the pods with the help a sharp knife or scalpel and then sown directly into the poly bags. In each poly bag one seed were sown; T_{11}: No pre-treatments were given to the pods of Red Sanders and directly sown in the poly bags in the Net house conditions. The observations on Days to first sprout, Germination percentage (%), Plant height (cm), Number of leaves per plants, Collar diameter (mm), Root length (cm), Survival percentage (%), Fresh weight of plant (g) and Dry weight of plant (g) were recorded. Statistical analysis of the data of various characters studied in present investigation was carried out through the procedure of Completely Randomized Design (CRD). The appropriate standard error of mean (S. Em. ±) and the critical difference (C. D.) were calculated at 5 percent level of probability.

3. Result and Discussion

It is evident from the data presented in table that days to first sprout, germination percentage, number of leaves per plant, collar diameter, plant height, survival percentage, root length, fresh weight and dry weight of shoot, root and plant were significantly influenced by different pre-sowing treatments in the present study.

1. Germination parameters

The results of the study revealed that the minimum number of days to first sprout and maximum germination percentage were recorded in pods treated with GA_3 at 500 ppm for 1 day (T_6 : 7.67 days and 66.67 %, respectively) which was at par with Separating seeds from pods with a sharp knife or scalpel and sown directly (T_{10} : 9.00 days and 63.33 %, respectively) and GA_3 at 250 ppm for 1 day (T_5 : 9.00 days and 63.33 %, respectively). The delayed sprouting and minimum germination percentage (18.00 days and 43.33 %, respectively) was recorded in control (T_{11}). It might be due to the involvement of GA_3 in the activation of cytological enzymes along with increase in cell wall plasticity and better water absorption. GA_3 acts directly on embryo relieving them from dormancy through promoting protein synthesis and elongation of coleoptiles and leaves and also helps in the production of ethylene. This ethylene invokes the synthesis of hydrolases, especially amylase, which favours the seed germination (Stewart and Freebairn, 1969) [21]. Another reason is that GA_3 stimulates seed germination by formation of a-amylase enzymes which converts insoluble starch into soluble sugars and it also initiates the radical growth by removing some metabolic blocks as suggested by Gillard and Walton (1973) [5]. The remarkable effect of GA_3 on seed germination especially in breaking seed dormancy has been well established by several workers; Dayanand and Lohidas (1988) [3], Naidu and Mastan (2001) [11] and Naidu (2001) [11] in Red sanders; Shivanna *et al*. (2007) [20] in *Terminalia bellerica*, Banyal (2010) [1] in *Pinus gerardiana*, Das and Tah (2013) [2] in *Santalum album*, Kala *et al*. (2014) [6] in *Canarium strictum*, Lilabati and Sahoo (2015) [9] in *Emblica officinalis* and Sutheesh *et al*. (2016) [22] in *Santalum album* and Rout *et al*. (2016a) [15] in *Delonix regia.* The results of the present studies revealed that the separating seeds from pods with a sharp knife or scalpel and sown directly increase the permeability of air and water through seed which favours the second most good seed germination and higher germination percentage which was statistically at par with GA_3 at 500 ppm for 1 day. Dayanand and Lohidas (1988) [3] also recorded highest seed germination up to 83.50 % in the treatment of separating seeds with a sharp knife or scalpel before sowing the Red Sanders seed. More or less similar results were observed by Shivanna *et al*. (2007) [20] in *Terminalia bellerica* and Khan (2013) [8] in *Pongamia pinnata* L. and *Pterocarpus marsupium* Roxb.

2. Growth Parameters

Among the different pre-sowing treatments, GA_3 500 ppm for 1 day (T_6) gave maximum plant height (41.20 cm), number of leaves per plant (20.44) and collar diameter (5.65 mm). The increase in plant height with GA_3 treatment was due to the fact that this hormone increased osmotic uptake of nutrients, causing cell multiplication and cell elongation in the cambium tissue of the intermodal region and thus increased height of the plant (Shanmugavelu, 1966) [19] and collar diameter also increased due to gibberellic acid promoted cell division and cell elongation in the collar region (Sen *et al.*, 1990) [18]. The production of more number of leaves might be due to higher growth of seedlings and also due to activity of GA_3 at the apical meristem resulting in more synthesis of nucleoprotein responsible for increasing leaf initiation (Sen and Ghunti, 1976) [17]. The results are also in accordance with result of Masilamani and Dharmalingan (2002) [10] in Silver Oak (*Grevillea robusta* A. Cunn.), Radhakrishnan and Renganayaki (2008) [12] in Simaruba (*Simaruba glauca* Linn) and Rout *et al*. (2016b) [16] in *Delonix regia*.

3. Biomass Parameters

For assessing the influence of different treatments on biomass the fresh and dry weight of plant were determined. The results of the present investigation significantly revealed that the maximum fresh (31.58 g/plant) and dry weight of plant (24.77 g/plant) were recorded in GA_3 at 500 ppm for 1 day. It might be due to overall growth of the seedling and increased rate of photosynthesis that lead to the overall assimilation and redistribution of photosynthates within the plant and hence, resulted in higher fresh and dry weight of plant. Thus, increased growth is a consequence of increased dry matter accumulation. The results are in close conformity with the findings of Masilamani and Dharmalingan (2002) [10] in Silver Oak (*Grevillea robusta* A. Cunn.), Radhakrishnan and

Renganayaki (2008) [12] in Simaruba (*Simaruba glauca* Linn) and Rout *et al.* (2016b) [16] in *Delonix regia*.

4. Survival Percentage

The results revealed the significant differences among the treatments on survival percentage of Red Sanders seedlings. Among different growth regulators survival percentage at the end of the experiment after sowing was significantly found to be the maximum when the pods were treated with GA_3 at 500 ppm for 1 day (63.33 %). This might be due to the overall performance in relation to growth parameters which ultimately increased the survival percentage. The observation analogues to these findings were reported by Masilamani and Dharmalingan (2002) [10] in Silver Oak (*Grevillea robusta* A. Cunn.), Radhakrishnan and Renganayaki (2008) [12] in Simaruba (*Simaruba glauca* Linn) and Rout *et al.* (2016b) [16] in *Delonix regia*.

Table 1: Effect of various pre-treatments on germination and growth parameters of Red Sanders (*Pterocarpus santalinus* L. f.)

Treatments	Days to first sprout	Germination percentage	Plant height (cm)	Number of leaves per plant	Collar diameter (mm)	Root length (cm)	Fresh weight (g/plant)	Dry weight (g/plant)	Survival Percentage (%)
T_1	12.00	56.67	34.73	17.22	5.43	27.20	16.92	10.09	53.33
T_2	12.00	56.67	35.23	17.44	5.43	27.33	19.57	12.89	53.33
T_3	11.00	56.67	36.23	17.78	5.46	28.13	20.29	13.57	53.33
T_4	10.67	60.00	37.40	18.11	5.45	28.17	24.91	18.13	56.67
T_5	9.00	63.33	40.17	19.22	5.49	29.37	30.26	23.35	56.67
T_6	7.67	66.67	41.20	20.44	5.65	30.57	31.58	24.77	63.33
T_7	12.00	53.33	32.97	17.11	5.33	27.10	15.33	8.53	50.00
T_8	12.33	53.33	33.43	17.11	5.34	27.20	16.83	10.14	50.00
T_9	12.33	50.00	32.20	15.11	5.34	25.23	14.50	7.80	46.67
T_{10}	9.00	63.33	38.53	19.00	5.47	29.30	28.26	21.40	60.00
T_{11}	18.00	43.33	28.37	10.00	5.10	17.53	12.13	5.50	40.00
S. Em.	0.611	3.015	1.187	0.964	0.161	0.996	1.558	1.106	2.659
C.D. @ 5%	1.79	8.84	3.48	2.83	0.47	2.92	4.57	3.24	7.80
C.V.%	9.24	9.22	5.79	9.74	5.15	6.39	12.88	13.50	8.68

4. Conclusion

From this investigation, it is concluded that among different pre-sowing treatments of Red Sanders (*Pterocarpus santalinus* L. f.), T_6 (GA3 @ 500 ppm for 1 day) performed best with respect to days to first sprout, germination percentage, collar diameter, plant height, number of leaves per plant, survival percentage, root length, fresh and dry weight of plant. The next best pre-sowing treatment were T_5 (GA3 @ 250 ppm for 1 day) and T_{10} (Separating seeds from pods with a sharp knife or scalpel and sown directly). The seeds which were no treated (T_{11}: Control) found poorest for all parameters under study. The further study is required to know the effect of GA_3 on plants at field conditions and to know the growth performance of those plants.

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