# EFFECT OF $GA_3$ AND TIME OF SEED SOAKING ON GERMINATION AND SEEDLING VIGOUR OF SANDALWOOD


## ABSTRACT

The experiment was carried out under greenhouse condition with two factors *i.e.*, different $GA_3$ levels *viz*., Control ($g_0$), seed soaking in $GA_3$ 100 ppm ($g_1$), seed soaking in $GA_3$ 200 ppm ($g_2$), seed soaking levels *viz*., in $GA_3$ 300 ppm ($g_3$), seed soaking in $GA_3$ 400 ppm ($g_4$), seed soaking in $GA_3$ 500 ppm ($g_5$) and seed soaking for 12 hours ($t_1$), seed soaking for 18 hours ($t_2$) and seed soaking for 24 hours ($t_3$). The results of the study revealed that, significantly minimum days for germination (21.44), higher survival percentage at 60 days after sowing (65.35), number of roots per seedling at the time of final survival (4.40), maximum length of roots per seedling at 60 days after sowing (7.58 cm) and height of plant at 90 days after sowing (12.27 cm), maximum survival percentage (100) at 15 days after bagging and stem diameter at 90 days after sowing (0.24 cm) was recorded with treatment $g_5$ (Seed soaking in $GA_3$ 500 ppm). From the pooled data, significantly early germination (22.00 days), maximum survival percentage (59.87) at 60 days after sowing, number of roots (4.00) per seedling at the time of final survival, length of roots per seedling (7.76 cm) at 60 days after sowing, height of plant at 90 days after sowing (12.03 cm), maximum survival percentage (99.69) at 15 days after bagging and stem diameter at 90 days after sowing (0.23 cm) was recorded with treatment $t_3$ (Seed soaking for 24 hours). From the present investigation, sandalwood seed soaking treatment with $GA_3$ 500 ppm for 24 hours recorded early germination, higher survival and superior in seedling vigour.



**Key word**: $GA_3$, Green house, Seed, Sandalwood and Time of soaking.


## INTRODUCTION

"Sandalwood (*Santalum album* L.) is the fragrant heartwood of some species of genus Santalum. The widely distributed and economically important Santalum genus belongs to the family Santalaceae . Sandal is one of the most primitive precious useful plants since ancient times. Ecologically sandal has adapted various agroclimatic and soil conditions for in situ regeneration with an exception of waterlogged areas and very cold places. Sapwood is white to pale yellow, sharply demarcated from the yellowish brown to dark brown heartwood, hard, heavy, lustrous

and straight-grained to slightly wavy, fine textured with pleasant characteristic smell" (Rao et al., 2007). Sandalwood trees are famous and very costly because of its fragrant heartwood and oil.

"The various PGR's treatment for specific period of time also helpful for early growth phases. GA triggers the respiratory and metabolic activities and activates certain genes resulting in the production of various components required for the active growth and development of embryo. Thus GA overcomes the dormancy and induces germination. In case of sandal, the basic problem is seed germination artificially. The seeds were treated with hot and cold water, GA3 in different concentrations for its artificial germination" (Rao et al., 2007).

"After a certain period, seedlings were started to germinate. By observing all these peculiarities the germinated seeds were transferred to polypots and hycopots. Now, it is being realized that the only way to counter smuggling activities and to meet demand for sandalwood encouraging sandal domestication may be the only option" [9,10]. But, "an easy technology is to be explored for the plantation to be taken up by the general people. Keeping all these views in mind the authors undertook the venture for the same since over a couple of years for its propagation and survivality to explore the areas of suitable as well as congenial edaphic factors. Day to day growth and development were observed and recorded all these data properly which have been exhibited in this context" [11].

The main aims and objects are to study the integrated scientific approach of seed germination, its growth behaviour in nursery for production of quality and healthy planting stock and raising successful plantation subsequently. There has no any work related to germination of sandalwood was carried out under Gujarat state, so, keeping above things in mind the attempt was being taken to study the "effect of $GA_3$ and time of seed soaking on germination and seedling vigour of sandalwood" was carried out under greenhouse condition.

## MATERIAL AND METHODS

An experiment entitled, effect of $GA_3$ and time of soaking on germination of sandalwood seed, was carried out under greenhouse condition at Department of Horticulture, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. Present experiment were evaluated with two factors viz., different $GA_3$ levels *viz*., Control ($g_0$), seed soaking in $GA_3$ 100 ppm ($g_1$), seed soaking in $GA_3$ 200 ppm ($g_2$), seed soaking in $GA_3$ 300 ppm ($g_3$), seed

soaking in $GA_3$ 400 ppm ($g_4$), seed soaking in $GA_3$ 500 ppm ($g_5$) and seed soaking for 12 hours ($t_1$), seed soaking for 18 hours ($t_2$) and seed soaking for 24 hours ($t_3$).

White Sandal (*Santalum album* L.) was tried in three trials viz., First trial: 17th May to 17th August, Second trial: 22nd July to 22nd October, Third trial: 27th September to 27th December were carried out in plug tray under greenhouse condition. Seed treatment of $GA_3$ was given as per treatment and standard media *i.e*. Vermiculite: Poultry Manure: Vermicompost (2:1:1) were used on volume basis in plug tray. The experiment was laid out in Factorial Completely Randomized Design as described by Nigam and Gupta (1979) with three repetitions. The treatments evaluated and observations were recorded periodically in relation to germination, survival and seedling vigour.

## RESULTS AND DISCUSSION

**Effect of time of seed soaking (T):**

The pooled data of three trial revealed that the significantly early germination (22.00 days), maximum survival percentage (59.87) at 60 days after sowing, number of roots (4.00) per seedling at the time of final survival, length of roots per seedling (7.76 cm) at 60 days after sowing and height of plant at 90 days after sowing (12.03 cm) were recorded with treatment $t_3$ (Seed soaking for 24 hours) and which was significantly superior over all other treatments.

From the pooled data, it was noted that not significant the maximum survival percentage (99.69) at 15 days after bagging and stem diameter at 90 days after sowing (0.23 cm) was recorded with treatment $t_3$ (Seed soaking for 24 hours). Similar results were found by Chitra and Jijeesh (2021) in sandalwood.

"It was observed that soaking of seeds in gibberellic acid is one of the most successful methods for accelerating the germination of the seeds of sandalwood" (Rai, 1990 and Tennakoon et al., 2000). Similar results have been reported by Raviraja Shetty et al. (2016) in *Celastrus paniculatus* a wild a threatened medicinal plant where the seeds treated with lower concentration of GA3 i.e. 400 ppm.

**Effect of level of $GA_3$ (G):**

"The results of three trial pooled data found that significantly minimum days for germination (21.44), higher survival percentage at 60 days after sowing (65.35) and number of roots per seedling

at the time of final survival (4.40) was recorded with treatment $g_5$ (Seed soaking in $GA_3$ 500 ppm), which was significantly superior over other treatments. The significantly maximum length of roots per seedling at 60 days after sowing (7.58 cm) and height of plant at 90 days after sowing (12.27 cm) were recorded with treatment $g_5$ (Seed soaking in $GA_3$ 500 ppm) and it was statistically at par with treatment $g_4$ (Seed soaking in $GA_3$ 400 ppm). The cytological basis of gibberellic acid involves the promotion of cell elongation and cell division ultimately increasing the length of root and shoot and also the plant height" (Achard et al., 2009).

From the pooled data, it was noted that not significant survival percentage (100) at 15 days after bagging and stem diameter at 90 days after sowing (0.24 cm) was recorded with treatment $g_5$ (Seed soaking in $GA_3$ 500 ppm).

"Gibberellic acid is known to induce the expression of genes encoding enzymes that mobilize the reserved food material stored in the endosperm which includes starch, protein and lipids. This helps in increasing the biological yield of the plant. The overall increase in the growth of the plant is due to gibberellic acid which leads to the increase in rate of photosynthesis" (Patel et al., 2018).

## Conclusion

From the present investigation, sandalwood seed soaking treatment with $GA_3$ 500 ppm for 24 hours recorded early germination, higher survival and superior in seedling vigour. An easy technology is to be explored for the plantation to be taken up by the general people. Keeping all these views in mind the authors undertook the venture for the same since over a couple of years for its propagation and survivality to explore the areas of suitable as well as congenial edaphic factors.

## Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

## REFERENCES

1. Achard P, Gusti A, Cheminant S, Alioua M, Dhondt S, Coppens F. (2009). Gibberellin signaling controls cell proliferation rate in Arabidopsis. *Current Biology*. 19:1188–1193.

2. Chitra P and Jijeesh CM. (2021). Biopriming of seeds with plant growth promoting bacteria *Pseudomonas fluorescens* for better germination and seedling vigour of the East Indian sandalwood. *New Forests*. 52(5):829-841.
3. Nigam A.K. and Gupta V.K. (1979). Handbook on Analysis of Agriculture Experiments. *Indian Agricultural Statistics Research Institute*. New Delhi. pp 39-54.
4. Patel HS, Tandel MB, Prajapati VM, Amlani MH, Prajapati DH. (2018). Effect of different pre-sowing treatments on germination of Red sanders (Pterocarpus santalinus L. f.) in net house condition. *International Journal of Chemical Studies*. 6(2):876-879.
5. Rai SN. (1990). Status and cultivation of sandalwood in India. Proceedings of the symposium on sandalwood in the Pacific, April 9-11, Honolulu-Hawaii, 1990, 66-71.
6. Rao RV, Hemavathi TR, Sujatha M, Shashikala S (2007). Status on Wood structure, heartwood formation, age, gaps and research needs in *Santalum album* L. Proceedings of National Seminar held in Institute of Wood Science and Technology (ICFRE), 12-13 December, Bangalore, India pp 165-171.
7. Raviraja Shetty G, Poojitha KG, Souravi K, Rajasekharan PE. (2016). Seed germination studies in Celastrus paniculatus Willd: A threated medicinal a plant. *International Journal of Applied and Agricultural Research*. 11(1):51-56.
8. Tennekoon KU, Ekanayake SP, Etampawala ERLB. (2000). An overview of *Santalum album* research in SriLanka. *Sandalwood Research Newsletter*.; 11:1-4.
9. Chitra P, Jijeesh CM. Biopriming of seeds with plant growth promoting bacteria Pseudomonas fluorescens for better germination and seedling vigour of the East Indian sandalwood. New Forests. 2021 Sep;52(5):829-41.
10. Sutheesh VK, Jijeesh CM, Divya TP. Evaluation of organic and inorganic pretreatments for better seed germination and seedling vigour in Santalum album L. Plant Archives. 2016;16(1):143-50.

**Table: 1 Effect of $GA_3$ and time of seed soaking on germination and survival of sandalwood (*Santalum album* L.)**

| Treatments | Days taken for germination | | | | Survival percentage at 60 days after sowing | | | | Survival percentage at 15 days after bagging | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Time of seed soaking (T):** | **Trial I** | **Trial II** | **Trial III** | **Pooled** | **Trial I** | **Trial II** | **Trial III** | **Pooled** | **Trial I** | **Trial II** | **Trial III** | **Pooled** |
| **$t_1$ (Seed soaking for 12 hours)** | 22.72 | 23.16 | 23.33 | 23.07 | 50.16 | 53.40 | 51.97 | 51.84 | 99.53 | 99.53 | 94.44 | 97.83 |
| **$t_2$ (Seed soaking for 18 hours)** | 22.44 | 23.33 | 22.77 | 22.85 | 52.21 | 54.86 | 52.96 | 53.34 | 98.61 | 99.53 | 100.0 | 99.38 |
| **$t_3$ (Seed soaking for 24 hours)** | 21.61 | 22.33 | 22.05 | 22.00 | 58.33 | 60.73 | 60.55 | 59.87 | 99.07 | 100.0 | 100.0 | 99.69 |
| **S.Em.±** | 0.17 | 0.31 | 0.24 | 0.14 | 0.92 | 0.79 | 0.64 | 0.45 | 0.75 | 0.37 | 3.20 | 1.10 |
| **C.D. at 5 %** | 0.50 | NS | 0.70 | 0.40 | 2.64 | 2.28 | 1.85 | 1.29 | NS | NS | NS | NS |
| **$GA_3$ levels (G):** | | | | | | | | | | | | |
| **$g_0$ (Control)** | 24.55 | 24.77 | 25.33 | 24.88 | 46.29 | 47.40 | 48.14 | 47.28 | 100.0 | 100.0 | 88.88 | 96.29 |
| **$g_1$ (Seed soaking in $GA_3$ 100 ppm)** | 22.22 | 23.11 | 22.88 | 22.74 | 51.47 | 52.18 | 51.84 | 51.83 | 97.22 | 99.07 | 100.0 | 98.76 |
| **$g_2$ (Seed soaking in $GA_3$ 200 ppm)** | 21.88 | 22.44 | 22.33 | 22.22 | 50.73 | 54.70 | 53.70 | 53.04 | 98.14 | 100.0 | 100.0 | 99.38 |
| **$g_3$ (Seed soaking in $GA_3$ 300 ppm)** | 22.00 | 22.88 | 22.66 | 22.51 | 51.47 | 56.92 | 55.18 | 54.52 | 99.07 | 100.0 | 100.0 | 99.69 |
| **$g_4$ (Seed soaking in $GA_3$ 400 ppm)** | 21.66 | 22.66 | 21.77 | 22.03 | 55.55 | 61.36 | 57.36 | 58.09 | 100.0 | 99.07 | 100.0 | 99.69 |
| **$g_5$ (Seed soaking in $GA_3$ 500 ppm)** | 21.22 | 21.77 | 21.33 | 21.44 | 65.88 | 65.44 | 64.73 | 65.35 | 100.0 | 100.0 | 100.0 | 100.0 |
| **S.Em.±** | 0.24 | 0.44 | 0.34 | 0.20 | 1.30 | 1.12 | 0.91 | 0.65 | 1.07 | 0.53 | 4.53 | 1.56 |
| **C.D. at 5 %** | 0.71 | 1.26 | 1.00 | 0.57 | 3.73 | 3.23 | 2.62 | 1.82 | NS | NS | NS | NS |
| **T X G** | | | | | | | | | | | | |
| **S.Em.±** | 0.43 | 0.76 | 0.60 | 0.35 | 2.25 | 1.95 | 1.58 | 1.12 | 1.85 | 0.92 | 7.85 | 2.70 |
| **C.D. at 5 %** | 1.23 | NS | NS | NS | 6.47 | 5.60 | 4.54 | 3.16 | NS | NS | NS | NS |
| **CV %** | 3.35 | 5.78 | 4.60 | 4.71 | 7.29 | 6.00 | 4.97 | 6.14 | 3.24 | 1.61 | 13.27 | 8.21 |

**Table: 2 Effect of $GA_3$ and time of seed soaking on number of roots and length of roots per seedling of sandalwood (*Santalum album* L.)**

| Treatments | Number of roots per seedling at the time of final survival | | | | Length of roots per seedling (cm) at 60 days after sowing | | | |
|---|---|---|---|---|---|---|---|---|
| **Time of seed soaking (T):** | **Trial I** | **Trial II** | **Trial III** | **Pooled** | **Trial I** | **Trial II** | **Trial III** | **Pooled** |
| **$t_1$ (Seed soaking for 12 hours)** | 3.55 | 3.66 | 3.88 | 3.70 | 6.22 | 5.75 | 5.77 | 5.91 |
| **$t_2$ (Seed soaking for 18 hours)** | 3.83 | 3.61 | 3.66 | 3.70 | 6.18 | 6.25 | 6.24 | 6.22 |
| **$t_3$ (Seed soaking for 24 hours)** | 3.94 | 3.88 | 4.16 | 4.00 | 8.25 | 7.41 | 7.63 | 7.76 |
| **S.Em.±** | 0.10 | 0.11 | 0.10 | 0.06 | 0.23 | 0.22 | 0.15 | 0.12 |
| **C.D. at 5 %** | 0.29 | NS | 0.29 | 0.17 | 0.67 | 0.65 | 0.44 | 0.33 |
| **$GA_3$ levels (G):** | | | | | | | | |
| **$g_0$ (Control)** | 3.22 | 3.11 | 3.44 | 3.25 | 5.55 | 4.98 | 4.98 | 5.17 |
| **$g_1$ (Seed soaking in $GA_3$ 100 ppm)** | 3.44 | 3.55 | 3.66 | 3.55 | 6.04 | 5.96 | 6.08 | 6.03 |
| **$g_2$ (Seed soaking in $GA_3$ 200 ppm)** | 4.00 | 3.66 | 3.88 | 3.85 | 7.13 | 6.68 | 6.55 | 6.79 |
| **$g_3$ (Seed soaking in $GA_3$ 300 ppm)** | 3.66 | 3.66 | 3.88 | 3.74 | 7.00 | 6.77 | 6.60 | 6.79 |
| **$g_4$ (Seed soaking in $GA_3$ 400 ppm)** | 3.88 | 4.00 | 4.11 | 4.00 | 7.80 | 7.10 | 7.46 | 7.45 |
| **$g_5$ (Seed soaking in $GA_3$ 500 ppm)** | 4.44 | 4.33 | 4.44 | 4.40 | 7.78 | 7.33 | 7.62 | 7.58 |
| **S.Em.±** | 0.14 | 0.16 | 0.14 | 0.08 | 0.33 | 0.32 | 0.21 | 0.17 |
| **C.D. at 5 %** | 0.41 | 0.47 | 0.41 | 0.24 | 0.95 | 0.91 | 0.62 | 0.47 |
| **T X G** | | | | | | | | |
| **S.Em.±** | 0.24 | 0.28 | 0.24 | 0.15 | 0.57 | 0.55 | 0.37 | 0.29 |
| **C.D. at 5 %** | NS | NS | NS | NS | 1.64 | NS | 1.08 | 0.82 |
| **CV %** | 11.39 | 13.18 | 11.01 | 11.87 | 14.43 | 14.83 | 10.00 | 13.30 |

**Table: 3 Effect of $GA_3$ and time of seed soaking on stem diameter and height of plant at 90 DAS of sandalwood (*Santalum album* L.)**

| Treatments | Stem diameter at 90 days after sowing (cm) | | | | Height of plant at 90 days after sowing (cm) | | | |
|---|---|---|---|---|---|---|---|---|
| **Time of seed soaking (T):** | **Trial I** | **Trial II** | **Trial III** | **Pooled** | **Trial I** | **Trial II** | **Trial III** | **Pooled** |
| **$t_1$ (Seed soaking for 12 hours)** | 0.21 | 0.20 | 0.21 | 0.21 | 11.00 | 10.23 | 10.30 | 10.51 |
| **$t_2$ (Seed soaking for 18 hours)** | 0.21 | 0.21 | 0.21 | 0.21 | 12.24 | 10.57 | 10.73 | 11.18 |
| **$t_3$ (Seed soaking for 24 hours)** | 0.22 | 0.22 | 0.23 | 0.23 | 13.02 | 10.40 | 11.68 | 12.03 |
| **S.Em.±** | 0.01 | 0.009 | 0.01 | 0.006 | 0.16 | 0.23 | 0.15 | 0.10 |
| **C.D. at 5 %** | NS | NS | NS | NS | 0.46 | 0.68 | 0.44 | 0.30 |
| **$GA_3$ levels (G):** | | | | | | | | |
| **$g_0$ (Control)** | 0.20 | 0.20 | 0.20 | 0.20 | 10.54 | 9.11 | 9.15 | 9.60 |
| **$g_1$ (Seed soaking in $GA_3$ 100 ppm)** | 0.22 | 0.20 | 0.20 | 0.20 | 11.12 | 10.18 | 10.50 | 10.60 |
| **$g_2$ (Seed soaking in $GA_3$ 200 ppm)** | 0.20 | 0.21 | 0.21 | 0.20 | 12.34 | 10.94 | 10.90 | 11.39 |
| **$g_3$ (Seed soaking in $GA_3$ 300 ppm)** | 0.22 | 0.22 | 0.24 | 0.22 | 12.67 | 11.12 | 11.38 | 11.72 |
| **$g_4$ (Seed soaking in $GA_3$ 400 ppm)** | 0.23 | 0.22 | 0.23 | 0.22 | 10.74 | 11.20 | 11.62 | 11.85 |
| **$g_5$ (Seed soaking in $GA_3$ 500 ppm)** | 0.24 | 0.24 | 0.24 | 0.24 | 13.11 | 11.85 | 11.86 | 12.27 |
| **S.Em.±** | 0.01 | 0.01 | 0.01 | 0.008 | 0.23 | 0.33 | 0.21 | 0.15 |
| **C.D. at 5 %** | NS | NS | NS | NS | 0.66 | 0.97 | 0.62 | 0.43 |
| **T X G** | | | | | | | | |
| **S.Em.±** | 0.02 | 0.02 | 0.02 | 0.01 | 0.39 | 0.58 | 0.37 | 0.26 |
| **C.D. at 5 %** | NS | NS | NS | NS | NS | NS | NS | NS |
| **CV %** | 19.53 | 17.76 | 18.37 | 18.58 | 5.71 | 9.46 | 5.99 | 7.14 |