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RESEARCH ARTICLE

GERMINATION BEHAVIOR AND MORPHO-PHYSIOLOGICAL ACTIVITIES OF WHITE SANDAL (*SANTALUM ALBUM* L.)

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ABSTRACT

White sandal (*Santalum album* L.) a precious timber yielding as well as medicinal plant which is rendering its service for the human society since human civilization in the globe. The plant is grown under tropical and sub tropical agro-climates with any sort of soil composition in high-land elevation. Though the plant is utilizing by the pharmaceuticals as well as cosmetic industries since ancient era but its improvement towards mass propagation and culture have not been took place by modern scientific technologies. In nature, seed propagating saplings occur in the forest gardens hardly 10 – 12%. But all the saplings cannot survive in wild state due to grazing and other mechanical injuries and illegal infiltration in the forest garden occur round the year. Artificially we can propagate the plants by means of vegetative propagation viz layering, cutting, inarching etc. which is time consuming, expensive and not adequate number of plants at a time. A considerable limited numbers of saplings can be raised through sucker propagation. The scientists have been exploring various seed propagation techniques utilizing various seed germinating as well as growth promoting chemicals to obtain a huge number of saplings at a time for its mass propagation. We have undertaken the task for utilizing different chemicals viz $CuSO_4$, Dithane M-45, Dithane Z-78, GA_3, Captan, Bavistin, Penicillin etc. for germinating the white sandal seeds in different seasons round the year to obtain maximum percentage of saplings. In this context, we have conducted an experiment on GA_3 allowing different concentration which have been observed and exhibited in the findings. The aims and objectives of this experiment were to study the highest rate of germination in GA_3 treatments and its adaptation in different locations of various districts in the state of West Bengal.

INTRODUCTION

White sandal (*Santalum album* L) is a hemi parasitic tropical tree. The word is very valuable for its essential oils and medicinal uses. The plant mainly grows in Maharashtra, Karnataka, Andhra Pradesh, Kerala etc. But recently (Das and Tah, 2013) there is a small population patch developed at Bankura & Burdwan District of West Bengal. The Sandal sapling needs various host plants for its establishment and proper growth and development. There are so many references for angiospermic association as its hot plant. Recently it is noticed that different pteridophytic plants can also act as associated host plant for its establishment, growth and development (Jadab *et al*., 2017). Though the plant is grown in Indian sub continent since more than 4000 years but indeed, there is suitable scientific know-how for artificial seed germination and its standardization over the location. In nature 10 – 15% seeds germinate in wild state which is not adequate for mass propagation at a time in any agro-climatic zone. Recently we have undertaken the venture of artificial seed germination of white sandal which has given us a positive indication to undertake the seed propagation program in this location.

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MATERIALS AND METHODS

A) Materials

1. Seed materials collected from (I) Bankura, (II) Burdwan, (III)Mokrampur
2. i) Chemicals: Gibberelic acid (GA_3), $HgCl_2$, ii) Miscellaneous: Distilled Water, Petridishes, Compost manure, Beakers, Conical flasks, measuring cylinder, Chemical weigh balance (digital), Hycopots, Note book, pen etc.

B) Methods

First of all sandal seeds were sun dried for about two weeks. A desire number of seeds were then counted for each location and measured their weight by weight balance before pour in the treatments. Three kinds of treatments were made viz i) control (Normal water), ii) 200 ppm GA_3 solution, iii) 500 ppm GA_3 solution. Seed were treated with each treatment for about 24 hours. Seeds were pretreated with HgCl2 (0.001%) for surface sterilization. After 72 hours of soaking in treatments, seeds were removed from the solutions, blot their surface and again measured their weight. There after seeds were taken to the nursery field for sowing. The germination data were recorded properly in each treatment and the raised seedlings were transferred into hycopotsbeds of nursery at 3 to 4 leaf stage.

i) Pretreatment by soaking in water

Sandalwood seeds are soaked in water for 72 hours before sowing. Seeds are sown in sand bed (6 mm deep). Germination starts after 28 days. In-between 61 to 100 days, only 32-27% germination is obtained.

ii) Pretreatment by Gibberellic Acid

Before sowing the sandal seeds were pre-treated properly with HgCl2 (0.001%) and imbibed for 72 hours in different concentration of GA_3 solutions (200ppm, 500ppm). The treated sandalwood seeds were then sown in the sand bed. The sand beds were watered twice daily in the morning & afternoon. First germination was started after 28 days of seed sowing. The number of seeds germinated in each treatment is recorded and the germination is continued up to 90 days after sowing.

RESULTS

After sowing seeds in the nursery beds serious observations were imposed upon the germination behavior of seeds sown in the seed bed which has been cited in Table – 1.

Table 1.

Plot –1/scarified/plant height

Treatment	location A	B	C	∑	X̄
T_0	5.4,4.8,6.1,7.1,5.8,5.6,5,3.1,6,5.1	3.6,4.8,4.1,5.6,3.6,5.8,4.4,3.1,4.9,6.5	6,4.2,3.1,4.6,5.3,4.4,4.1,3.9,6.5,3.5	14.6	4.86
	∑ =54	∑=46.4	∑=45.6		
	X̄=5.4	X̄=4.64	X̄=4.56		
T_1	4.5,5.8,3.5,4.3,2.8,3.4,5,6.1,5.2,4.4	4.8,3.9,4,5.4,4.1,2.9,6.5,3.4,5,4.9	2.1,4.8,4.2,3.6,5.2,4.2,7.1,3.8,4.5,3.1	13.2	4.61
	∑=45	∑=44.9	∑=33.2	5	
	X̄=4.5	X̄=4.49	X̄=3.32		
T_2	4,3.7,5.2,2.9,3.1,5.1,5.4,4.5,5.3,3.8	2.8,5.5,6,7.3,3.6,5,3.9,6,3.1,2.3	0,0,0,0,0,0,0,0,0,0	8.85	2.95
	∑=43	∑=45.5	∑=0		
	X̄=4.3	X̄=4.55	X̄=0		
∑	14.2	13.68	8.82	GT=36.7	
X̄	4.73	4.56	2.94		

T_0= Treatment 0 (Control), T_1= Treatment 1 (200 ppm GA3 solution), T_2= Treatment 2 (500 ppm GA_3 solution), Location A= Hirbandh (Bankura), Location B = Aushgram (Burdwan), Location C (Midnapore).

Plot –1/scarified/leaf number

Treatment	location A	B	C	∑	X̄
T_0	10,12,9,11,12,10,10,11,8,7	10,8,7,16,11,10,10,10,12,12	10,8,7,12,11,10,12,12,10	30.8	10.26
	∑ =100	∑=106	∑=102		
	X̄=10	X̄=10.6	X̄=10.2		
T_1	10,8,8,11,7,9,11,12,14,10	12,16,12,12,10,8,14,12,9,11	6,10,8,10,12,10,14,12,10,5	31.3	10.43
	∑=100	∑=116	∑=97		
	X̄=10	X̄=11.6	X̄=9.7		
T_2	8,10,10,8,6,12,12,10,10,7	9,10,12,10,12,12,12,12,9,9	0,0,0,0,0,0,0,0,0,0	20	6.6
	∑=93	∑=107	∑=0		
	X̄=9.3	X̄=10.7	X̄=0		
∑	29.3	32.9	19.9	GT= 82.1	
X̄	9.7	10.96	6.63		

T_0= Treatment 0 (Control), T_1= Treatment 1 (200 ppm GA3 solution), T_2= Treatment 2 (500 ppm GA_3 solution), Location A= Hirbandh (Bankura), Location B = Aushgram (Burdwan), Location C (Midnapore).

Plot –1/non scarified/plant height

Treatment	location A	B	C	∑	X̄
T_0	5.5,4.2,5.6,3.4,6.7,5.2,4.8,6.2,7.3	3.6,4.2,4.1,4.1,3.2,1.7,5,3.1,6,4	0,0,0,0,0,0,0,0,0,0	9.4	3.13
	,6.1	∑=39	∑=0		
	∑ =55	X̄=3.9	X̄=0		
	X̄=5.5				
T_1	4.5,7,6.2,5.3,4.4,8.3,5.2,5.3,4,7.3	3.7,5,6.1,5.2,6.3,4.7,5.6,5.5,4,4.9	4.3,3.9,6.2,5.5,4.9,3.6,4.9,3.2,6.1,5.4	15.55	5.18
	∑=57.5	∑=50	∑=48		
	X̄=5.75	X̄=5	X̄=4.8		
T_2	0,0,0,0,0,0,0,0,0,0	3.7,4.9,4,3.1,3.1,4.4,2.1,5,3.2,3.5	4.6,7.1,3.6,2.6,4.2,7.3,4.6,5.5,5.1,4.3	8.59	2.86
	∑=0	∑=37	∑=48.9		
	X̄=0	X̄=3.7	X̄=4.89		
∑	11.25	12.6	9.69	GT=33.54	
X̄	3.75	4.2	3.23		

T_0= Treatment 0 (Control), T_1= Treatment 1 (200 ppm GA3 solution), T_2= Treatment 2 (500 ppm GA_3 solution), Location A= Hirbandh (Bankura), Location B = Aushgram (Burdwan), Location C (Midnapore).

Plot –1/non scarified/leaf number					
Treatment	location			∑	Ẋ
	A	B	C		
T_0	12,10,12,10,12,12,10,14,14,14	10,10,12,10,9,8,10,9,12,10	0,0,0,0,0,0,0,0,0,0	22	7.33
	∑ =120	∑=100	∑=0		
	Ẋ=12	Ẋ=10	Ẋ=0		
T_1	12,14,14,12,10,18,10,9,11,10	9,12,11,12,14,12,11,10,11,8	8,10,12,10,10,8,11,9,12,10	33	11
	∑=120	∑=110	∑=100		
	Ẋ=12	Ẋ=11	Ẋ=10		
T_2	0,0,0,0,0,0,0,0,0,0	8,9,10,8,9,10,8,10,9,9	10,14,12,8,8,16,8,12,12,10	20	6.66
	∑=0	∑=90	∑=110		
	Ẋ=0	Ẋ=9	Ẋ=11		
∑	24	30	21	GT= 75	
Ẋ	8	10	7		

T_0= Treatment 0 (Control), T_1= Treatment 1 (200 ppm GA3 solution), T_2= Treatment 2 (500 ppm GA_3 solution), Location A= Hirbandh (Bankura), Location B = Aushgram (Burdwan), Location C (Midnapore).

Plot –2/scarified/plant height					
Treatment	location			∑	Ẋ
	A	B	C		
T_0	4,4.5,3,2.5,3,3,3.5,4.5,3,3	4.5,4,4.1,7,3.4,6.6,6.5,4.7,2.5,6.7	4.5,6,3.5,3.5,3.9,5.5,2.8,3.4,4.1,3.4	12.46	4.15
	∑ =34	∑=50	∑=40.6		
	Ẋ=3.4	Ẋ=5	Ẋ=4.06		
T_1	4,5.4,3.64.5,3.2,3.5,3.7,4,3.3,4.8	3.9,7,6.8,6,5.2,4.2,5,5,5.5,5	2.3,5,3.6,2.8,3,5,4,2.5,2,3	12.68	4.22
	∑=40	∑=53.6	∑=33.2		
	Ẋ=4	Ẋ=5.36	Ẋ=3.32		
T_2	3.2,6.5,6,5.5,5,4.5,5.5,6,6.5,3.7	3.9,6.5,3.7,6.2,1.8,2.7,3.2,5.5,4.2,3.6	4.5,3,4,4,2.9,3,4,1.5,3,4	12.76	4.25
	∑=52.4	∑=41.3	∑=33.9		
	Ẋ=5.24	Ẋ4.13	Ẋ=3.39		
∑	12.64	14.49	10.77	GT=37.9	
Ẋ	4.21	4.83	3.59		

T_0= Treatment 0 (Control), T_1= Treatment 1 (200 ppm GA3 solution), T_2= Treatment 2 (500 ppm GA_3 solution), Location A= Hirbandh (Bankura), Location B = Aushgram (Burdwan), Location C (Midnapore).

Plot –2/scarified/leaf number					
Treatment	location			∑	Ẋ
	A	B	C		
T_0	9,11,6,6,8,6,8,12,10,4	8,11,14,15,10,10,9,8,7,9∑=101	10,12,11,10,12,10,10,8,10,9	28.3	9.43
	∑ =80	Ẋ=10.1	∑=102		
	Ẋ=8		Ẋ=10.2		
T_1	8,10,9,11,12,10,12,8,12,8	7,10,12,13,10,12,12,17,12,10	9,15,12,8,9,12,10,9,6,8	31.3	10.43
	∑=100	∑=115	∑=98		
	Ẋ=10	Ẋ=11.5	Ẋ=9.8		
T_2		17,10,10,12,4,8,12,11,9,8		30.4	10.13
	10,14,6,10,9,12,8,11,9,9	∑=101	9,9,12,8,10,8,12,20,9,8∑=105		
	∑=98	Ẋ=10.1	Ẋ=10.5		
	Ẋ=9.8				
∑	27.8	31.7	30.5	GT=90	
Ẋ	9.26	10.56	10.16		

T_0= Treatment 0 (Control), T_1= Treatment 1 (200 ppm GA3 solution), T_2= Treatment 2 (500 ppm GA_3 solution), Location A= Hirbandh (Bankura), Location B = Aushgram (Burdwan), Location C (Midnapore).

Plot –2/non scarified/plant height					
Treatment	location			∑	Ẋ
	A	B	C		
T_0	0,0,0,0,0,0,0,0,0,0	5.5,1.6,6.5,4.2,6,3.5,2.8,4.3.1,3.4	4.6,3.5,7,7.6,4.4,6.5,4.8,3.9,6.1,4.6	9.36	3.12
	∑ =0	∑=40.6	∑=53		
	Ẋ=0	Ẋ=4.06	Ẋ=5.3		
T_1	0,0,0,0,0,0,0,0,0,0	0,0,0,0,0,0,0,0,0,0	3,5,6.5,1.5,4,5,3.7,4.2,3.1,4	4	1.33
	∑ =0	∑=0	∑=40		
	Ẋ=0	Ẋ=0	Ẋ=4		
T_2	0,0,0,0,0,0,0,0,0,0	4.8,5.4,2.5,4.2,4.3,5.2,4.1,3.9,2.6,5.6	6.5,5,4,2.3,4.5,6.5,6,2.2,3,4.4	8.7	2.9
	∑=0	∑=42.6	∑=44.4		
	Ẋ=0	Ẋ=4.26	Ẋ=4.44		
∑	0	8.32	13.74	GT= 22.06	
Ẋ	0	2.77	4.58		

T_0= Treatment 0 (Control), T_1= Treatment 1 (200 ppm GA3 solution), T_2= Treatment 2 (500 ppm GA_3 solution), Location A= Hirbandh (Bankura), Location B = Aushgram (Burdwan), Location C (Midnapore).

Plot –2/non scarified/leaf number					
Treatment	location			∑	Ẋ
	A	B	C		
T_0	0,0,0,0,0,0,0,0,0,0	9,11,4,6,10,9,8,10,9,10	12,11,14,18,11,13,12,11,14,12	21.4	7.13
	∑ =0	∑=86	∑=53		
	Ẋ=0	Ẋ=8.6	Ẋ=5.3		
T_1	0,0,0,0,0,0,0,0,0,0	0,0,0,0,0,0,0,0,0,0	9,9,14,6,9,11,8,10,8,10∑=94	9.4	3.13
	∑=0	∑=0	Ẋ=9.4		
	Ẋ=0	Ẋ=0			
T_2	0,0,0,0,0,0,0,0,0,0	12,14,9,11,12,13,11,10,8,14	16,13,10,8,13,21,14,7,9,12	23.7	7.9
	∑=0	∑=114	∑=123		
	Ẋ=0	Ẋ=11.4	Ẋ=12.3		
∑	0	20	34.5	GT=54.5	
Ẋ	0	6.66	11.5		

T_0= Treatment 0 (Control), T_1= Treatment 1 (200 ppm GA3 solution), T_2= Treatment 2 (500 ppm GA_3 solution), Location A= Hirbandh (Bankura), Location B = Aushgram (Burdwan), Location C (Midnapore).

Plot –3/plant height					
Treatment	location			∑	Ẋ
	A	B	C		
T_0	4,4.5,3,2.5,3,3,3,3.5,4.5,3,3	4.5,4,4.1,7,3.4,6.6,6.5,4.7,2.5,6.7	4.5,6,3.5,3.5,3.9,5.5,2.8,3.4,4.1,3.4	12.46	4.15
	∑ =34	∑=50	∑=40.6		
	Ẋ=3.4	Ẋ=5	Ẋ=4.06		
T_1	5,4.5,4.2,5,5.2,6.2,4.8,3.2,4,4.7	6.5,7.5,8,5.5,5.5,5.5,9,5.5,5,10	7,5,5.5,7,5.5,5.8,5.6,5.6,7,3	17.13	5.70
	∑ =46.8	∑=67.5	∑=57		
	Ẋ=4.68	Ẋ=6.75	Ẋ=5.7		
T_2	5.5,8,4.5,3.3,3,4.1,6.2,5.3,4.7,4	6.5,5,3,7.5,8.6,6,5.5,8,4.5,5.5	5.5,3,6.5,5,6.5,7,5,8.5,8.5,5	16.92	5.64
	∑=48.6	∑=60.16	∑=60.5		
	Ẋ=4.86	Ẋ=6.01	Ẋ=6.05		
∑	12.94	17.76	15.81	GT=46.51	
Ẋ	4.31	5.92	5.27		

T_0= Treatment 0 (Control), T_1= Treatment 1 (200 ppm GA3 solution), T_2= Treatment 2 (500 ppm GA_3 solution), Location A= Hirbandh (Bankura), Location B = Aushgram (Burdwan), Location C (Midnapore).

Plot –3/leaf number					
Treatment	location			∑	Ẋ
	A	B	C		
T_0	9,11,6,6,8,6,8,12,10,4	8,11,14,15,10,10,9,8,7,9∑=101	10,12,11,10,12,10,10,8,10,9	28.3	9.43
	∑ =80	Ẋ=10.1	∑=102		
	Ẋ=8		Ẋ=10.2		
T_1	11,8,17,8,14,10,12,8,10,12	11,10,12,16,10,9,12,10,11,14	10,10,12,10,12,18,10,10,8,8	33.3	11.1
	∑=110	∑=115	∑=108		
	Ẋ=11	Ẋ=11.5	Ẋ=10.8		
T_2	12,12,10,8,8,12,8,10,12,8	11,17,6,15,14,9,7,16,15,10	14,9,10,2,13,11,6,12,12,10,11	31.8	10.6
	∑=100	∑=120	∑=98		
	Ẋ=10	Ẋ=12	Ẋ=9.8		
∑	29	33.6	30.8	GT= 93.4	
Ẋ	9.66	11.2	10.26		

T_0= Treatment 0 (Control), T_1= Treatment 1 (200 ppm GA3 solution), T_2= Treatment 2 (500 ppm GA_3 solution), Location A= Hirbandh (Bankura), Location B = Aushgram (Burdwan), Location C (Midnapore).

Plot –4/plant height					
Treatment	location			∑	Ẋ
	A	B	C		
T_0	4,4.5,3,2.5,3,3,3,3.5,4.5,3,3	4.5,4,4.1,7,3.4,6.6,6.5,4.7,2.5,6.7	4.5,6,3.5,3.5,3.9,5.5,2.8,3.4,4.1,3.4	12.46	4.15
	∑ =34	∑=50	∑=40.6		
	Ẋ=3.4	Ẋ=5	Ẋ=4.06		
T_1	6.5,5.5,4.5,6.2,7.3,4.8,4.2,5.3,5.1,5.6	5.5,5.5,6,6,7.5,6.5,2.5,3.5,2.8,5.5	4,4.5,5,2.7,6,5,5,4,6,6.3	15.48	5.16
	∑ =55	∑=51.3	∑=48.5		
	Ẋ=5.5	Ẋ=5.13	Ẋ=4.85		
T_2	7,6.4,6.5,7.3,6.5,7.7,8.7,5.9,6.4,7.6	5.5,3.5,4,6.5,4.5,5.5,4.5,4,2.5,3	7.5,5.5,5.2,3.3,6,7.5,6.2,4.5,6.3,6	17.15	5.71
	∑=70	∑=43.5	∑=58		
	Ẋ=7	Ẋ=4.35	Ẋ=5.8		
∑	15.9	14.48	14.71	GT= 45.09	
Ẋ	5.3	4.82	4.90		

T_0= Treatment 0 (Control), T_1= Treatment 1 (200 ppm GA3 solution), T_2= Treatment 2 (500 ppm GA_3 solution), Location A= Hirbandh (Bankura), Location B = Aushgram (Burdwan), Location C (Midnapore).

Plot –4/leaf no					
Treatment	location			∑	X̄
	A	B	C		
T_0	9,11,6,6,8,6,8,12,10,4 ∑ =80 X̄=8	8,11,14,15,10,10,9,8,7,9∑=101 X̄=10.1	10,12,11,10,12,10,10,8,10,9 ∑=102 X̄=10.2	28.3	9.43
T_1	14,9,10,11,10,8,10,10,8,12 ∑ =102 X̄=10.2	18,11,12,14,14,13,8,12,12,12 ∑=126 X̄=12.6	12,13,14,8,14,12,10,8,9,11 ∑=111 X̄=11.1	33.9	11.31
T_2	8,6,6,8,10,8,10,8,10,6,8,10 ∑=80 X̄=8	12,12,13,13,14,8,9,9,7,6 ∑=103 X̄=10.3	13,10,9,10,12,10,10,9,8,9 ∑=100 X̄=10	28.3	9.43
∑	26.2	33	31.3	GT= 90.5	
X̄	8.73	11	10.43		

T_0= Treatment 0 (Control), T_1= Treatment 1 (200 ppm GA3 solution), T_2= Treatment 2 (500 ppm GA_3 solution), Location A= Hirbandh (Bankura), Location B = Aushgram (Burdwan), Location C (Midnapore).

From the table – 1, we have computerized the data for calculating the analysis of variances (ANOVA) as per the biometrical model of Singh and Chaudhary (2005). The table of variance ratios ('F' values) in each treatment location wise has been cited in table – 2 at a glance.

Table 2.

Plot		Source	df	SS	MSS	F
1	Scarified/Plant height	Replication	2	140.56	70.28	0.188
		Treatment	2	140.72	70.36	0.188
		Error	4	1495.26	373.81	
	Non-scarified/Plant height	Replication	2	113.91	56.95	0.153
		Treatment	2	122.15	61.07	0.164
		Error	4	1487.21	371.80	
	Scarified/ Leaf number	Replication	2	704.08	352.04	0.193
		Treatment	2	701.22	350.61	0.192
		Error	4	7294.81	1823.70	
	Non-scarified/Leaf no	Replication	2	429.5	214.75	0.118
		Treatment	2	595.16	297.58	0.164
		Error	4	7242.84	1810.71	
2	Scarified/Plant height	Replication	2	145.94	72.97	0.2024
		Treatment	2	143.65	71.82	0.1993
		Error	4	1441.45	360.36	
	Non-scarified/Plant height	Replication	2	80.6	40.3	0.1728
		Treatment	2	54.36	27.18	0.1165
		Error	4	932.64	233.16	
	Scarified/ Leaf number	Replication	2	812.66	406.33	0.2121
		Treatment	2	811.58	405.79	0.2118
		Error	4	7660.76	1915.19	
	Non-scarified/Leaf no	Replication	2	497.07	248.53	0.1800
		Treatment	2	336.32	168.16	0.1217
		Error	4	5522.6	1380.65	
3	Plant height	Replication	2	220.24	110.12	0.2017
		Treatment	2	220.96	110.48	0.2023
		Error	4	2183.55	545.88	
	Leaf number	Replication	2	875.94	437.97	0.2047
		Treatment	2	876.75	438.37	0.2049
		Error	4	8554.39	2138.59	
4	Plant height	Replication	2	203.69	101.84	0.2024
		Treatment	2	207.07	103.53	0.2058
		Error	4	2011.8	502.95	
	Leaf number	Replication	2	827.27	413.68	0.2094
		Treatment	2	825.99	412.99	0.2090
		Error	4	7900.48	1975.12	

From the above table (table – 2) it has been observed that no need of calculation of CD values in each location from the ANOVA table depending up on the values of variance ratio. So, it can be mentioned that the rate of seed germination was favorable against all the treatments over this location. The soil components of this location were analyzed by taking soil samples from the nursery bed before taking the sowing program in the nursery bed. The data of soil characteristics have been furnished below.

DISCUSSION

Three treatments were considered for the experiment on seed germination. The seeds were sown in four different lots in the nursery bed. From the result table no – 2, it has been observed that the rate of germination in GA_3 500ppm was highest. It is also remarkable that the control set showed the rate of germination ranging from 27 – 32%. Indeed in nature sandal seed germination occurs maximum 15%. But in this case control set differ the normal hypothesis. This might be due to the effect of surface sterilization treatment by $HgCl_2$. From the table no – 2, it has been observed that the seeds sown in plot – 2, showed the maximum germination potentiality in case of scarified seeds due to GA_3 500ppm treatment. In other lots (lot – 3 and 4) showed the considerable rate of germination but lower than lot – 2. The optimum concentration of GA_3 could not assess because only two chemical treatments (GA_3 200ppm and 500ppm) were under taken for the experiment.

Fig.1. Weighing of seeds before soaking

Fig.2. 14 days seedling in the nursery

Fig.3. Sprouted seed in the nursery bed

Fig.4. Seedling transferring into hycopot

Fig.5. Hycopots in modern nursery cage

Fig.6. Healthy seedling before final plantation

Fig.7. Healthy seedlings of another treatment

Fig.8. Seedling showing whorl phyllotaxy

Fig : Seedlings raising from sandal seeds and maintenances in modern nursery

It is also found that the plant height number of leaves per plant was positively correlated visually. Ananthapadmanava et al. (1984) stated that though the sandal plant can survive without host, but it has proved beyond doubt that the host plants are absolutely necessary for the better growth of sandal plant. He also published his work on survival % and mean height growth of sandal plants following standard error (SE) model. Indeed, there is no reference of frequency distribution model and correlation co-efficient model on sandal plant. Some other workers like Barber (1903); Rama Rao (1903); Rao (1942); Scott (1871) gave the evidence of hemi-root parasite and parasitic nature of sandal which revealed that the presence of houstoria in sandal roots. Nagaveni and Srimathi (1985) studied houstoria less sandal plants and their growth and yield attributes. Other workers like Barber (1906, 1903); Fischer (1922); Govinda (1916,1922); Hole (1918); Lushington (1903,1918); Rao (1942); Rama Rao (1918); Scott (1871); Srinivasaya (1933a,1948); Varadaraja (1965); Venkata (1924); Venkata Rama (1918) described the hemi-parasites as they have green leaves which are photosynthetically active and the presence of houstoria which act as an organ of attachment to draw nutrients from the host plants. Ananthapadmanava et al (1988) clearly carified the classification of host as poor, medium and good for the growth of sandal plants. Rangaswamy et al. (1986a), Venkata Rao (1938) and Rangaswamy and Griffith (1939) worked on the effect of association of different hosts of sandal. Venkata Rao (1939) enumerated that the sandal plant may drain the nutrient completely and may kill it in course of time. Nair and A.Padmanava (1974) studied the bio-assey of tetracycline which helps to indicate that such reverse process can occur in sandal plants also. Nagaveni and Vijoylakshmi (1989) studied on the response in the haustorial formation and growth of sandalwood plant. Rangaswamy and Griffith (1939) expressed the effect on association of different host plant. Parthasarathi et al. (1974) focused the parasitism with different host by cataion exchange capacity (CEC) and accepted three categories of good, medium and poor host plants for sandal plant. Nagaveni and Vijoylashmi (2004) also accepted that the host is necessary for good growth of sandalwood plant and recognized three categories of host plant as good, medium and poor hypothesis. Radomiljac et al. (1998) also experimented *S.album* with different hosts in field experiment.

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