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Research Paper

Frequency Distribution Study on the Growth of *Santalum Album* L. in west Bengal.

Agriculture

KEYWORDS : introduced, survive, hindrances, propagation, edaphic factors.

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ABSTRACT

White sandal (Santalum album L.) is a rare plant in the state of West Bengal. The Forest Department of West Bengal took an initiative to introduce this plant in Bankura Forest Division procuring seeds from Institute of Wood Science and Technology (IWST), Bangalore in 1960s. Few plants were found in Hirbandh Beat campus under Bankura South Forest Division before taking this venture in the year 2009-10. Of course, there must have some reasons not to grow and survive this plant species in this region. Keeping all these hindrances and natural constraints behind mass propagation of this plant, a venture was undertaken to establish this plant in this forest division and its adjoining areas. The aims and objects of the study are to observe the influence of host plants and edaphic factors of the locations in favour of the growth and development of Santalum album L.

Introduction:

Ecologically sandalwood has adapted various agro - climatic and soil conditions for in situ regeneration with an exception of waterlogged areas and very cold places. In India, 8 Sandalwood growing areas have been identified as potential provenances of Sandal on the basis of population density, phenotypic characteristics, latitude, longitude and eco-climate (Jain et al., 1998). The provenances vary in climate and edaphic preference since they are located in different localities of South and Central India. The state of West Bengal is cited in the map of occurrence and distribution of Santalum album in India (Srinivasan et al., 1992).

Distribution of Santalum album is also found outside India, e.g. in Sri Lanka and South East Asia (Timor, Indonesia, Malaysia, Cambodia, Vietnam, Myanmar, Thailand and China), the Pacific (Papua New Guinea, Fiji, New Caledonia and Hawaii) and to some extent northwest of Western Australia (Kanunurra). Recently the Govt. of Australia had undertaken the venture of commercial cultivation of Sandalwood specially they considered the Indian Sandalwood species (Santalum album) is the best due to its higher oil and santalol content which is responsible for its fragrance. It is believed that S. album is an exotic in India, having been taken there from East Indonesia by traders of the fragrant wood and holding a pre-eminent position in the Indonesian island (Malay Archipelago), Timor (Ajaubaki, Siso, Buat, Niki –Niki, Kokoi and Netpala districts) (Effendi, 1994) and to a small extent in Alor, Roti, Sumba and Flores islands. In Australia, a small naturalized area in the northwest of Western Australia which is believed to have been established through the activities of Mallacan traders. S. album was believed to be first grown experimentally in the Ord River Irrigation Area, Kununurra Western Australia in 1983. The first private sector

commercial plantations of S. album were established in Kununurra in 1999 (Clarke, 2006).

White Sandal (Santalum album L.) was tried in various locations of South West Bengal since nineteen sixties. The area has predominantly laterite soil having rainfall from 1200mm to 1600mm with maximum temperature 45^{0}C and minimum temperature 7^{0}C. To ensure protection, Sandal was grown in various forests Range & Beat Office compounds located in the district of Bankura, Birbhum, Burdwan, Purulia and West Midnapur bringing quality seeds from Institute of Wood Science and Technology (IWST), Bangalore time to time. Sandal is one of the very few tree species in which research has been carried out for more than a century. The demand for Sandalwood and Oil is increasing and the gap between demand and supply is widening. To bridge the gap between demand and supply, afforestation and plantation programme should aim at increasing the productivity of plantations.

In sixties Sandalwood trees were also planted in Hirbundh Beat Office compound under Khatra Range of Bankura District. Trees started flowering after 10-12 years and lot of natural regeneration has started coming up in Hirbundh Block both in forest areas and in the adjoining non-forest areas of the Block from the bird droppings. But very few records of growth and yield of white sandals grown in South West Bengal are available. An attempt was being taken in 2009-10 to study growth & yield of sandal trees grown in Hirbundh Beat office compound of Khatra Range in Bankura South Division (Das, 2013).

Some hindrances and problems for its propagation were observed by various workers in these areas. Keeping all these views in mind we are going to undertake the venture for its mass propagation through seeds and its cultivation with their agronomical maintenance properly.

Materials and Methods

Materials:

1.Sandalwood seeds : Seeds of *Santalum album* L.were collected from Hirbundh mouza of Hirbundh Range under Bankura South Forest Division during the month of November -December and May-June of 2011 and 2012 for experimentation. Simultaneously seeds of Santalum album L. were also procured from Institute of Wood Science & Technology, Bangalore in the month of February, 2012 for the same experimentation purposes.

2.Chemicals : Gibberelic acid(GA_3).

3.Apparatus : container, markin cloth, polypots, hycopots.

4.Miscellaneous : Sand, bricks, seive, FYM, water, etc.

5.Meteorological information.

6.Name of Location:

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No. of Location	Name of Location
L_1	Bagaldhara/Bankura (S) Forest Division
L_2	Rangamati/Bankura (S) Forest Division
L_3	Kamalpur/Bankura (S) Forest Division
L_4	Beliatore/Bankura (N) Forest Division
L_5	Khandari/Burdwan Forest Division

7.Year of Plantation and Data Collection

Plantation Code	Year of Plantation	Year Code	Yr. of Data Collection
P1	2011	Y1	2012
P2	2012	Y2	2013
P3	2013	Y3	2014

8.Information of Treatments

Name of Treatment	Composition of Host/s
T_0	No Host
T_1	Arhar (*Cajanus cajan*)
T_2	Tulsi (*Ocimum sanctum*)
T_3	Arhar+Tulsi
T_4	Akand (*Calotropis procera*)
T_5	Arhar+Akand
T_6	Ghetu (*Clerodendron infortunatum*)
T_7	Arhar+Ghantu
T_8	Nayantara (*Catharanthus roseus*)
T_9	Tulsi+Nayantara

9. Growth Parameters, viz. plant height (cm) and basal girth (cm), were measured out of all planted saplings year-wise from each and every forest garden Santalum album L.

Methods:

A) Germination Study in Nursery: i) Pretreatment by soaking in water: Sandalwood seeds are soaked in water for 24 hours before sowing. Seeds are sown in sand bed (6 mm deep). Germination starts after 60 days. In-between 61 to 100 days, only 3-4% germination is obtained.

ii) Pretreatment by boiling water: Sandalwood seeds are pretreated with boiling water (10 parts of boiling water with one part of seeds) for 1 minute and then kept in normal water overnight for soaking. Treated seeds are sown in sand bed. Germination starts after 50 days. In-between 51 to 100 days, hardly 8% germination is obtained.

iii) Pretreatment by alternate wetting & drying: Sandalwood seeds are exposed to alternate wetting & drying for 12 hours wetting followed by 12 hours drying in sun. This process is repeated for 7 days and then the seeds are sown in sand bed (6 mm deep). Germination starts after 40 days. In-between 41 to 100 days, 8 to 9% germination is obtained. Few germination is found even after 100 days upto 150 days. iv) Pretreatment by Gibberellic Acid: Matured seeds were collected from the sandalwood trees of Hirbandh Block in November- December, depulped, dried in sun and stored in polybags for germination test. 6 samples each of 300 sandalwood seeds were taken and tied in markin cloth. 3 containers (1 liter each) were taken for 4 different concentrations (0.01%, 0.03%, 0.05% & 0.1%) of gibberelic acid. 2 seed samples were dipped in each container for 16 hours & 24 hours soaking. 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 24 days of seed sowing. The number of seeds germinated in each treatment is recorded and the germination is continued upto 90 days after sowing. The results were shown in the Table-2. The germinated seedlings were transplanted in polypot (8″x4″ & 9″x 5″) and 300 cc hycopots in nursery at 3 to 4 leaf stage.

B) Cultivation of Sandal in Field:

Pits of size 60cm x 45cm x 45cm were dug in the field in March-April for planting of the potted seedlings. The pits were filled with soil and 500 gms of cowdung manure in the month of May-June after a good premonsoon shower. The potted seedlings (6 month old) were planted in the field in July after getting a good rain at a spacing of 2.5m x 2.5m. After planting, a host plant (Arhar, Tulsi, Nayantara, Akand) was planted at the side of the sandalwood sapling singly as well as in combination of hosts. Some sandalwood saplings were allowed to grow without host. Growth parameters (basal girth & plant height) were measured after 1 year, 2 year & 3 year.

C) Statistical Model :

Biometrical analysis was done by following the Statistical Models and methods as followed by Singh & Choudhury (1995) and Panse & Sukhatme (1995).

Results and Discussions

Results:

A) Germination of Sandalwood Seeds: Soaking in cold water or hot water or alternate soaking in hot & cold water did not found any improvement either in the rate of germination or the % of germination in case of Sandalwood seeds.

But soaking of seeds in 0.05% and 0.1% GA_3 for 16 to 24 hours gave good results on germination of sandalwood seeds. We have two nursery facilities in two different forest areas. The following Table-1 exhibited the germination % in details.

Table-1: Treatment with different concentration of GA_3

Sample size – 300 seeds per treatment				
GA_3	No. of seeds germinated 90 days after sowing		Germination %	
Conc.	16 hours	24 hours	16 hours	24 hours
0.01%	101	154	33.67	51.33
0.03%	125	165	41.67	55.00
0.05%	162	201	54.00	67.00
0.1%	171	209	57.00	69.67
0.0%	25	30	8.33	10.00

B) Frequency Distribution Study on the growth of Sandalwood:The seedlings of Santalum album L. were planted in four Forest gardens under Bankura (North & South) Forest Divisions viz. 1.Bagaldhara, 2.Rangamati, 3. Kamalpur and 4.Beliatore and one forest garden under Burdwan Forest Division viz.Khandari. The seedlings of Santalum album L. were planted at Bagaldhara in 2011 and 2012, at Rangamati in 2011, at Kamalpur in 2012, at Khandari in 2012 and at Beliatore in the year 2013. The plant height was measured year-wise in each and every garden and the arithmetic mean (x'), standard deviation (SD) and co-efficient of variation (CV) were calculated following frequency distribution model of Panse and Sukhatme (1995) which have been exhibited in this context (Table-1 to Table-61) in nutshell (Table-2).

Table-2: Nutshell of Frequency Distribution (F.D) table of 61 table.

Frequency distribution table	Class value(x)		Frequency (f)	∑d=x-x'	∑ d^2	∑ f d^2	X'	SD	CV
	Min.	Max.							
1.($L_1P_1T_1Y_1$)	65.5	165.5	40	181.5	13994.75	23710	99	24.34	24.58
2.($L_1P_1T_2Y_1$)	55.5	115.5	12	0	2800	4200	85.5	18.71	21.88
3.($L_1P_1T_3Y_1$)	78	183	12	170	13062.5	8306.25	109.25	26.31	24.08
4.($L_1P_1T_4Y_1$)	54.5	94.5	6	41.7	1347.7	1083.33	66.16	13.43	20.29
5.($L_1P_1T_5Y_1$)	65.5	105.5	7	21.45	1092.02	1371.43	81.21	13.99	17.22
6.($L_1P_1T_0Y_1$)	35.5	65.5	7	14.3	551.27	685.71	46.92	9.89	21.09
7.($L_1P_1T_1Y_2$)	139.5	299.5	40	148.5	26450.75	61510	203	39.21	19.31
8.($L_1P_1T_2Y_2$)	124.5	214.5	13	3.9	8251.51	7123.08	169.11	23.4	13.84
9.($L_1P_1T_3Y_2$)	133	298	12	60	32475	18825	210.5	39.6	18.81
10.($L_1P_1T_4Y_2$)	114.5	154.5	5	20	1080	1320	130.5	16.24	12.44
11.($L_1P1T_5Y_2$)	124.5	184.5	7	30	2928.59	2171.43	150.21	17.61	11.72
12.($L_1P_1T_0Y_2$)	84.5	114.5	5	4	504	720	98.5	12	12.18
13.($L_1P_1T_1Y_3$)	204.5	384.5	40	-31.5	25341.75	85590	299	46.25	15.46
14.($L_1P_1T_2Y_3$)	204.5	324.5	13	-80.75	10304.11	17307.69	280.65	7.85	2.79
15.($L_1P_1T_3Y_3$)	264.5	384.5	12	-37.5	9281.25	16425	332	7.03	2.12
16.($L_1P_1T_4Y_3$)	174.5	294.5	5	0	9000	9000	234.5	6.19	2.64
17.($L_1P_1T_5Y_3$)	174.5	324.5	7	-90	17100	23400	264.5	9.41	3.55
18.($L_1P_1T_0Y_3$)	114.5	204.5	7	84	6264	2520	138.5	4.26	3.08
19.($L_2P_1T_1Y_1$)	44.5	74.5	11	-23.64	639.72	690.93	65.41	7.93	12.12
20.($L_2P_1T_2Y_1$)	34.5	94.5	27	31.15	2938.62	9066.67	60.05	18.32	30.5
21.($L_2P_1T_3Y_1$)	44.5	74.5	10	4	504	1240	58.5	11.13	19.02
22.($L_2P_1T_8Y_1$)	44.5	64.5	6	5.01	208.37	283.33	52.83	6.87	13
23.($L_2P_1T9Y_1$)	34.5	84.5	7	38.58	1998.07	2285.71	53.07	18.07	34.04
24.($L_2P_1T_0Y_1$)	34.5	54.5	7	21.42	352.94	142.86	37.36	4.51	12.07
25.($L_2P_1T_1Y_2$)	74.5	144.5	11	-10	5300	4400	114.5	20	17.46
26.($L_2P_1T_2Y_2$)	54.5	134.5	25	50.4	6282.24	12816	88.9	22.64	25.46
27.($L_2P_1T_3Y_2$)	57	147	10	-42	6552	6840	108	26.15	24.21
28.($L_2P_1T_8Y_2$)	54.5	84.5	6	-13.32	544.36	1083.33	72.83	13.44	18.44
29.($L_2P_1T_9Y_2$)	54.5	114.5	8	-52.5	3193.75	2950	92	19.2	20.86
30.($L_2P_1T_0Y_2$)	44.5	54.5	5	2	52	120	48.5	4.89	10.08
31.($L_2P_1T_1Y_3$)	120.5	220.5	11	114.6	9188.86	8290.91	151.4	7.4	4.88
32.($L_2P_1T_2Y_3$)	80.5	180.5	25	64.8	7699.84	14784	119.7	11.11	9.28
33.($L_2P_1T_3Y_3$)	110.5	210.5	10	36	7216	15040	154.5	9.86	6.38
34.($L_2P_1T_8Y_3$)	79.5	139.5	6	26.64	2177.42	2733.33	102.84	5.15	5.01
35.($L_2P_1T_9Y_3$)	79.5	139.5	8	10	2025	3950	107	6.07	5.67
36.($L_2P_1T_0Y_3$)	55.5	85.5	5	12	536	680	67.5	3.17	4.7
37.($L_1P_2T_1Y_1$)	44.5	124.5	42	49.32	6270.27	13240.48	79.02	17.75	22.46
38.($L_1P_2T_2Y_1$)	34.5	94.5	39	7.21	2807.43	8958.98	63.47	15.15	21.81
39.($L_1P_2T_3Y_1$)	54.5	94.5	8	-12.5	1031.25	950	77	10.89	14.15
40.($L_1P_2T_4Y_1$)	54.5	64.5	5	2	52	120	58.5	4.89	8.35
41.($L_1P_2T_6Y_1$)	74.5	104.5	4	20	600	600	84.5	12.25	14.49
42.($L_1P_2T_8Y_1$)	34.5	74.5	13	26.9	1144.72	1723.08	49.12	11.51	23.43
43.($L_1P_2T_0Y_1$)	24.5	54.5	30	21.32	613.64	1096.67	34.17	6.05	17.69
44.($L_1P_2T_1Y_2$)	133	283	41	-80.52	25339.41	53604.88	215.32	36.15	16.78
45.($L_1P_2T_2Y_2$)	118	283	38	170.52	34598.09	66913.82	186.29	41.96	22.52
46.($L_1P_2T_3Y_2$)	208	313	6	140	11900	7950	243	36.4	14.97
47.($L_1P_2T_4Y_2$)	118	208	5	-21	6363	6030	166	34.72	20.91
48.($L_1P_2T_6Y_2$)	148	208	4	-18.75	2320.31	1518.75	181.75	19.48	10.71
49.($L_1P_2T_8Y_2$)	103	208	14	-111.92	11015.76	26421.48	169.5	43.44	25.62

50.($L_1P_2T0Y_2$)	73	193	28	62.68	13936.48	35316.96	126.04	35.51	28.17
51.($L_3P_2T_0Y_1$)	34.5	94.5	15	56	3248	3440	56.5	15.14	26.79
52.($L_3P_2T_0Y_2$)	78	198	12	180	17100	21750	118	42.57	36.07
53.($L_4P_3T_1Y_1$)	44.5	124.5	22	118.64	7563.89	11077.27	71.32	22.44	31.46
54.($L_4P_3T_2Y_1$)	34.5	114.5	23	187.83	9920.01	7582.61	53.63	18.16	33.85
55.($L_4P_3T_0Y_1$)	34.5	44.5	10	2	52	240	38.5	4.89	12.72
56.($L_5P_2T_1Y_1$)	54.5	94.5	12	8.35	1013.94	2033.06	69.5	13.01	18.72
57.($L_5P_2T_2Y_1$)	44.5	84.5	10	-10	1020	1560	66.5	12.49	18.78
58.($L_5P_2T_0Y_1$)	44.5	74.5	10	0	500	1050	55.5	10.24	18.45
59.($L_5P_2T_1Y_2$)	83	158	10	-27	3451.5	5260.5	116	22.93	19.76
60.($L_5P_2T_2Y_2$)	83	128	8	7.5	1139.06	2221.88	103.62	16.66	16.07
61.($L_5P_2T_0Y_2$)	43	98	7	7.16	1837.81	2271.42	68.71	18.01	26.21

Discussions:

A) Germination of Sandalwood Seeds: Sandalwood seeds have a post drop dormancy of two months due to presence of hard seed coat or due to presence of chemical substances in the seed coat which are impervious to water and gases. Germination of Sandalwood seeds is found profuse from the bird droppings in the forest floor as well as in the village yards and bunds of the agricultural fields. Sandalwood is also found growing wild in some farmlands, homesteads and wastelands in Hirbundh block of Bankura District, Arabari forests of Midnapur District and Ausgram forests of Burdwan District. This indicates the potential of growing the tree in the farmlands. However, germination of seeds are very low (10-15% within 60 days) when the seeds are sown in mother bed (sand beds) after hot and cold water treatment or alternate wetting & drying due to its hard seed coat and dormancy. Sandalwood seeds have been found to germinate faster when the seed coat is completely removed, or seeds are soaked in 0.05% gibberelic acid for 12-16 hours (Nagaveni and Srimathi, 1981). In sandal seeds, the duration of germination is much prolonged after the dormancy period. It starts in 25 days and reaches hardly 50% in 90 days with 0.05% GA_3 soaking for 16 hours (Das and Tah, 2013). Germination study conducted in Hirbundh & Kamalpur nurseries of Bankura South Division in 2011, 2012 & 2013 where seeds are soaked in different concentration (0.01%, 0.03%, 0.05% & 0.1%) of gibberelic acid for 16 hours & 24 hours respectively and sown in sand beds of nursery. The germinated seedlings are pricked out from sand bed and planted in polypot & hycopot beds of nursery at 3 to 4 leaf stage and kept in nursery without & with host (Cajanus cajan).

B) Frequency Distribution Study on the growth of Sandalwood: In the year 2011, plantation (plantation-1) was done in Bagaldhara and Rangamati forest gardens under Bankura (S) Forest Division.

Similarly in the year 2012 (plantation-2), plantation was done in Bagaldhara and Kamalpur forest gardens under same forest division and Khandari Beat garden under Burdwan Forest Division. In the year 2013, plantation (plantation-3) was done in Beliatore under Bankura (N) Forest Division. The metrical character, plant height (cm) is the most significant to assess the plant growth. The plant height as measured is reflected in frequency distribution model in each and every treatment. Nine treatments were applied to study the growth of S. album. In Table-1, it is found that minimum plant height was 65.5 cm and the maximum was 165.5 cm in case of T_1 (Arhar host). The highest class value was observed in T_3 (Arhar + Tulsi host). In that case the minimum class value was 78.0cm and the maximum was 183.0cm (Table-3). In both the cases (Table-1 & 3) the CV value was almost same i.e. 24.58 & 24.08 respectively. T_2 (Tulsi host) and T_5 (Arhar+Akand) was moderate effective for Santalum growth. The CV was 21.88 & 17.22 respectively. But the standard deviation (SD) of T_2 was 18.71 which was greater than T_5 (SD-13.99). It indicates that more SD value will be the indicator of more effective growth variability. T_4 (Akand host) was found lowest class value (Table-4). In that case the minimum and maximum class value was 54.5 & 94.5 and the SD value was 13.43 which was very much similar to T_5 (SD-13.99).

Indeed the control set (Table-6) T_0 (No host) was found to be lowest class value (Min-35.5cm & Max-65.5cm) and SD value i.e. 9.89. When we have gone to assess the growth behavior in the 2nd year, i.e. in 2013 of the same treatment in same location, we found that the T_1 (Table-7) gave the highest class value (min-139.5cm & max-299.5cm).

In the previous year T_1 (Arhar host) was not found the highest class value, the reason might be the effect of host plant. In this case the host plant was Arhar. Probably the root nodule of Arhar was very much effective during 2nd year growth of Santalum. Though T_3 was very much similar to T_1, the SD value of T3 (Table-9) was 39.60 which was slight greater than T_1 (Table-7: SD=39.21). It proves that the effect of Arhar host was no doubt excellent. The effect of Tulsi host (T_2) was more or less similar to T_5 (Arhar+Akand). The effect of Akand host only (T_4 : Table-10) was found to be moderate growth performance. In Table-12, T_0 (No host) was found to be lowest performance as in earlier year. In the 3rd year i.e. in 2014, the effect of Arhar+Tulsi host (T_3 : Table-1) was found to be the highest class value. In that case minimum class value was 264.5cm and the maximum was 384.5cm. The 2nd highest host performance was T_1 (Arhar host : Table-13). The 3rd highest host effect was T_2 (Tulsi host : Table-14), thereafter in the 4th and 5th treatment effect were found in T_5 (Arhar+Akand host) and T_4 (Akand host) in Table -17 & 16 only. The effect of control set is in similar manner as in earlier years. In another location, i.e. in Rangamati, the effect of Tulsi host (T_2 : Table-20) was found to be highest class value. In that case the minimum and maximum class values were 34.5cm & 84.5cm. The effect of T_1 and T_3 (Arhar + Tulsi host) was found to be same class value (Table-19 & Table-21 respectively). But the SD value of T_3 (SD=11.13) was greater than T_1 (SD=7.93). It proves that the effect of combined host plants, i.e. Arhar+Tulsi host (T_3) is better than that of Arhar host only (T_1). The effect of Nayantara host (T_8 : Table-22) was found to be the lowest. In this case the class value was found 44.5cm - 64.5cm. The effect of T_0 was lowest than all other treatments.

In this case the class value was found 44.5cm - 64.5cm. The effect of T_0 was lowest than all other treatments.

The range of class value was 34.5 – 54.5cm and the SD value was 4.51 (overall lowest). In the 2nd year (2013), the effect of Arhar+Tulsi host (T_3 : Table-27) was found to be highest class value and highest SD value (26.15). In this case the range of class value was 57.0 – 147.0cm. The 2nd highest host performance was found in T^1 (Arhar host : Table-25). In this case the minimum class value was 74.5cm and the maximum was 144.5cm. The 3rd

& 4th highest performance was found in T_2 (Tulsi host) and T^9 (Tulsi+Nayantara host). The class value range was 54.5 – 134.5cm in case of T_2 (Table-1) and 54.5 – 114.5 in case of T_9 (Table-29). The effect of Nayantara host (T_8 : Table- 28) was lower than four treatments (T_1,T_2, T_3 & T_9). In this case the range value was 54.5 – 84.5cm and the SD value was 13.43. The effect T_0 (No host : Table- 30) was found obviously lowest class value and SD value as in earlier locations and years. In the 3rd year (2014), it was found that the effect of Arhar host (T_1 : Table-31) gave the highest class value. In this case the range of class value was 120.5 -220.5cm. It was also found that the effect of Arhar+ Tulsi host (T_3 : Table-33) was the 2nd highest host performance. In this case the range of class value was 110.5 – 210.5cm and the SD value was 9.86 which is greater than that of the SD value (7.40) of T_1 (Arhar host). It indicates the more potentiality in future of T_3 (Arhar+Tulsi). Further the effect of Nayantara host (T_8 : Table-34) and Tulsi+Nayantara host (T_9 : Table -35) was almost same. The SD value (6.07) of T_9 was calculated which is greater than the SD value (5.15) of T_8. The effect of T_0 was found to be lowest class value (55.5 – 85.5cm) and the lowest SD value (3.17).

Once again, the 2nd plantation was done in Bagaldhara location for further experimentation in details. In this plantation year one more treatment was added for the experiment. It was found that the effect of T_1 (Arhar host : Table -37) was the best performance. In this case the range of class value was 44.5-124.5cm and the highest SD value (17.75). The 2nd highest performance was the effect of Ghetu host (T_6 : Table-41). In this case the range of class value was 74.5 – 104.5cm and the SD value was 12.24. The 3rd highest performance was the effect of Tulsi host (T2 : Table-38). In this case the minimum and maximum class values were 34.5cm and 94.5cm respectively. The SD value was 15.15. The 4th, 5th and 6th experiment trial performance were found to be the effect of T_3 (Arhar+Tulsi host : Table -39), T8 (Nayantara host : Table-42) and T_4 (Akand host : Table- 40). The effect of T_0 (No host: Table-43) was found to be the lowest class value (24.5 – 54.5cm) and the lowest SD value (6.04). In the 2nd year (2014), the effect of T_3 (Arhar+Tulsi host : Table-46) gave the highest class value which ranges from 208 – 315. 2nd highest performance was found to be T_1 (Arhar host : Table-44) and T_2 (Tulsi host : Table-45). In these cases the class values were in-between 133-283cm and 118-283cm respectively. The SD values were also similar which were 36.15 and 41.96 respectively. Simultaneously the maximum class value was same in case of the effect of T_4 (Akand host : Table-47), T_6 (Ghetu host : Table-48) and T8 (Nayantara host : Table-49). The minimum class values were 118cm, 148cm and 103cm respectively but the SD value(43.44) was higher than the SD value of T_4 (34.72) and T_6 (19.48). Hence the Nayantara host proved itself as a potential host in this location.

The effect of T_0 (No host : Table-50) was found to be lowest class value. The plantation of Sandalwood was done in another site in Kamalpur in 2012 without having any host plant. The effect of no host was found the best performance than other locations. In this location the range of class value was 34.5 - 94.5cm in the 1st year. In the 2nd year i.e. in 2014, the effect of T_0 (No host : Table-52) was found to be the best class value than other locations. This might be due to edaphic factors of this location and soil characteristics. It is notable that the survival% of sandalwood in this location was very low but the survived population were proved themselves the highest class value of plant height than other locations. The sandalwood plantation was also done in Beliatore forest garden under Bankura (N) Forest Division in 2013 having three treatment supports. In this location, the effect of T_1 (Arhar host : Table-53) was found to best performance amongst three treatments. The effect of T_2 (Tulsi host : Table -54) was found to be significant class values (34.5 – 114.5cm) which is far better value than other locations after a year. T_0 (No host) was not found remarkable but above average than other location. The range of class value was 34.5 – 44.5cm. The frequency distribution study on plant height of S. album was done in Khandari Beat garden under Burdwan forest Division (Table-56 to 61). It has been found that the highest mean value of plant height was noted in case of Table-59 and the lowest was found in case of Table-58. Similarly the Standard deviation was found to be highest in T_1 and lowest in T_0 whereas the coefficient of variation (CV) was found to be highest in Table-61 and lowest (16.07) in Table -60 under the T_0 and T_2 respectively.

Conclusion

From the experiment, it is revealed that combination of host plants is always found to be better than that of single host treatment. Arhar (Cajanus cajan) + Tulsi (Ocimum sanctum), Tulsi (Ocimum sanctum) + Nayantara (Catharanthus roseus) gave best result for the sandal growth and development during treatment period.

It has been found that Arhar (Cajanus cajan) is the best single host plant over Tulsi (Ocimum sanctum), Akand (Callotropis procera) and Nayantara (Catharanthus roseus) host plants. It has also revealed that Sandalwood plants may grow without support of any host plant. Reasons behind this might be the presence of rhizo-mycorrhisal or AM fungus in the soil of sandalwood garden, though it is a chance factor and needs further study.

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