AUCTORES
Globalize your Research

Biomedical Research and Clinical Reviews

Roshan Kumar Yadav *

Open Access

Research Article

"Assessment of the Role of Environmental factors and Associated Plants for the Mass Cultivation of Santalum album L in Nepal and India"

Roshan Kumar Yadav[1*], Jagatpati Tah[2], Subrata Mukhopadhyay[3]

[1]Department of Life Science and Biotechnology, Jadavpur University, Kolkata – 700 032.

[2]Professor of Botany, Department of Botany, the University of Burdwan, Golapbag, Burdwan 713 104, West Bengal, India.

[3]Professor of Chemistry, Department of Chemistry, Jadavpur University Jadavpur, Kolkata – 700 032, West Bengal, India.

***Corresponding Author:** Roshan Kumar Yadav, Department of Life Science and Biotechnology, Jadavpur University, Kolkata, 700 032.

Received date: August 06, 2020; Accepted date: December 28, 2020; Published date: January 04, 2021

Citation: Roshan K Yadav, J Tah, S Mukhopadhyay. (2021) Assessment of the Role of Environmental factors and Associated Plants for the Mass Cultivation of Santalum album L in Nepal and India. *Biomedical Research and Clinical Reviews*. 3(1); DOI: 10.31579/2692-9406/016

Abstract

Sandalwood (White Sandal) is the fragrant heartwood of some species of genus Santalum. The widely distributed and economically important Santalum genus belongs to the family Santalaceae which includes 30 genera with about 400 species, many of which being completely or partially parasitic (John, 1947). The word Sandal has been derived from Chandana (Sanskrit), Chandan (Persian), Savtador (Greek) and Santal (French). There are references of Sandalwood in Indian mythology, folklore and ancient scripts. 'Chandana' the Sanskrit name ascribed to Santalum album L. was known and used in India from the earliest historic times and is frequently mentioned in the ancient Sanskrit writings, some of which dated before Christian era. Kautilya's Arthashastra (320 B.C.) considered Sandal as one of the important forest products to increase royal revenue. Charaka Sanhitha, the major text book of internal medicine in Ayurveda (300 B.C.) quotes uses of Sandal over 160 time in the entire text. In treatment of major diseases like fever, piles, hemorrhagic conditions, diabetes, dropsy, mental disorders, management of poisons & skin disorders wide spread uses of sandal is seen. Susrutha Samhita (150 B.C.) a great text on Indian wisdom on surgical procedures, equally preferred sandal for the management of wounds.

Keywords: environmental factors; associated plants; mass cultivation; santalum; Nepal; India

Introduction

Sandalwood (White Sandal) is the fragrant heartwood of some species of genus Santalum. The widely distributed and economically important Santalum genus belongs to the family Santalaceae which includes 30 genera with about 400 species, many of which being completely or partially parasitic (John, 1947). The word Sandal has been derived from Chandana (Sanskrit), Chandan (Persian), Savtador (Greek) and Santal (French). There are references of Sandalwood in Indian mythology, folklore and ancient scripts. 'Chandana' the Sanskrit name ascribed to Santalum album L. was known and used in India from the earliest historic times and is frequently mentioned in the ancient Sanskrit writings, some of which dated before Christian era. Kautilya's Arthashastra (320 B.C.) considered Sandal as one of the important forest products to increase royal revenue. Charaka Sanhitha, the major text book of internal medicine in Ayurveda (300 B.C.) quotes uses of Sandal over 160 time in the entire text. In treatment of major diseases like fever, piles, hemorrhagic conditions, diabetes, dropsy, mental disorders, management of poisons & skin disorders wide spread uses of sandal is seen. Susrutha Samhita (150 B.C.) a great text on Indian wisdom on surgical procedures, equally preferred sandal for the management of wounds. Sandal fumigation is indicated in warding off evils and organisms, which contaminate the wounds. Such fumigations hasten the wound healing & surgical wards remain aseptic. Dusting of wounds with sandal for early healing is common. In the Amarkosha (Lexicon 3rd or 4th Century A.D.) sandal is mentioned and it is said that 'Vina-malayam anyathra chandanam vivarditha' [Majumdar, 1941].

Objective

- Manipulation of seed germination by different concentrations of chemicals like IAA/ kinetin/ GA_3.
- To explore the suitable conditions for the proper growth of this plant with various associated plants in Nepal.
- Quantitative assessment of growth data till its establishment.
- To study any morphogenetic peculiarities & to study differential seeding of each type.
- To assess the qualitative parameters through biochemical analyses.

Materials and Methods

Materials for Experiment- 1:

i) Sandalwood seeds: Seeds of *Santalum album* L. were procured from Hirbandh Range under Baankura South Forest Division during the month of November- December and May- June of 2015 and 2016 respectively for experimentation.

Simultaneously, seeds of *S. album* L. were also collected from Mukberia village, Midnapore East, West Bengal, India.

ii) Chemicals: Gibberelic acid (GA-3)

iii) Apparatus: Container, markin cloth, polypots, hycopots, modern nursery cage

iv) Sand, bricks, sieve, Farm Yard Manure (FYM), irrigation and other agronomical infrastructure.

v) Meteorological informations

Materials for Experiment- 1 : (Contg)

No. of Treatment	Host (s) composition
T-0	No host
T-1	Arhar
T-2	Tulsi
T-3	Arhar+Tulsi
T-4	Akand
T-5	Arhar+Akand
T-6	Ghantu
T-7	Arhar+Ghantu
T-8	Nayantara
T-9	Tulsi+Nayantara

Arhar = Cajanus cajan; Tulsi = Ocimum sanctum; Akand = Calotropis procera; Ghantu = Clerodendron sp.; Nayantara = Vinca rosea, Syn. Catheranthus roseus.

Materials for Experiment- 1 : (Contg)

Information of plantation:

No. of plantation	Year
P-1	2015
P-2	2016
P-3	2017
P-4	2018

Materials for Experiment- 1: (Contg)

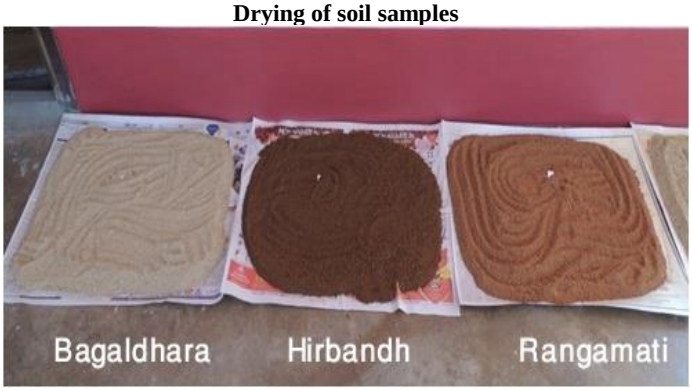
Growth parameters:

i) Plant height (cm),
ii) Basal girth (cm),
iii) Branch no,
iv) Leaf length (cm)
v) Leaf breadth (cm)

Soil smaples

Collection of soil samples

Drying of soil samples



Results and Discussion

Results: Soil Parameters Study Six soil samples were collected from the different forest gardens of Bankura and Burdwan district, viz. Bagaldhara, Rangamati, Kamalpur, Beliatore & Hirbandh of Bankura and Khandari of Burdwan. Similarly, we have collected samples from Nepal also for testing. The soil samples were tested for pH, Organic carbon, available N, P and K and presented in Table-I. Only one table (Table-I) has been cited below:

Location	pH	OC (%)	Available N (Kg ha-1)	Available N (PPM)	Available K (PPM) Available P (PPM	Available P (PPM
Rampur	5.71	0.51	234.6	106.63	106.63	8.2
Malangwa	5.70	0.47	221.3	100.59	51.8	7.9
Kamalpur	5.57	0.34	198.8	90.36	49.8	5.7
Bardibas	4.95	0.35	211.3	105.51	50.5	5.6

Table - I: Soil Test Reports of Macronutrients

Results (Contg)

Micronutrient analysis was done for 4 soil samples, viz. Bagaldhara, Rangamati, Kamalpur and Hirbandh and reflected in Table-II. It is evident from the results that the micronutrient (Cu,Zn,Mn,Fe,Mo & B) content is lowest in Bagaldhara, Cu content is maximum in Rangamati, Zn & Fe content is highest in Kamalpur, Mn content is highest in Hirbandh. In all the cases B content is below the critical level (0.3 ppm) and Mo content is below dection level (BDL).

Sl.no.	Test parameter	Critical levels of micronutrients (mgkg-1or PPM)	Results			
			Hirbandh	Kamalpur	Rangamati	Bagaldhara
1	Copper (Cu)	0.2	0.67	1.08	1.38	0.50
2	Zn (Zn)	0.6	0.32	0.86	0.46	0.19
3	Manganese (Mn)	2.0	73.72	45.89	69.50	25.89
4	Iron (Fe)	4.5	8.66	17.15	7.96	2.25
5	Molybdenum (Mo)	0.05	BDL	BDL	BDL	BDL
6	Boron (B)	0.3	0.17	0.14	0.17	0.14

Table - II: Soil Test Report of Micronutrients

Discussion

Study of soil parameters:

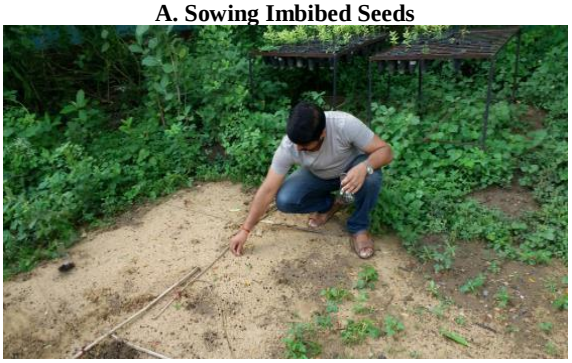
White sandal requires good drainage and does not stand waterlogging. Best growth of sandal trees are found on rich fairly moist soil such as garden loam and well drained deep alluvium on the river banks (Troup, 1921). A significant relataionship between available nitrogen content in 'A' horizon and annual growth increment was observed in the soils of Talamalai Range (Krishnamurthy et al., 1983). In a study carried out by Jain et al.,(1988) on soil properties and their relationship to the growth of sandal in three areas, it was observed that lime status, water holding capacity, pore space, volume expansion on wetting, exchangeable calcium and magnesium and available potash, exert positive influence on the increment in girth and height. Requirement of host for proper growth of sandal was demonstrated in a field study by Ananthapadmanabha et al., (1984). Further analysis of soil and leaf samples from this trial had shown that sandal depands on its host for K, P and Mg (Rangaswamy et al., 1986b). Sandal can draw other nutrients directly from soil because its roots have good cation exchange capacity (Parthasarathi et al., 1971).

Comment

It is evident that the soil components viz; Phosphorus, potassium, Ammonical nitrogen, carbon, PH of soil etc. have their specific individual or combined role for the growth and development of the plant population. On the contrary, the meteorological activities has specific action upon the plant population for their morpho-phisiological performances towards survivalibility over the location.

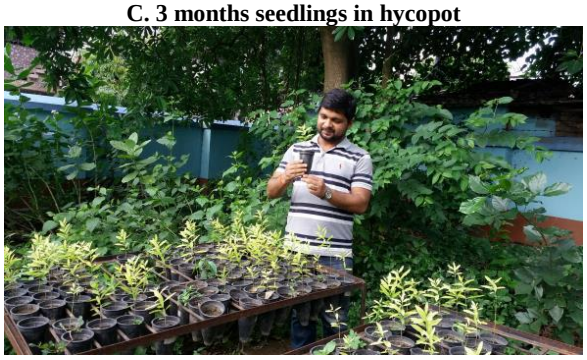
Photographs

A. Sowing Imbibed Seeds



B. Seedlings planted in hycopot

C. 3 months seedlings in hycopot



D. One year old plant

Materials and Methods [Experiment- 2]

Materials: As same as Experiment – 1
Methods:
(i) A Randomized Block Design Field (RBD) having 12 'X 15' plant spacing,
(ii) Provide uniform agronomic cultures in both the forest gardens,
(iii) Collection of data (Plant height, branch number, leaf number) in regular manner,
(iv) Biometric calculations followed by Tah, 2018.

Study area:
This study was conducted in Khandari (Burdwan), Basudevpur (Bankura), Bagaldhara (Bankura), and Rangamati (Bankura)

Results [Experiment- 2]

Location /	R-I	R-II	R-III	R-IV	Σ
L-1	1780,17900,350, 280,16600 ∑=52930 x̄ = 10586	19200,800,1200, 13600,19500 ∑=54300 x̄ = 10860	18800,16900,6000, 8600,17500 ∑=62400 x̄ =12480	14800,16200,10900, 9300,14100 ∑=65300 x̄ = 13060	46986
L-2	12500,14600,10800 8600,16500 ∑=63000 x̄ =12600	11300,13400,6000, 9600,12000 ∑=52300 x̄ =10460	7600,9800,4200, 8100,9600 ∑=39300 x̄ = 7860	6300,8100,4600, 9000,8600 ∑= 36600 x̄ = 7320	38240
L-3	20200,16400,18900, 4200,4600 ∑= 64300 x̄ =12860	10200,9000,12500, 16900,14600 ∑= 62700 x̄ = 12540	10700,6000,14100, 7200,7800 ∑= 45800 x̄ =9160	9300,8200,7100, 4600,3800 ∑= 33000 x̄ =6600	41160
L-4	16700,8500,3200, 4500,7100 ∑=40000 x̄ =8000	16800,9700,7400, 9000,9500 ∑=52400 x̄ = 10480	8900,7200,8300, 7600,9600 ∑= 41600 x̄ = 8320	8200,9100,9600, 6100,7500 ∑= 40500 x̄ = 8100	34900
Σ	44046	44340	37820	35080	GT= 161286

Table 1. Total number of leaves of S. album in different study sites

Calculations

[Calculations: CF = (161286)2/80 =325164672.45 TSS = 10094500900- 325164672.45 = 9769336227.55 RSS = (6567044516/ 4)- 325164672.45 = 1316596456.55 TRSS = (6582137396/4)- 325164672.45 = 1320369676.59 ESS = 9769336227.55- (1316596456.55+1320369676.59) = 7132370094.45]

SV	Df	SS	MSS	F
Rep	**3**	**1316596456.55**	**438865485.516**	**0.5537**
Treat	**3**	**1320369676.59**	**440123225.516**	**0.5553**
Error	**9**	**7132370094.45**	**792485566.05**	

Results [Experiment- 2]

Location	R-I	R-II	R-III	R-IV	Σ
L-1	30,35,5,5.8,3,30, 35.2,5.9,5.9,30.6 ∑=107.6 x̄ = 21.5	30.5,5.9,6.9,24.5, 33,20,18,22,26,28 ∑=105.3 x̄ = 21.06	23.8,28.7,9.8,12,30. 6 ∑= 104.9 x̄ = 20.98	23,25.7,16.9,14,18 ∑= 97.6 x̄ = 19.52	83.06
L-2	10.8,13.6,8,12.1 ,25.3 ∑= 69.8 x̄ =13.96	18,16.7,9,8.8,10.9 ∑= 63.4 x̄ = 12.68	9.7,11.4,8.6,12.4, 12.6 ∑= 54.7 x̄ = 10.94	10.8,12.7,9.8,11.8, 12.1 ∑= 57.2 x̄ = 11.44	49.02
L-3	10,10,12,12,11,10. 9, 10.7,12,14.6,16.7 ∑= 64.9 x̄ = 12.98	8,7.7,10.8,14.1,11. 2 ∑= 51.8 x̄ = 10.36	13.7,9.9,18,11.3,10. 7 ∑= 63.6 x̄ = 12.72	14.3,15.2,11,10, 4.9 ∑=59.9 x̄ = 11.98	48.04
L-4	10.6,9.9,8.6,9,14.6 ∑=52.7 x̄ = 10.54	12.3,10.9,11,14,10. 3 ∑= 58.5 x̄ = 11.7	10.9,11.2,12,11,14. 4 ∑= 59.5 x̄ = 11.9	11.6,12.3,12.2,9.8,1 0 ∑= 55.9 x̄ = 11.18	45.32
Σ	58.98	55.8	56.54	54.12	GT=225.4 4

Table 2: Plant height (cm) of S. album L. in different study site

Calculations

[Calculations: F= (225.44)2/80 = 635.28 TSS = (30)2 + (3.5)2 + (5.9)2 + (5.9)2 + (30.6)2 ……..……...+ (10)2 - CF = 19361.08 – 635.28 = 18725.8 RSS = {(58.98)2 + (55.8)2 + (56.54)2 + 954.12)2}/ 4– 635.28 = (12718.02)/4 – 635.28 = 2544.42 TRSS = {(83.06)2 + (49.02)2 + (48.04)2 + (45.32)2}/ 4- CF = 3415.9-635.28 = 2780.635 ESS = TSS- (RSS + TRSS) = 18725.8- (2544.22 + 2780.63) = 13400.95]

S.V.	df	SS	MSS	F
Rep	3	2544.22	848.07	0.5695
Treat	3	2780.635	926.87	0.6224
Error	9	13400.95	1488.99	

Results [Experiment- 2]

Location	R-I	R-II	R-III	R-IV	Σ
L-1	85, 27,15,14,18 ∑=159 x̄ = 31.8	44,10,8,12,19 ∑= 93 x̄ = 18.6	15,18,7,21,14 ∑= 75 x̄ = 15	21,33,25,6,18 ∑= 103 x̄ = 20.6	86
L-2	8,9,12,23,10 ∑= 62 x̄ = 12.4	12,8,6,12,7 ∑= 45 x̄ = 9	6,28,12,14,18 ∑= 78 x̄ = 15.6	27,19,11,7,16 ∑= 80 x̄ = 16	53
L-3	16,25,30,22,24 ∑= 120 x̄ = 24	4,4,11,9,7 ∑= 35 x̄ = 7	22,18,25,19,17 ∑= 101 x̄ = 20.2	11,25,19,8,18 ∑=81 x̄ = 16.2	67.4
L-4	8,2,4,15,25 ∑= 54 x̄ = 10.8	19,9,6,12,8 ∑= 54 x̄ = 10.8	19,23,15,6,18 ∑= 81 x̄ = 16.2	34,10,6,9,14 ∑= 73 x̄ = 14.6	52.4
Σ	79,0	45.4	67.0	67.4	GT= 258.8

Table 3: Total Branches/plant of S. album L in different study site

Calculations

[Calculations: CF= (258.8)2/80 = 837.218 TSS = 30934- 837.218 = 30096.782 RSS = (17333.92/4) - 837.218 = 3496.262 TRSS = (17493.52/4) - 837.218 = 3536.162 ESS = 30096.782 – (3496.262+3536.162) = 23064.35]

S. V.	df	SS	MSS	F
Rep	3	3496.262	1165.42	0.4547
Treat	3	3536.162	1178.72	0.4599
Error	9	23064.35	2562.7	

Discussion

The average number of leaves found in different geographical regions of our study showed L1 (46986), L2 (38240), L3 (41160), L4 (34900). The average height of plants as in the study site was found to be 83.06, 49.02, 48.04 and 45.32 feet respectively for L1, L2, L3 and L4. Similarly, the average branch number were in the order of 86, 53, 67.4 and 52.4 as shown in the table above. Sandalwood (Santalum album L.) is a partial root parasite, small evergreen tree attaining a height of 12 to 15 metres and a girth of 1 to 2.4 metres with slender drooping as well as erect branching. FAO, 1995 published a bulletin on Flavours and Fragrances of Plants origin which is very much related with *Santalum album* L. This plant has been rendering its performance properly for the sake of human beings since ancient time of civilization. There was no existence of sandal plant in West Bengal in national map. Recently, Das and Tah (2014) reported its existence in West Bengal in an international forum. A few plants were grown by forest executive in undivided Bankura Forest Division. It was felt by present workers that there is certainly some scientific lacuna for its seed propagation and also adaptation due to specific edaphic factors and less germination percentage. Keeping all these views in mind, this venture was undertaken to find out any reason behind this problem.

Discussion (Contg)

Jahan and Rahman, 2014 explained that sandal dissolves inflammation and tumours and stabilizes palpitation. Sandalwood is used as a disinfectant in bronchial and genitourinary tract infection. Das and Tah (2013) observed the effect of concentration of GA3 on seed germination of sandal (Santalum album L.). Das and Tah (2014) vividly experimented on Silvicultural practices for its adaptability with different host species and natural regeneration in south-West Bengal in different forest gardens in Bankura and Burdwan Forest Divisions in South Bengal Das and Tah (2015) studied the soil nutrients for the growth of white sandal (*Santalum album* L.) in southern part of West Bengal. Batabyal et al., (2014, 2015 and 2017) experimented on different seed-sources on germination parameters by means of artificial seed germination of Santalum album L ., different seed bed materials and GA3 on seed germination of *Santalum album* L. and Characterization of *Bacillus cereus* Symbiotic to Hemi-parasitic Plant Santalum album L. Yadav et al., 2018 took up a venture on the Study of Edaphic Factors of the Location for the Growth of White Sandal (Santalum album L.) in Indo-Nepal Border.

Conclusion

The productivity of timber plants is measured by analysing the plant height and breast height girth (b.h.g) in specific unit area. In this case four locations are distributed in both the Forest Divisions, Bankura (South & North). The plant height and basal girth were measured critically as much as it was possible out of 700 of S. album plants, grown in Forest gardens. The yield of heartwood varies from locality to locality and with the age of the tree. In India, trees of 100cm girth have been reported to yield between 85kg and 240kg of heartwood according to the area from which they come (FAO, 1995). Timber wood production is expressed by its timber volume. It is measured by the plant height and basal girth.

Photographs

In Khandari, Burdwan Forest Div

In Khandari, Burdwan Forest Div

In Khandari, Burdwan Forest Div

In nursey, Khandari, Burdwan Div

Materials and Methods [Experiment-3]

Materials

1. Seed materials collected from (I) Bankura, (II) Burdwan,(III)Mokrampur 2. i) Chemicals: Gibberelic acid (GA3), ii) HgCl2 Miscellaneous: Distilled Water, Petridishes, Compost manure, Beakers, Conical flasks, measuring cylinder, Chemical weigh balance (digital), Hycopots, Note book, pen etc. Seeds of white sandal (Santalum album L.) were grown in nursery bed to rage the seedlings of the plant. The six months seedlings were planted in the different locations having 15x12 feet plant spacing in the garden. The randomized block design (RBD) having three replications was followed for the plant populations in each locations. The Uniform agronomic measures were provided for the proper growth and development in each locations. The metrical characters were studied annually in each garden. After 5th year the plant population was observed and the metrical characters were analyzed in correlation and coefficient model of Panse and Sukhatme 2005. On the contrary the soil samples were also taken from each locations at least 20 sample annually and analised it in the laboratory properly. All those data were calculated properly and tabulated it in table no. 1 and 2.

Materials [Experiment-3(Contg)]

Statistical Models: Statistical Models and methods were done as followed by Singh & Chaudhary (1995) and Panse&Sukhatme (1995).

Results [Objective- 3]

S. no1 vs2	Location -1								Location - 2								Location - 3							
	1vs 2		1vs 3		1vs 4		1vs 5		1vs 2		1vs 3		1vs 4		1vs 5		1vs 2		1vs 3		1vs 4		1vs 5	
1	600	30	600	9	600	8.0	600	2.5	550	14.1	600	4	600	8	600	2.5	1200	36.0	600	3	600	3.3	600	2.2
2	800	36	800	12	800	9.0	800	2.5	350	9.1	800	5	800	7	800	2.4	1100	37.0	800	2	800	3.9	800	.23
3	400	30	400	6	400	8.0	400	2.5	410	8.4	400	6	400	9	400	2.5	1250	48.0	400	2	400	4.2	400	2.7
4	840	50	840	6	840	5.0	840	2.6	590	11.6	840	7	840	8	840	2.5	1400	47.0	840	2	840	4.1	840	2.8
5	900	43	900	5	900	6.0	900	2.7	520	17.0	900	4	900	7	900	2.5	1450	50.0	900	2	900	4.7	900	2.5
6	1000	25	1000	12	1000	6.0	1000	2.4	380	16.0	1000	3	1000	9	1000	3.4	1450	42.0	1000	2	1000	2.9	1000	2.6
7	810	60	810	6	810	7.0	810	2.8	460	15.5	810	7	810	6	810	2.5	1500	50.2	810	2	810	3.2	810	2.1
8	850	70	850	5	850	8.0	850	3.8	500	14.9	850	3	850	8	850	2.4	1500	52.0	850	2	850	3.0	850	1.9
9	600	72	600	5	600	8.0	600	3.7	490	13.7	600	4	600	7	600	2.9	1510	58.0	600	2	600	2.6	600	3.0
10	310	80	310	10	310	7.0	310	4.1	440	12.6	310	5	310	9	310	2.5	1500	59.0	310	2	310	3.7	310	2.9
11	1200	25	1200	8	1200	8	1200	4.0	560	11.9	1200	2	1200	6	1200	2.5	1600	60.0	1200	2	1200	4.1	1200	2.6
12	1000	70	1000	8	1000	8.3	1000	4.0	510	12.0	1000	3	1000	8	1000	2.4	1600	61.0	1000	2	1000	3.6	1000	2.2
13	1000	52	1000	7	1000	8.0	1000	3.5	430	13.0	1000	4	1000	7	1000	2.4	1620	53.0	1000	2	1000	3.5	1000	2.3
14	730	58	730	7	730	8.2	730	4.0	490	14.9	730	3	730	7	730	2.5	1610	54.0	730	2	730	3.8	730	2.1
15	280	60	280	8	280	8.0	280	3.9	390	16.6	280	4	280	7	280	2.5	1580	56.0	280	2	280	4.0	280	2.0
16	680	72	680	9	680	8.1	680	2.5	380	16.0	680	5	680	6	680	2.4	1570	31.0	680	2	680	4.1	680	2.4
17	950	42	950	9	950	8.2	950	3.7	530	13.7	950	2	950	9	950	2.5	1590	39.0	950	2	950	4.3	950	2.5
18	1100	32	1100	10	1100	8.4	1100	2.6	560	14.8	1100	2	1100	8	1100	2.5	1625	44.0	1100	3	1100	4.4	1100	2.4
19	890	60	890	12	890	8.0	890	4.1	570	15.7	890	3	890	8	890	2.4	1638	49.0	890	4	890	3.9	890	2.1
20	640	80	640	10	640	8.1	640	3.8	590	17.3	640	2	640	7	640	2.3	1670	68.0	640	2	640	4.6	640	2.0
r - value	1.051		0.186		0.088		-0.050		0.185		0.309		0.045		0.283		0.496		0.027		0.001		-0.217	

Table 1: Statement of Correlation coefficients of White sandal (Santalum album L.) from three locations of Nepal

Discussion

Three locations were allotted to study in this location. Observations after one year were considered bi-variate correlation co-efficient analysis. The calculated r-values were presented in Table -127. The r-values against each treatment are lying in-between 0.149 – 0.839 in first set experiment, 0.383 – 0.882 in second set of experiment and 0.086 – 0.867 in third set of experiment respectively which are most acceptable in biometrical view point. Das and Tah (2013) experimented on the effect of seed germination of Sandal plant and thereafter observed the adaptability on this crop with different host plant species in varied edaphic factors in South Bengal .Batabyal and Tah (2014), Batabyal et al. (2014) studied the variation of seed morphology of different sources and its contribution to seed germination of *S. album* and germination parameter by means of artificial seed germination and its responses of some phyto-hormones for vegetative propagation of this ancient crop species. Das and Tah (2014) reconfirmed the stability parameters of *S. album* through different silviculture programmes. Batabyal et al., (2014) have been exercised lot experiments in this problem. Das et al., (2015) vividly studied on frequency distribution on the growth of *Santalum album* L. Karmaker et al., (2017) observed an extensive study on "Germination behaviour and morphological activities of white sandal" whereas Jadav et al. (2017) showed the "Role of edaphic factors over seed production and rate of seed germination of white sandal (*Santalum album* L.). 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.

Conclusion

It is evident that the soil components viz; Phosphorus, potassium, Ammonical nitrogen, carbon, PH of soil etc. have their specific individual or combined role for the growth and development of the plant population. On the contrary, the meteorological activities has specific action upon the plant population for their morpho-phisiological performances towards survivalibility over the location.

Materials for Experiment-4:

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 *S. album* were also procured from Institute of Wood Science and Technology, Bangalore in the month of February, 2012 for the same experimentation purposes.

2. Chemicals: Gibberellic acid (GA3)
3. Apparatus: Container, Markin cloth, Polypots, Hycopots.
4. Miscellaneous: Soil samples (for analysis), Sandalwood Samples (for oil and santalol content analysis), Sand, Bricks, Seive, FYM, Water, etc.
5. Meteorological Informations of Bankura District from 2016-2019:

Materials [Experiment-4 (Contg)]

Six types of this genus taken for the experiment:
Peculiarities were observed in leaf shape, leaf size, colour, thickness, texture and flowering seasons. The seadling planted in different forest gardens have been shown foliar variations. Leaves are opposite, and opposite decussate, sometimes show whorled arrangement. The leaf shape varies from lanceolate to ovate or elliptical (Kulkarni and Srimathi 1982). Two consipicuous types of white sandal trees are observed where from the seeds were collected in Hirbandh forest garden which are as follows:

Materials [Experiment-4 (Contg)]

S.No.	Characterstics	Observation-1	Observation-2
1st Type	Leaf shape	lanceolate	ovate
2nd Type	Leaf Length	5.5cm	5.5cm
3rd Type	Leaf Width	1.7cm	2.7cm
4th Type	Leaf colour	Light green	Deep green
5th Type	Leaf thickness	Less thick	More thick
6th Type	Leaf texture	Less glossy	More glossy

Various types of leaves:
-Shape and measurements-
Table I: Morphogenetic peculiarities of *S album* L.

Ovate type leaf

Lanceolate type leaf

Results and Discussion

The following data of the phenotypic characters were observed and tabulated In the following tables:

- Plant Height (cm) overaged over 5 samples per plot of each type for 6 types of white sandal plant *Santalum album* L. [Table no: 1.1]
- Branches / plant (no) overaged over 5 samples per plot of each type for 6 types of white sandal plant *Santalum album* L. [Table no: 2.1]
- Basal girth (cm) overaged over 5 samples per plot of each type for 6 types of white sandal plant *Santalum album* L. [Table no: 3.1]
- Leaf length (cm) overaged over 5 samples per plot of each type for 6 types of white sandal plant *Santalum album* L. [Table no: 4.1]
- Leaf breadth (cm) overaged over 5 samples per plot of each type for 6 types of white sandal plant *Santalum album* L. [Table no: 5.1]
- Similarly all the tables [Table 1.2 to Table 5.7] towards anova for G*E, total for g, l and g*l, total y and g*y, total l*y, annova for GxE interaction estimates of variance components and h heritability.

Results (Contg)

T /R	Location – 1 [Hetauda]								Location – 2 [Biratnagar]								Location – 3 [Bagaldhara]							
	Year - 1				Year - 2				Year - 1				Year - 2				Year - 1				Year - 2			
	I	II	III	Σ	I	II	III	Σ	I	II	III	Σ	I	II	III	Σ	I	II	III	Σ	I	II	III	Σ
1	5.0	7.7	7.5	20.2	10.0	12.0	11.1	33.1	3.8	4.9	5.9	14.6	3.8	4.0	5.3	13.1	10.0	10.0	12.0	32.0	7.0	14.0	1.0	22.0
2	7.0	8.0	8.4	23.4	11.0	12.4	11,5	34.9	3.9	4.3	5.7	13.9	33.5	4.3	5.9	13.7	12.0	12.0	11.0	35.0	11.2	13.7	9.0	34.0
3	7.0	3.0	4.5	14.5	10.5	11.8	12.0	34.3	3,8	4.6	5.6	14.0	3.3	4.9	5.2	13.4	10.0	9.0	10.1	29.1	18.0	11.3	1.07	30.37
4	6.5	5.5	6.4	18.4	10.4	11.5	12.3	34.2	4.1	4.1	5.9	14.1	4.0	3.9	5.0	12.9	7.0	12.0	14.0	33.0	14.3	15.2	11.0	40.5
5	6.0	6.3	7.2	19.5	10.7	11.9	12.4	35.0	4.2	5.0	6.0	15.2	3.9	4.5	5.5	13.9	6.0	10.7	8.0	30.7	10.0	4.9	16.9	31.8
6	7.0	6.9	7.1	21.0	11.3	12.0	10.8	34.1	3.5	5.2	6.1	14.8	4.1	4.4	5.3	13.8	7.0	6.0	8.0	21.0	18.6	13.6	9.8	42.0
Σ	38.5	37.4	41.1	117.0	63.9	71.6	70.1	205.6	23.3	28.1	35.2	86.6	22.6	26.0	32.2	80.8	52.0	65.7	63.1	180.8	79.1	72.7	49.67	201.17

Table -1.1: Plant height (m) over K=5 samples/plot for 6 types of white sandal in 3 locations for 2 years' plantation having 3 replications

Results (Contg)

Tables >	1.2: Total for g, l and gxl			1.3: Total for y and gxy			1.4: Total for lxy			
Variety	L-1	L-2	L-3	Variety	Year-1	Year-2	Loc	Yr-1	Yr-2	Σ
A	TAL1= 53.3	TAL2=27.7	TAL3= 54.0	A	TAY1= 66.8	TAL2= 68.2	1	GT1= 117.0	GT2= 205.6	T11= 322.6
B	TBL1=58.3	TBL2 =27.6	TBL3= 69.8	B	TB Y1= 72.3	TBL2 = 83.4	2	GT3= 86.6	GT4= 80.8	T12= 167.4
C	TCL1= 48.8	TCL2=27.4	TCL3= 59.47	C	TC Y1= 57.6	TCL2= 78.07	3	GT5= 180.8	GT6= 201.17	T13= 381.97
D	TDL1= 52.6	TDL2=27.0	TDL3= 73.5	D	TD Y1= 65.5	TDL2= 87.6	Σ	384.4	487.57	871.97
E	TEL1= 54.5	TEL2=29.1	TEL3= 62.5	E	TE Y1= 65.4	TEL2= 80.7				
F	TFL1= 55.1	TFL2=28.6	TFL3= 63.0	F	TF Y1= 56.8	TFL2= 89.9				
Σ	322.6	167.4	382.27	Σ	384.4	487.87				

Results (Contg)

Table – 2.1: Basal Girth of Plant (cm) over K=5 samples/plot for 6 types of white sandal in 3 locations for 2 years' plantation having 3 replications

T /R	Location – 1 [Hetauda]								Location – 2 [Biratnagar]								Location – 3 [Bagaldhara]							
	Year - 1				Year - 2				Year - 1				Year - 2				Year - 1				Year - 2			
	I	II	III	Σ	I	II	III	Σ	I	II	III	Σ	I	II	III	Σ	I	II	III	Σ	I	II	III	Σ
1	30.0	34.0	16.0	80.0	48.0	58.0	66.0	172.0	9.1	11.5	13.0	33.6	14.0	22.0	16.0	52.0	80.3	66.1	42.0	188.4	10.8	6.5	4.3	21.6
2	36.0	25.0	27.5	88.5	80.0	52.0	80.0	212.0	8.4	16.0	11.1	35.5	17.0	25.0	20.2	62.2	9.8	16.0	15.2	41.0	9.8	18.6	3.5	31.9
3	10.0	29.9	25.9	64.9	60.0	82.5	68.5	211.0	11.6	10.9	11.9	34.4	15.0	26.0	24.5	65.5	7.6	50.0	15.8	73.4	7.8	9.2	4.8	21.8
4	32.0	39.0	38.7	109.7	42.0	72.0	48.0	162.0	11.9	11.8	11.6	35.3	14.5	17.0	25.7	57.2	48.6	52.3	58.0	158.9	3.7	19.6	18.6	41.9
5	26.0	40.0	45.5	111.5	72.0	70.5	77.5	220.0	11.0	8.4	8.4	27.8	16.0	21.0	23.5	60.5	36.3	42.9	18.8	98.0	17.3	14.8	19.3	51.4
6	36.5	44.5	39.5	120.5	60.0	66.5	59.5	186.0	13.0	10.5	9.1	32.6	16.0	27.0	27.5	70.5	33.2	21.0	9.8	64.0	15.4	13.2	18.0	46.6
Σ	170.5	211.5	193.1	575.1	362.0	401.5	399.5	1163.0	65.0	69.1	65.1	199.2	92.5	138.0	137.4	367.9	215.8	248.3	159.6	623.7	64.8	51.9	68.5	215.2

TR_1 = 970.6, TR2 = 1150.3, TR3 = 1023.2, GT= 3144.1

Results (Contg)

Tables >	2.2: Total for g, l and gxl of S. album L.			2.3: Total for y and gxy of S. album L.			2.4: Total for lxy of S. album L.			
Variety	L-1	L-2	L-3	Variety	Year-1	Year-2	Loc	Yr-1	Yr-2	Σ
A	TAL1= 252	TAL2=85.6	TAL3=21.0	A	TAY1= 188.4	TAL2= 245.6	1	GT-1= 575.1	GT2= 1163.0	T11= 1738
B	TBL1= 300.5	TBL2= 97.7	TBL3=72.9	B	TB Y1= 165.0	TBL2= 306.1	2	GT3= 199.2	GT4= 367.9	T12= 567.1
C	TCL1= 275.9	TCL2= 99.9	TCL3=95.2	C	TC Y1= 172.7	TCL2= 298.3	3	GT5= 623.7	GT6215.2	T13= 838.9
D	TDL1= 271.7	TDL2= 92.5	TDL3=200.8	D	TD Y1= 303.9	TDL2= 261.1	Σ	1398.0	1746.1	3144.1
E	TEL1= 331.5	TEL2= 88.3	TEL3=149.4	E	TE Y1= 237.3	TEL2= 331.9				
F	TFL1= 306.5	TFL2=103.1	TFL3=110.6	F	TF Y1= 217.3	TFL2= 303.1				
Σ	1738.1	567.1	838.9	Σ	1398.0	1746.1				

Results (Contg)

Table – 3.1: Branches/Plant (no) over K=5 samples/plot for 6 types of white sandal in 3 locations for 2 years' plantation having 3 replications

T /R	Location – 1 [Hetauda]								Location – 2 [Biratnagar]								Location – 3 [Bagaldhara]							
	Year - 1				Year - 2				Year - 1				Year - 2				Year - 1				Year - 2			
	I	II	III	Σ	I	II	III	Σ	I	II	III	Σ	I	II	III	Σ	I	II	III	Σ	I	II	III	Σ
1	6	6	6	118	10	12	9	31	2	4	2	8	4	5	4	13	85	27	15	127	6	18	8	32
2	6	8	7	21	9	10	12	31	3	5	2	10	3	6	7	16	14	18	44	76	9	12	23	44
3	5	9	8	22	5	10	11	26	2	2	3	7	4	7	6	17	10	8	12	30	10	16	25	51
4	6	5	8	19	7	11	10	28	2	3	2	7	5	4	5	14	19	15	18	52	30	21	24	76
5	5	6	5	16	6	10	11	27	3	4	3	10	7	4	4	15	7	21	14	42	4	4	11	19
6	5	5	6	16	5	12	10	27	1	3	3	7	6	5	5	16	21	33	25	79	9	7	22	38
Σ	33	39	40	112	42	65	63	170	13	21	15	49	29	31	31	91	156	122	128	406	68	79	113	260

TR_1 = 341.0, TR2 = 357.0, TR3 = 390.0, GT= 1088.0

Results (Contg)

Tables >	3.2: Total for g, l and gxl			3.3: Total for y and gxy			3.4: Total for lxy			
Variety	L-1	L-2	L-3	Variety	Year-1	Year-2	Loc	Yr-1	Yr-2	Σ
A	TAL1= 49.0	TAL2= 31.0	TAL3= 159.0	A	TAY1= 153.0	TAL2= 76.0	1	GT1= 112.0	GT2= 170.0	T11= 282.0
B	TBL1= 52.0	TBL2= 26.0	TBL3= 120.0	B	TB Y1= 107.0	TBL2 = 91.0	2	GT3= 49.0	GT4= 91.0	T12= 140.0
C	TCL1= 48.0	TCL2= 24.0	TCL3= 81.0	C	TC Y1= 59.0	TCL2= 94.0	3	GT5= 406.0	GT6= 260.0	T13= 666.0
D	TDL1= 47.0	TDL2= 24.0	TDL3= 128.0	D	TD Y1= 78.0	TDL2= 118.0	Σ	567.0	521.0	1088,0
E	TEL1= 43.0	TEL2= 25.0	TEL3= 61.0	E	TE Y1= 68.0	TEL2= 61.0				
F	TFL1= 43.0	TFL2= 23.0	TFL3= 117,0	F	TF Y1= 102	TFL2= 81.0				
Σ	282.0	143.0	666.0	Σ	567	521.0				

Results (Contg)

Table – 4.1: Leaf length (cm) over K=5 samples/plot for 6 types of white sandal in 3 locations for 2 years' plantation having 3 replications

T /R	Location – 1 [Hetauda]								Location – 2 [Biratnagar]								Location – 3 [Bagaldhara]							
	Year - 1				Year - 2				Year - 1				Year - 2				Year - 1				Year - 2			
	I	II	III	Σ	I	II	III	Σ	I	II	III	Σ	I	II	III	Σ	I	II	III	Σ	I	II	III	Σ
1	5.4	6.1	6.0	17.5	8.0	8.2	9.0	25.2	5.5	7.0	6.5	19.0	8.0	8.0	9.1	25.1	9.0	6.0	8.0	23.0	8.0	9.0	8.3	25.3
2	5.3	5.2	6.1	16.6	9.0	8.4	8.5	25.9	5.6	6.2	6.0	17.8	8.5	8.5	8.7	25.7	6.0	7.0	9.0	22.0	4.0	8.0	7.0	19.0
3	5.5	6.4	5.0	16.9	8.5	8.0	7.0	23.5	6.5	6.3	6.0	18.8	8.8	8.4	9.0	26.2	8.0	7.0	6.0	21.0	8.0	9.0	8.2	25.2
4	6.0	6.3	7.0	19.3	7.0	8.2	8.0	23.2	7,0	7.5	7.0	21.5	8.4	8.7	9.0	26.1	7.0	5.0	7.0	19.0	7.6	8.3	8.1	24.0
5	6.3	5.7	8.0	20,0	8.3	8.1	8.4	24.8	7.1	7.1	6.9	21.1	8.9	8.9	9.3	27.1	8.0	8.2	8.3	24.5	9.0	8.4	6.6	24.0
6	5.8	5.5	7.2	18.5	8.2	8.3	8.3	24.8	7,0	6.8	7.0	20.8	9.0	9.0	9.7	27.7	5.0	7.0	7.3	19.3	8.0	7.4	7.0	22.4
Σ	34.3	35.2	39.3	108.8	49.0	49.2	49.2	147.4	38.7	40.9	39.4	119.0	51.6	51.5	54.8	157.9	143.0	40.2	45.6	128.8	44.6	50.1	45.2	139.9

TR_1 = 361.2, TR2 = 267.1, TR3 = 273.5, GT= 901.8

Results (Contg)

Tables >	4.2: Total for g, l and gxl			4.3: Total for y and gxy			4.4: Total for lxy			
Variety	L-1	L-2	L-3	Variety	Year-1	Year-2	Loc	Yr-1	Yr-2	Σ
A	TAL1= 42.7	TAL2= 44.1	TAL3= 48.3	A	TAY1 = 59.5	TAL2= 75.6	1	GT-1= 108.8	GT2= 147.4	T11= 256.2
B	TBL1= 42.5	TBL2 = 43.5	TBL3= 41.0	B	TB Y1 = 56.4	TBL2= 70.6	2	GT3= 119.0	GT4= 157.9	T12= 276.9
C	TCL1= 40.4	TCL2= 45.0	TCL3=46.2	C	TC Y1= 56.7	TCL2= 74.9	3	GT5= 128.8	GT6= 139.9	T13= 268.7
D	TDL1= 42.5	TDL2= 47.6	TDL3=43.0	D	TD Y1 = 59.8	TDL2= 73.3	Σ	356.6	445.2	801.8
E	TEL1= 44.8	TEL2= 48.2	TEL3= 48.5	E	TE Y1 = 65.6	TEL2= 75.9				
F	TFL1= 43.3	TFL2= 48.5	TFL3=41.7	F	TF Y1 = 58.6	TFL2= 74.9				
Σ	256.2	276.9	268.7	Σ	356.6	445.2				

Results (Contg)

Table – 5.1: Leaf breadth (cm) over K=5 samples/plot for 6 types of white sandal in 3 locations for 2 years' plantation having 3 replications

T /R	Location – 1 [Hetauda]								Location – 2 [Biratnagar]								Location – 3 [Bagaldhara]							
	Year - 1				Year - 2				Year - 1				Year - 2				Year - 1				Year - 2			
	I	II	III	Σ	I	II	III	Σ	I	II	III	Σ	I	II	III	Σ	I	II	III	Σ	I	II	III	Σ
1	2.5	3.9	2.5	8.9	2.8	4.1	4.2	11.1	2.3	2.9	2.6	7.8	3.4	3.0	4.1	10.5	2.4	2.5	3.6	8.5	2.4	2.5	2.3	7.2
2	2.6	2.5	2.6	7.7	3.1	3.8	4.1	10.9	2.4	2.5	2.7	7.6	3.0	3.4	4.0	10.4	2.8	3.2	2.4	8.4	2.2	2.5	2.9	7.6
3	2.5	3.0	2.8	8.3	3.5	4.0	4.4	11.9	2.2	2.4	2.9	7.5	3.1	3.6	4.0	10,7	2.7	2.3	2.1	7.1	3.8	3.6	3.3	10.7
4	2.7	2.6	2.7	8.0	3.3	3.9	4.5	11.7	2.5	2.0	2.0	6.5	3.3	3.5	3.9	10.7	2.6	3.1	3.2	8.9	4.1	7.6	3.9	15.6
5	2.5	2.6	2.4	7.5	3.4	3.7	4.6	11.7	2.4	2.2	2.1	6.7	3.2	3.5	3.7	10.4	3.9	3.9	2.0	9.8	3.3	3.1	2.8	9.2
6	2.7	2.5	2.8	8.0	3.7	4.0	4.9	12.6	2.1	2.1	2.4	6.6	3.5	3.7	3.9	11.1	4.3	4.1	2.8	11.2	2.6	2.5	2.1	7.2
Σ	15.5	17.1	15.8	48.4	19.7	23.5	26.7	69.9	13.9	14.1	14.7	42.7	19.5	20.7	23.6	63.8	18.7	19.1	16.1	53.9	18.4	21.8	17.3	57.5

TR_1 = 105.7, TR2 = 116.3, TR3 = 114.2, GT= 336.2

Results (Contg)

Tables >	5.2: Total for g, l and gxl			5.3: Total for y and gxy			5.4: Total for lxy			
Variety	L-1	L-2	L-3	Variety	Year-1	Year-2	Loc	Yr-1	Yr-2	Σ
A	TAL1= 20.0	TAL2= 18.3	TAL3= 15.7	A	TAY1= 25.2	TAL2= 28.8	1	GT-1= 48.4	GT2= 69.9	T11= 118.3
B	TBL1= 18.6	TBL2= 18.0	TBL3= 16.0	B	TB Y1= 23.7	TBL2= 28.9	2	GT3 42.7	GT4= 63.8	T12= 106.5
C	TCL1= 20.2	TCL2= 18.2	TCL3= 17.8	C	TC Y1= 22.9	TCL2=33.3	3	GT5= 53.9	GT6= 57.5	T13= 111.4
D	TDL1=19.7	TDL2= 17.2	TDL3= 24.5	D	TD Y1= 23.4	TDL2= 38.0	Σ	145.0	191.2	
E	TEL1= 19.2	TEL2= 17.1	TEL3= 19.0	E	TE Y1= 24.0	TEL2= 31.3				
F	TFL1= 20.6	TFL2= 17.7	TFL3= 18.4	F	TF Y1= 25.8	TFL2= 30.9				
Σ	118.3	106.5	111.4	Σ	145.0	191.2				

Results (Contg)

Table-6: ANOVA for GXE interaction

S.V.	df	SS	MSS	Expect
Rep(r)	r-1	RSS	RMS	--
Loc (l)	l-1	LSS	LMS	---
Year(y)	y-1	YSS	YMS	---
L x y	(l-1)(y-1	LYSS	LYMS	---
Gen (g)	(g-1)	GSS	GMS	$\delta^2 e+r\delta^2gly+ry\delta^2gl+rl\delta^2gy+rly\delta^2eg$
G x l	(g-1)(l-1)	GLSS	GLMS	$\delta^2 e+r\delta^2gly+ry\delta^2gl$
G x y	(g-1)(y-1)	GYSS	GYMS	$\delta^2 e+r\delta^2gly+ry\delta^2gl+rl\delta^2gy$
Gxlxy	(g-1)(l-1)(y-1	GLYSS	GLYMS	$\delta^2 e+r\delta^2gly$
Error(e)	(r-1)(gly-1)	ESS	EMS	$\delta^2 e$
Σ				

Table-7: ANOVA for GXE interaction (calculated value)

S.V.	df	MSS				
		X_1	X_2	X_3	X_4	X_5
Rep(r)	2	3.399	237.09	17.34	76.79	0.87
Loc (l)	2	341.74	10433.68	2068.71	-785.68	0.97
Year(y)	1	-199.13	1121.97	19.59	-1504.72	19.76
L x y	2	62. 50	6952.321	345.68	795.78	2.90
Gen (g)	6	4.116	110.031	83.27	-31.234	0.50
G x l	12	2.932	284.57	61.47	158.61	0.65
G x y	6	6.421	409.41	88.47	315.90	0.94
Gxlxy	12	22.166	219.20	119.08	-153.97	0.87
Error(e)	42	4.900	69.45	58.88	-1.96	0.39
Σ	85					

Table-8: Estimates of variance components and h^2

Estimate	X_1	X_2	X_3	X_4	X_5
$\delta^2 g$	-1.52	-44,61	-10.32	-35.26	-0.10
$\delta^2 e$	4.90	69.45	58.88	-1.96	0.39
$\delta^2 gl$	-3.20	10.89	-9.60	52.09	-0.03
$\delta^2 gy$	-1.74	21.13	-3.40	52.20	0.007
$\delta^2 gly$	5.75	49.91	20.06	-50.67	0.16
$\delta^2 p$	-0.59	-6.50	-89.46	-8.82	-0.01
h^2_{BS}	2.54	6.86	2.07	3.99	6.05

Discussion

- In this context, it has been found that the total replication value over the location was found to be greater in case of Biratnagar location than the second position location was Bagaldhara. In case of total g, l and gxl (table 1.2, 2.2, 3.2 4.2 and 5.2), it has been found that the location three was the highest adaptive zone but, location 1 and location 2 were the 2nd and 3rd position of locations. According to the phenotypic data the plant height played an important major role. That's why we considered plant height as the constant phenotypic character in all cases. Considering all the characteristics features it has been summarized as follows:
- Bagaldhara, India > Hetauda, Nepal > Biratnagar in regard to stem girth. But, in case of plant height it has been observed that Bagaldhara, India > Biatnagar, Nepal > Hetauda, Nepal.
- However, in context to the calculation of all the locations, there were a mixed model of tendencies in regard to growth and development at this stage. Indeed, after 20 to 25 years there might be a nice observations to complete each and every location but, Bagaldhara has a specific constant steady role for growth and development in a regular manner.

Suggestions

- Each and every house hold should plant sandal wood plant(s) in their premises, if possible, for availing reserve bank touch and care.
- Proper agronomic care should be taken for growing sandal plants.
- Most appropriate host plants should be chosen for the proper growth and development of sandal plant.
- Host plants should be replanted time to time, if necessary till two-three years.
- Proper drainage system should be provided in the sandal plant field so that no excess water can deposit for a long time as stagnant water body.
- Should not ignore for the application of organic manure.
- Avoid chemical fertilizer application in the plants.

Sl.no	Name of Chemical	Content%
Hetauda	α- santalol	60.1%
	β-santalol	30.5%
	Total Santalol	90.6%
	Oil content	4.2%
Biratnagar	α- santalol	59.9%
	β-santalol	30.9%
	Total Santalol	90.8%
	Oil content	4.1%
Bagaldhara	α- santalol	59.40%
	β-santalol	30.25%
	Total Santalol	89.65%
	Oil content	4.0%

Table 9: Quality Assessment (oil content) of sandalwood

Acknowledgements

- The speaker acknowledges his heartiest and sincere thanks to respected Supervisors, Prof. Subrata Mukhopadhyay and Prof. Jagatpati Tah for their guidance of this PhD work.
- The deeply acknowledges with thanks to HOD and all respected Faculty members, Department of Life Sc. and Biotechnology, JU for generous help and enormous co-operaton for carrying out this PhD work in this department.
- The speaker extends his sincere gratitude and thanks to the Vice-chancellor, JU for proving me a scope to join as Foreign Research Fellow.
- The speaker extends his heartiest sincere thanks to Dr. Atish Kumar Chattopadhyay, Principal Secretary, F. Sc. and all administrative staff members for their necessary support.
- The speaker deeply acknowledges with thanks to (i). Brindavan Plant research center, Hetauda, (ii) Gyan Udhyan, KLD Group, Biratnagar and (iii) Swastik oil industries, Sunsari, Nepal for their assistance and enormous cooperation for carrying out our research investigation under their institutional premises.

Seminar/Conference Attended

i. 7 months project on ("In-silico Studies on DNA-Drug Interaction") at Molecular Biophysics Unit, Indian Institute of Science (IISC), Bangalore from December 2012 to June 2013.

ii. Participant, "International Conference on Biomolecular forms and functions", IISC, Bangalore, 8-11 January 2013. A Celebration of 50 years of the Ramachandran Map. REG ID; 894.

iii. Participant, 7th National Conference on Science and Technology held at Hotel Yak and Yeti, Kathmandu, Organized by Nepal Academy of Science and Technology (NAST) from March 29-31, 2016.

iv. Participant, 5th International Conference at Jadavpur University, Calcutta, India.

v. Invited speaker on "Germination behavior of Sandal wood seed and effect of GA_3 chemical on it in Nepal" at 6th international conference of world science congress held at PGIMER, RML Hospital, and New Delhi during 23rd to 25th December 2016.

vi. Participant, International Conference on Wild Harvests, Governance and Livelihoods in Asia held at Hotel Annapurna, Kathmandu, Nepal from Nov. 30 to Dec. 02, 2017. vii. Invited Speaker at 54th International Convention of Chemists held at UkaTarsadia University, Surat, and Gujarat from 23-25 December 2017.

vii. Chaired a session at 'National Seminar on reaching the unreached through Science and Technology' organized by The Indian Science Congress Association-Patna Chapter from Nov. 18 to Nov. 19 2017.

viii. Delegate, 3rd International Conference "Is Science able to explain the Scientist?" – 2015, Kathmandu, organized by Tribhuvan University.

ix. Invited speaker, 8th National Science Conference held at Jadavpur University from 28th to 29th February, 2016.

x. Member, International organizing Committee, "International Symposium on Recent Advances on Molecules and materials (RA2M - 2018) held at Haldia Institute of Technology, Haldia, and West Bengal during on 2nd – 3rd August, 2018.

xi. Keynote speaker, International Conference on Green Engineering and sustainable development at Mugberia Gangadhar Mahavidyalaya, Bhupatinagar, and West Bengal on 20-21st August, 2018. xiii. Invited Speaker, International Conference on Chemical Sciences in New Era (ICCSNE - 2018), held at PAHER University, Udaipur, India during during 5th – 6th October, 2018.

xii. Invited Lecture – 8 : (AEC-IL(08)) on " Application of chemistry for Isolation and purification of DNA from various sources" at 55th Annual convention of chemists (RACS2A-2018) held at G.B. college, Naughachia, Bihar from Dec 28 to 30, 2018.

xiii. Chairperson, Oral papers: AEC (0P). Analytical and Environmental Chemistry section, International seminar on "Recent Advances on Chemical Sciences and Allied Areas (RACS2A-2018)" held at G.B. College, Bhagalpur from 28 to 30 Dec 2018.

xiv. Invited talk on Effect of Soil Nutrients on the Growth and Survivability of White sandal (Santalum album L.) in South West Bengal at International Conference on 'Next Generation Pteridology : The Indian Perspective' held at at Burdwan, India during 8 – 10th March, 2019.

xv. Chairperson, Invited lecture at International Conference on 'Next Generation Pteridology: The Indian Perspective' held at Burdwan, India during from 8 – 10thMarch, 2019.

xvi. Guest of Honour, International Conference on Networks and Cryptology (NETCRYPT) held at Jawaharlal Nehru University, New Delhi during 14-16 June 2019.

References

1. Roshan Kumar Yadav, Subrata Mukhopadhyay and JagatpatiTah. (2018) Study of Edaphic factors of the location for the growth of white sandal (*Santalum album* L.) in Indo-Nepal border. Asian Journal of Applied Science and Technology (AJAST). 2(3) Pages 115 – 126.
2. Joyita Dutta, Angana Banerjee, Avijoy Mukherjee, Saheli Kulavi, Aparna Kalawate, Pijus Kanti Khatua, Anjan Mishra, Roshan Kumar Yadav, Gourisankar Roymahapatra. (2018) Effect of Biofertilizer on Garlic (*Allium sativum* L.) cultivation. International Journal of HIT Transaction on ECCN. Int.J.HIT.TRANSC:ECCN. Vol.4 (2A).
3. Roshan Kumar Yadav, Jagatpati Tah, Subrata Mukhopadhayay. Factors Associated for the growth and development of White Sandal (*SANTALUM ALBUM* L.) plants in Bankura and Burdawan forest divisions. Registration Id; IJRAR_ 206223. International Journal of Research and Analytical Reviews (IJRAR).
4. A Short Review on white sandalwood (*Santalum album* L.) – Roshan Kumar Yadav et al., IJSRR/ 84/84002, Vol. 8th, Issue 4th, October-December, 2019, International Journal of Scientific Research and Reviews (IJSRR).
5. Roshan Kumar Yadav etal.Comparative Study of Correlation Co-efficient of white sandal (*Santalum album* L.) from three Locations of Nepal. Internation Journal of Current Research (IJCR). ISSN-0975833X Quarterly.
6. Roshan Kumar Yadav, Subrata Mukhopadhyay and JagatpatiTah. (2018) Study of Edaphic factors of the location for the growth of white sandal (*Santalum album* L.) in Indo-Nepal border. Asian Journal of Applied Science and Technology.2 (3) 115-126.

7. Joyita Dutta, Angana Banerjee, Avijoy Mukherjee, Saheli Kulavi, Aparna Kalawate, Pijus Kanti Khatua, Anjan Mishra, Roshan Kumar Yadav, Gourisankar Roymahapatra. (2018) Effect of Biofertilizer on Garlic (*Allium sativum* L.) cultivation. International Journal of HIT Transaction on ECCN. Int.J.HIT.TRANSC:ECCN. Vol.4(2A).
8. Roshan Kumar Yadav, Jagatpati Tah, Subrata Mukhopadhayay. Factors Associated for the growth and development of White Sandal plants in Bankura and Burdawan forest divisions. International Journal of Research and Analytical Reviews.
9. Roshan Kumar Yadav et al. (2019) A Short Review on white sandalwood (*Santalum album* L.) Vol. 8(4). International Journal of Scientific Research and Reviews (IJSRR).
10. Roshan Kumar Yadav et al. Comparative Study of Correlation Co-efficient of white sandal (*Santalum album* L.) from three Locations of Nepal. Internation Journal of Current Research.
11. Roshan Kumar Yadav, Subrata Mukhopadhyay and JagatpatiTah. (2018) Study of Environmental factors of the location for the growth of white sandal (*Santalum album* L.) in Nepal forest gardens. Original contribution, Int.J.HIT.TRANSC:ECCN.4(1A) 30-39.
12. Sandalwood Seeds- Tapping the full potentials, Roshan Kumar Yadav, The Himalayan Times, August 2016
13. Invited for TV Programme on Scope and importance of Sandalwood in Nepal, Arniko Television, Nepal, 16th August, 2019.
14. Roshan Kumar Yadav, Subrata Mukhopadhyay and Jagatpati Tah. (2020) Gei Study On White Sandalwood (Santalum Album L) From The Nepal And India. International Journal of Current Advanced Research. 2319-6505