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RESEARCH ARTICLE

COMPARATIVE STUDY OF CORRELATION COEFFICIENTS OF WHITE SANDAL (*SANTALUM ALBUM* L.) FROM THREE LOCATIONS IN NEPAL

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ABSTRACT

White Sandal (*Santalum album* L), an indigenous best White sandal producing species, grown in Nepal in three different locations for exploring its edaphic factors as well as soil environmental factors through exercising different metrical characters. Indeed this *S. album* species is the most productive and high yielding species in regard to qualitative and quantitative aspects. It's a high adaptive plant species which grows in a broad range of environmental as well as metrological conditions. These saplings of the plant were procured from India for taking up a trial programme as a case study first in 2012. Observing the plant survibility in the garden in Nepal, after a year once again they took initiative to have mega project programme and planted white sandal in three gardens in three different locations considering five thousand plant population in each garden. Twenty soil samples were collected from each garden before planting saplings in the field. The main aims and objective of this experiment were to study the growth behavior and adaptive index in each location in Nepal.

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INTRODUCTION

White sandal *Santalum album* L. is a tropical hemi parasitic plant. White sandal wood plant (Santalum album L.) is widely distributed and very much economically important plant. It renders its service to the human society by providing precious timber and medicinal properties since human civilization all over the world. It has also been used in the pharmaceuticals as well as cosmetic industries since ancient era. The plant is very valuable for its essential oils and medicinal uses. In India *Santalum album L.* mainly grow in Maharashtra, Karnataka, Andhra Pradesh, Kerala etc. According to Das and Tah, (2013) a small population of white sandal also developed at Bankura & Burdwan and Midnapore District of West Bengal. Various host plants are needed for the establishment, proper growth and development of the sandal saplings. White sandal can make association with many angiosperms as its hot plant. In nature germination of white sandal seeds is 10 – 15% which is not adequate for mass propagation at a time in any agro-climatic zone.

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Recently we have undertaken the venture of artificial seed germination by applying different concentration of GA3 which has given us a positive indication to undertake the seed propagation program in this location. Ecologically sandal 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 Sandal 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). 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 45C0 and minimum temperature 7C0. 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. But very few records of growth and yield of white sandals grown in South West Bengal is 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. The collected were analysed for the study of correlation and coefficient for the comparative study over the locations.

MATERIALS AND METHODS

Materials

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 5^{th} 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 analysed it in the laboratory properly . All those data were calculated properly and tabulated it in table no. 1 and 2.

No.of Location	Name of the location
L-1	Hetauda
L-2	Biratnagar
L-3	Duhabi, sunsari

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

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 weigh balance before pouring it in the chemical treatments. Three types of seeds viz. (i) natural scarified (ii) non-scarified (iii) randomly selected seeds were considered for the experiment. These were treated in three treatments. Before going through treatments, three kinds of treatments were made viz i) control (Distilled water), ii) 500

ppm GA3 solution, iii) 700 ppm GA3 solution. Seed were treated with each treatment for about 72 hours. Seeds were pre-treated with HgCl2 (0.001%) for surface sterilization for 30 minutes. After 72 hours of soaking in chemical 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. Date viz.: (i) plant height, (ii) stem girth, (iii) branches/plant (no.), (iv) leaf length (cm) and (v) leaf breadth (cm) were considered or analyzing after five years of plant age. All these data calculated following bi-variate correlation regression as per Singh and Chaudhary (2005) for measuring the trend of correlation and its increments. Soil testing methods was followed by IARI soil testing kits for measuring N,P, K….. Mean data of five observations were considered in the correlation table for one average observation. Likewise 20 observations were noted in the coorelation table following the models of correlation coefficient(Pansa and sukhatme 2005) . We calculated the coorelation value(r) in each bivariate coorelation study in each location which have been cited in the table 1. All the soil components as measured in the laboratory have been cited in the table 2.

RESULTS AND DISCUSSION

Discussion correlation study: Three locations were allotted to study in this location.

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

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	

1 vs 2= plant height vs. stem girth (cm), 1 vs. 3= plant height vs. branch/plant (no), 1 vs. 4= plant height vs. leaf length (cm) and 1 vs. 5= plant height vs. leaf breadth (cm)

Table 2: Soil analyses of the soil samples taken from the field of White sandal (*Santalum album* L.) from three locations of Nepal

Componets	Location - 1	Location -2	Location- 3
Phosphorous	Very high	Very high	High
Potassium	High	High	High
Ammoniacal nitrogen	Low	Low	Very low
Carbon	Very high	Very high	High
pH	6.9	6.8	6.5

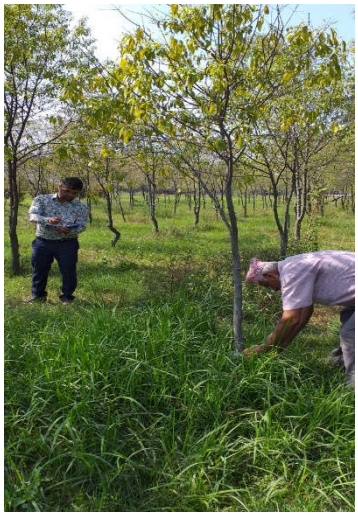

Photo-A:Taking data in the field

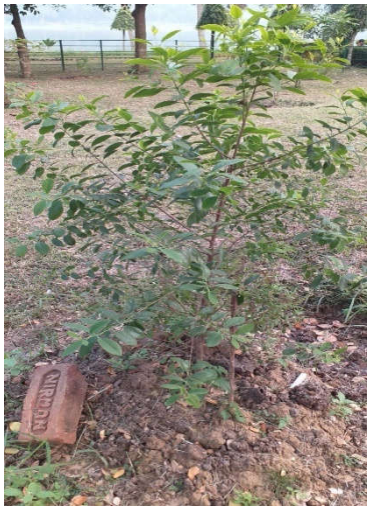

Photo – B: A 1 year plant (L-1, block – II)

Photo – C: Noting data in the field

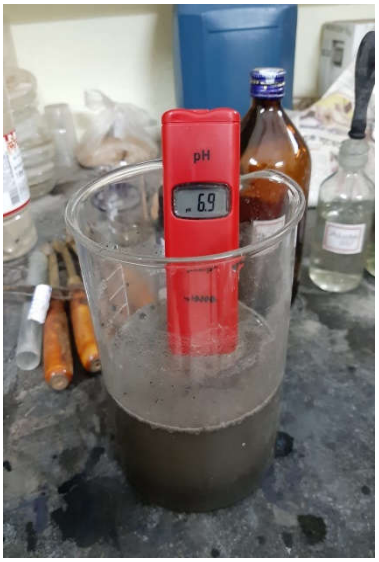

Photo – D: pH meter showing Ph

Photo – E: A 1 year plant (L-1, block – I)

Photo – G: A 1 year plant (L-1, block –III)

Photo H: A 7 years plant

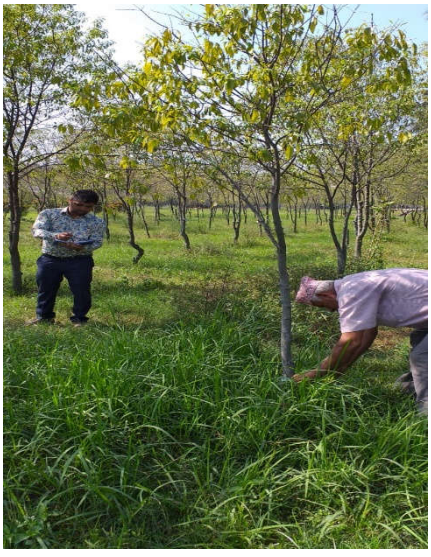

Photo – I: Taking data in the filed

Photo J: Taking data in the filed

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. 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 &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 [VOLUME 5 I ISSUE 4 I OCT.– DEC. 2018] E ISSN 2348 –1269, PRINT ISSN 2349-5138 652u IJRAR- International Journal of Research and Analytical Reviews Research Paper (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 & 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.

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.

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