ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 10, Issue, 12, pp.76264-76267, December, 2018
DOI: https://doi.org/10.24941/ijcr.33691.12.2018

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

EFFECT OF SOIL NUTRIENTS ON THE GROWTH AND SURVIVILITY OF WHITE SANDAL (*SANTALUM ALBUM* L) IN SOUTH WEST BENGAL

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ARTICLE INFO

Article History:
Received 26th September, 2018
Received in revised form
20th October, 2018
Accepted 29th November, 2018
Published online 31st December, 2018

Key Words:
Sandalwood, Regeneration,
Soil nutrients, Parasitic,
Agro-climatic.

ABSTRACT

Sandalwood (*Santalum album* L.) is a precious timber plant which has been serving the world's population since human civilization. It (*S. album* L.) grows in sandy alluvial or laterite soil having adequate edaphic as well as environmental factors. But it ensures its survivility when host plants are available in its surrounding root zone. It has also been found that host is no more required for its growth and development after 3-4 years. Demand for sandalwood and oil is increasing and the gap between demand and supply is widening. To bridge the gap, afforestation programme is aimed at for increasing the productivity. Considering all these facts a venture was undertaken to conduct an experiment for its mass cultivation in the forest gardens under Bankura(S) and Bankura(N) Forest Divisions in West Bengal. The aim and objective of the study is to observe the influence of soil nutrients of the locations on the growth and development of *Santalum album* L. in this tract.

Citation: Sudhir Chandra Das, Shreya Das and Jagatpati Tah. **2018.** "Effect of soil nutrients on the growth and survivility of white sandal (santalum album l) in south West Bengal", *International Journal of Current Research*, 10, (12), 76264-76267.

INTRODUCTION

White Sandal is the fragrant heartwood of some species of genus *Santalum*, belongs to family Santalaceae, includes 30 genera with about 400 species, many of which being completely or partially parasitic (John,1947). Brandis (1903) suggested that though sandal is a root parasite, it may derive part of its nutrition from the soil as well. It is a moderate sized evergreen large shrubs or small trees (*S. spicatum*) to tall trees of 12-15 m. in height. In India, *S. album* is mainly distributed in the Deccan Plateau. Ecologically Sandal has adapted various agro-climatic and soil conditions for *in situ* regeneration with an exception of waterlogged areas and very cold places. Indian Sandalwood species (*Santalum album* L.) is the best due to its higher oil (Santalol) content. 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 max. temperature 45^0C and min. temperature 7^0C. In sixties Sandalwood trees were 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.

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An attempt was taken in 2009-10 to study the growth and yield of sandalwood trees grown in Hirbundh Beat office compound of Khatra Range in Bankura (South) Division (Das, 2013). The soil in the sandal tract is black cotton except in the districts of Bidar and parts of Gulbarga and Bhir, where Deccan Trap being of metamorphic origin contains ferruginous loams commonly called lateritic soils (Khan, 1957). Sandal is found in almost every type of soil. It is found in stony red soil along the higher reaches of Moyar valley, on alluvial soil along Hallurhalla, on rich loams in Hulical, Kallar, Jacanare Reserve Forest and shallow gravelly soil on the Melur and Pillur slopes (Jayaraman, 1973). A study of the soils of sandal bearing areas of Karnataka, Tamil Nadu and Kerala for their morphology, physical and chemical properties was made by Rangaswamy, *et al.,*(1986a). In Wattle plantation of Teragalli and Londa of Khanapur range, where sandal occurs, the soil pH varied from 6.7 to 7.5 (Quireshi, 1955). The texture of soil in A, B and C horizons is sandy clay, clayey and gravelly loam respectively (Krishnamurthy *et al*., 1983). Sandal requires good drainage and does not withstand waterlogged ground. Best growth of tree is found on rich fairly moist soil such as garden loam and well drained deep alluvium on the river banks (Troup, 1921). A significant relationship between available nitrogen content in 'A' horizon and annual growth increment was observed in the soil of Talaalai 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. Analysis of soil and leaf samples from this has shown that sandal depends on its host for potassium, phosphorous and magnesium (Rangaswamy *et al*., 1986b). Sandal can draw other nutrients directly from soil as its roots have good cation exchange capacity (Parthasarathi *et al*., 1971). It is believed that the wood with finest odour is obtained from the driest region particularly on red or stony ground (Gunther, 1952) and that yield of oil will be much higher than those grown in fertile tracts (Bhatnagar, 1965). Ahir *et al* (2014) studied the effect of soil type on the growth of Indian Sandalwood (*Santalum album* L.) and observed that survival and overall growth of six month old seedlings for height, collar diameter and survival rate were similar in potting medium having red and yellow soil type. But no study record on influence of soil nutrients on the growth and survivility is found in reference to White Sandal growing tracts of West Bengal. The present venture is undertaken to study the effect of soil nutrients on the growth and survivility of White Sandal growing tracts of the State.

MATERIALS AND METHODS

Soil samples were collected from the white-sandal growing tracts of South West Bengal by removing the grasses from the surface. With the help spade, a V-shaped pit was dug upto 75cm depth and soil samples were collected taking entire profile upto 75cm depth. Soil samples were dried in shade and composite samples were prepared following standard method (quartering formula) for analysis. The procedure followed to analyse the soil samples are as follows:

Soil pH: The pH of the soil was determined with the help of a pH meter in 1: 2.5 (soil: water) suspension ratio as described by Jackson (1973).

Oxidizable Organic Carbon: Organic carbon was determined by oxidizing soil with 1 (N) potassium dicromate $K_2Cr_2O_7$ in presence of concentrated H_2SO_4 and back titrating the remaining $K_2Cr_2O_7$ with ferrous ammonium sulphate solution using diphenylamine indicator, following the wet digestion method of Walkley and Black as described by Jackson (1973).

Available nitrogen (N): The available nitrogen (N) of the soil was estimated through the hot alkaline potassium permanganate method as suggested by Subbiah and Asija (1956).

Available phosphorus (P): Available phosphorus (P) of soil is determined by using Olsen's method. In this method, the extractant is 0.5M $NaHCO_3$ solution adjusted to pH 8.5 with 10% NaOH as described by Jackson (1973).

Available potassium (K): Available potassium content of the soil was determined by flame photometer after extraction with neutral normal ammonium acetate solution as described by Jackson (1973).

Available Zinc (Zn), Copper (Cu), Manganese (Mn) & Iron (Fe): The method developed by Lindsay and Norvell (1978) using DTPA (Diethylene Triamine Penta Acetic Acid) extract for separating soils into deficient and non-deficient categories for Zn, Cu, Mn & Fe is useful and adopted in this Laboratory analysis.

Analysis for Available Molybdenum (Mo): Ammonium oxalate (pH 3.3) or Grigg's reagent is considered to be the best one for the determination of available Mo. Further, this extractant is easy to prepare, have sufficient buffering capacity to prevent any material change in the pH of the soil extract and forms stable complexes with Mo ($MoO_3 \cdot C_2H_2O_4$ and $(MoO_3)_2 \cdot C_2H_2O_4$) Molybdate absorbed on soil colloids and clay is presumably replaced by the oxalations. This exchange is made irreversible by the formation of strong Mo-oxalic acid complexes to make a single extraction effective.

Analysis for Available Boron (B): Out of several methods devised to assess the level of available B in soil, the hot water soluble B method of Berger and Troug (1939) has been most widely accepted. Recent description of this method includes some changes (Keren and Bingham 1985), but the basic procedure remains the same. Throughout boron analysis, use of borosilicate glassware should be avoided even for storage of chemicals. Plastic containers or corning Pyrex glassware should be used.

RESULTS AND DISCUSSIONS

Soil Parameters Study: Six (6) 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. The soil samples were analysed for pH, Organic Carbon, total nitrogen (N), available nitrogen (N), phosphorus (P) and potassium (K) are presented in Table-1. The result show that Bagaldhara soil has highest macro-nutrient content and lowest is Kamalpur soil. Micro-nutrient analysis was done for 4 soil samples, viz. Bagaldhara, Rangamati, Kamalpur and Hirbandh and their content ($mgkg^{-1}$ or ppm) is presented in Table-2. It is evident from the results that the micro-nutrient (Cu, Zn, Mn, Fe, Mo & B) content is lowest in Bagaldhara, Cu & Fe content is maximum in Rangamati, Zn 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 detection level (BDL). The growth data (both height and girth) of 6 plantations of 2011, 2012 and 2013 raised at Bagaldhara, Rangamati, Kamalpur in Bankura South Division and Beliatore in Bankura North Division are presented in Table-3. The plant height and basal girth was measured year-wise in each and every garden and compiled.

The results show that pH range of Sandal growing areas varies from 4.95 to 5.81. The growth of Sandal seedlings in Bagaldhara is better than other areas due to slightly higher pH of 5.81. The organic carbon% (OC%) varies from 0.34 to 0.57. The growth of seedlings is also better in Bagaldhara than other areas due to higher organic carbon content (0.57%). From the soil analyses report, it was remarkable that the differences of macro- and micro- soil nutrients were distinctly exhibited location-wise. In the contrary, it has proved the availability of organic compound in the soil in each garden. Those organic compounds were responsible for stimulating the sandal plant's growth and development. Total nitrogen (N) and available nitrogen (N) content of the 6 soil samples varies from 198.8 to 234.6 ppm (Kg/ha or ppm) and 90.36 to 106.63 ppm respectively. It is also reflected that higher the total N and available N content, better is the growth (both height and girth)

Table 1. Soil Test Reports of Macro-nutrients

Location	pH	OC (%)	Total N (ppm)	Available N (ppm)	Available K (ppm)	Available P (ppm)
Bagaldhara	5.81	0.57	234.6	106.63	57.6	8.2
Rangamati	5.70	0.47	221.3	100.59	51.8	7.6
Kamalpur	5.57	0.34	198.8	90.36	49.8	5.7
Beliatore	4.95	0.35	211.3	100.51	50.5	5.6
Hirbandh	5.76	0.54	217.7	98.95	54.7	7.8
Khandari	5.30	0.42	210.8	95.82	52.1	5.5

Table 2. Soil Test Report of Micro-nutrients

Sl.No	Test Parameters	Critical level of micronutrients (ppm)	Results in ppm			
			Hirbandh	Kamalpur	Rangamati	Bagaldhara
1	Copper (Cu)	0.2	0.67	1.08	1.38	0.50
2	Zinc (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	17.96	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 3. Growth data of Sandal saplings as on December'16

Location	Yr. of Plan-tation	No. of seedling planted	No. of seedling survived	Height (Cm)	Av. Height (Cm)	Basal Girth (Cm)	Av. Basal Girth (Cm)	Survival in 1st year
Bagaldhara	2011	100	85	310-520	409.72	12-32	20.5	85%
Bagaldhara	2012	200	166	250-490	348.56	10-34	18.9	83%
Rangamati	2011	100	73	250-460	302.36	9-26	15.6	73%
Kamalpur	2012	50	42	240-470	347.00	14-22	18.9	84%
Kamalpur	2013	100	78	100-300	211.87	5-17	10.8	78%
Beliatore	2013	100	80	100-290	208.7	5-16	8.6	80%

of white sandal seedlings in Bagaldhara soil which is 234.6 and 106.63ppm respectively. The range of available potassium (K) and phosphorus (P) in these tracts varies from 49.8 to 57.6 ppm and 5.5 to 8.2 ppm respectively. Available potassium (K) and phosphorus (P) plays important role in Bagaldhara plantations for enhancing the height and girth growth of sandal seedlings. All the micronutrients viz. copper (Cu), Zinc (Zn), Manganese (Mn), Iron (Fe), Boron (B) and Molybdenum (Mo) are lowest in Bagaldhara soil and highest in Rangamati soil (Table-2) which shows that micro-nutrients seems to have not much influence on the growth of sandal seedlings as compared to macro-nutrients and pH of the soil in addition to the host plant. Study conducted by Das & Tah (2016) revealed that combination of host plants, Arhar (*Cajanus cajan*) + Tulsi (*Ocimum sanctum)* is always found to be better than that of single host treatment.

The soils of Bagaldhara is porous and well drained which helps the seedlings for better root respiration and root-shoot growth in comparison to the soils of Rangamati which is hard specially when dry, slightly rocky, compact and full of laterites. Sandal requires good drainage and does not withstand waterlogging. Red ferruginous loam is the most common soil on which sandal tree occurs, the underlying rock often is metamorphic and is chiefly gneiss. It is not exacting as to the depth of the soil and is frequently found on rocky ground and on stony or gravelly soils [Troup, 1921]. Heartwood of sandal is the economically important product and is the source of oil. The sandalwood found in South West Bengal having heartwood contains α-santalol-59.40% and β-santalol-30.25%. Hence, total santalol content is 89.65% which is excellent in nature (Das & Das, 2015). The oil content of the heartwood is also estimated by the Authors and it is recorded as 4.0%. The quality of the heartwood of sandal of this region is one of the best. It is believed that the wood with finest odour is obtained from the driest region particularly on red or stony ground (Gunther,1952) and the yield of oil will be much higher than those grown in fertile tracts (Bhatnagar,1965) which co-relates the Author's above findings.

Conclusion

From the soil nutrients analysis report, it is found that the higher the organic carbon and macro-nutrients (N, P & K) content of the soil, the better is the growth (both height and girth) and survival of the sandalwood seedlings. Micro-nutrients seem to have not much influence on the growth of sandalwood seedlings in this experiment. There are a few rumors that sandalwood plants may grow in any soil environment prevailing in any climatic condition. If grows, those plants will not bear α- and β- santalol. Our laboratory tests have proved beyond doubt that the plants which are grown in these areas prevailing in all these edaphic factors contain adequate chemical properties (α-santalol : 59.25% and β-santalol : 30.40%) which is responsible for its fragrance.

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