IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Standardisation Of Edaphic Factors For Growth And Morphophysiological Activity Of *Santalum Album* L. In Rarh Bengal

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Abstract

Santalum album is a tree species that belongs to the family Santalaceae. It is a medium-sized hemiparasitic tree. Though the plant has a well-developed tap root system to draw nutrients from the soil, it requires a host plant for its growth and development. White sandalwood plants have the ability to naturally adapt wide range of edaphic factors as well as diverse agroclimatic conditions, with the exception of damp and extremely cold areas. Excess water in the soil or waterlogged areas are very much unfavourable for white sandalwood as excess water causes mechanical damage or decay of tap roots. *Santalum album* prefers slightly alkaline laterite soil to grow. Bankura, Purulia, Midnapore, Burdwan, Birbhum are the prime sites for mass cultivation of white sandalwood because the soil components of these locations meet all the essential mineral elements for perfect growth of the plant.

The aims and objectives of this study are to analyse the different edaphic factors, their quantity as well as their quantity in the soil, and to standardise their optimum quantity required by the Santalum album for its proper growth.

Key word: Hemiparasite, Agroclimate, Edaphic factors, Mass cultivation etc.

Introduction

The white sandalwood (Santalum album L) plant is a hemi parasitic, tropical vulnerable tree. Researchers such as Barber (1903), Rama Rao (1903), Rao (1942), and Scott (1871) demonstrated the existence of haustoria in sandal roots and the hemi-root parasite and parasitic nature of sandal. The growth and yield characteristics of haustoria-less sandal plants were examined by Nagaveni and Srimathi (1985). Barber (1906, 1903), and other contributors. Ecologically Sandal has adapted various agroclimatic as well as edaphic conditions except the water-logged soil areas that cause mechanical injury or decaying of the roots. Water logged areas need proper drainage to grow white sandalwood. Elevated lands are most favourable for mass cultivation of this economically important plant species.

Since ancient times, this plant has been utilized in a variety of wood, pharmaceutical, cosmetic, and fragrance industries. The presence of essential oils such as beta and alpha santalol makes the plant extremely valuable, significant, and expensive. Although there are a number of other components, such as santyl acetate and santalene, that are also present but not as important as alpha and beta santalol. *Santalum album*, sometimes referred to as tropical or Indian sandalwood, is the most valuable of the commercially utilised species because of its attractive odour and high heartwood oil concentration (6–10% by dry weight). The quality and quantity of the essential oils, as well as the wood characteristics, depend on the availability of the essential mineral elements.

Santalum album prefers slightly alkaline laterite soil to grow. Bankura, Purulia, Burdwan, Midnapore, Birbhum are the most appropriate sites for the proper growth and development of *Santalum album* as the soil is enriched with all the essential elements required by the plants. The pH range of the soil in which sandal grows is 6.7 to 7.5.

Materials and methods

A) Materials

1. Seeds of *Santalum album*

2. i) Chemicals: $HgCl_2$, Gibberelic acid (GA_3).

ii) Miscellaneous: Conical flasks, measuring cylinder, Petridishes, Beakers, Distilled Water, Blotting papers, Chemical weigh balance (digital), Compost manure, Hycopots, Digger, pen, Note book, computer, PH meter etc.

Method:

The sandal seeds were first dried by being exposed to the sun for two weeks. A weight scale was used to determine the desired amount of seeds for each location before the treatments were added. Three distinct treatments were developed: 500 ppm, 700 ppm, GA3 Solution and control (normal water). The seeds received each treatment for around 72 hours. The seeds' surface was first sterilised with HgCl2 (0.001%). After 72 hours, the seeds were removed from the treatments, their weight was measured again, and their surfaces were blotted. Seeds were then transported to the nursery field for planting. At the three to four-leaf stage, the growing seedlings were transferred into hycopots, and the germination statistics for each treatment were precisely recorded. The seedlings were then planted in the nursery gardens. Before plantation, soil samples from each study site were collected and examined properly using soil testing kits (Model A/O). After plantation metrical data of growth and development were recorded properly to standardise the optimum amount of various soil components.

i) Pretreatment through water soaking

The sandalwood seeds are soaked in water for 72 hours before sowing. The seeds are planted in a 6mm deep layer of sand. The germination process starts after 28 days. The germination rate between 61 and 100 days is only 25–35%.

ii) Pretreatment with Gibberellic Acid

The sandal seeds were treated for 72 hours in various concentrations of GA3 solutions (500 ppm, and 700 ppm) and controls after being suitably pre-treated with HgCl2 (0.001%). After that, the treated sandalwood seeds were sown in the sand bed. The sand beds received water twice daily in the morning and afternoon. The first seed germination started after 28 days and lasted for up to 90 days. The number of seeds that sprouted from each treatment is accurately counted and documented.

iii) Soil test methods:

Soil samples from different study sites were collected and their various edaphic factors especially soil pH i.e. acidity or alkalinity, nitrate nitrogen, ammoniacal nitrogen, available phosphate, available potassium, and organic carbon were estimated to standardize the optimum amount of the soil constituents for proper growth and development of white sandalwood seedlings. All the soil samples were tested using a soil testing kit (model: A/O). I have followed the detailed soil testing procedure step by step as described in the kit.

Determination of soil pH i.e. Acidity or Alkalinity
Procedure:

- Take clean test tube & pour distilled water up to 5ml. mark
- Put 2g. of soil into the test tube with the scoop provided.
- Add 0.5g. (1 spoonful) of barium sulphate from Container No. 3.
- Allow the test tube to stand for 20 minutes with occasional shaking.
- Add 5 drops of indicator No.1 from Container No. 1 to the above, close the mouth of the tube with a clean rubber stopper and shake the contents thoroughly. Allow the soil to settle down completely.
- Compare the colour of the upper liquid in the test tube with the Colour Chart No.1 and find out the nearest match which will indicate its pH.
- If the colour of the upper liquid in the test tube indicates pH near 6 then repeat the whole experiment using indicator No. 2 instead of indicator No. 1 and match the colour of the upper liquid with the Chart No.2.

Estimation of nitrogen
Procedure:

- Take a clean test tube & fill it with distilled water up to 10 ml. mark
- Add to above 2g. Of soil sample with the scoop provided and close the test tube with a clean stopper.
- Shake thoroughly for 5 minutes and filter.

For Nitrate Nitrogen

- Transfer 1 drop of the filtrate to a clean 2” test tube and carefully add 8 drops Of Solution from Container No.13.Compare the c colour with the colour Chart No. 5

For Ammoniacal Nitrogen

- Transfer 4 drops of filtrate from step 3 to another clean 2” test tube and add 1 drop of solution from Container No.14.Compare the colour with the Colour Chart No. 6.

Estimation of available phosphate
(Olsen's method)
Procedure

- Take a clean test tube.
- Pour solution from Container No. 4 in the test tube up to 10ml. mark.
- Add a pinch of Darco from Container No. 5 to the above test tube.
- Add to above, 5g. Of soil with the scoop provided.
- Close the tube with a clean rubber stopper. Shake the contents thoroughly for 3 minutes and filter the solution.
- Take the filtered solution up to 2 ml. mark in another test tube.
- Pour 2ml. of solution from container No. 6 in the above test tube containing filtered solution.
- Wash the inner side of the test tube with about 2ml of distilled water from the wash bottle. Keep it, this will be required at step No. 11.
- Take 66 ml. of distilled water in a 100ml. beaker.
- Add to the beaker containing water 0.5ml. of the solution from Container No. 7.
- Take 1ml. of this solution from the beaker and add it to the solution at step No. 8.
- Shake the contents thoroughly after closing the tube with a stopper.
- Add distilled water up to 10ml. mark in the above test tube.
- Compare the colour of the solution with colour Chart No. 3.

Note: Solution in container No. 7 (Stannous Chloride) Oxidizes or deteriorates if kept for more than three months. So, it should be reduced before use at step 10. 2pcs. of Zinc granule from Container No. 9 and 2 or 3 drops of Hydrochloric Acid from container No. 8 may be used for reducing the 0.5ml. solution in a separate test tube before it is put to use at step 10.

Estimation of available potassium
Procedure

- Take a clean test tube.
- Pour in it solution from Container No. 10 up to 10ml. mark.
- Add 5g. Of soil with the scoop provided to the above solution.
- Shake the solution for one minute after closing the tube with a rubber stopper and then filter. Keep the filtrate for use at step 8.
- Take another clean test tube.
- Pour solution from Container No. 11 up to 2ml. mark.
- Add 6 drops of solution from container No. 12 to the above without touching the side of the test tube.
- Take 2 ml. of the solution from step 4 in a syringe.
- Inject the solution from the syringe with force into the other solution at step 7.
- Turbidity will develop in the solution after five minutes.
- Compare the turbidity with the Colour Chart No. 4.

Note: The heavy black lines should be observed through the solution and not the Colour. The temperature should be maintained below 20°C throughout the experiment. For this purpose, the solution should be cooled in an ice bath or pitcher water.

Estimation of available organic carbon

Procedure

- Take a clean test tube & fill it with distilled water up to 10 ml. Mark.
- Add to it 2g. Of soil sample with the scoop provided and close the test tube with a clean stopper.
- Shake the above thoroughly for 5 minutes and quickly take out 0.5ml. of clay-suspended liquid with a clean graduated dropper.
- Transfer the liquid from the dropper to a clean test tube and add 1ml. of solution from container No. 15 and 2ml. of solution from Container No. 16 while swirling the test tube.
- Keep the test tube for half an hour. Compare the colour with the Colour Chart No.7.

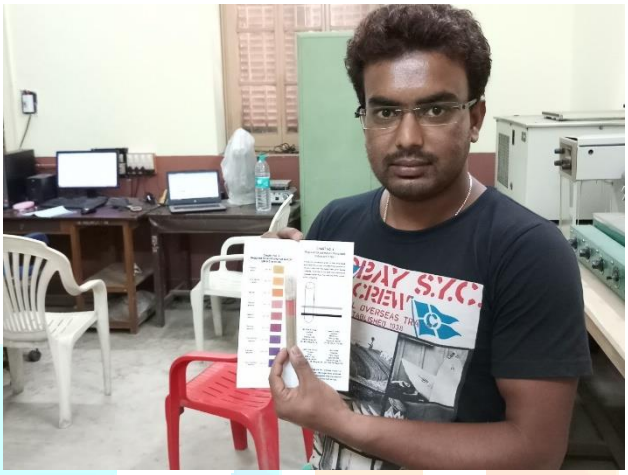

Fig 1: Testing of soil sample at laboratory

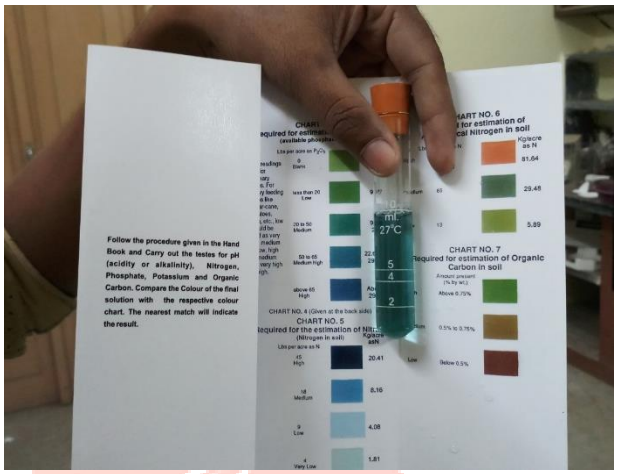

Fig 2: Testing of soil sample at laboratory.

Results and analysis

Table 1: Components of soil collected from Bankura_Bagaldhara

Location : Bankura_Bagaldhara		
Estimated objectives	**result**	**Remarks**
P^H	7.5	Slightly alkaline
Carbon	Below 0.5%	Low
Nitrogen (Nitrate)	18Lbs/acre as N or 8.16 kg/ acre	Medium
Nitrogen (Amonical nitrogen)	13Lbs per acre as N or 5.89 kg/acre as N	Low
Phosphorus	20 to 50Lbs per acre as P_2O_5 or 9.07 to 22.68 kg/acre	Medium
Potassium	100 to 250Lbs/acre as (K) or 45.36 to 113.40 kg/acre	Last 2 lines visible, Medium

Table 2: Components of soil collected from Ausgram, Burdwan

Location : Ausgram, Burdwan		
Estimated objectives	**result**	**Remarks**
P^H	7.2	Slightly alkaline
Carbon	0.5% to 0.75% by wt.	Medium
Nitrogen (Nitrate)	18Lbs/acre as N or 8.16 kg/ acre	Medium
Nitrogen (Amonical nitrogen)	13Lbs per acre as N or 5.89 kg/acre as N	Low
Phosphorus	0Lbs per acre as P_2O_5 or 0 kg/acre	Blank
Potassium	100 to 250Lbs/acre as (K) or 45.36 to 113.40 kg/acre	Last 2 lines visible, Medium

Table 3: Components of soil collected from Khandari, Panagarh range

Location : soil test – Khandari, Panagarh range		
Estimated objectives	**results**	**Remarks**
P^H	6.0	Slightly acidic
Carbon	Below 0.5%	Low
Nitrogen (Nitrate)	45Lbs/acre as N or 20.41 kg/ acre	High
Nitrogen (Amonical nitrogen)	180Lbs per acre as N or 81.64 kg/acre as N	High
Phosphorus	0Lbs per acre as P_2O_5 or 0 kg/acre	Blank
Potassium	Below 100Lbs/acre as (K) or 45.36 kg/acre	All 3 lines are visible, Low

Table 4: Components of soil collected from Krishnasayar Udyan

Location : Krishnasayar Uddyan		
Estimated objectives	**result**	**Remarks**
P^H	6.0	Slightly acidic
Carbon	Below 0.5%	Low
Nitrogen (Nitrate)	45Lbs/acre as N or 20.41 kg/ acre	High
Nitrogen (Amonical nitrogen)	13Lbs. per acre as N or 5.89 kg/acre as N	Low
Phosphorus	0Lbs per acre as P_2O_5 or 0 kg/acre	Blank
Potassium	Above 350Lbs/acre as (K) or 158.76 kg/acre	No lines visible, very high

Table 5: Components of soil collected from Behind Aduria Beat Compound Mouza - Punrijhurgh

Estimated objectives	Sample A (Behind Aduria Beat Compound Mouza - Punrijhurgh)	
	result	Remarks
P^H	6.0	Slightly acidic
Carbon	Below 0.5%	Low
Nitrogen (Nitrate)	9Lbs/acre as N or 4.08 kg/ acre	Low
Nitrogen (Amonical nitrogen)	13Lbs. per acre as N or 5.89 kg/acre as N	Low
Phosphorus	0Lbs. per acre as P_2O_5 or 0 kg/acre	Blank
Potassium	100 to 250 Lbs./acre as (K) or 45.36 to 113.40 kg/acre	Last 2 lines are visible, Medium

Table 6: Components of soil collected from Midnapore_Arabari range

Estimated objectives	Midnapore_Arabari range	
	result	Remarks
P^H	6.5	Very Slightly acidic
Carbon	Medium 0.5% to 0.75	Low
Nitrogen (Nitrate)	45Lbs/acre as N or 20.41 kg/ acre	High
Nitrogen (Amonical nitrogen)	13Lbs. per acre as N or 5.89 kg/acre as N	Low
Phosphorus	20 to 50Lbs. per acre as P_2O_5 or 9.07 to 22.68 kg/acre	Medium
Potassium	Below 100Lbs./acre as (K) or 45.36 kg/acre	All 3 lines are visible, Low

Table 7: Components of soil collected from Purulia_Balarampur

Location : Purulia_Balarampur		
Estimated objectives	**Result**	**Remarks**
P^H	7.0	Neutral
Carbon	Below 0.5%	Low
Nitrogen (Nitrate)	45Lbs/acre as N or 20.41 kg/ acre	High
Nitrogen (Amonical nitrogen)	13Lbs. per acre as N or 5.89 kg/acre as N	Low
Phosphorus	65Lbs. per acre as P_2O_5 or 29.48 kg/acre	High

Potassium	Above 350Lbs/acre (as K) or 158.76 Kg/acre	No lines visible, very high

Table 8: Components of soil collected from Birbhum_Tasarkata

Location : Birbhum_Tasarkata		
Estimated objectives	**result**	**Remarks**
P^H	7.5	Slightly alkaline
Carbon	Below 0.5%	Low
Nitrogen (Nitrate)	45Lbs/acre as N or 20.41 kg/ acre	High
Nitrogen (Amonical nitrogen)	13Lbs. per acre as N or 5.89 kg/acre as N	Low
Phosphorus	20 to 50Lbs per acre as P_2O_5 or 9.07 to 22.68 kg/acre	Medium
Potassium	100 to 250Lbs/acre as (K) or 45.36 to 113.40 kg/acre	Last 2 lines visible, Medium

Discussion

From the study of analysis of edaphic factors, it is found that *Santalum album* prefers slightly alkaline laterite soil to grow. Bankura, Midnapore, Birbhum are the prime sites for the proper growth and development of *Santalum album* as the soil meets all the essential components for their growth. It is also found that *Santalum album* grow vigorously beneath the tree canopy that means they also prefer shade instead of direct sunlight along with laterite soil.

Puran Singh (1911) discovered the variance in the oil content of plants growing in various soil types and locales. It is thought that the driest area yields the wood with the best aroma, especially on stony or red soil [Gunther, 1952], and that the oil output will be significantly larger than that of wood cultivated in fertile areas [Bhatnagar, 1965]. Due to its roots' high ability for cation exchange, sandals can directly absorb additional nutrients from the soil [Parthasarathi et al., 1971]. In a field investigation of Ananthapadmanabha et al. (1984), it is found that a host is necessary for the proper growth of sandal. Additional examination of soil and leaf samples [Rangaswamy et al., 1986b] has shown that Sandalwood depends on its host for magnesium, phosphorus, and potassium.

The most prevalent underlying rock in the upper hills, according to Sothers (1928) in the working Plan for the sandalwoods of the Khanapur, Nagargali, and Gijnal Ranges, is laterite, with schists and trap rock to the northwest and an outcrop of crystalline limestone to the southwest, respectively.

Rangaswamy et al. conducted a study on the morphology, physical characteristics, and chemical composition of the soils in districts of Karnataka, Tamil Nadu, and Kerala that are known for producing sandals (1986a). The pH of the soil where sandal grows ranged from 6.7 to 7.5 in the Wattle plantations of Teragalli and Londa in the Khanapur range, [Quireshi, 1955]. According to Krishnamurthy et al. (1983), the soil in the A, B, and C strata has a sandy clay, clayey, and gravelly loam texture, respectively.

Sandals cannot withstand water-logged ground and need proper drainage. Rich, somewhat damp soils like garden loam and well-drained deep alluvium along riverbanks are ideal for tree growth [Troup, 1921]. In the Talaalai range's soil, a strong correlation was found between the amount of accessible nitrogen in the "A" horizon and the increase in yearly growth [Karthinurthy et al., 1983]. According to Jain et al.'s (1988) study on the characteristics of the soil and how they relate to sandal growth in three different regions, the following factors positively affect the increase in girth and height: available

potash, exchangeable calcium and magnesium, pore space, lime status, and volume expansion upon wetting.

According to Lahiri (2010), sandal can thrive in areas of laterite tract that are abandoned in woodland and agricultural soil which is quite poor, but it cannot tolerate waterlogging. It can also be grown on farms or homestead territory. Thus, the introduction of sandalwood in the region (laterite tract of South West Bengal) needs to be carefully considered.

Conclusion

After testing several soil samples collected from different study site it is revealed that the -

Optimum amount of nitrogen (nitrate) requires for proper growth of white sandal wood is 45lbs/acre as N or 20.41kg/ acre.

Optimum amount of amonical nitrogen requires for proper growth of white sandal wood is 13 Lbs per acre as N or 5.89 kg/acre as N.

Optimum amount of Carbon requires for proper growth of white sandal wood is Below 0.5%

Optimum amount of Phosphorus requires for proper growth of white sandal wood is 20 to 50 Lbs per acre as P2O5 or 9.07 to 22.68kg/acre.

Optimum amount of Potassium requires for proper growth of white sandal wood is 100 to 250 lbs/acre as (K) or 45.36 to 113.40kg/acre.

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