The Pharma Innovation Journal 2023; 12(5): 2137-2139

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(5): 2137-2139

www.thepharmajournal.com
Received: 28-03-2023
Accepted: 30-04-2023

Venkatesh L
Department of Silviculture and Agroforestry, College of Forestry, Sirsi UAS, Dharwad, Karnataka, India

Channabasappa KS
Department of Silviculture and Agroforestry, College of Forestry, Sirsi UAS, Dharwad, Karnataka, India

Manjunath GO
Department of Silviculture and Agroforestry, College of Forestry, Sirsi UAS, Dharwad, Karnataka, India

Corresponding Author:
Venkatesh L
Department of Silviculture and Agroforestry, College of Forestry, Sirsi UAS, Dharwad, Karnataka, India

Performance of host trees on heartwood and oil content on seven year old sandalwood plantations in Uttara Kannada district

Venkatesh L, Channabasappa KS and Manjunath GO

Abstract
A study was conducted during the year 2018-2021 at College of Forestry, Sirsi for studied on sandalwood tree (*Santalum album*. L.) based Agroforestry systems in Karnataka. The important objectives of this study was screening of secondary host plants on heartwood and oil content of sandalwood tree in different agroforestry systems of Karnataka in Uttara Kannada district, the results revealed that 20.85 percent increment was recorded in clear bole height of sandalwood tree with *Sesbania grandiflora* followed by 20.43 percent in *Casuarina equisetifolia* as host plant of sandalwood tree at 7 year old plantations of Uttara Kannada district. The volume of main stem of sandaqlwood tree was increased 47.82 percent with a secondary host of *Sesbania grandiflora* followed by 36.39 percent in *Casuarina equisetifolia* Among the different identified secondary host plants, the percent increment in heartwood content was increased by 58.49 percent with *Casuarina equisetifolia* and 41.75 increased with *Areca catechu* and 60.00 percent increased in oil content of sandalwood as influenced by *Casuarina equisetifolia* followed by 39.68 percent increment was recorded with *Sesbania grandiflora*.

Keywords: Indian mustard, path coefficient analysis

Introduction
Indian Sandalwood tree (*Santalum album* L.) one of the world's most valuable commercial timbers and is currently valued globally for its heartwood and oil. The tree being used by humans from time immemorial and it is one of the first items traded with other countries from India (Rai and Sarma, 1990) [7]. It is popularly known as "Dollar earning parasite" (Krishnappa, 1972; Durairaj and Kamraj, 2013) [5, 2]. It is native to the peninsular region of Indian sub-continent, distributed almost in all the states of India covering a total area of 9040 sq. km and more than 90 percent lies in Karnataka and Tamil Nadu (Dutt and Verma, 2005) [3] hence called "East Indian Sandal wood" (Gairola *et al.*, 2008) [4]. It is an evergreen tree species found usually in the dry deciduous forests. An average tree can reach a height upto 20 m and girth of upto 2.5 m. The species can thrive upto an altitude of 5000 m from the sea level and in diverse agroclimatic conditions (Annapurna *et al.*, 2006) [1]. Commonly, the tree grows well in deep red soil however, found in varied range of soil types, in varied rainfall ranging 500 – 3000 mm and temperature between 0 °C-38 °C. The plant needs partial shade in the initial stages followed by full sunlight and small quantity of water for growing. Sandal matures and bears fruits after seven years and important tree trunk (heartwood) is noticed after 10 years of development (Pullaiah and Swamy, 2021) [6].

Sandalwood tree is intimately associated with human civilization since time immemorial and is a part of Indian culture and heritage (Srinivasan *et al.*, 1992) [10]. *Santalum album* is designated as the 'state tree of Karnataka'. Mysuru is praised as a sandalwood shrine (Gandhada Gudi), while Karnataka is known as the state of sandalwood. The majority of religions, especially Hinduism and Buddhism worship Indian sandalwood. The sole largest market category for Indian sandalwood is comprised of goods and uses intended for ceremonial, ritual and religious functions. Every facet of human life involves the usage of sandalwood, particularly in Indian culture and civilizations where it is necessary from birth to cremation. These days sandalwood is used for different purposes in different parts of the world. In Europe and North American markets, the essential oil from wood is consumed as fine perfumes, body care products and in pharmaceutical preparation. Similarly, in China, Japan and Republic of Korea sandal is used for solid furniture, carvings, traditional medicines and religious uses; for attars funeral pyres and chewing tobaccos in India; and for customary

uses in the Middle East

Materials and Methods

Survey was undertaken in different locations in Uttara Kannada district. The basic information was collected with help of questionnaires. In each location/AF systems five trees were selected randomly for estimation of heartwood and oil content.

Observation were recorded during the survey

- Name of the location
- Age of the tree (years)
- Name of the secondary host introduced
- Method of planting
- Spacing adopted (m)
- Growth parameters
- Percent heartwood formation
- Percent oil content

Site characteristics: Location, latitude, Altitude (m) longitude, Rainfall (mm), Temp. soil type

- Canopy volume

Canopy volume was estimated using the following formula (Thorne *et al.*, 2002) [11].

$$V = \frac{2}{3}\pi h\left(\frac{a}{2} X \frac{b}{2}\right)$$

Where, h is the height of the canopy; a and b are spread of mid canopy at perpendicular axes.

Volume of the main stem

The main stem volume indicates the dry matter accumulation in the sandalwood tree and marketable yield. It was calculated considering the main stem as cylinder using the formula as a non-destructive observation.

$V = \pi r^2 h$

Where h is clear bole height and r is radius derived from tree girth

Estimation of Heart wood formation and oil content in *Santalum album* wood

To estimate heartwood percent and oil yield for all the identified locations of selected district. Data from three replicates/ sample trees in each girth class was recorded. Girth at breast height (GBH) and height of the trees were recorded. The core sample from each tree was extracted using a Haglof increment borer. The core sample was extracted by using the bark, sapwood, transition region and heartwood percentage. The heartwood portion of the core sample used for oil content estimation and the collected core samples was collected at breast height level and its wrapped with blotting paper and kept in a desiccators.

From the core samples, bark thickness, sapwood radius, transition region and heartwood radius was estimated (by converting tree girth to tree diameter) accordingly percentage of heartwood has been calculated. Sandalwood oil was being estimated from the core samples using the method developed by Shankaranarayana *et al*. (1997) [8]. This non- destructive method has been found to be very convenient for quick screening of plants for their oil content from the standing trees. The heartwood portion was then cut into fine pieces using a blade. 100 mg of the sample was weighed on a weighing balance and then 100 ml of hexane (60-700 boiling points) was added to the 100 ml standard flask. The samples were kept aside for 18 hours with periodic shaking. The supernatant was taken in quartz cell and optical density at 219 nm (maximum) was measured by UV Spectrophotometer (Shimadzu-240). The mean values are worked out and the data expressed as mean ± SE. Statistical significance was determined using student t-test in Microsoft Excel 2010 at 95 percent probability level ($p<0.05$)

Results and Discussion

Influence of secondary host trees on growth, heartwood initiation and oil content of seven years old sandalwood tree in Uttara Kannada district. The influence of secondary host on sandal wood clear bole height showed significant (Table 4 and Fig. 9 depicted that) difference. The significantly higher sandalwood clear bole height was recorded with *Sesbania grandiflora* (1.87 m) followed by *Casuarina equisetifolia* (1.86 m), *Calliandra haematocephala* (1.84 m), *Emblica officinalis* (1.76 m), *Melia dubia* (1.71 m) *and Manilkara zapota* (1.66 m). The lowest sandal clear bole height was observed in *Mangifera indica* (1.48 m) on par with *Areca catechu* (1.50), *Annona squamosa* (1.50 m) and *Psidium guajava* (1.63 m).

Tree girth under different secondary host showed significant difference. The significantly higher tree girth was observed with *Sesbania grandiflora* (22.58 cm) on par with the host *Psidium guajava* (21.26 cm) and lowest tree girth was observed under the host *Melia dubia* (18.16 cm) and which was on par with the host of *Calliandra haematocephala* (19.16 cm) and *Manilkara zapota* (19.00 cm). The field hosts significantly influence the economic growth components of sandalwood tree *i.e.,* clear bole height and girth. Significantly higher volume of main stem was recorded with *Sesbania grandiflora* (7.57 dm^3). The least volume of main stem was observed under *Mangifera indica* (3.95 dm^3) and on par with the *Melia dubia* (4.51dm^3) as a secondary host under field condition.

Heart wood content under different secondary host was recorded significant difference. The significantly higher heartwood content was observed with *Casuarina equisetifolia* (15.66dm^3) and the lowest heart wood content recorded under *Annona squamosa* (6.50 dm^3) and *Sesbania grandiflora* (6.50 dm^3) on par with the host species of *Psidium guajava* (9.60 dm^3) *Melia dubia* (7.00 dm^3) *Mangifera indica* (8.21 dm^3) *Manilkara zapota* (9.33dm^3) and *Emblica officinalis* (8.00dm^3) at seven year old tree of sandalwood.

The significantly higher oil content was observed with *Casuarina equisetifolia* (0.95%) and lowest oil content was observed under the field host of *Calliandra haematocephala* (0.37%) on par with *Psidium guajava* (0.46%), Annona *squamosa* (0.55%), *Melia dubia* (0.45%), *Sesbania grandiflora* (0.63%), *Areca catechu* (0.61%), *Mangifera indica* (0.58%), *Manilkara zapota* (0.61%) and *Emblica officinalis* (0.37%).

The secondary host plants influences the net photosynthetic rate, stomatal conductance and transpiration rate and apart from structure and efficiency of haustoria of sandalwood (Ouyang *et al.*, 2016) [12] Various secondary hosts' plants influenced sandalwood tree growth differently with respect to

varied climatic conditions. Among various secondary sandal host, *Punica granatum, Sesbania grandiflora, Emblica officinalis, Casuarina equisetifolia, Murraya koenigii, Acacia nilotica, Melia dubia* contributed higher growth and improving of clear bole height and tree girth in sandalwood. The similar study was conducted by Bilas *et al.* (2018) [13] and reported that *Citrus aurantium, Casuarina equisetifolia, Punica granatum* showed the greater height, girth, crown size and clear bole length of *S. album* trees. Similarly Srikantaprasad *et al.*, (2022) [9] reported that secondary host exhibited better growth in terms of tree height, canopy spread, canopy volume, stem girth and volume in sandal cultivation in farmers field of northern dry zone of Karnataka.

Table 1: Influence of host trees on growth, heart wood initiation and oil content on seven year old sandalwood trees at Uttara Kannada district

Sl. No.	Secondary host trees	Sandal clear bole height (m)	Tree girth (cm)	Volume of main stem (dm^3)	Heart wood content (%)	Oil content (%)
1	*Psidium guajava*	1.63	21.26	5.85	9.66	0.46
2	*Annona squamosa*	1.50	20.33	4.94	6.50	0.55
3	*Melia dubia*	1.71	18.16	4.51	7.00	0.45
4	*Sesbania grandiflora*	1.87	22.58	7.57	6.50	0.63
5	*Areca catechu*	1.50	20.70	5.10	11.16	0.61
6	*Calliandra haematocephala*	1.84	19.16	5.37	7.16	0.37
7	*Casuarina equisetifolia*	1.86	20.50	6.21	15.66	0.95
8	*Mangifera indica*	1.48	18.26	3.95	8.21	0.58
9	*Manilkara zapota*	1.66	19.00	4.78	9.33	0.61
10	*Emblica officinalis*	1.76	20.75	6.05	8.00	0.38
	S.Em ±	0.068	0.57	0.26	1.09	0.10
	C D @ 5%	0.203	1.72	0.80	3.28	0.30

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