World Journal of Engineering Research and Technology
WJERT
www.wjert.org
SJIF Impact Factor: 5.218

A FIELD STUDY ON GROWTH PERFORMANCE OF *SANTALUM ALBUM* PROPAGATED BY FRUGIVORES

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Article Received on 14/01/2019 **Article Revised on 04/02/2019** **Article Accepted on 25/02/2019**

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ABSTRACT

A core research team headed by Forest Ranger (Research) has taken up a field study, on well grown Sandal trees propagated by means of birds with its associated host tree species are found in periphery region of experimental plots of State Forest Research Institute at Kattankulathur Research Center, Tamil Nadu. Growth performance of sandal was found to be better with host trees *Eucalyptus tereticornis* and *Pterocarpus santalinus.* Seed dispersed avian frugivores were enlisted. Haustorial connections of the roots of Sandal with chosen host tree species were also documented. As the study area is under tight protection well grown sandal trees in the dense bushes were enumerated. It reveals that *E. tereticornis* has enhanced the growth of Sandal followed by *P. santalinus* than the other host tree species. Enlisted avian frugivores are considered as the most important seed dispersers in the protected study area.

KEYWORDS: Frugivores; *S. album*; *E. tereticornis*; *P. santalinus.*

INTRODUCTION

Santalum album, Indian sandalwood is a small steamy tree, the major source of sandalwood. It usually grows from coastal dry forests up to 700 meter height and in dirty or stony red soils and occurs in wide range of soil types, temperature range from 0 to 38°C, 500 and 3000 mm annual rainfall. It is capable of growing in combination with horticultural species as host plant species using haustorial connections.

In India, sandalwood is mainly distributed on the Deccan Plateau with an extent around 9000 km^2 of which 8200 km^2 has been covering the states of Karnataka and Tamil Nadu. In ancient time, sandal naturally found in peninsular India, but subsequently it was introduced in other parts too. It commonly grows in the dry deciduous forests of Deccan Plateau at the edge of the Western Ghat Range. *Santalum album* L. is intimately associated with Indian culture and heritage and is acclaimed as the most precious and valuable among Indian forest trees. Sandalwood trees are the source of highly priced and fragrant heartwood, the 'East Indian Sandalwood' which on steam distillation yields on an average 57% oil (Mc Kinnell, 1990) of high perfumery value.

Sandalwood, being a hemi root parasitic tree, root connection with a host species is required for nutrition to young plants as well as to the adult trees (Rao, 1942; Fox et al., 1994a; Fox et al., 1994b). Additionally, host plants can also provide shade required for the healthy growth of seedlings.

Natural regeneration of *S. album* occurs by means frugivores in dissemination of sandal seed. *S. album* access their host resources through a key organ called the haustorium, which provides a physical as well as a physiological bridge between the parasite and the host, directing the host's resources to the parasite and functioning at multiple stages in the parasitism. Being a hemiparasite sandal is peculiar in silvicultural practice due to no adequate understanding of the same. Because of the poor knowledge on host-parasite relationships establishment has been problematic (Surendran et al., 1998).

Tropical Dry Evergreen Forest (TDEF's) is rich in fruit resources on which numerous frugivorous (i.e. fruit-eating) birds and mammals depends (Corlett 1998b; Fleming 1991; Fleming *et al.* 1987; Hanya &Bernard 2013; Snow 1981). Frugivore feeds on the fruits and disperse the seeds using mechanism of the passage of fruits via the gut followed by dropping them after chewing the pulp paves the way for dissemination of fruit or seed away from the

parent tree. Seed dispersal by frugivores plays a vital role in seeds escape predation, competition, and fungal attack under the parent tree (Howe 1980; Janzen 1970; Pizo 1997).

Earlier works were focused on sandal spike diseases and pathogens, Thomas and Balasundaran (1999). Studies on genetic variation of sandal was studied by a few investigators. G S Woodall & C J Robinson (2002) studied on Same day plantation establishment of the root hemiparasite sandalwood and hosts. C. G. Jones *et al.*, 2008 has reported on the Collection – Implications for Tree Improvement Potential of an Australian *S. album.* Most of the studies envisaged on the growth of sandal with primary host species and its selection but study on sandal with its associated host tree species seed dispersed by frugivores has been limited, in the present study author is trying assess the frugivores involved in seed dissemination of sandal tree in protected study area and to explore the identified Haustorial connections of root of *Santalum album* trees propagated by means of birds and its growth performance with two different economically important Forest host tree species were also interpreted in this paper.

MATERIALS AND METHODS

Location of the study

During 2011 – 2012, a field trip was made on the experimental research plots established by the State Forest Research Institute at Kattankulathur Research Center, Tamil Nadu. It was casually observed that 162 numbers of naturally regenerated *S. album* were grown along the experimental plots around dense bushes. *S. album* was regenerated by means of seeds dispersed frugivores (bird/mammal) in the protected study area. Frugivores visit to the trees were watched for 3-hr duration were made for a total of 48-hr at a distance of 7 – 10 m away and recorded (Table – 2). Besides, the best performing *S. album* were chosen with their respective well grown host trees and tried to expose the haustorial connections.

Out of 162 sandal trees, 24 numbers of well grown *S. album* trees were observed with 12 numbers of *E. tereticornis* (Figure – 1) and 12 numbers of *P. santalinus* (Figure – 2) respectively were taken up to assess the growth performance parameter such as height and girth along with host tree species.

Figure 1: A view of *S. album* with *E. tereticornis*. Figure. 2: A view of *S. album* with *P. santalinus.*

The roots of (Figure – 3) sandal with two different host species *E. tereticornis* and *P. santalinus* were exposed by excavating the soil particles in their rhizosphere zone was removed using scalpel (Figure – 4) with atmost care without causing any damage to the roots to visualize the haustoiral connections of the plants and photographed (Figure – 3 to 8). Observations were made on the growth performance of *S. album* with *E. tereticornis* and *P. santalinus* with respect to each host plants were recorded and tabulated (Table – 2).

RESULTS AND DISCUSSION

In Kattankulathur Research Center, frugivores played a vital role in dissemination of sandal seed naturally. The visited frugivorus were recorded and tabulated (Table – 1). It was observed that among avian species most frequent visit was made by *Eudynamys scolopacea* followed by *Acridotheres tristis.* Besides, *Funambulus palmarum* also visited sandal.

Table 1: Frugivorus recoreded in dissemination of sandal seed.

Common Name	Scientific Name
Asian Koel	*Eudynamys scolopacea*
Common Myna	*Acridotheres tristis*
Black Drongo	*Dicrurus macrocercus*
White-headed Babbler	*Turdoides affinis*
Three-striped Palm Squirrel	*Funambulus palmarum*

Balasubramanian *et al.,* 2011 studied the Avian frugivory and seed dispersal of Indian *S. album* in Tamil Nadu, India and reported that in Anaikatty Hills of Western Ghats a total of 217 birds belonging to 8 species visited *S. album.* In the present study, the major beneficial dispersers of *S. album* seeds was due to the birds *Eudynamys scolopacea* and *Acridotheres tristis* dropping in the midst of dense thorny bushes. The mammal *Funambulus palmarum* also defecate the seeds. His study revealed that 349 birds belonging to 3 species including Asian Koel, Common Myna and Rose-ringed Parakeet were observed and recorded in dissemination of sandal seed in the Pachaimalai Hills. The present study results correlated the above findings. Patrick David *et al.,* 2015 observed and enlisted the frugivory and seed dispersal of Coastal Tropical Dry Evergreen Forests (TDEF) of South India. Present investigation confirms the occurrence and dissemination of sandal seed by frugivours on Sandal in the study area.

Growth performance

A total of 162 *S. album* trees found to be grown naturally with various host species prevailed in the study area. The following table – 2 reveals the growth performance of *S. album* with their respective host plants.

Table 2: Growth performance of *S. album* with its associated host plants.

S. No.	Name of the species	Number of trees observed	Host plants		*S. album*	
			Average Height (m)	Average Girth (cm)	Average Height (m)	Average Girth (cm)
1	*E. tereticornis*	12	14	86	6	23
2	*P. santalinus*	12	9	57	6	19

Figure 3: A view of *S. album* with host trees Figure 4: Excavation of soil particles from the rhizosphere zone.

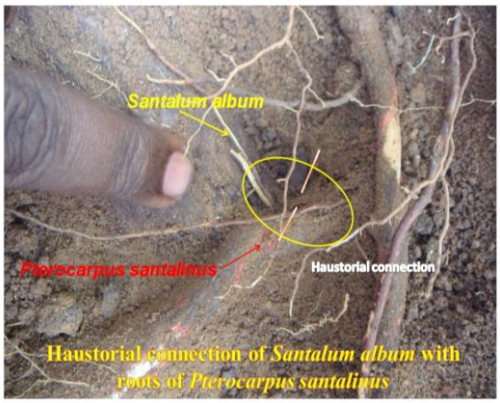
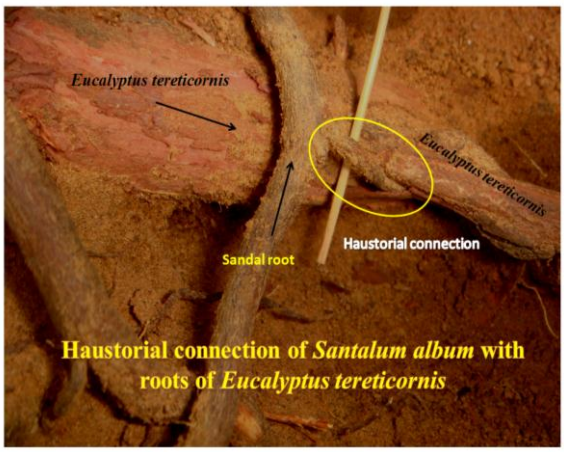


Figure 5: Identifying haustorial connections. Figure 6:

After excavation of soil particles in their rhizosphere zone, a clear haustorial connection with their respective host plants were photographed and documented (Figure – 5 – 8).



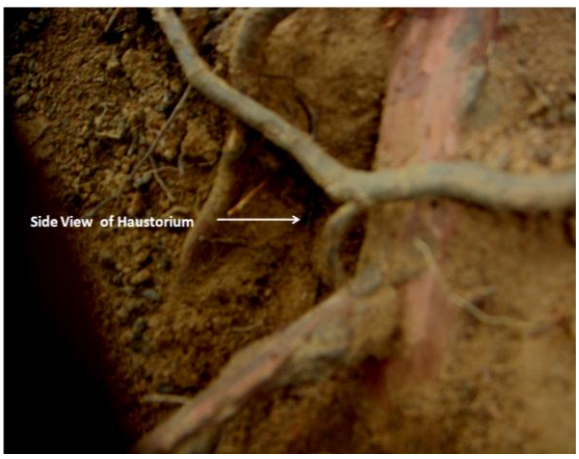


Figure: 7. Figure: 8.

The root parasitic nature of *S. album* was first recognized by Scott in 1871. Y V. Sreenivasa Rao, 1933 in his study stated that *S. album* depends on its host for its vital requirements of organic compounds such as NPK and constituents such as calcium, iron and alumina would directly absorbed from the soil. Kuijt, (1969) reported that *S. album* is not totally nutritionally dependent on their hosts but host provides adequate water, nutrients, minerals and physical support at the varying levels depending upon the host species. Sandal benefits from a primary host at the nursery stage and from a secondary host (long term) in the field (Srinivasan et al., 1992; Barrett and Fox, 1995; Fox et al., 1996; Radomiljac et al., 1998a; Fox, 2000).

Shobha N. Ral 1990 has suggested in his study that sandal under forest conditions is a slow-growing tree with 1 cm girth/year and can attain 5 cm of girth or even more per year under suitable growing conditions such as soil and moisture. Formation of heartwood in sandal starts from 10-13 years of age confined to natural forests recorded from Javadis in Tamil Nadu up to Dharwad area of Karnataka.

In the present study, naturally grown *S. album* growth was found to be a maximum average girth of 23 cm with the associated *E. tereticornis* followed by 19 cm with *P. santalinus* associated hosts respectively. Obviously it is presumed that growth performance of *S. album* was directly attributed to the secondary host species. Besides, natural regeneration of Sandal may due to its protection of thorny bushes, under the associated host trees where frequent occurrence of birds prevails. The growth performance and higher population of naturally regenerated sandal might have been the reason that the restriction of grazing animals, free from recurrent fire with certain favorable protected condition of the study area.

In general, several study reports revealed that *E. tereticornis* would exhibit allelopathic effect on associated plants. In contrast, the present study shown best growth performance of *S. album* with *E. tereticornis* than other host species. Shobha N. Ral 1990 reported that *S. album* has about 300 number of host species and suggested *Casuarina equisitifolia, Acacia nilotica, Pongamia binnata, Melia dubia, Wrightia tinctoria,* and *Cassia siamea* as best performing hosts. In the present work, the author trying to explore *E. tereticornis* (Figure 7 & 8) would also contribute for the best growth of sandal as secondary host using dynamic haustorial connection of vascular tissue of the roots.

Generally, leguminous hosts supported maximum chlorophyll content in sandal as compared to non-leguminous host. Ananthapadmanabha et al. (1988), Rai (1990) and Taide et al.

(1994) had observed *Casuarina equisetfolia* to be the best pot host in large size containers and have confirmed that legumes do have an advantage over on legumes as hosts for sandal. Shobha N. Ral 1990 has reported 28 Number of Haustorical Connections of *S. album* with *P. santalinus* in his experimental findings. In the present study leguminous host tree *P. santalinus* had big size haustorial connections to enhance nutrient passage contributing to the better growth of *S. album*. In the present findings, the leguminous host *P. santalinus* has shown better performance in growth and huge size of the haustorial connections with roots of *S. album* (Figure – 6).

In the past failure of pure Sandal plantations might have been due to lack of understanding of the dynamics of parasitism. It can profusely propagate naturally in the absence of fire and grazing. If well protected, the established Sandal plants will fruiting and regenerating naturally, the birds also may help in natural propagation. It can be concluded from the present study that inventory on the anatomy of haustorial connections with host plants and frugivours visit frequency, heartwood formation of Sandal prevailing in the study area have to be analyzed and evaluated, which will provide new information for further research.

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