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# Pruning Effects on the Health of Indian Sandalwood (*Santalum album* Linn) in Agroforestry Conditions of South India

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**Abstract:** Surveys in south India revealed that *Santalum album* Linn. is commonly grown with forest trees and horticultural and agricultural crops. As a silvicultural practices in cultivation of *S. album* though pruning is not recommended many farmers follow the practice of regular pruning there by adversely affecting the health of trees. Severely pruned trees were found losing their erectness and bending indicating that pruning causes change, disorder and affect many physiological functions resulting in deterioration of overall tree health. The wounds caused by pruning sever tissue connections and enhances the infection of decay fungi. It attracts the infestation of insect pests particularly the stem and wood borers. The incidence of bark caterpillar *Indarbela quardinotata* Walker, red stems borer *Zeuzera coffeae* Nietn. and heart wood borer *Aristobia octofasciculata* Aurivillius was found significantly higher in pruned plantations compared un-pruned plantations. The heartwood loss ranging from 22.6 to 34.5% was observed during extraction and this loss might be attributed due to the adverse effect of pruning and other mechanical injuries inducing infection of decay fungi and infestation of stem borers in young plantations of *S. album*. Hence, to avoid not only the pruning but also any silvicultural practices that cause injury to sandalwood are recommended for its healthy growth and thereby to obtain desirable returns.

**Keywords:** Santalum Album, Stem Borer, Pruning, Silviculture, Agroforestry

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## 1. Introduction

Indian sandalwood (*Santalum album* Linn) which is acknowledged as “Royal Tree” in Indian subcontinent is one of the most economically important tree species occupying a pre-eminent position in Indian forestry. The tree has been synonymous with ancient Indian culture and is having long history through and its importance and medicinal value has been mentioned in many quotes of age-old writings. For more than 5000 years, India has been the traditional leader of sandalwood oil production for perfumery and pharmaceuticals [1]. The economic importance of sandalwood is well documented and is the second most expensive wood in the world [2]. During the past one hundred years, the prices of sandalwood have seen many variations. The annual global sandalwood production is estimated to be approximately 5610 tonnes which has

declined markedly over the past 20-30 years. The production of sandalwood in India decreased annually at the rate of 20 percent since 1995 [3]. Due to increased demand in internal and external markets and also the decrease in supply, sandalwood price has skyrocketed. As per Karnataka Government outlet 2012, cost of 5 g of oil sold is Rs 1500, which works out to be Rs 300,000/kg [2]. The decline in sandalwood production is mainly due to the depletion of sandalwood trees in forest. The depletion is attributed to factors like illicit felling, disease and smuggling, which are very rampant and is the major problem in the entire sandalwood tree growing states [4]. Due to the drastic reduction in the population of sandalwood in natural sandalwood growing states of south India viz, Karnataka and Tamil Nadu and realizing that the existing rules are primarily responsible for its reduction the states have amended the Sandalwood rule which clearly states that “every occupant or

the holder of the land shall be legally entitled to the sandalwood tree in his land". The purpose of the amendment is to encourage farmers and corporate bodies to take sandalwood plantations to meet the growing demand [5]. The most important characteristic of sandalwood tree is its hemiparasitic nature which makes it good species for agroforestry setup and it can parasitize over 300 species of plants [6]. The above facts encouraging community and private entrepreneurs to cultivate *S. album* in agro-forestry, farm forestry and varied agri-silvi-horticultural and mixed plantation systems as per their choice and many small to large scale plantations are coming up. In this context, many complaints have been received from sandalwood growers reporting death of sandalwood trees. Hence, surveys were conducted to assess the farmer's way of growing sandalwood in south India with their health status and the reason for the death of trees were analyzed and the findings are presented in this communication.

## 2. Materials and Methods

Surveys were conducted in states of south India viz, Andhra Pradesh, Karnataka, Tamil Nadu and Telangana covering different sandalwood plantations grown by farmers. In each field, the details of other agricultural/horticultural

and forestry tree species grown along with sandalwood were recorded. Further, in farmers' field from 2015 to 2016 observations were taken on the general health and incidence of different stem borers of *S. album* viz. bark caterpillar, Indarbela quadrinotata Walker, red stemborer *Zeuzera coffeae* Nietn. and heartwood borer *Aristobiaoctofasciculata* Aurivillius which followed pruning and no pruning. For this purpose ten plantations each of *S. album* which followed pruning and no pruning were selected for the study. The overall health of the plants which experienced pruning and no-pruning were assessed. The percentage incidence of different bores was also assessed in these plantations. The data thus collected were pooled and t test was performed to compute the difference in the incidence of borers in these plantations. In addition, decay caused by the entry of fungus in the cut ends was assessed and their impact on the health status was assessed.

## 3. Results and Discussion

Surveys revealed that *S. album* is commonly grown with forest trees and horticultural and agricultural crops (Table 1) as per the local soil conditions and the requirement of the farmers.

*Table 1. Farmer's choice of growing sandalwood with other plant species.*

SI NO.	Plant Species	Economical Importance
1	Acacia auriculiformis A. Cunn	Forestry/Timber
2	A. nilotica L.	Forestry/Timber
3	Anacardium occidentale L.	Commercial/Traditional medicine
4	Areca catechu L.	Commercial/Ornamental
5	Azadirachta indica A. Juss.	Commercial/Horticulture
6	Cajanus cajan (L) Millsp.	Agriculture/Food Industry
7	Capsicum annum L.	Horticulture/Traditional medicine
8	Carica papaya L.	Horticulture/Culinary
9	Casuarina equisetifolia L.	Commercial/removal of textile dye
10	C. junghuhniana Miq.	Commercial/removal of textile dye
11	Cocos nucifera L.	Horticulture/Traditional medicine/Food industry
12	Coffea arabica L.	Commercial/Traditional
13	C. robusta L. Linden	Commercial/Traditional
14	Cucumis sativus L.	Food Industry/Horticulture
15	Curcuma longa L.	Medicinal/Culinary
16	Cymbopogon citrates (DC. ex Nees)	Medicinal
17	Dalbergia latifolia Roxb.	Agriculture/Commercial
18	Eleusine coracana Gaertn.	Soil stabilizer/Industrial
19	Eucalyptus spp.	Commercial/Timber
20	Gmelina arborea Roxb.	Commercial/Timber
21	Grevillea robusta A. Cunn.	Agriculture/Horticulture
22	Jasminum sambac (L) Aiton	Horticulture/Ornamental/Traditional medicine
23	Macrotyloma uniflorum (Lam) Verdc.	Traditional medicine/Food industries
24	Mangifera indica L.	Horticulture/Traditional medicine/Wood industry
25	Manilkara zapota (L) P. Royen	Horticulture
26	Melia dubia Cav.	Agro Forestry/commercial
27	Moringa oleifera Lam	Horticulture/Culinary
28	Musa spp. L.	Horticulture/Fertilizer industries/Culinary
29	Phyllanthus emblica L.	Horticulture/Traditional medicine
30	Pongamia pinnata (L) Pierre	Landscaping purposes/commercial/Ornamental
31	Psidium guajava L.	Wood industry/Horticulture/Food industry
32	Pterocarpus santalinus L. f.	Commercial/Forestry
33	Punica granatum L.	Horticulture/Culinary
34	Sesbania grandiflora (L) Poiret	Culinary/Medicinal
35	Sorghum bicolor (L) Moench	Agriculture/Industrial

SI NO.	Plant Species	Economical Importance
36	<i>Syzygium cumini</i> L.	Horticulture/Traditional medicine/Food industry
37	<i>Tectona grandis</i> L.f.	Commercial/Forestry
38	<i>Vanilla planifolia</i> Jacks.	Commercial/Domestic
39	<i>Vigna unguiculata</i> (L) Walp.	Culinary
40	<i>Zingiber officinale</i> Roscoe	Medicinal/Culinary

The inter-cultivation of sandalwood with other plants are commonly preferred than the pure plantations. It confirms the fact that the cultivation of *S. album* absolutely requires the host plant [7]. In the cultivation of *S. album* though pruning is not recommended as a silvicultural practice, many farmers follow the practice of regular pruning which was found affecting the general health of the trees. Severely pruned trees were found losing their erectness and bending indicating that pruning causes change, disorder and affect many physiological functions resulting in deterioration of overall tree health (Figure 1). This compelled the farmers to give support to the plants by bamboo or other wooden poles (Figure 2) for erectness which led to attraction of termites and enhance their infestation (Figure 3). The wounds caused by pruning sever tissue connections and enhances the infection of decay fungi (Figure 4, 5). In many cases, extreme pruning resulted in death of plants (Figure 6). The death starts from top, whole plant dies, and in rare cases, recovery by new sprouting from the base was observed (Figure 7). The findings corroborates the report of [8, 9] and reported many species of rotting fungi from the old, rotted, vascular tissue of pruning wounds and in deep cracks in cordons, trunks, and spurs of grapevine [10]. Several rot fungi were isolated from *S. album* in Western Australia and reported that the fungi were entering the branches and main stem via wounds made during pruning or when branches are damaged [11]. Heartwood rot fungal diseases entering via the pruning wound has the potential to significantly reduce the sandalwood oil production [12]. Further the wounds caused by the pruning attracts the infestation of insect pests particularly the stem and wood borers. The incidence of *I. quardinotata*, *Z. coffeae*. and *A. octofasciculata* was found significantly higher in pruned plantations compared unpruned plantations (Table 2).



**Figure 1.** Bending of *S. album* due to severe pruning.



**Figure 2.** Severely pruned *S. album* with support.



**Figure 3.** Termite damage in the wooden support.



Figure 4. Entry of decay and bio-deterioration due to pruning.



Figure 6. Death of *S. album* due to severe pruning.



Figure 5. Termite damage in pruned *S. album*.



Figure 7. New sprouts from the base of severely pruned *S. album*.

Table 2. Impact of pruning on the incidence of stem borers in sandalwood.

Parameters	Incidence of different stem borers in sandalwood (%)							
	Inderbela quadrinotata		Zeuzera coffeae		Aristobia octofasciculata		Total	
	No Pruning	Pruning	No Pruning	Pruning	No Pruning	Pruning	No Pruning	Pruning
Mean	3.87	0.89	2.72	8.12	0.83	3.36	7.42	12.35
Variance	3.0321	0.2369	0.7151	3.7373	0.4223	0.556	2.7928	5.2472
Pooled Variance	1.6345		2.226222		0.489167		4.020056	
Hypothesized Difference	Mean 0		0		0		0	
df	20		18		18		18	
t Stat	5.466447		-8.09272		-8.08867		-5.49814	
P (T<=t) one-tail	1.19E-05		1.04E-07		1.05E-07		1.6E-05	
t Critical one-tail	1.724718		1.734064		1.734064		1.734064	
P (T<=t) two-tail	2.38E-05		2.08E-07		2.09E-07		3.2E-05	
t Critical two-tail	2.085963		2.100922		2.100922		2.100922	

Many insects are known to be attracted to wound for laying eggs [13], wounds attract more damaging pests [14], wounds may provide oviposition sites [15], and insect takes advantage of wounds [16]. Some host kairomones released

due to wound may have long range attraction potential [17]. The heartwood loss ranging from 22.6 to 34.5% (Figure 8) was observed during extraction of sandalwood and this loss might be attributed due to the adverse effect of pruning and

other mechanical injuries inducing infection of decay fungi and infestation of stem borers in young plantations of *S. album*. These bio-deteriorating agents would have been active for many years during the growth of sandalwood resulting in extensive loss of valuable sandalwood. It confirms the fact that such infection is carried throughout the life of sandalwood resulting in more than one-third loss of heartwood [18]. Also though selection cutting has many advantages, its potential for damage to residual trees is a major challenge of forest management [19]. Hence, silvicultural practices that cause injury to sandalwood to be avoided and no pruning should be followed to curtail the attack of bio-deteriorating agents, thereby healthy growth of sandalwood and the desirable returns are assured.



Figure 8. Heartwood loss in extracted *S. album*.

#### 4. Conclusion and Recommendation

Any form of mechanical injury and the practice of pruning were found adversely affecting the overall health of *S. album*, and in severe cases causing death of trees. It also enhances the incidence and establishment of bio-deteriorating agents. Hence, it is recommended to avoid not only the pruning but also any silvicultural practices that cause injury to sandalwood for its healthy growth and thereby to obtain desirable returns.

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