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Research Article

Habitat diversification in the cultivation of Indian sandalwood (*Santalum album* Linn.): An ideal option to conserve biodiversity and manage insect pests

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ABSTRACT: In 15 combinations of growing sandalwood with other plant species the incidence of insect pests and their predators were observed for two years from 2014 to 2015 in Karnataka. The more diversified areas recorded more species of insect pests and natural enemies but the severity of the infestations were less and resulted in no insecticidal application. In less diversified areas the severity of sap suckers and stem borers were more often seen and resulted in undertaking control measures. An analysis of sapsuckers and defoliators with the natural enemies like coccinellids, mantids and spiders showed positive linear relationship between pest and predators. The findings demonstrated that habitat diversification in growing sandalwood is an ideal option to manage the insect pest problems.

KEY WORDS: Agroforestry, insect pests, *Santalum album*

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INTRODUCTION

Agroforestry systems are not new to India; traditionally each and every Indian locality has its own types of indigenous agroforestry systems (Dhyani and Handa, 2014). In fact, India has around 24,602 million trees outside forests spread over an equivalent area of 17 million ha (Prasad *et al*., 2000). National Agriculture Policy (2000) emphasized the role of agroforestry, thus putting lots of inputs into agroforestry research and agroforestry plantation establishments. Indian sandalwood (*Santalum album* Linn.) is emerging as one of the important agroforestry species due to the amendments in the Sandalwood acts in 2001 and 2002, respectively by the Karnataka and Tamil Nadu governments. Economic importance of sandalwood tree is well documented and as of now it is the second most expensive wood in the world (Arun Kumar *et al*., 2012). These facts have generated interest in public and private sectors to raise sandalwood plantations and a large number of farmers and individuals with large land holdings have taken up commercial plantation of sandalwood in Karnataka, Maharashtra, Andhra Pradesh and Rajasthan (Kulkarni, 2011). The most important characteristic of sandalwood tree is its hemi-parasitic nature which makes it good species for agroforestry setup. It can parasitize over 300 species of plants. This prospective sandalwood is not devoid of diseases and pests. Among the various factors insect pests are one of the most important factors limiting the successful establishment of sandalwood plantations (Sundararaj and Muthukrishnan, 2011). Insect pest attack on sandalwood may get aggravated when it is grown in agro-horticulture forestry systems as pests of other species are showing shift to the sandalwood (Sundararaj, 2011). Studies were conducted to assess the impact of habitat diversification on the incidence of insect pests and their natural enemies in different combinations of growing sandalwood along with other agricultural/ horticultural.

MATERIALS AND METHODS

The studies were conducted in farmer's field in Karnataka by observing the diversity of insect pests and predators in 2014 and 2015 with one observation each in pre-monsoon and post-monsoon periods in 15 selected combinations of growing sandalwood in Karnataka. The selected combinations were *Santalum album* with one more plant *viz*., *Aloe vera, Musa paradisiaca, Melia dubia, Manilkara zapota, Coriandrum sativum* and *Psidium gujava;* with two more plants *viz., Cocos nucifera* and *Eleusine coracana, Acacia auriculiformis* and *Tectona grandis, Mangifera indica* and *Arachis hypogaea,* and *Morus alba* and *Manilkara zapota;* with three more plants *viz., Moringa oleifera, Sesbania grandiflora* and *Citrus limon, Macrotyloma uniflorum, Punica granatum* and *Mangifera indica* and *Areca catechu, Vanilla sp.* and *Piper betel;* with four more plants *viz., Coffea arabica, C. robusta, Greviliea robusta* and *Piper betel* and with five more plants *viz., Cajanus cajan, Tectona grandis*, *Mangifera indica, Citrus reticulata,* and *Punica granatum.* All these plantations, were less than five years old and in each plantation thirty sandalwood trees at random were examined for the presence of insect pests and predators and the data were recorded on the number of species of pests and predators. The data thus collected were pooled and mean number of species

were computed. Since, among the pest insects only the number of species of defoliators and sap suckers are prominent they were analysed for correlation and regression with major three predatory groups *viz*., coccinellids, mantids and spiders. The details of any insecticide spray were ascertained from the concerned farmers.

RESULTS AND DISCUSSION

The details of the number of species of insect pests in different feeding habitats and the different predators recorded in different combinations of growing sandalwood is shown in Table 1

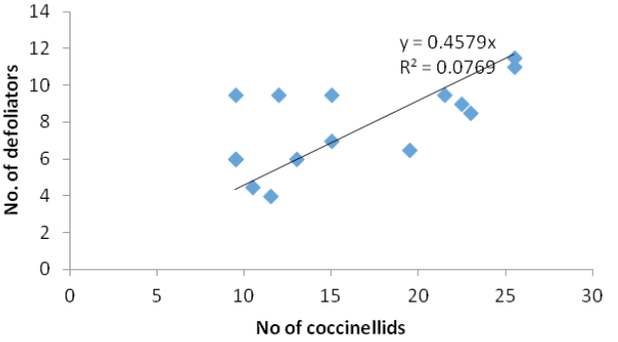

Fig. 1. The relationship of defoliators with coccinellids

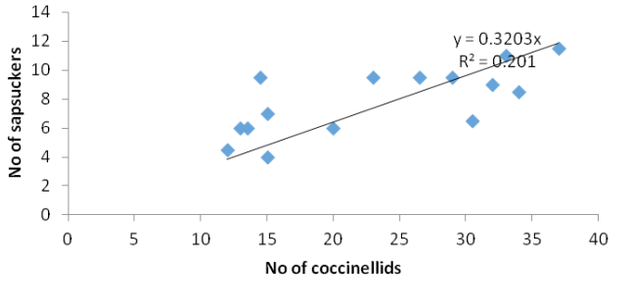

Fig. 2. The relationship of sapsuckers with coccinellids

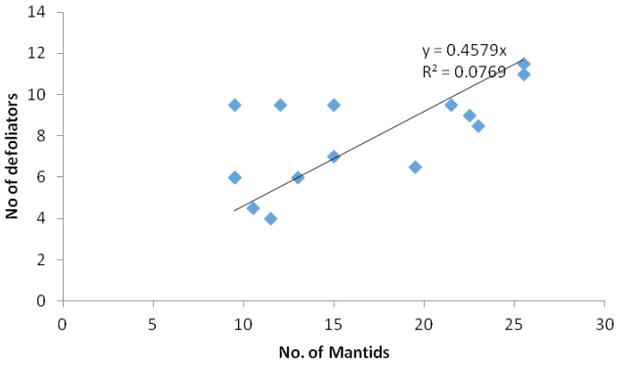

Fig. 3. The relationship of defoliators with mantids

and 2. In general post-monsoon period recorded higher number of insect pests in all the combinations of growing sandalwood though in total the difference is insignificant. It corroborates the report

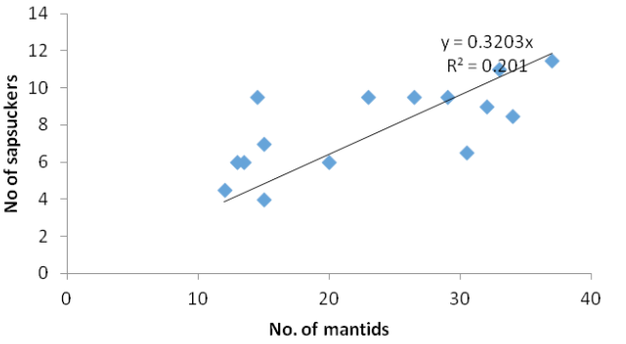

Fig. 4. The relationship of sapsuckers with mantids

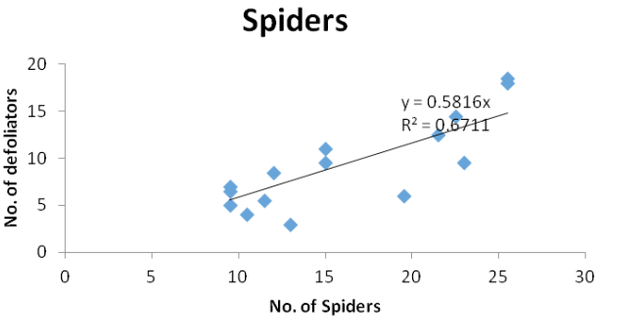

Fig. 5. The relationship of defoliators with spiders

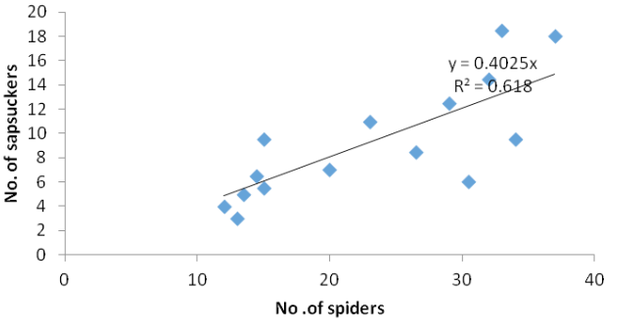

Fig. 6. The relationship of sapsuckers with spiders

of Sundararaju (1994) that the build-up of insect populations and their damage synchronizing with emergence of new flushes/ panicles after the cessation of monsoon rains. Among the feeding groups of insects, the bark/dead wood feeders, flower feeder, leaf miners and stem borers did not show any significant difference among the combinations, while there is significant difference among defoliators and sapsuckers. Among the predatory groups, reduvids, odonates and neuropterans did not show significant difference among the combinations. This may be due to the fact that the diversity of these groups is less compared to coccinellids, mantids and spiders. *Spalgius epius* (Lepidoptera: Lycaenidae) is commonly found in all the combinations in pre and post-monsoon seasons. The more diversified areas recorded more species of insect pests and natural enemies but the severity of the infestations were less. In less diversified areas, the severity of sapsuckers and stem

Table 1. Details of number of insect pest species recorded in different combinations of growing sandalwood

Plant species grown with sandalwood	Mean no. of insect pest species recorded													
	Bark/dead wood feeders		Defoliators		Flower feeder		Leaf miners		Sapsuckers		Stem borers		Total	
	Pre-M	Post-M	Pre-M	Post-M	Pre-M	Post-M	Pre-M	Post-M	Pre-M	Post-M	Pre-M	Post-M	Pre-M	Post-M
Aloe vera	1.0	0.5	7.0	12.5	1.0	1.0	0.0	0.0	12.5	18.0	1.0	1.0	22.5	33.0
Musa paradisiaca	1.0	1.0	9.0	14.0	1.0	1.0	1.0	0.5	15.5	18.5	1.0	1.0	28.5	36.0
Melia dubia	1.0	1.0	5.0	4.5	0.0	0.0	0.0	0.5	8.5	11.5	1.0	1.0	15.5	18.5
Manilkara zapota	1.0	1.0	4.5	7.0	0.0	0.0	0.0	0.0	7.0	8.0	1.0	1.0	13.5	17.0
Coriandrum sativum	1.0	1.0	4.5	7.5	0.0	0.0	0.5	0.5	11.5	15.0	1.0	1.0	18.5	25.0
Psidium gujava	1.0	1.0	7.5	7.5	0.5	1.0	1.0	1.0	10.5	12.5	1.0	1.0	21.5	24.0
Cocos nucifera+Eleusine coracana	1.0	1.0	4.5	5.0	0.0	0.0	0.5	0.5	6.0	7.5	1.0	1.0	13.0	15.0
Acacia auriculiformis + Tectona grandis	1.0	1.0	5.0	4.5	0.0	0.0	1.0	1.0	7.5	7.0	1.0	1.0	15.5	14.5
Mangifera indica +Arachis hypogaea	1.0	1.0	8.5	13.0	0.5	0.5	1.0	1.0	13.5	15.5	1.0	1.0	25.5	32.0
Morus alba+Manilkara zapota	1.5	1.5	10.5	15.0	0.0	0.0	1.0	1.0	14.5	18.5	1.0	1.0	28.5	37.0
Moringa oleifera + Sesbania grandiflora + Citrus limon	1.0	1.0	12.0	13.5	1.0	1.0	1.0	1.0	17.0	20.0	1.0	1.5	33.0	38.0
Macrotyloma uniflorum, Punica granatum + Mangifera indica	1.0	1.0	4.0	6.5	0.0	0.0	0.0	0.0	5.5	6.5	1.0	1.0	11.5	15.0
Areca catechu, Vanilla sp. + *Piper betel*	1.0	1.0	6.0	7.0	0.0	0.5	1.0	0.5	6.0	7.0	1.0	1.0	15.0	17.0
Coffea arabica + C. robusta + Greviliea robusta + Piper betel	1.0	1.0	6.5	8.5	0.0	0.0	0.5	0.5	6.5	8.5	1.0	1.0	15.5	19.5
Cajanus cajan + Tectona grandis + Mangifera indica + Citrus reticulata +Punica granatum	1.0	1.0	9.5	13.0	1.0	1.0	0.0	1.0	15.0	17.0	1.0	1.5	27.5	34.5
CD (P = 0.05%)	NS	NS	2.23	3.6	NS	NS	NS	NS	1.91	2.47	NS	NS	NS	NS

Pre-M: Pre-monsoon; Post-M: Post- monsoon

borers were more often encountered and there was need to take up control measures. An analysis of sapsuckers and defoliators with the natural enemies like coccinellids, mantids and spiders showed positive linear relationship between pest and predators (Figures 1 to 6). It is known that increased plant species diversity support diversity and abundance of natural enemies as well as their activity (Haddad *et al*., 2001). Intercropping provide additional resources such as food and shelter that enhance abundance and effectiveness of natural enemies (Mensah, 1999). Sandalwood grown with five plant species viz., *Cajanus cajan + Tectona grandis + Mangifera indica + Citrus reticulata +Punica granatum,* with four plant species viz., *Coffea arabica + C. robusta + Greviliea robusta + Piper betel* and among the combinations with three plant species, viz., *Macrotyloma uniflorum, Punica granatum* and *Mangifera indica* did not necessitate any insecticidal spray. This confirms the fact that presence of natural enemies play important role in suppression of herbivores inagro-ecosystems (Marković, 2013). The findings demonstrated that habitat diversification in growing sandalwood is an ideal option to manage the insect pest problems without use of any insecticide. It will avoid environmental pollution, health problems and species loss caused by the over dependence on synthetic insecticides and exploration of multi-function agricultural biodiversity that enhance pest management (Gurr *et al*., 2003).

Table 2. Details of number of predator species recorded in different combinations of growing sandalwood

Plant species grown with sandalwood	Mean no. of predator species recorded															
	Coccinellids		Mantids		Reduvids		Odonata		Neuroptera		*Spalgius epius*		Spiders		Total	
	Pre-M	Post-M	Pre-M	Post-M	Pre-M	Post-M	Pre-M	Post-M	Pre-M	Post-M	Pre-M	Post-M	Pre-M	Post-M	Pre-M	Post-M
Aloe vera	3.0	3.5	3.0	3.5	1.0	1.0	5.0	6.5	2.0	1.5	0.5	1.0	3.0	3.0	17.5	20.0
Musa paradisiaca	3.0	4.0	3.5	5.0	0.5	1.0	7.0	9.5	1.0	2.0	1.0	11.0	4.5	5.0	20.5	27.5
Melia dubea	1.5	2.0	3.0	3.0	0.5	0.5	2.5	3.0	0.0	0.5	1.0	0.5	2.5	4.5	11.0	14.0
Manilkara zapota	2.0	2.5	1.5	2.5	0.5	0.5	2.5	4.0	1.0	0.5	0.5	1.0	2.5	3.0	10.5	14.0
Coriandrum sativum	7.0	6.5	4.0	5.5	1.5	2	3.5	4.0	2.5	2.0	1.0	1.0	3.5	5.0	23.0	26.0
Psidium gujava	5.5	6.5	3.5	6.0	2.0	1.5	7.0	10	2.0	3.5	1.0	1.0	4.5	6.5	25.5	35.0
Cocos nucifera+Eleusine coracana	3.5	4.5	3.0	3.0	1.0	2.0	3.0	2.5	2.0	2.5	1.0	1.0	2.5	2.5	16.0	18.0
Acacia auriculiformis + Tectona grandis	2.5	3.5	4.5	5.0	0.0	0.5	3.5	5.0	1.0	1.5	0.5	1.0	3	3.5	15.0	20.0
Mangifera indica +Arachis hypogaea	3.5	6.0	5.0	4.5	1.5	2.0	5.0	6.5	1.5	1.0	1.0	1.0	5.5	7.0	23.0	28.0
Morus alba+Manilkara zapota	6.5	7.5	4.5	6.5	1.5	2.5	7.0	8.5	3.5	3.5	1.0	1.0	9	9.5	33.0	39.0
Moringa oleifera + Sesbania grandiflora + Citrus limon	8.5	11.0	5.0	6.5	2.5	2.0	10.0	12.0	2.5	4.0	1.0	1.0	9.5	8.5	39.0	45.0
*Macrotyloma uniflorum, Punica granatum and Mangifera indica**	2.0	2.5	2.5	2.0	0.5	0.0	2.0	3.5	1.0	1.0	0.0	0.0	1.5	2.5	9.5	11.5
Areca catechu, Vanilla sp.and *Piper betel*	2.5	3.0	2.5	3.5	0.0	0.5	1.5	3.0	1.0	1.0	0.5	1.0	1	2.0	9.0	14.0
*Coffea arabica + C. robusta + Greviliea robusta + Piper betel**	2.5	2.5	3.0	4.0	0.5	1.0	4.5	5.0	1.0	1.5	0.5	0.5	4	5.5	16.0	20.0
*Cajanus cajan + Tectona grandis + Mangifera indica + Citrus reticulata +Punica granatum**	6.5	9.5	3.5	5.5	1.5	2.0	6.5	7.0	2.5	3.0	1.0	1.0	7	7.5	28.5	35.5
CD (P = 0.05%)	3.31	4.45	1.95	2.51	NS	NS	4.49	3.69	NS	NS	NS	NS	3.08	4.88	16.08	19.60

Pre-M: Pre-monsoon; Post-M: Post- monsoon. *. No spray operation necessitated on sandalwood

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