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Research Paper

Exploration of Lac Cultivation on Non-Traditional Host *Flemingia Macrophylla* (Willd.) Kuntze Ex Merr. and it's Possibility in Understorey Plantations of *Dalbergia sissoo* Roxb.

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Abstract: Lac is a natural resin of animal origin derived from protective body covering of tiny insect Kerria lacca Kerr. (Tachardiidae: Homoptera). It is commercially cultivated on traditional hosts like Kusum (Schleichera oleosa), Palas (Butea monosperma) and Ber (Zizyphus mauritiana). To overcome the problems of long gestation period, scattered distribution and high crown of these traditional hosts, efforts were made to explore suitable non-traditional hosts of short gestation period and low crown. In this context, Flemingia macrophylla is one of the promising non-traditional host species which was explored as intercrop in understorey of Dalbergia sissoo and control condition. The experiment was conducted in Aghani (winter) and Katki (rainy) seasons for Kusumi and Rangeeni strains respectively. Survival per cent of F. macrophylla was higher in understorey (100) as compared to control (96). The mean plant height of F. macrophylla in understorey was 141.87 cm, whereas 237.46 cm in control. Average inoculable shoots per plant were 4.41 and 2.27 under control and understorey respectively. After 75 days of inoculation, density of settlement was higher under control (45.71/cm2, 16.2/cm2) than in understorey (38.05/cm2, 13.5/cm2) for winter and rainy crop respectively. Sex ratio at 45 days of inoculation was higher in understorey in winter(13:95 M: F/cm2) and control in rainy (14:84 M: F/cm2). Lac shell weight after emergence was higher under control for both winter (0.02012 g) and rainy (0.0313 g) with 307 and 315 insects respectively. The average 'scrap lac' yield in control was 166.64 g/plant, which was 2.6 times to that in understorey (63.63 g/plant) for winter crop. Experimental results revealed that inspite of significant reduction in the scrap lac yield; lac cultivation is feasible on F. macrophylla in under-storey. With proper canopy management, there is potential of increasing not only its economic viability, but also ecological development via Joint Forest Management through peoples' participation in resource generation, management and sharing of benefits.

Key words: Lac, Aghani, Katki, Flemingia macrophylla, Dalbergia sissoo, Kerria lacca.

Introduction

Lac is a resinous exudation from the body of female scale insect *Kerria lacca* Kerr. (Tachardiidae: Homoptera). This insect grows on certain host trees from which it consumes the phloem sap as its food and produces a fluid that envelops its body as a protective cover. This fluid, when hardened, becomes the resin that is known as "lac". The word Lac is derived from the Sanskrit word "laksha", which means 100,000 and refers to the vast swarms of insect larvae that inundate lac trees during brood season. South Asian countries like India, Thailand, Indonesia, Myanmar and Vietnam are the key lac producing countries in the world. India and Thailand dominates global lac market. While Thailand exports the bulk of its production, India consumes more than half of its lac production internally.

Lac insects, the crowning glory of India's rich insect fauna (representing 21.8% diversity of the known lac insect species) are exploited for their products of commercial value, viz. resin, dye and wax. Indian lac production accounts for about 50–60 per cent of the world lac production (Sharma *et al*. 2006) and is around 20,000 metric tonnes per year. Though lac is considered as a minor forest produce but has significant contribution in the tribal economy in major lac-producing states of India viz. Jharkhand (57 per cent of the country's production), Chhattisgarh (23 %), West Bengal (12 %). About 20–38 per cent of the total agricultural income of the tribal growers of Jharkhand is contributed by lac (ILRI 1998). Nearly one million mandays per annum are generated by the industries engaged in post-harvest processing of lac. Besides, India fetches approximately Rs 120–130 crores of foreign exchange through export of lac every year (Sharma *et al*. 2006). Lac resin being natural, biodegradable and non-toxic, finds several applications in food, textiles and pharmaceutical industries in addition to surface-coating, electrical and other fields and provides immense employment opportunities.

Although lac enjoys plethora of uses and high export potential, current international trade in lac based products is about half what it was in the 1950's. Especially in Jharkhand – India, production is shrunk to 55 per cent from 75 per cent of the national total in 1960s. There are several reasons for reduction in area under lac cultivation and inturn total production loss. Among these, the problems of long gestation period, scattered distribution and high crown associated with traditional hosts like Kusum (*Schleichera oleosa*), Palas (*Butea monosperma*) and Ber (*Zizyphus mauritiana*) compounded the total production loss. Added to this land degradation in new and young plantations of *Dalbergia sissoo* is a matter of concern. Keeping present scenario in due consideration, an exploration of lac cultivation on non-traditional host *Flemingia macrophylla* underneath the shades of *Dalbergia sissoo* Roxb. (Leguminosae, subfamily Papilionoideae) was conducted.

Material and methods

The study was conducted at Forest Research Centre, Institute of Forest Productivity Mandar, Ranchi district [latitude: 23 27 40 N, longitude: 85 05 56 E, altitude 2320 ft msl]. Seeds of *Flemingia macrophylla* were procured from NB farm, Turhamu, Chandwa [latitude: 23 40 29N, longitude: 84 43 44 E, altitude 2830 ft msl]and sown on sand bed under open condition. Healthy

seedlings of 6 months old were planted at spacing of 1 X 1m as per experimental design (Fig. 1). In split-split plot design, control (open) and experimental (shade) condition are treated as main plot, *Flemingia* species as subplot and lac strains as sub-sub plot treatment. Plot size of 50 m^2 (50 bushes) for each treatment combination was maintained. From this whole experiment only part with one species of *Flemingia* i.e. *Flemingia macrophylla* and two crops (*winter* and *rainy*) out of four crops of two strains are presented and discussed in this paper. After one year of planting, pruning was carried out at six inch above the ground level to encourage new shoots. For *winter* and *rainy* crop, pruning was done during February - 2004, and January - 2004 respectively. Five shoots per plant were maintained by thinning of excess shoots. Plantation was maintained by proper weeding, basin preparation, watering in initial stages of establishment and timely application of fertilizers (NPK 10:10:5 g/plant) and insecticide (chloropyrifos 20 % EC @ 1ml/lit of water).

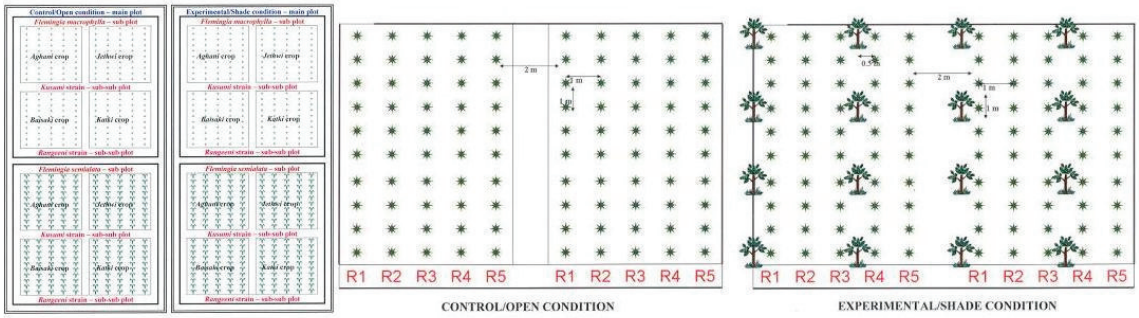
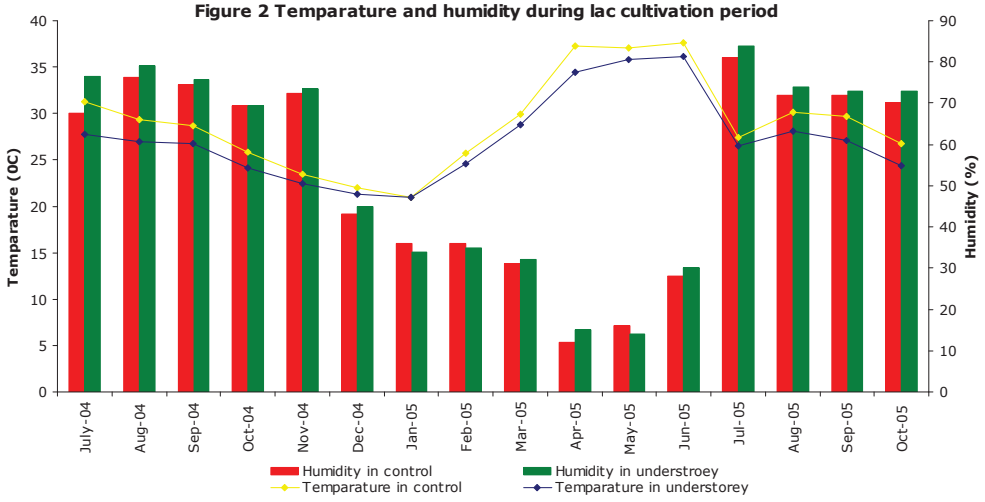


Figure 1 Layout of Experimental plot

Figure 2 Temparature and humidity during lac cultivation period



Broodlac was procured at right time ie June/July – 2004 for *winter* and *rainy* crop inoculation. Broodlac was cut into pieces of 3-5 g and inserted in a small nylon net of 60 mesh size (16 X 6 cm). Nylon mesh was used to avoid the parasite present in broodlac. Two cotton pieces were tied on each shoot (to be inoculated) at a spacing of 30 cm to restrict insect settlement. Broodlac along with nylon mesh was tied on each shoot in between the two cotton pieces (Plate 1). Insects which settle beyond 30 cm of restricted length were wiped off to protect plant from drying by excessive usage of phloem sap especially during lac maturation. Field operations like pesticide spray were carried out as per schedule. First spray (Endosulfan 35 EC – 0.05 %) after one month of inoculation. Second spray (Dichlorifos 0.03 %) if required after one month of the first spray to be sprayed either before male emergence or when fertilization process is complete. For *winter* and *rainy* crop first spray of Endosulfan 0.05 % and Carbendazim 0.01 % was done in August. Second spray of Dichlorvos 0.03 % and Carbendazim 0.01 % in September and October for *rainy* and *winter* crop respectively. Combination spray of insecticide (Endosulfan) and fungicide (Carbendazim) was used if simultaneous attack of pests and fungi is noticed. 3rd spray with Nuvon was carried only on detection of crysopa attack. Other operations like phunki (used brood lac) removal, cotton removal and harvesting were done after 15 days of inoculation, 45 days of inoculation and on crop maturity respectively. Crop maturity was identified based on development of yellow spot on below part of encrustation. Observations were recorded on lac hosts (plant height, collar diameter, inoculable shoots, survival percentage) and on lac insect (length of settlement - 21 and 75 days, density of settlement - 21 and 75 days, Sex ratio at 45 days after inoculation, fecundity and crop maturity). Daily temperature humidity and light intensity during study period was recorded and average monthly temperature, humidity and light intensity are presented in figure 2 and 3.

Results and Discussion

F. macrophylla seeds recorded germination percentage of 58.70 per cent. Survivality of *F. macrophylla* under control and understorey condition was 96 per cent and 100 per cent respectively (data not given). Average number of per plant shoots

available for inoculation was 4.22, 3.10 under control and understorey condition for *winter* crop and 4.41, 2.27 under control and understorey condition for *rainy* crop respectively.

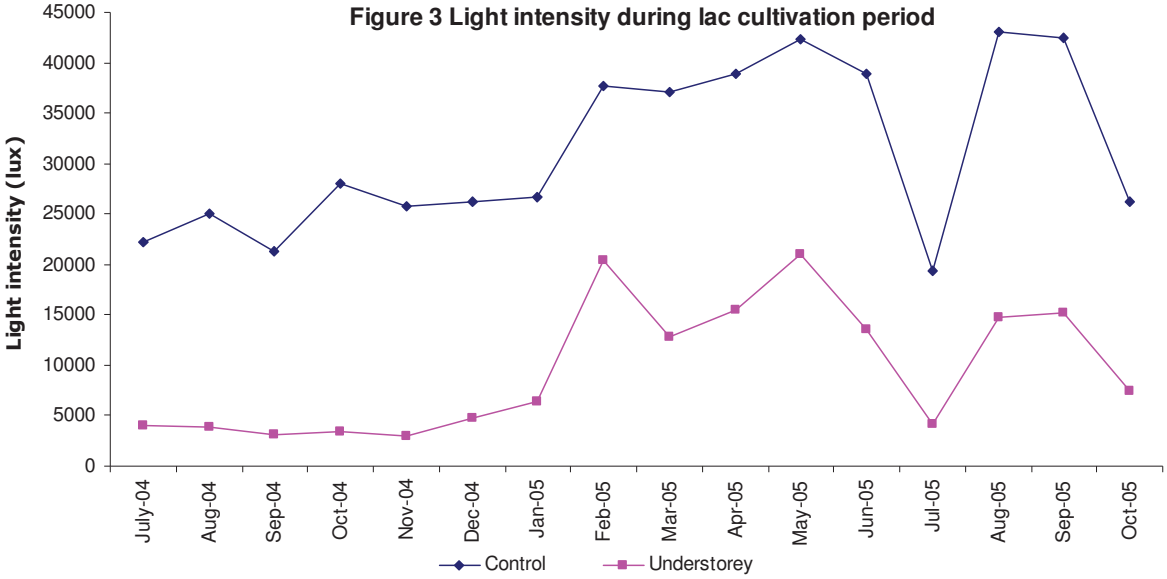




Plate 1. Cotton tying and inoculation of brood lac

Table 1 Mean morphometric performance of *Flemingia macrophylla* for *Aghani* and *Katki* crop

Months (2004)	Kusumi strain – *Aghani* (winter) crop				Rangeeni strain – *Katki* (rainy) crop			
	Control plot		Understorey plot		Control plot		Understorey plot	
	Height (cm)	Collar diameter (cm)	Height (cm)	Collar diameter (cm)	Height (cm)	Collar diameter (cm)	Height (cm)	Collar diameter (cm)
March	41.97±18.10	0.68±0.19	38.70±16.79	0.58±0.15	46.01±17.37	0.65±0.18	24.34±14.13	0.47±0.13
April	51.20±25.50	0.77±0.21	43.89±20.41	0.68±0.21	60.62±24.54	0.81±0.26	27.31±15.28	0.51±0.15
May	70.99±32.58	0.91±0.28	52.19±23.40	0.74±0.20	73.83±30.17	0.88±0.27	30.03±17.06	0.56±0.16
June	92.11±36.34	1.03±0.29	61.98±25.78	0.76±0.22	88.95±33.48	0.97±0.33	38.07±20.03	0.57±0.17
July	158.84±35.23	1.37±0.30	118.29±27.57	1.06±0.19	163.11±35.02	1.38±0.31	90.01±20.82	0.95±0.17
August	199.55±42.85	1.56±0.37	130.76±31.29	1.16±0.23	193.42±39.08	1.54±0.36	109.04±25.01	1.05±0.23
September	233.18±51.33	1.73±0.44	134.92±35.98	1.21±0.25	226.59±51.04	1.61±0.40	126.57±29.69	1.16±0.26
October	234.31±54.24	1.74±0.43	138.07±32.16	1.23±0.22	229.94±51.23	1.65±0.38	132.53±29.12	1.22±0.27
November	235.81±55.35	1.78±0.40	140.69±35.43	1.27±0.24	-	-	-	-
December	237.46±57.15	1.82±0.45	141.87±34.48	1.54±0.21	-	-	-	-

Mean morphometric performance of *F. macrophylla* reveled that, height growth in understorey condition (141.87) was 60 per cent of height growth in control condition (237.46) in *winter* crop. Whereas in *rainy* crop, height growth in understorey was 55 per cent to that in control. Similarly collar diameter growth was reduces by 15 per cent and 25 per cent under understorey condition compare to control in *winter* and *rainy* crop respectively. The reduction of 35 – 40 per cent in height and 15 – 25 per

cent in collar diameter under understorey conditions compared to control may be an indication of light demanding nature of leguminous *F. macrophylla*. Marginal growth changes of *F. macrophylla* during September, October in *rainy* crop and September, October, November, December in winter crop may be an indicative of possible active lac growing stage. However there is no published evidence to support the same.

Lac insects average length of settlement in *winter* and *rainy* crop on *F. macrophylla* in understorey didn't show much difference at both 21 and 75 days. Anyhow, the difference was visible under control conditions for both *winter* and *rainy* crop at 21 and 75 days after inoculation. In general, at 75 days after inoculation, length of settlement was higher in understorey than control condition for *winter* (84.6 per cent) and *rainy* (85.8 per cent) crops. At 21 days after inoculation, *winter* crop recorded maximum density of insect settlement in understorey (77.8/cm^2) compare to control (70.08/cm^2). Whereas in *rainy* crop at 21 days after inoculation, the trend was reverse. After 75 days of inoculation, density of settlement was higher under control (45.71/cm^2, 16.2/cm^2) than in understorey (38.05/cm^2, 13.5/cm^2) for *winter* and *rainy* crop respectively. This change is because of microclimatic influence in understorey of *Dalbergia sissoo* plantation. Overall, performance of lac insects on *F. macrophylla* was better in *winter* crop than *rainy* crop. Reduced length of settlement and lower density of settlement at 75 days compare to 21 days can be attributed to mortality of insects.

Table 2 Performance of kusumi and rangeeni strain lac insects on *Flemingia macrophylla*

Lac data	Kusumi strain – *Aghani* (winter) crop								Rangeeni strain – *Katki* (rainy) crop							
	Control				Understorey				Control				Understorey			
	Length of settlement (cm)	Density of settlement/cm^2			Length of settlement (cm)	Density of settlement/cm^2			Length of settlement (cm)	Density of settlement/cm^2			Length of settlement (cm)	Density of settlement/cm^2		
		Live	Dead	Total		Live	Dead	Total		Live	Dead	Total		Live	Dead	Total
21 days after inoculation																
Maximum	30 (100 %)	130	16	141	30 (100 %)	141	5	141	30 (100 %)	144	18	162	30 (100 %)	122	8	130
Minimum	11 (36.6 %)	23	3	26	10 (33.3 %)	14	1	22	13 (43.3 %)	38	1	41	13 (43.3 %)	17	0	21
Average	27.84 (92.8 %)	64.36	5.72	70.08	27.63 (92.1 %)	72.76	4.8	77.8	26.07 (87 %)	70.26	4.21	74.48	26.1 (87 %)	73.95	3.45	71.55
75 days after inoculation																
Maximum	30 (100 %)	85		85	30 (100 %)	65		72	29 (96.66 %)	25		25	29 (96.66 %)	21		21
Minimum	6 (20 %)	10		11	11 (36.6 %)	20		21	16 (53.3 %)	12		12	11 (36.6 %)	06		06
Average	21.52 (71.73 %)	45.51		45.71	25.39 (84.6 %)	36.35		38.05	22.53 (75.06 %)	16.15		16.15	25.75 (85.8 %)	13.5		13.5

Average sex ratio (Male:Female) of lac insects in *winter* crop on *F. macrophylla* at forty five days of inoculation was higher in understory (12:95, M:F) as compared to control (15:90, M:F). Whereas in *rainy* crop, sex ratio was higher in control (14:84, M:F) as compare to understory (11:57, M:F). Comparison of crops indicated that, *winter* have higher female per cm^2 than *rainy* under both control and understorey condition.

Table 3 Average sex ratio of lac insects on *Flemingia macrophylla* after forty five days of inoculation

Sex	Control	Understorey
Kusumi strain – *Aghani* (winter) crop		
Male	15.10±07.41	12.60±06.94
Female	90.40±18.56	95.00±17.90
Total	105.50±20.65	107.00±22.34
Rangeeni strain – *Katki* (rainy) crop		
Male	14.00±03.15	11.40±1.23
Female	84.30±16.13	57.30±8.76
Total	98.30±21.40	68.70±9.81

Fecundity experiments reveled that, lac shell weight before and after emergence is higher under control condition compare to understorey in *winter* (0.0285g, 0.0201g) and *rainy* (0.0382g, 0.0313g) with 307 and 315 number of insects respectively. Comparison of between crop showed higher lac shell weight before and after emergence and number of insects in *rainy* than *winter* crop.

Table 4 Fecundity of lac insects on *Flemingia macrophylla*

Treatments	Lac shell weight (g)		Number of insects
	Before emergence	After emergence	
Kusumi strain – *Aghani* (winter) crop			
Control	0.0285±0.011	0.0201±0.0054	307.00±206.58
Understorey	0.0262±0.008	0.0197±0.0048	264.00±180.37
Rangeeni strain – *Katki* (rainy) crop			
Control	0.0382±0.031	0.0313±0.0071	315.00±189.3
Understorey	0.0317±0.025	0.0231±0.0073	297.00±163.14

Table 5 Average *Ahgani* and *Katki* crop lac yield on *Flemingia macrophylla*

Parameters	Kusumi strain – *Aghani* (winter) crop		Rangeeni strain – *Katki* (rainy) crop	
	Control plot	Understorey plot	Control plot	Understorey plot
Number of shoots	4.22±1.06	3.10±01.19	4.41±0.89	2.26±01.20
Brood lac (g)	622.64±335.44	159.29±70.68	448.76±175.33	74.53±42.48
Stick lac (g)	342.74±189.76	93.38±37.73	219.02±85.76	39.47±22.81
Scrap lac (g)	166.64±88.66	63.63±25.30	81.47±27.03	17.00±11.78

Average brood and stick lac yield per plant is higher under control than understorey condition in both *winter* (622.64g, 342.74g) and rainy (448.76g, 219.02g) crop. The average 'scrap lac' yield in control was 166.64 g/plant, which is 2.6 times to that in understorey (63.63 g/plant) for *winter* crop. In *rainy* crop, average scrap lac yield is 81.47 g/plant, which is 4.8 times to that of yield in understorey (17.00g/plant). Experimental results revealed that though there was significant reduction in the scrap lac yield, lac cultivation is feasible on *F. macrophylla* in under-storey. With proper canopy management, there is potential of increasing not only its economic viability, but also ecological development via Joint Forest Management through peoples' participation in resource generation, management and sharing of benefits.

Conclusions

In understorey condition host plant growth is reduced by 40 per cent compared to control. Mortality of lac insect in understorey is more than 50 per cent because of microclimatic influence.

Average 'scrap lac' yield in control is 2.6 and 4.8 times of that in understorey for *winter* and *rainy* crop, respectively. These indicates that the cultivation of *winter* and *rainy* crop on non-conventional host *F. macrophylla* in not viable during initial years of intercropping. The significant reduction in the scrap lac yield in understorey has to be addressed by proper canopy management and long term experiment. However, if intangible benefits like soil and water conservation, nutrition enrichment by addition of organic carbon and nitrogen fixation if been taken into consideration by future explorations on long term basis, lac cultivation in understorey of plantations may become viable.

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