Article

Influence of soil nutrient combination on *Flemingia semialata*, lac insect growth and lac insect pest

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Received 30 March 2017; *Accepted 10 May 2017*; *Published 1 September 2017*

Abstract
Lac is a natural resin of outstanding properties and exceptional versatility, secreted by tiny coccid insect *Kerria lacca*, which is reared on some specific plants. Lac insect take their nutrition from the host plant, hence soil nutrient become most important component for sustainable lac cultivation and host plant growth. Therefore, to determine the suitable nutrient combination dose of N, P and K on lac host plant growth, lac yield and their predation and parasitization an experiment was undertaken. The result showed N, P and K soil nutrient combination in treatment 2 ($T2=N_{15}:P_5:K_5$) was found to be the most suitable for lac production and least insect pest infestation. The soil nutrient supplied to plants was positively influences the *F. semialata* plant growth. It shows that soil nutrient must be applied for lac cultivation on *F. semialata* for their sustainable development, better lac production and less predator infestation.

Keywords *Flemingia semialata*; lac; parasite; predator; soil nutrient.

Arthropods
ISSN 2224-4255
URL: http://www.iaees.org/publications/journals/arthropods/online-version.asp
RSS: http://www.iaees.org/publications/journals/arthropods/rss.xml
E-mail: arthropods@iaees.org
Editor-in-Chief: WenJun Zhang
Publisher: International Academy of Ecology and Environmental Sciences

1 Introduction

Lac is a resin of outstanding properties and exceptional versatility. Particularly, it is the only known commercial resin of animal origin, which is secreted by tiny insect *Kerria lacca* (Kerr.), belongs to order Hemiptera and family Coccidae. Lac insect, feed on tender shoot of the plant and secrete resin from their body, which become hardened in contact of air called 'lac'. India is the largest producer (Sharma *et. al*, 1999) and exporter of lac since the last 30 years which contributes approximately 60% of the total lac followed by Thailand in global lac trade (Kujur and Lall, 2013). Lac resin has a unique combination of properties utilizes as medicine, cosmetics, electronic, furniture, etc industries (Ansari, 2013). The lac insect is traditionally cultivated on Kusum (*Schleichera oleosa*), Palas (*Butea monosperma*) and Ber (*Ziziphus mauritiana*). The lac production witnessed steep downfall in the past decades, due to reduction in population amid of indiscriminate deforestation, infection of disease and insect pests and loosing vigor of host tree. There is need to increase the host plant population of short duration like *Flemingia semialata* (Papilionacae: Laguminasae). *F. semialata* is a fast growing perennial woody shrub of short height and tender shoots which showed grater promise for lac host and cultivation (Yadav et al., 2005). *F. semialata* has proved as a potential lac host plant and being cultivated by the farmers in Jharkhand, Chhattisgarh, West Bengal and Madhya Pradesh. *F. semialata* is a potential host plant for *kusmi* strain of lac insect and gives good economic return (Krishnaswami et al., 1959, Yadav et al., 2005). Subsequently, lac insect is infested with many parasite and predator and they causes major loss to the lac yield. About, 40 % lac yield loss causes by *Eublemma amabilis* (Bhattacharya et al. (2007) and by 18.40 % in *kusmi* and 26 % in *rangeeni* strain due to parasitization was reported (Sharma *et. al*, 2007). Additional soil nutrient supply to the lac host plant is major factor for plant health and additionally for lac insect growth and development. It is proved by Fennah (1959) that N, K and P, causes positive, negative and indifferent effects, respectively on mealy bug population. Subsequently, safety of lac insect while supply of nutrition to the host plant is most challenging for scientific lac cultivation. Nutrients supply to the plant influences the growth of mealy bug (Fennah, 1959) and also of lac (Thakur, 1932). Though, no work has been done on screening of the effect of soil nutrients combination on *F. semialata* growth and lac development. Keeping these in view into consideration, the present study has been undertaken to investigate the soil nutrient combination effect on *F. semialata* growth a lac production and lac insect pest infestation.

2 Materials and Methods

2.1 Location and layout

The present study was carried out from 2011 to 2014 at Institute of Forest Productivity (IFP) research campus, Ranchi, India situated at latitude $23^0$21’26”N, longitude $84^0$14’44”. The *F. semialata* seed was collected from Indian Institute of Natural Resin and Gums, Ranchi, India and nursery was raised at IFP Ranchi in poly bags filled with mixture of 2:1:1 of Soil: Sand: FYM in the month of May, 2011. Seedlings were transplanted after two months of age. The distance between rows was 1.5 m and plant to plant 1.0 m was maintained in the 3.5m x 3.5m sized plots. This way, 12 plants were planted in each treatment and each treatment was replicated thrice. Regular irrigation and weeding were done for better growth of the plants. Total nine treatments with different combination of soil nutrient (N, P & K) as T1=N_5:P_{15}:K_5; T2=N_{15}:P_5:K_5; T3=N_{15}:P_{10}:K_{15}; T4=N_5:P_5:K_{10}; T5=N_{10}:P_{15}:K_{10}; T6=N_{10}:P_{15}:K_5; T7=N_{10}:P_{10}:K_{10}; T8=N_{15}:P_{10}:K_5; T9=N_5:P_5:K_5 and a control were applied in randomized block design (RBD) manner. The soil nutrients (NPK) were applied twice in a year in the month of July and February followed by irrigation. Urea fertilizer was used for nitrogen supply; DAP fertilizer was used for phosphorus and muriate of potash was used for supply of potash nutrient.

2.2 Cultivation practices

The basic cultivation practice was followed of Yadav *et al.*, 2005. After one year of transplanting, ‘*Kusmi’* strain brood lac stick @ 20 gm /plant was filed in the nylone net bags and tied with the plants in the month of July. This brood lac was removed after 21 days of inoculation. Basic lac insect protection measures were applied uniformly for each treatment.

2.3 Data observations

To assess effect of nutrient management on growth and development of *F. semialata,* five plants were randomly selected and plant height was recorded at two months of interval and final data was recorded in the month of January just before the lac harvesting. Randomly three plants were tagged for observation of lac insect predator of *Eublemma amabilis, Psudohypatropa pulverea* and parasite infestation. This observation was taken at monthly interval and data was pulled for overall infestation per unit of branch. Similarly, parasite infestation data was also observed at monthly interval by cutting and rearing of lac encrusted branches in glass jars under laboratory condition and parasite emerged were counted. The lac insect cell was weight just before harvesting lac cells, twenty lac cells were randomly removed from four plants in each replication and weighed in the month of February and data was recorded. Matured lac was harvested manually in the month of

February and three randomly selected plants encrusted with lac insects were recorded for brood lac yield. The encrusted lac of the same harvested plant was used for stick lac and scrap lac yield.

2.4 Statistical analysis

To get a comprehensive picture of result of growth, predator and parasite infestation and yield attributes, data were subjected to statistical analysis. One way ANOVA (analysis of variance) data analysis performed and significant differences were found at P = 0.05; additionally, correlation among plant growth, lac production and parasite and predator infestation was also calculated suing the SPSS 21.0 statistical package.

3 Results

Observations recorded during the course of experimentation has been presented in tables, illustrated graphically and described in this chapter as follows.

3.1 *F. semialata* plant growth and lac yield

The maximum height growth of the host plant was observed (180.89 cm) in T5=N_{10}:P_{15}:K_{10} was significantly superior followed by T3=N_{15}:P_{10}:K_{15} (164.89 cm) and T2=N_{15}:P_5:K_5 (160.60 cm) as compared to control (111.83 cm) (Table 1).

While, brood lac production was highest (359.06 gm / plant) in T2=N_{15}:P_5:K_5 significantly higher, followed by T9=N_5:P_5:K_5 (294.44 gm / plant) as compared to control (101.75), but the stick lac was maximum in T9=N_5:P_5:K_5 (105.42 gm) followed by T2=N_{15}:P_5:K_5 (103.79 gm) as compared to control (42.41gm). Scrap yield was maximum produced in T2=N_{15}:P_5:K_5 (43.76 gm), followed by T9=N_5:P_5:K_5 (30.77 gm) as compared to control (9.60 gm). Similarly, lac shall weight was maximum obtained in T2=N_{15}:P_5:K_5 (0.0502 gm) followed by T9=N_5:P_5:K_5 (0.0442 gm) as compared to control (0.0343 gm) (Table 1).

3.2 Infestation of predator and parasite on lac insect

The soil nutrient combination of T2=N_{15}:P_5:K_5 has received significantly minimum parasite infestation (12.39 /cm), followed by T9=N_5:P_5:K_5 (13.50/ cm), as compared to control (23.61 parasite/cm). Minimum infestation of *P. pulverea* was found to be in T8=N_{15}:P_{10}:K_5 (2.50/ 4 cm), followed by T6=N_{10}:P_{15}:K_5 (2.65/ 4 cm) as compared to control (3.81/4cm). While, non-significantly minimum infestation of *Eublemma amabilis* (1.33 /4cm) was observed in T2=N_{15}:P_5:K_5, followed by T5= N_{10}:P_{15}:K_{10} (1.44/ 4cm), as compared to control (2.50 larvae/4cm) (Table 2).

Table 1 Soil nutrient effect on *F. semialata* and lac yield.

Treatments	Plant height (cm)	Brood lac (gm)	Stick lac (gm)	Scrap lac (gm)	cell weight (gm)
T1=N_5:P_{15}:K_5	160.22	215.44	82.81	28.28	0.0428
T2=N_{15}:P_5:K_5	160.61	359.06	103.79	43.76	0.0502
T3=N_{15}:P_{10}:K_{15}	164.89	262.56	78.33	25.73	0.0357
T4=N_5:P_5:K_{10}	156.72	246.46	89.61	29.2	0.0428
T5=N_{10}:P_{15}:K_{10}	180.89	212.22	64.04	20.17	0.0382
T6=N_{10}:P_{15}:K_5	145.00	186.28	63.71	18.74	0.0370
T7=N_{10}:P_{10}:K_{10}	156.00	215.61	76.66	21.58	0.0383
T8=N_{15}:P_{10}:K_5	129.89	124.94	43.235	13.14	0.0372
T9=N_5:P_5:K_5	138.22	294.44	105.42	30.77	0.0442
Control	111.83	101.75	42.41	9.6	0.0343
Cd at 0.05%	**26.13**	**99.10**	**32.70**	**10.48**	**0.0083**
SEM±	**9.27**	**35.15**	**11.00**	**3.52**	**0.0029**

Table 2 Soil nutrient effect on predator and parasite of lac insect.

Treatments	Parasite /cm	*P. pulverea* /4 cm	*E. amabilis* /4 cm
$T1=N_5:P_{15}:K_5$	19.39	2.76	2.06
$T2=N_{15}:P_5:K_5$	12.39	2.69	1.33
$T3=N_{15}:P_{10}:K_{15}$	17.61	2.66	1.67
$T4=N_5:P_5:K_{10}$	18.67	2.92	1.83
$T5=N_{10}:P_{15}:K_{10}$	18.89	2.87	1.44
$T6=N_{10}:P_{15}:K_5$	19.28	2.65	1.69
$T7=N_{10}:P_{10}:K_{10}$	16.94	2.83	2.17
$T8=N_{15}:P_{10}:K_5$	18.56	2.50	2.11
$T9=N_5:P_5:K_5$	13.50	2.89	1.42
Control	23.61	3.81	2.50
Cd at 0.05%	**5.69**	**0.88**	**0.90**
SEM±	**2.01**	**0.31**	**0.32**

Correlation result showed that (Table 3) nutrient application influences the plant growth, which was positively correlated with brood lac (0.572), stick lac production (0.517) and lac cell weight (0.308). Similarly, soil nutrient effect was also observed in the correlation with brood lac production, which was positively correlated with stick lac (0.939), scrap lac production (0.961) and lac cell weight (0.809), but, negatively correlated with parasite infestation (-0.875), *P. pulverea* (-0.404) and *E. amabilis* infestation(-0.797). Similarly, scrap lac was positively correlated with scrap lac (0.931), cell weight (0.829), and negatively correlated with the parasite infestation (-0.809), *P. pulverea* (-0.307) and *E. amabilis* infestation (-0.692). Cell weight was negatively correlated with parasite infestation (-0.769), *P. pulverea* (-0.294) and *E. amabilis* infestation (-0.574), but the parasite infestation was found to be positively correlated with *P. pulverea* (0.559) and *E. amabilis* infestation (0.744).

Table 3 Correlation between plant growth, lac production and insect pest.

Correlation matrix	Plant height	Brood lac	Stick lac	Scrap lac	Cell weight	Parasite /cm	*P. pulverea* /4 cm
Brood lac	0.572						
Stick lac	0.457	0.939					
Scrap lac	0.517	0.961	0.931				
Cell weight	0.308	0.809	0.829	0.912			
Parasite /cm	-0.364	-0.875	-0.809	-0.819	-0.769		
P. pulverea /4 cm	-0.527	-0.404	-0.307	-0.388	-0.294	0.559	
E. amabilis /4 cm	-0.605	-0.797	-0.692	-0.692	-0.574	0.744	0.513

4 Discussion

The plant required some minimum nutrient for their survival, growth and propagation, which they take from soil, but if the soil has no ability to supply enough nutrient, then additional nutrient application to the plant is required. Subsequently, if any other organism is getting food from the plant then additional nutrient must be supplied. In my study, the host plants supplied with more nitrogen, phosphorus and potash has obtained the maximum height. This may be due to effect of nitrogen, which increases the plant growth, and phosphorus and potash which induces the resistance in plant against insect pest. Trials on lettuce plants showed that shoot growth rate was directly proportional to total N concentration, and linearly related to K and P concentration (Burns, 1992). Similarly, the plant growth of *Vigna mungo* was positively influences by the phosphorus application (Rajput and Verma, 1982). In this study, treatment with maximum level of nitrogen (15g/plant), and minimum level of phosphorus (5g/plant) and potash (5g/plant) supplied plants has given the best lac yield and lac cell development. The treatment supplied with maximum nitrogen has made the plant more succulent and susceptible to the lac insect feeding. Scriber (1984) and Slansky and Rodriguez (1987) also reported that total nitrogen is the critical nutrient for both plants and herbivore. In this study, lac host plant *F. semialata* needs more nutrients for their sustainable development and nutrient supply to the lac insect. Similarly, Mattson (1980), Meyer (2000) and Fennah (1959) reported that nitrogen fertilizer increases the survival ability of plant and to recover from herbivore. Mattson (1980) reported that, with increasing supply of N fertilizer in Larrea tridentate plant, increases the amount of nutrients availability for insect and increase the populations of sucking insects.

Application of fertilization can influence susceptibility of plant to insect pests by altering plant tissue nutrient levels (Altieri and Nicholls, 2003). Nitrogen soil nutrient has increases the lac insect population and subsequently lac yield in this study, supported by the findings of Supriya et al. (2009); Lu et al. (2007); Ghorbani and Khajehali (2013) in which they argued that the increasing level of nitrogen fertilizer increases the population density of sucking pest in the crop. Similarly, proved that increases in soluble nitrogen in leaf tissue increases the fecundity and developmental rates of the green peach aphid, *Myzus persicae* (ven Emden 1966), leafhopper (Venugopal, 1987). Hence, the lac growth and development is supported with N nutrient application.

The application of phosphorus soil nutrient was found to be negative for the development of lac insect and lac production in this study. The similar findings of Narayansamy et al. (1976), Venugopal (1987), Raju et al. (1996) and Kulagod et al. (2011) show that, application of phosphorus fertilizer negatively influences the leafhopper population, and reduce the sucking pest population in paddy. It is also proved by Fennah (1959) that phosphorus indifferently influences the growth of sucking pest mealy bug. Similarly, response of P fertilizers was found to be negative on *T. telarius* mite in Apples by (Luna, 1988),

The response of potash (K) soil nutrient was found to be negative on the lac production in this study, because maximum lac production was recorded in the treatment supplied with lower potash fertilizer. The finding of this study was supported by the studies of Luna (1988) in which negative effect of K was noticed on *M. persicae* aphid infesting to *Bryobia praetiosa* and leafhopper population in rice (Kulagod et al., 2011). Additionally, Raju et al. (1996) reported that potassium at enhanced doses induced resistance to rice against leafhopper.

In this study, the minimum population of parasitoid was observed in the treatment 2 ($T2=N_{15}:P_5:K_5$), having maximum level of nitrogen and minimum level of phosphorus and potash, while no significant effect was noticed in case of predators infestation. The findings of Lohaus et al. (2013) argued that increasing nitrogen input suppresses the activity of cereal aphid parasitic wasps. While, Zhao et al. (2015) reported that the increasing input of nitrogen fertilizer significantly enhanced the primary parasitism in wheat field but negatively affected the predator/pest ratio. Finally, it may be concluded that the nitrogen soil nutrient supports the plant growth as well as the lac insect growth, but phosphorus and potash fertilized increases the resistance in the plant against insect pest, hence these two fertilizers showed the negative effect against lac insect. But a minimum level of phosphorus and potash fertilizer must be applied to the lac host plant for their sustainable growth.

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