ISSN 2449-8955 European Journal of Biological Research Research Article

DOI: http://dx.doi.org/10.5281/zenodo.3551585

Lac, *Kerria lacca* rearing on *Flemingia macrophylla* with NPK fertilizer: impact on plant growth, lac yield, and lac parasitisation

Arvind Kumar[1]*, Manju Rani[2]

[1] Forest Protection Division, Forest Research Institute, Dehradun-248006 (Uttarakhand), India

[2] Institute of Forest Productivity, Ranchi (Jharkhand), India

*Correspondence: Phone: +91-135-2224281; E-mail: arvind.ento@gmail.com

Received: 22 September 2019; **Revised submission:** 06 November 2019; **Accepted:** 18 November 2019

http://www.journals.tmkarpinski.com/index.php/ejbr

ABSTRACT: Lac insect, *Kerria lacca* Kerr. is the only commercial lac producing insect in the world. This tiny insect reared commercially on many specific host plants. Lac product is a natural resin of outstanding properties which is utilized in many products worldwide. Lac insects get settled on the host tree and take their nutrition continuously from the same part. Hence, additional fertilizer application becomes most important component for sustainable host plant growth and lac cultivation. Therefore, to determine the effect of chemical fertilizers (NPK) on *Flemingia macrophylla* and lac productivity, present study has been conducted. The result revealed that chemical fertilizer combination N_{15}:P_5:K_5 was found to be the best for *Flemingia macrophylla* growth which gives best lac yield and least pest infestation on *Kerria lacca*. The correlation study has also proved that NPK has positively influences on plant growth and lac productivity.

Keywords: *Flemingia macrophylla*; *Kerria lacca*; Soil nutrient; Parasitoids; *Eublemma amabilis*; Predator; Bhalia.

1. INTRODUCTION

Kerria lacca Kerr. (Hemiptera: Coccidae) is also called as lac insect in the world and produces a natural resin. Lac resin is the only commercial natural resin of economic importance secreted by *K. lacca*, which has many outstanding properties; hence has demand throughout the world. Lac resin is a lac gland secretion of *K. lacca* which become hardened in contact with air [1]. Lac is considered as a miner forest produce but has significant contribution in tribal economy lac producing states of India [2]. India is leading lac producer and exporter [3] globally sharing about 60 percent world's lac production followed by Thailand [4]. Lac resin has versatile properties which make its hues demand in electronic, food, medicine, cosmetics, furniture and many other industries [5]. The tribal communities of Jharkhand, Chhattisgarh, Madhya Pradesh and Maharashtra are conventionally engaged in *K. lacca* rearing on natural host plants viz. *Ziziphus mauritiana, Butea monosperma* and *Schleichera oleosa*. A significant population reduction in these natural hosts has been observed in the past decades [6]; due to climatic and biotic factors; subsequently, lac production has also been declined drastically. Therefore, *Flemingia macrophylla* (Papilionaceae:

Laguminosae) (Willd.) Kuntze Ex Merr., has been introduces for *K. lacca* rearing. *F. macrophylla* is a fast growing perennial shrub of short height and produce tender shoots, easy to manage and showed great potential as a *K. lacca* host, has been utilized to sustainable increase in *K. lacca* rearing and lac production [7-10]. *F. macrophylla* was found to be a potential *K. lacca* host plant for it's both *'kusumi'* and *'rangeeni'* strains [11-13] *K. lacca* population loss due to insect predation was recorded about 40% [14] and due to parasitoids about 18.40% in *kusmi* and 26% in *rangeeni* strain [15] has been recorded. This loss caused by insect predator and parasitoids has been addressed by many means, but in this study emphasis has also been given to assess the effect of NPK on *K. lacca* insect predation and parasitisation in addition to plant growth and lac yield. It was recorded application of chemical fertilizer for better plant growth and development was found to be very effective. Subsequently, nitrogen fertilizer supply in host plants positively influence the sucking pest population, phosphorus gives indifferent effect, but potash recorded as negative impact on mealy bug population [16] and also of *K. lacca* [17], but no study has been undertaken to assessment the effect of NPK on *K. lacca*.

Hence, to promote the *F. macrophylla* for *K. lacca* rearing and fetch a great lac yield, present study has been conducted with NPK application on *F. macrophylla*. NPK effect has been assessed on host plant growth, *K. lacca* shell development, lac yield and lac insect pest infestation.

2. MATERIALS AND METHODS

This experiment was carried out at research campus, Institute of Forest Productivity (IFP) Ranchi, India (Latitude $23^0$21'26"N, longitude $84^0$14'44"E). The seeds of plants were brought from IINRG, Ranchi, India and nursery was raised at the Institute of Forest Productivity. Environmental condition parameters viz. average temperature, relative humidity and rainfall of the lac cultivation period is presented in Table 1. The seedlings were planted at the distance row to row 1.5 m and plant to plant 1.0 m. The experiment was conducted in randomized block design (RBD) manner with nine treatments of chemical fertilizers N, P & K at different combinations *viz.*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 along with a control. Two months old twelve seedlings were planted in each treatment and were replicated thrice. Fertilizers treatment was applied in July and February months followed by irrigation twice in a year. All the recommended basic cultivation practice *viz.* irrigation and weeding [18] were done regularly. After one year, '*Kusmi'* 20 gm brood lac per plant was inoculated in the month of July.

Table 1. Environmental parameters (average) of lac cultivation location (2012-2014).

Months	Temperature (^{0}C)	Humidity (%)	Rainfall (mm)
July	27.11	74.14	385.00
August	26.31	77.97	564.33
September	25.00	70.00	638.83
October	22.10	63.17	529.50
November	18.73	63.17	268.67
December	15.18	56.17	274.50
January	15.14	56.67	405.33
February	19.05	55.83	410.50

Five plants were randomly selected and plant growth data was recorded at two months of interval till lac harvesting. Plant parts along with lac incrustation were collected at monthly interval and brought to the laboratory and reared for predator *E. amabilis, P. pulverea* and parasitoids infestation observation. Host plant was harvested at lac maturity in the month of February. Three randomly selected plants out of five selected host plant, encrusted with lac insects were recorded for lac yield. Subsequently, same harvested lac yields were used for stick lac and scrap lac yield observations. Twenty lac insect shells were randomly removed from four plants and weight have been recorded just before hatching of nymphs. Data was statistically analysis with one way ANOVA (analysis of variance) to drown the result and significant differences were calculated at P = 0.05. To find out the relation among plant growth, lac yield and parasitoids and predator infestation, correlation analysis was done using the SPSS 21.0 statistical package.

3. RESULTS AND DISCUSSION

The data of experiment recorded are presented in tables and described as follows:

3.1. *F. macrophylla* plant growth and lac yield

The data presented in Table 2 revealed that maximum growth of the host plant was observed (243.50 cm) in T2=N_{15}:P_5:K_5 was significantly superior followed by T3=N_{15}:P_{10}:K_{15} (228.67 cm) over control (136.33 cm).

Table 2. Effect of chemical fertilizer on *F. macrophylla* and lac yield.

Treatments	Plant height	Brood lac yield	Stick lac	Scrap lac	Shell wt.
T_1=N_5:P_{15}:K_5	216.89	502.11	115.09	20.13	0.0392
T_2=N_{15}:P_5:K_5	243.5	659.33	127.36	36.25	0.0482
T_3=N_{15}:P_{10}:K_{15}	228.67	533.94	102.01	26.36	0.0451
T_4=N_5:P_5:K_{10}	220.00	448.72	95.79	20.90	0.0422
T_5=N_{10}:P_{15}:K_{10}	197.17	399.22	86.02	17.02	0.0393
T_6=N_{10}:P_{15}:K_5	209.78	387.44	83.77	14.74	0.0417
T_7=N_{10}:P_{10}:K_{10}	202.72	597.33	136.7	24.34	0.0467
T_8=N_{15}:P_{10}:K_5	210.39	420.83	85.75	14.35	0.0453
T_9=N_5:P_5:K_5	202.94	368.78	84.97	16.89	0.0462
T_{10}= control	136.33	249.33	58.97	7.8	0.0322
SEM±	11.53	294.15	16.65	3.62	0.0031
CD at 5%	30.89	105.12	51.24	10.83	0.0091

Brood lac yield was found to be maximum (659.33 g/plant) in T2=N_{15}:P_5:K_5 significantly higher, followed by T7=N_{10}:P_{10}:K_{10} (597.33 g/plant) over control (249.33 g), But, stick lac was maximum recovered in T7=N_{10}:P_{10}:K_{10} (136.7 g) followed by T2=N_{15}:P_5:K_5 (127.36 g) over control (58.97 g). Scrap lac yield was maximum found in T2=N_{15}:P_5:K_5 (36.25 g), followed by T3=N_{15}:P_{10}:K_{15} (26.36 g) over control (7.80 g). Lac shell weight was highest recorded in T2=N_{15}:P_5:K_5 (0.0482 g) followed by T7=N_{10}:P_{10}:K_{10} (0.0467 g) over control (0.0322 g).

In this study, fertilizer combination supplied with maximum nitrogen and least phosphorus and potash has obtained the maximum growth. It seems that nitrogen increases the plant succulence, additionally, potassium application in soil increased water uptake and reduces dry matter per cent in plant shoot [19] and make the plant more succulent which favours lac insect feeding and growth. The findings of [20] confirmed that nutrient management of lac host trees increased the lac production. *K. lacca* insect has obtained the maximum yield [21] shell weight reared on *Zizyphus mauritiana* [22]; and in *F. semialata* applied with NPK in combination [6]. Additionally, the findings of Burn [23] argued that, lettuce plant growth was positively related to N concentration while, K and P concentration was linearly related. In the same treatment plants has given the best brood lac, scrap lac yield and lac shell weight. This may be because of treatment supplied with maximum nitrogen which has made the plant more succulent and susceptible to the lac insects feeding. This finding of previous worker says that nitrogen fertilizer positively influences the plant growth and herbivores [24], nitrogen fertilizer which increases the survival ability of plant and to recover from herbivore feeding [25-27]. The increasing supply of N fertilizer in *Larrea tridentate* and other plants plant increases the amount of nutrients availability for insect and also increase the population of sucking insect pests [25, 28-30]. Similarly, increase in soluble nitrogen in leaf tissue, increases the fecundity and developmental rates of the green peach aphid, *Myzus persicae* [31] and leafhopper [32].

Increasing application of phosphorus fertilizer negatively influences the leafhopper population and reduces the sucking pest population in paddy [32-35]; mealy bug on and *T. telarius* mite population [16, 36]. Minimum level of potash supported the lac growth in my study this may be because potash fertilizer increases water intake and reduces the dry matter content in the plant and, similar to potassium at enhanced doses induced resistance to rice against leafhopper and negative effect of K was also noticed on *M. persicae* aphid and on leafhopper population in rice [34-36].

3.2. Predation and parasitisation on *K. lacca*

Table 3 reveled that minimum infestation of predator *P. pulverea* was recorded in T2=N_{15}:P_5:K_5 (1.87/4 cm), followed by T4=N_5:P_5:K_{10} (2.00/4 cm) over control (2.89/4 cm). While, least infestation (non-significant) of *Eublemma amabilis* (1.53/4 cm) was recorded in T2=N_{15}:P_5:K_5, followed by T3=N_{15}:P_{10}:K_{15} (1.58/4 cm), over control (2.00 larvae/4 cm). Chemical fertilizer nutrient combination T2=N_{15}:P_5:K_5 was recorded significantly least parasitoids infestation (11.06/cm), followed by T7=N_{10}:P_{10}:K_{10} (12.78/cm), over control (19.94 parasitoids/cm).

Table 3. Effect of chemical fertilizer on predator and parasitoids of *K. lacca*.

Treatments	*P. pulverea* population/4 cm	*E. amabilis* population/4 cm	Parasitoids
T_1=N_5:P_{15}:K_5	2.33	1.64	14.67
T_2=N_{15}:P_5:K_5	1.87	1.53	11.06
T_3=N_{15}:P_{10}:K_{15}	2.39	1.58	14.89
T_4=N_5:P_5:K_{10}	2.00	1.86	15.78
T_5=N_{10}:P_{15}:K_{10}	2.19	1.70	16.11
T_6=N_{10}:P_{15}:K_5	2.18	1.71	15.17
T_7=N_{10}:P_{10}:K_{10}	2.49	1.73	12.78
T_8=N_{15}:P_{10}:K_5	2.38	1.83	14.89
T_9=N_5:P_5:K_5	2.15	1.72	15.72
T_{10}= control	2.89	2.00	19.94
SEM±	0.23	0.27	1.63
CD at 5%	0.66	0.77	3.86

The similar findings were also recorded by Kumar [6] where it was revealed that fertilizer combination with more nitrogen received less parasitoids and predator infestation in lac insect. Similarly, increasing nitrogen doses suppresses the activity of parasitic wasps of cereal aphid was recorded [37] and negatively affected the predator/pest ratio [38].

3.3. Correlation study

Chemical fertilizer NPK application influences the plant growth, which was positively correlated (table 4) with brood lac yield (0.789), stick lac yield (0.672), scrap lac yield (0.800) and lac shell weight (0.788). Similarly, brood lac yield production showed positive correlation with stick lac yield (0.952), scrap lac yield (0.941) and lac shell weight (0.727), but negatively correlated with *P. pulverea* (-0.482); *E. amabilis* infestation(-0.758) and parasitoids infestation (-0.932). Similarly, stick lac yield was positively correlated with scrap lac yield (0.835), shell weight (0.653) and infestation of *P. pulverea*, *E. amabilis* predators and parasitoids was negatively correlated (-0.385); (-0.667) and (-0.888), subsequently. Shell weight was found to be negatively and significant correlation with *P. pulverea* (-0.604), *E. amabilis* infestation (-0.621) and parasitoids infestation (-0.868), but the parasitoids infestation was found to be positively correlation with *E. amabilis* infestation (0.777) and *P. pulverea* (0.631).

Table 4. Correlation between plant growth, lac production and insect pest infestation on *K. lacca.*

Correlation matrix	Brood lac	Stick lac	Scrap lac	Shell weight	*P. pulverea* /4 cm	*E. amabilis* /4 cm	Parasitoids /cm
Plant height	0.789	0.672	0.800	0.788	-0.807	-0.801	-0.843
Brood lac		0.952	0.941	0.727	-0.482	-0.758	-0.931
Stick lac			0.835	0.653	-0.385	-0.667	-0.888
Scrap lac				0.709	-0.607	-0.795	-0.865
Shell weight					-0.604	-0.621	-0.846
P. pulverea/4 cm						0.583	0.631
E. amabilis/4 cm							0.777
Parasitoids/cm							0

An experiment conducted for lac rearing on *F.* semialata resulted same correlation [6] and it has also proved that application of phosphorus, negatively influences the leafhopper population and reduce the sucking pest population in paddy [32-35].

4. CONCLUSION

Each organism on the planet need energy for their developments, similarly, plant fulfils their nutritional requirements from the soil for their survival, growth and propagation. Sometimes, soil become inefficient to supply required nutrient to the plant in this condition additional nutrient required to be apply in the soil in form of chemical fertilizer or other means. And, if any other insect is drawing food from the plant then, additional nutrient application become critical for plant survival. In this study, host *F. macrophylla* was grown with additional nitrogen, phosphorus and potash has obtained the maximum growth. But maximum lac yield was recovered in least P and K treatment. This may be due to effect of nitrogen, which increases the plant growth and made the plant more succulent and favorable for insect feeding. Subsequently, potash increases the water uptake and reduced the dry matter content in the plant. Hence, it may be recommended that rearing of *K. lacca* on *F. macrophylla* should be applied with additional NPK to get better lac yield and less *K. lacca* insect pest infestation.

Authors' Contributions: The first author is an entomologist and he has contributed the insect rearing and other lac incest related parameters while second author is a soil scientist and she has contributed the soil nutrition and its effect on *Flemingia macrophylla*. Both authors wrote, read and approved the final manuscript.

Conflict of Interest: The authors have no conflict of interest to declare.

REFERENCES

1. Kumar A, Prasad RS, Singh O. Comparative study of two bushy lac insect host plants *Flemingia semialata* Roxb. ex W.T. Aitonand *Flemingia macrophylla* (Wild.) Merr. and lac insect performance. J Entomol Zool Stud. 2017; 5(5): 1134-1136.
2. Diwakar BN. Exploration of lac cultivation on non-traditional host *Flemingia macrophylla* (Willd.) Kuntze Ex Merr. and its possibility on understory of *Dalbergiasissoo* Roxb. Int J Forest Soil Erosion. 2013; 3(4): 129-133.
3. Sharma KK, Jaiswal AK, Kumar KK. Biological control in lac cultivation - limitations and prospects. J Insect Sci. 1999; 12(2): 95-99.
4. Kujur RS, Lal RR. Lac market: An overview. In: Kumar A, Das R, eds. Prospects of Scientific lac cultivation in India. 2013: 263-269.
5. Ansari MF. Merits of shellac in lacquers and paints. In: Kumar A, Das R, eds. Prospects of Scientific lac cultivation in India; 2013: 159-172.
6. Kumar A. Influence of soil nutrient combination on *Flemingia semialata*, lac insect growth and lac insect pest. Arthropods. 2017; 6(3): 95-101.
7. Lal S, Ram M, Singh BP, Shrivastava SC. Bhalia: A versatile lac host plant. Indian Farming. 1976; 27(8): 9-11.
8. Bhagat ML. Field studies on the initial mortality of lac insect *Kerria lacca* Kerr. in relation to host plants. Indian Forester. 1988; 114(6): 339-342.
9. Sen AK, Bhattacharya A, Srivastava SC. Record of *Aphis craccivora* Koch. and *Aphis gossypii* Glov. (Fam: Aphididae) on *Moghania macrophylla* a host plant of lac insect. Entomon. 1987; 12(3): 229.
10. Kumar P, Chauman NS. Problems and prospects of lac-host breeding. Indian Farming. 1976; 27(8): 31-33.
11. Krishnaswami S, Purkayastha BK, Chauhan NS. *Moghania macrophylla* (Wild). O. Ktze. (Syn. *Flemingia congesta* Roxb. var. semialata Bak.) as a new lac host for growing the Kusmi strain of the lac insect. Curr Sci. 1959; 28: 419-420.
12. Purkyastha BK. Studies on the introduction of *Moghania macrophylla* for the cultivation of lac. Indian Forester. 1969; 95: 560-566.
13. Bhattacharya A, Kumar S, Jaiswal AK. Evaluation of *Trichogramma* species for the suppression of Lepidoptera insect predator, *Eublemma amabilis* Moore in lac culture on *Flemingia macrophylla*. J Biol Control. 2007; 21(2): 267-270.
14. Bhattacharya A, Mishra YD, Sushil SN, Jaiswal AK, Kumar KK. Relative efficacy of some *Trichogramma* spp. for management of lepidopteran predators of lac insect, *Kerria lacca* (Kerr) under field conditions. Biological control of Lepidopteran pests. Proceedings of the Symposium of Biological Control of Lepidopteran Pests, July 17-18, 2002, Bangalore, India. 2003: 301-303.
15. Sharma KK, Kumari K, Lakhanpaul S. Superparasitism in Indian lac insect, *Kerria lacca* (Kerr) and its implication on fecundity and resin producing efficacy of its two strains. Entomon. 2007; 32(1): 33-39.

16. Fennah RT. Nutritional factors associated with development of mealy bugs in Cacao. Rep Cacao Res Inst. 1959; 1957-58: 18-28.
17. Thakur AK. Comparative study of lac hosts with special reference to *A. catechu* and *C. florida*. ILRI Bulletin 1932; 9.
18. Yadav SK, Mishra YD, Singh BP, Kumar P, Singh RN. Kusmi lac production on *Flemingia semialata*. Indian Lac Research Institute, Namkum Ranchi. Technical Bull. 2005; 5: 11.
19. Zengin M, Fatma G, Atilla MY, Gez Gin S. Effect of potassium magnesium and sulphur containing fertilizers on yield and quality of sugar beets (*Beta vulgaris* L.). Turk J Agric 2009; 33: 495-502.
20. Paul B, Kumar S, Das A. Lac cultivation and their host trees found in Bastar Forest Division. Plant Sci Feed. 2013; 3(1): 8-12.
21. Namdev BK, Thomas M, Kurmi A, Thakur AS, Upadhyaya A. Impact of nutrient management of *Zizyphus mauritiana* (Lamb.) on the yield of kusmi lac. Bioscan. 2015; 10(3): 1219-1222.
22. Shah TH, Thomas M, Bhandari R. Impact of nutrient management in *Zizyphus mauritiana* (Lamb.) on the survivability of lac insect and the yield of Aghani crop of *Kusmi* lac. J Entomol Zool Stud. 2014; 2(5): 160-163.
23. Burns IG. Influence of plant nutrient concentration on growth rate: Use of a nutrient interruption technique to determine critical concentrations of N, P and K in young plants. Plant Soil. 1992; 142(2): 221-233.
24. Slansky F, Rodriguez JG. 1987. Nutritional Ecology of Insects, Mites, Spiders and Related Invertebrates. Wiley, New York.
25. Mattson WJJr. Herbivory in relation to plant nitrogen content. Annu Rev Ecol Systemat. 1980; 11: 119-161.
26. Meyer GA. Interactive effects of soil fertility and herbivory on *Brassica nigra*. Oikos. 2000; 22: 433-441.
27. Scriber JM. 1987. Nitrogen nutrition of plants and insects invesion. In: Hauck RD, ed. Nitrogen in crop production. American Society of Agronomy, Madison, WI.
28. Supriya B, Mahato B, Panda P, Guha S. Effect of different doses of nitrogen on insect pest attack and yield potentiality of Okra, *Abelmonschuse sculentus* (L.). Indian J Entomol. 2009; 33(3): 219-222.
29. Zhong-xian Lu, Xiao-ping Yu, Cui Hu. Effect of nitrogen fertilizer on herbivores and its stimulation to major insect pests in Rice. China Entomol. 2007; 14(1): 56-66.
30. Ghorbani R, Khajehali J. The effect of irrigation regimes and N-fertilizer levels on developmental time and parameters of fecundity life table of Spodoptera exigua (Hubner) on sugar beet. Iran J Agric. 2013; 1(5): 505-513.
31. van Emden HF. Studies on the relations of insect and host plant. III. A comparison of the reproduction of *Brevicoryne brassicae* and *Myzus persicae* (Hemiptera: Aphididae) on Brussels sprout plants supplied with different rates of nitrogen and potassium. Entomol Exp Applic. 1966; 9: 444-460.
32. Venugopal MS. Role of potassium nutrition on the incidence of the rice pests and its implications in pest management. Indian Potash J. 1987; 8(2): 16-19.
33. Narayanasamy P, Bhaskaran P, Balasubramanian M, Adaikalan Y. Different levels of N, P and K on the incidence of rice insect pests. Rice Entomol Newsl. 1976; 4: 37.
34. Raju NR, Nagarajan R, Rajendran, Kareem A. Role of nitrogen (N) and potassium (K) in the incidence of green leafhopper (GLH) *Nephotettix virescence* (Distant) in Rice. J Potassium Res. 1996; 12(3): 313-318.

35. Kulagod MSD, Hegde G, Nayak GV, Vastrad AS, Hugar PS. Influence of fertilizer on the incidence of insect pests in paddy. Karnataka J Agric Sci. 2011; 24(2): 241-243.
36. Luna JM. Influence of soil fertility practices on agricultural pests. In: Proceedings of the Sixth International Science Conference of IFOAM on Global Perspectives on Agroecology and Sustainable Agricultural Systems, Santa Cruz, CA, pp. 1988: 589-600.
37. Lohaus KS, Vidal C. The farming practices change food web structures in cereal aphid-parasitoid-hyperparasitoid communities. Oecologia. 2013; 171: 249-259.
38. Zhao Zi-Hua C, Hui He, Da-Han, Li Bai-Lian. Effects of agricultural intensification on ability of natural enemies to control aphids. Scient Rep. 2015; 5: 8024.