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EFFECT OF SHOOT NUMBER, DIAMETER AND LAC ENCRUSTATION THICKNESS ON KUSMI BROODLAC YIELD OF *KERRIA LACCA* FROM *FLEMINGIA SEMIALATA*

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ABSTRACT

This study aims to identify the significant factors affecting kusmi broodlac yield and the relationship between the broodlac yield and the relevant factors for providing the practical basis of maximizing this yield. The regression analysis between the yield and independent variables revealed that the major factors influencing yield include encrustation thickness followed by shoot diameter in a significantly positive relationship. The yield was increasing up to 12 shoots/ plant and started declining after this.

Key words: *Kerria lacca*, kusmi, aghani, *Flemingia semialata*, host plant, broodlac, yield, regression, multicollinearity test, shoots/ diameter, encrustation thickness, positive relationship, 12 shoots/ plant

Lac insects constitute a family, the Tachardiidae (=Kerriidae) (Varshney, 1999; Ben-Dov and Lit, 1998), of morphologically distinctive scale insects that produce resinous secretion which thrives on > 400 tree species (Sharma, 2017). *Kerria lacca* (Kerr) is the most commonly cultivated lac insect in India, with kusmi and rangeeni strains (Kapur, 1962; Ramani, 2005). Kusum (*Schleichera oleosa* Oken), palas (*Butea monosperma* Lam.), ber (*Ziziphus mauritiana* Lam.) and bushy host semialata (*Flemingia semialata* Roxb.) are the commercial lac hosts (Sharma, 2017). In India, the central lac producing states are Jharkhand, Chhattisgarh, Madhya Pradesh, West Bengal, and Maharashtra and Odisha, contributing >90% (Meena et al., 2019; Yogi et al., 2017), and plays crucial role in maintaining the sustainable livelihood of the forest and subforest dwellers (Yogi et al., 2017). Semialata, one of the promising host plant species for lac cultivation, gives an economically fair yield of lac (Srivastava et al., 2002). It is shrubby, leguminous, fast-growing, short height, highly responsive to coppicing with ratooning property and can inoculate lac after one year of plantation (Kumar et al., 2015). The kusmi strain that is superior in quality can be inoculated in semialata for summer (jethwi) and winter (aghani) crop. Due to such propitious traits, farmers widely accept cultivating this plant in their farmland for lac production. With high market demand for lac in other countries, increase in productivity of lac is a crucial need. Broodlac, the lac sticks with mature gravid female insects, ready to give rise next generation by crawler emergence, can be influenced by several factors, such as encrustation thickness, shoot diameter, settlement density, length of shoots etc. Encrustation thickness is directly related to high resin productivity and crawler emergence from the unit brood, and hence it is a good indicator of broodlac yield. In lac yield, shoot diameter and number of shoots play an essential role in governing lac yield (Ghosal and Mishra, 2009; Ghosh et al., 2018). This study analyzes the relationship between number of shoots, shoot diameter and encrustation thickness with broodlac yield. Also, explores the major factors influencing broodlac yield.

MATERIALS AND METHODS

The experiment was conducted at the Institute Research Farm, ICAR-Indian Institute of Natural resins and Gums in March 2020. The data was recorded from 67 randomly selected plants with shoots varying from 1-24/ plant at the harvesting time of the aghani crop (kusmi winter crop). The observations like shoot diameter and encrustation thickness were recorded, along with encrustation diameter covering shoot. Measurement was taken at the middle of the lac encrustation length and for shoot diameter, measurement was taken at both the ends of the encrustation length where lac was not present using a digital Vernier caliper. The formula- encrustation thickness = (encrustation diameter covering shoot- shoot diameter)/ 2 for each shoot was used and averaged. The variables analysed include- broodlac yield (g)/ shoot as dependent variable (y) and three independent variables i.e., x_1= no. of shoots/ plant, x_2= mean encrustation thickness (mm)/ shoot, and x_3= shoot diameter (mm)/ shoot. Statistical analysis was performed using SPSS 25 and R Studio. The relationships were evaluated using bivariate and multivariate regression analysis and Pearson correlation coefficients and a two-tailed test of significance (α= 0.05). In addition, a multicollinearity test among the independent variables was performed, and pairwise comparisons and variance inflation factor (VIF) test were made for all the variables to predict a situation where two or more variables are highly linearly correlated. To find the optimum number of shoots to be retained for enhancing yield, a polynomial function curve was developed between the broodlac yield (g)/ shoot and no. of shoots/ plant.

RESULTS AND DISCUSSION

The data given in Table 1 reveal that no. number of shoots/ plant, encrustation thickness (mm)/ shoot, shoot diameter (mm)/ shoot and broodlac yield (g)/ shoot (n=67) were 8.12± 0.60, 4.15± 0.13, 12.80± 0.23 and 105.69± 5.12, respectively; of these 25% (Q_1) yield of broodlac was laid below 79.1 (g)/ shoot; and in addition, 75% (Q_3) of observations for shoot diameter was laid down from ≤14.3 mm/ shoot. The correlation coefficients reveal that the correlation between the independent variable is ≤±50% (Fig. 1- positive correlations in blue and negative in red; colour intensity and the size of circles being proportional to the correlation coefficients). The VIF value for the number of shoots/ plant, encrustation thickness (mm)/ shoot and shoot diameter (mm)/ shoot were 1.08, 1.20 and 1.29, respectively; however, since the VIF values are <10, there is no collinearity effect. The simple linear regression analysis of broodlac yield (g)/ shoot reveals that no. of shoots and shoot thickness are significantly correlated, while encrustation thickness is not significantly correlated (α= 0.05) (Fig. 2a-c); and Fig. 2d reveals that broodlac yield/ shoot increases till 12 shoots and declines thereafter. The multiple

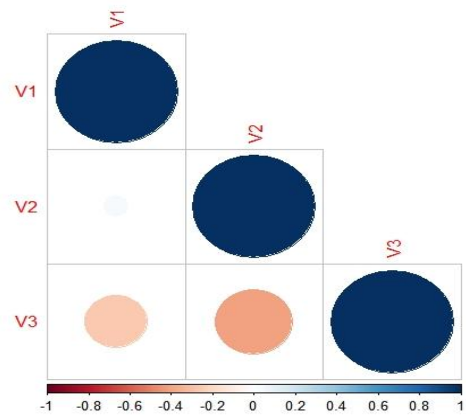

Fig. 1. Correlation coefficients- no. of shoots/ plant (V_1); encrustation thickness (mm)/ shoot (V_2); shoot diameter (mm)/ shoot (V_3)

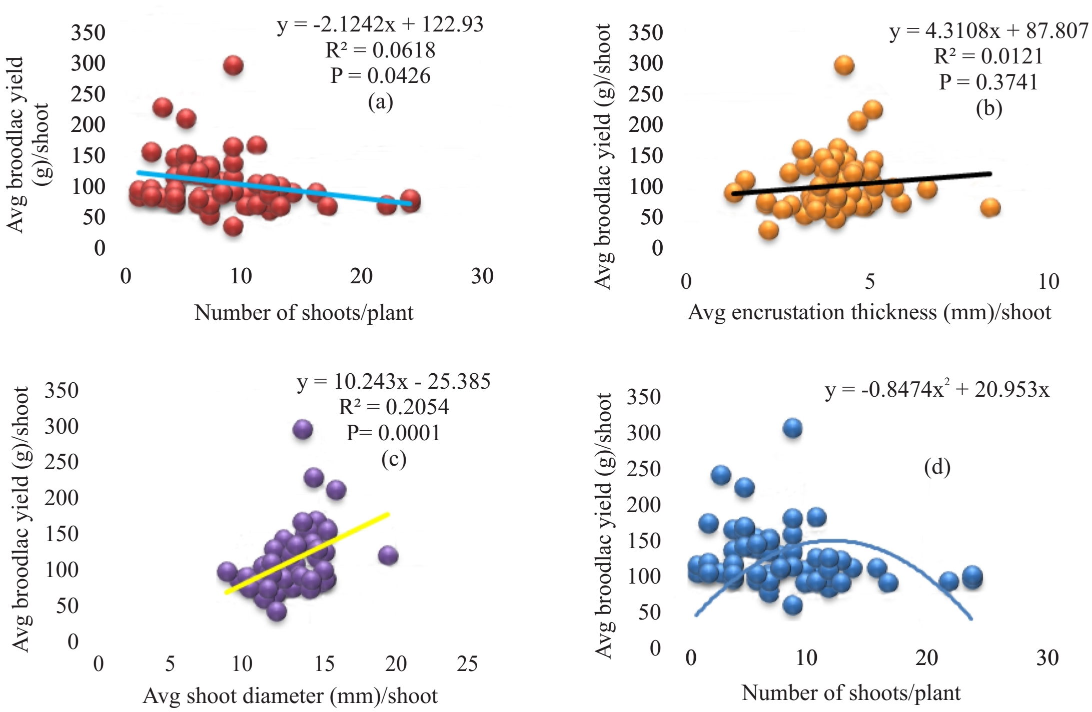

Fig. 2. Simple linear regression of broodlac yield (g)/ shoot- vs no. of shoots/plant (a), encrustation thickness (mm)/ shoot (b), shoot diameter (mm)/ shoot (c); and Polynomial function curve- broodlac yield (g)/shoot vs. no. of shoots/ plant (d)

linear regression analysis reveals that encrustation thickness and shoot diameter exhibit a significant effect on the broodlac yield; and no. of shoots with significant effect (α= 0.05), and there exists a positive relationship between broodlac yield and encrustation thickness and shoot diameter; 95% confidence interval for encrustation thickness and thickness of shoot were 4.80, 22.63 and 7.29, 17.54, respectively. The negative value of intercept indicates that the expected value of broodlac yield is <0 when all independent variables were set to 0. The most important factors affecting broodlac yield was encrustation thickness, as it has a high coefficient followed by shoot diameter. The results also reveal that 28.7% of the broodlac yield gets explained by the variation of encrustation thickness and the shoot diameter the estimated equation will be thus- broodlac yield = -103.76-0.98 No. of shoots/plant + 13.36 encrustation thickness (mm)/ shoot + 12.65 shoot diameter (mm)/ shoot (Table 1).

Thus, the effective way to increase the broodlac yield will be by shoot diameter, ultimately increasing encrustation thickness, with maintaining number of shoots/ plant up to 12 shoots. Sticklac weight/ bush increased significantly with increase in shoots/ bush up to 9 shoots of F. semialata (Anon., 2002). The present results corroborate with those of Ghosal et al. (2011), that thickness of broodlac encrustation is the most important factor governing the settlement of lac insect, followed by phunki (empty broodlac) scrap weight and weighted living cell weight in kusum tree. With the maturity of lac insect, the cell size of insect and resin content increases (Meena et al., 2019), leading to an increase in encrustation thickness, which maximizes lac production and, ultimately, the crawler emergence also increases. Larger shoot diameter provided more surface area for insect settlement, thus increasing lac productivity/ unit area. Ghosh et al. (2018) observed that the length and width of new shoots of palas had significant and positive correlation with kusmi broodlac yield ratio (0.67 and 0.50, respectively).

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Table 1. Descriptive statistics, multiple linear regression [Broodlac yield vs. no. of shoot/ plant, encrustation thickness (mm)/ shoot and shoot diameter (mm)/ shoot]

Variables	N	Min	Max	Mean	Std. error	Std. Dev	Q_1	Q_3
No. of shoots/ plant	67	1.00	24.00	8.12	0.60	4.91	5	11
Encrustation thickness (mm)/ shoot	67	1.31	8.34	4.15	0.13	1.07	3.6	4.6
Shoot diameter (mm)/ shoot	67	8.54	19.44	12.80	0.23	1.86	11.4	14.3
Broodlac yield (g)/ shoot	67	36.20	294.67	105.69	5.12	41.94	79.1	126.6

Variables	Coefficients (b)	Std. error	t_{cal} value	P value	95.0% CI for b
Intercept	-103.76	47.48	-2.18	0.033	(-198.64, -8.88)
Number of shoots/ plant	-0.98	0.92	-1.05	0.294	(-2.82, 0.86)
Avg. encrustation thickness (mm)/ shoot	13.36	4.46	2.99	0.004	(4.80, 22.63)
Avg. shoot diameter (mm)/ shoot	12.65	2.57	4.75	0.000	(7.29, 17.54)
Model 1	R	R square	Adj. R square	F_{cal} value	P value
	0.566	0.320	0.287	9.876	0.000

Dependent Variable: broodlac yield (g)/shoot; CI: Confidence Interval

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