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Calliandra calothyrsus: A Potential Host for the Indian Lac Insect [*Kerria lacca* (Kerr.)] Cultivation in India

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***Abstract*:** More than 400 host plants have been reported to support lac insects throughout the world but not all have been exploited for their commercial potential except some traditional hosts. In this study, potentially of four host plants *viz., Calliandra calothyrsus, Calliandra surinamensis, Dalbergia assamica* and *Malvaviscus penduliflorus* was evaluated for *kusmi* and *rangeeni* strain of *Kerria lacca* (Kerr.) during three consecutive years 2014-15, 2015-16 and 2016-17. The data on pre and post-harvest parameters *viz*., initial settlement density, mortality, fecundity, cell weight, resin weight, broodlac, broodlac ratio and total scrapedlac were recorded based on pre and post-harvest attributes of *rangeeni* (summer season (*baisakhi)* & rainy season (*katki)* crop) and *kusmi* summer season (*jethwi)* & winter season (*aghani*). *C. calothyrsus* outperformed other hosts during all the three years. In addition to this, *C. calothyrsus* is having quick growth, bushy nature and high response to coppicing make this host ideal for Lac Integrated Cropping System (LICS).

Keywords: *Calliandra calothyrsus, Kerria lacca, Rangeeni, Kusmi*

Indian lac insect, *Kerria lacca* (Kerr.) belongs to the family Tachardiidae (=Kerridae), order Hemiptera and superfamily Coccoidea is phytosuccivorous and sessile. The presence of lac insects was first reported on *Ficus religiosa* L. and *Ficus indica* L. (now *F. benghalensis*) along with *Butea monosperma* Lam (*palas*), *Ziziphus mauritiana* Lamk (*ber*) from Bihar region (Now Bihar, Jharkhand and some parts of West Bengal). More than 400 plant species are reported as a host for lac insects from different parts of the country. There are two strains of the Indian lac insect *viz., rangeeni* and *kusmi*. Each strain completes its life-cycle twice a year with varying period. Of the two strains i.e., *kusmi* and *rangeeni*, *aghani* (winter season) crop of *kusmi* strain contributes the most to the total lac production (Sharma and Ramani 1999). Lac insect strains have been generally characterized by different life-cycle and their respective host plants. Lac production and quality are dependent on the host plant and the strain of lac insect. Besides lac host plant, *K. lacca* is associated with large pest complex comprising predatory and parasitic insects which influence lac production and quality. Various parasitoids such as *Aprostocetus purperous* (Cam.), *Trachidaephagus trachidae* (How.) are responsible for majority of crop loss. Among these parasitoids, *A. purperous* alone has acquired the most dreaded pest of lac insect (Mohanasundaram et al 2016). Lac tree=*Kusum* (*Schleichera oleosa* Lour.), Indian jujube=ber (*Ziziphus mauritiana* Lamk.) and Flame of forest=*palas* (*Butea monosperma* Lam.) are major lac hosts, however these host plants have some constraints like longer gestation period to raise new plantation (5 to 10 years), longer waiting period after pruning like *kusum* (12-18 months), strain specificity *i.e.* only *kusmi* strain on *kusum* and *rangeeni* on *palas* and difficulty in lac culture operation due to a few morphological characters like thorns on *ber*. Studies have been conducted earlier on exploring the bushy host plants so that they can be integrated with the agricultural crops. One such bushy host plant, *Flemingia semialata* Roxb. (*Semialata*) has gained popularity among farmers recently. *Calliandra calothyrsus* Meisn, *Calliandra surinamensis* Benth, *Dalbergia assamica* Benth and *Malvaviscus arboreus var. penduliflorus* (DC.) Schery has been reported as a lac insect host plants (Ramani and Sharma 2010, Sharma et al 2012). Looking into the major host plants, there is a need to identify more host plants which are easy to maintain from lac cultivation aspects. The lac host plants under study are bushy in nature and quick growing in habit. Therefore, the present study was undertaken to evaluate the potentiality of these hosts for lac cultivation under Ranchi conditions.

MATERIAL AND METHODS

Evaluation was carried out in the summer and rainy seasons of *Rangeeni* strain of lac insect and summer and winter (seasons of *kusmi* strain of lac insect on four bushy hosts *viz., C. calothyrsus, C. surinamensis, D. assamica* and

M. penduliflorus during three consecutive years (2014-15 to 2016-17). Field experiments were undertaken at Institute Research Farm, ICAR- Indian Institute of Natural Resins and Gums (IINRG), Namkum, Ranchi, Jharkhand (23.19ºN latitude and 85.22ºE longitude and elevation 2076 feet). Seedlings were grown in paired row system in triangular method of planting by keeping four meter distance between plants, two meter distance between a paired row and four meter distance between two paired rows during the year 2012 (Fig. 1). Ten plants of each host were taken per season (5 for *rangeeni* lac insect and 5 for *kusmi* lac insect); in total 40 plants were used for this experiment. Required agronomic practices *viz*., weeding, earthing up, pruning, FYM and fertilizer application, pesticide application, irrigation etc. were followed for maintenance. Plants were pruned in the month of February-March for inoculation of winter season crop and in June-July for inoculating summer season crop of *kusmi* strain. Similarly, plants were pruned in the month of February-March for inoculation of rainy season crop and in April-May for inoculating summer season crop of *rangeeni* strain. Recommended packages of practices for lac cultivation were followed. Observations on biological and economic attributes of lac insect were recorded as per the standard procedure (Mohanasundaram et al 2016). Pre-harvest productivity parameters *viz*., settlement density (crawlers per sq cm), initial mortality (%), sex ratio (% male); post-harvest productivity parameters *viz*., fecundity (Nos./Female), cell weight (mg), resin weight (mg) and yield parameters *viz*., broodlac (includes both stick and lac insect cell weight) (g), rejected lac (g), total scrapedlac (without stick weight *i.e* only lac resin, dye and wax etc.) (g), broodlac ratio (output/input) were taken. The performance of all the four host plants was compared for all season crops of *K. lacca*. The experiment was conducted in Randomized Block Design. Three consecutive years' data were pooled. Field level evaluation of the best performing host in the study *i.e. C. calothyrsus* was also conducted at farmer's field at two different villages' *viz*., Lodama and Benyazara of Ranchi district, Jharkhand during 2017-20 to further ensure its potential for commercial lac cultivation. Lac cultures on stunted host plants during different seasons are (Figs. 2 to 5).

RESULTS AND DISCUSSION

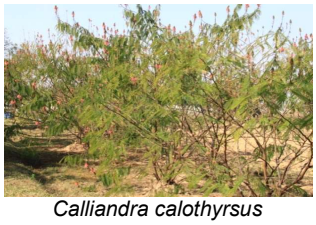
Evaluation of *K. lacca* (*rangeeni*) during summer (*baisakhi*) crop: Though initial settlement density of *K. lacca* (*rangeeni*) on *M. penduliflorus* was more than the other hosts but lac insect mortality was observed before sexual maturation. Initial mortality was minimum in *C. calothyrysis* (12.55 %) and maximum in *C. surinamensis* (27.06 %) (Table 1). Sex ratio ranged between 46.89 to 64.20 per cent, whereas, lac insect mortality was observed on *M. penduliflorus* before sexual maturation. Average fecundity was significantly more on *C. calothyrsus* (337.5) followed by *D. assamica* and *C. surinamensis*. Cell weight (15.41 and 12.46 mg) and resin weight (12.51 and 9.95 mg) was maximum in *C. calothyrsus* and minimum in *D.assamica,* respectively. Yield attributes, *viz.,* broodlac, rejected lac, total scrapedlac and broodlac ratio were significantly higher in *C. calothyrsus* (1712.53, 476.87g, 126.33 and 4.8 g per plant, respectively) than *C. surinamensis* and *D. assamica*. Monobrullah et al (2016) reported that the pre-harvest parameters of *rangeeni* lac insect *viz*., initial mortality, sex ratio and broodlac yield were significantly different between hosts *ber* and *palas*. Initial mortality and sex ratio ranged from 12.86 to 47.85 per cent and 22.97 to 40.86 per cent, respectively and resin weight also significantly differed between these hosts during *rangeeni* summer season crop. Sharma and Jaiswal (2011) observed that, density of settlement of lac insect is on an average about 150 larvae settled in one square cm area. Depending upon the host-

Table 1. Bio-economical parameters of summer season (*baisakhi*) crop of *rangeeni* lac insect during 2014-2016 (Pooled)

Bushy host plants	Pre-harvest productivity parameters			Post-harvest productivity parameters			Yield parameters			
	Settlement density (Nos./cm^2)	Initial mortality (%)	Sex ratio (% Male)	Fecundity (nos./ Female)	Cell weight (mg)	Resin weight (mg)	Broodlac (g)	Rejected lac (g)	Total scraped lac (g)	Broodlac ratio (Output/ input)
C. calothyrsus	90.53 (9.52)	12.55 (3.60)	53.26 (7.33)	337.53 (18.38)	15.41 (3.99)	12.51 (3.61)	1712.53 (41.16)	476.87 (20.61)	126.33 (11.16)	4.80 (2.30)
C. surinamensis	47.18 (6.90)	27.06 (5.25)	64.20 (8.03)	127.69 (11.28)	14.66 (3.89)	11.65 (3.48)	527.00 (22.67)	511.33 (19.67)	16.22 (3.81)	1.40 (1.38)
D. assamica	70.16 (8.40)	11.00 (3.37)	46.89 (6.87)	195.98 (13.98)	12.46 (3.59)	9.95 (3.23)	414.00 (20.35)	20.67 (4.39)	35.92 (5.98)	1.80 (1.52)
M. penduliflorus	91.60 (9.58)	18.87 (4.35)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
CD (p=0.05)	0.66	0.73	0.50	0.95	0.24	0.23	3.56	10.56	1.67	0.11

*Figures in parentheses are square root √ (X+0.5) transformation values; Means are significant at p< 0.05


Malvaviscus penduliflorus


Calliandra calothyrsus


Calliandra surinamensis


Dalbergia assamica

Fig. 1. Field view of bushy host plants at Institute Research Farm, IINRG, Ranchi

Fig. 2. *K. lacca* (*rangeeni*) on *C. calothyrsus* during summer (*baisakhi*) crop

Fig. 3. *K. lacca* (*rangeeni*) on *C. calothyrsus* during rainy (*katki*) crop

plant and season of inoculation, carrying capacity of the host plant varies. Kumar et al (2007) concluded that fecundity of lac insects when grown on *F. macrophylla* was 338.0 and 460.8 nos. and resin weight (9.46 and13.67 mg) during *katki* and *baisakhi* crops, respectively. The density of settlement of lac insect varied between 48.3 to 162.0 no. of crawlers/cm^2 and resin output ranged from 5.60 to 8.15 mg per cell for summer crop of *rangeeni* strain on *F. macrophylla* (Gupta et al 2020).

Evaluation of *K. lacca* (*rangeeni*) during rainy (*katki*) crop: Settlement density was more with lesser initial mortality on *C. calothyrsus* (75.76 crawlers per sq cm and 33.58 per cent) while more than 50 per cent initial morality was recorded on *D. assamica, C. surinamensis* and *M. penduliflorus* (Table 2). Optimum sex ratio recorded was

Fig. 4. *K. lacca* (*kusmi*) on *C. calothyrsus* during summer (*jethwi*) crop

Fig. 5. *K. lacca* (*kusmi*) on *C. calothyrsus* during winter (*aghani*) crop

ranging from 25.94 to 35.50 per cent male except on *M. penduliflorus* (1.59 % male) lac insect died before sexual maturation on *M. penduliflorus*. Average fecundity was significantly higher on *C. calothyrsus* (211.55) and minimum on *C. surinamensis* (32.95). Cell weight and resin weight recorded were maximum on *C. calothyrsus* (17.47 and 12.64 mg) and minimum on *D. assamica* (12.62 and 9.72 mg). Yield attributes, *viz.,*broodlac produced was recorded maximum on *C. calothyrsus* (2937.87 g) and minimum on *D. assamica* (153.33 g). No broodlac was obtained from *C. surinamensis*. Rejected lac was obtained from three hosts *C. calothyrsus, C. surinamensis* and *D. assamica.* Total scrapedlac was significantly more on *C. calothyrsus* (555.67 g) followed by *C. surinamensis* and *D. assamica.* Broodlac ratio could be calculated only from *C. calothyrsus* (4.46) and *D. assamica* (1.75). The results of the present study also corroborated with the findings of Meena et al (2019) on biological parameters. Kalahal et al (2017) revealed that the initial density of settlement of crawlers varied in different parts of pigeonpea (*Cajans Cajan*) during *Katki* season of *rangeeni* strain. The cell and resin weight ranged from 6-24 mg and 4-19 mg per cell, respectively. The highest fecundity and cell weight was recorded from *ber* (450.6 nos. and 10.12 mg) and lowest on *C. cajan* (315.4 and 9.4mg) during *katki* crop whereas it was 525.2 and 14.21 mg on *ber* and 407 and 13.6 mg on pigeonpea respectively, during *baisakhi* .

Evaluation of *K. lacca* (*kusmi*) during summer (*jethwi*) crop: Settlement density of *K. lacca* (*kusmi*) varied between 62.98 and 77.78 crawlers per sq cm on *C. surinamensis, M. penduliflorus, D. assamica* and *C. calothyrsus* while mortality was less on *C. calothyrsus* (19.99 %) followed by *D. assamica, M. penduliflorus* and *C. surinamensis* (Table 3). Sex ratio ranged between 36.42 and 45.05 per cent male but sex ratio could not be obtained on *M. penduliflorus* as lac insect did not prefer this host for further development. Fecundity was more on *C. calothyrsus* (214.92) followed by *C. surinamensis* and *D. assamica*. Major difference was not observed in cell weight and resin weight on *C. calothyrsus*, *C. surinamensis* and *D. assamica*. Broodlac and broodlac ratio was more on *C. surinamensis* (996.00 g and 2.73) followed

Table 2. Bio-economical parameters of rainy season (*katki*) crop of *rangeeni* lac insect during 2014-2016 (Pooled)

Bushy host plants	Pre-harvest productivity parameters			Post-harvest productivity parameters			Yield parameters			
	Settlement density (Nos./cm^2)	Initial mortality (%)	Sex ratio (% Male)	Fecundity (nos./ Female)	Cell weight (mg)	Resin weight (mg)	Broodlac (g)	Rejected lac (g)	Total scraped lac (g)	Broodlac ratio (Output/ input)
C. calothyrsus	75.76 (8.73)	33.58 (5.81)	35.50 (5.99)	211.55 (14.55)	17.47 (4.24)	12.64 (3.62)	2937.87 (53.47)	1097.00 (32.03)	555.67 (23.48)	4.46 (2.22)
C. surinamensis	64.80 (8.08)	81.24 (9.04)	25.94 (5.14)	32.95 (5.28)	5.88 (2.37)	4.33 (2.07)	0.00 (0.71)	493.33 (21.17)	105.80 (10.30)	0.00 (0.71)
D. assamica	62.47 (7.92)	50.88 (7.15)	26.49 (5.18)	126.31 (11.24)	12.62 (3.61)	9.72 (3.18)	153.33 (12.38)	115.33 (10.57)	78.67 (8.89)	1.75 (1.50)
M. penduliflorus	51.07 (7.18)	66.17 (8.16)	1.59 (1.15)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
CD (p=0.05)	0.41	0.78	0.65	1.94	0.59	0.47	7.07	8.75	1.81	0.09

*Figures in parentheses are square root √ (X+0.5) transformation values; Means are significant at p< 0.05

Table 3. Bio-economical parameters of summer season (*jethwi*) crop of *kusmi* lac insect during 2014-2016 (Pooled)

Bushy host plants	Pre-harvest productivity parameters			Post-harvest productivity parameters			Yield parameters			
	Settlement density (Nos./cm^2)	Initial mortality (%)	Sex ratio (% Male)	Fecundity (nos./ Female)	Cell weight (mg)	Resin weight (mg)	Broodlac (g)	Rejected lac (g)	Total scraped lac (g)	Broodlac ratio (Output/ input)
C. calothyrsus	77.78 (8.83)	19.99 (4.48)	39.51 (6.30)	214.92 (14.67)	11.40 (3.45)	8.99 (3.08)	658.00 (25.33)	0.00 (0.71)	102.00 (9.94)	2.03 (1.58)
C. surinamensis	62.98 (7.97)	51.93 (7.23)	36.42 (6.05)	201.02 (14.17)	11.33 (3.44)	9.10 (3.10)	996.00 (30.72)	58.67 (6.27)	70.00 (8.17)	2.73 (1.78)
D. assamica	70.89 (8.45)	33.64 (5.83)	45.05 (6.74)	181.70 (13.47)	11.83 (3.51)	9.68 (3.19)	135.27 (11.42)	131.53 (10.91)	34.00 (5.82)	1.24 (1.30)
M. penduliflorus	66.36 (8.17)	45.21 (6.74)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
CD (p=0.05)	0.57	0.68	0.73	1.19	0.19	0.16	6.93	4.16	2.08	0.26

*Figures in parentheses are square root √ (X+0.5) transformation values; Means are significant at p< 0.05

Table 4. Bio-economical parameters of winter season (*aghani*) crop of *kusmi* lac insect during 2015-2017 (Pooled)

Bushy host plants	Pre-harvest productivity parameters			Post-harvest productivity parameters			Yield parameters			
	Settlement density (Nos./cm^2)	Initial mortality (%)	Sex ratio (% Male)	Fecundity (nos./ Female)	Cell weight (mg)	Resin weight (mg)	Broodlac (g)	Rejected lac (g)	Total scraped lac (g)	Broodlac ratio (Output/ input)
C. calothyrsus	107.91 (10.40)	20.29 (4.56)	34.04 (5.87)	184.52 (13.58)	24.58 (5.01)	21.73 (4.71)	1606.00 (40.00)	2049.00 (45.22)	849.67 (29.13)	3.52 (2.00)
C. surinamensis	60.71 (7.81)	63.78 (8.01)	41.20 (6.45)	47.78 (6.94)	7.03 (2.74)	6.19 (2.58)	0.00 (0.71)	426.67 (20.40)	17.33 (4.17)	0.00 (0.71)
D. assamica	69.36 (8.35)	31.71 (5.66)	42.39 (6.55)	39.73 (6.31)	7.99 (2.91)	6.95 (2.73)	16.00 (3.41)	255.33 (15.97)	37.67 (6.13)	0.08 (0.76)
M. penduliflorus	85.38 (9.24)	55.39 (7.47)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
CD (p=0.05)	0.75	0.41	0.28	0.80	0.13	0.12	2.769	3.23	1.13	0.06

*Figures in parentheses are square root √ (X+0.5) transformation values; Means are significant at p< 0.05

by *C. calothyrsus* and *D. assamica* whereas, total scrapedlac obtained was significantly more on *C. calothyrsus* (102.00 g) than others and minimum in *D. assamica* (34.00 g). Mohanta et al (2014), initial settlement density of crawler varied between 104.62-126.74 no/cm^2, sex ratio 1:3 and resin output per female was 19.00 to 25.60 mg for summer crop of *kusmi* strain on *kusum* and *ber* plants. Slight variation of results may be attributed to different host plants and climatic condition.

Evaluation of *K. lacca* (*kusmi*) during winter (*aghani*) crop: Settlement density of *K. lacca* (*kusmi*) was more (107.91 crawlers per sq cm) on *C. calothyrsus* followed by *M. penduliflorus, D. assamica* and *C. calothyrsus.* Initial mortality was less on *C. calothyrsus* (20.29 per cent) than the other three hosts (Table 4). Optimum sex ratio (34.04 to 42.39 per cent male) was from three hosts *C. calothyrsus, C. surinamensis* and *D. assamica* except *M. penduliflorus*. Average fecundity (184.52), cell and resin weight (24.58 and 21.73 mg) were recorded significantly more on *C. calothyrsus* than *C. surinamensis* and *D. assamica. C. calothyrsus* produced higher broodlac (1606 g per plant) compared to others and the least on *D. assamica.* Total scrapedlac and broodlac ratio obtained were more on *C. calothyrsus* (849.67 g and 3.52 per plant) than other three hosts. Sharma and Jaiswal (2011) wherein they reported that the mean density of settlement in *rangeeni* strain of *K. lacca* is lower than that of *kusmi* strain. The *kusmi* strain performed better than *rangeeni*. Results of the present finding of cell and resin weight are significantly more during *kusmi* winter season crop, respectively.

Field level evaluation of *C. calothyrsus:* Field level evaluation of *C. calothyrsus* was conducted at farmers' fields at two different villages' *viz*., Lodama and Benyazara of Ranchi district, Jharkhand during 2017-20 for evaluating its potential for commercial lac cultivation. *Kusmi* broodlac inoculated on *C. calothyrsus* provided broodlac (470 g per plant), brood per meter lac encrustation (144 g), broodlac ratio (10.5), scrapedlac weight per meter lac encrustation (45 g), per cent scrapedlac (29 %) during *aghani*, 2018-19 and 2019-20 at Lodma, Ranchi district. Similarly, broodlac (900 g per plant), Brood per meter lac encrustation (111 g), broodlac ratio (5.5), Scrapedlac weight per meter lac encrustation (21 g), per cent Scrapedlac (19 %) was recorded on *C. calothyrsus* during *aghani*, 2019-20 at Benyazara, Angara block, Ranchi. This study was also carried out during rainy season crop, 2019 at Lodma which yielded 214 g of broodlac per plant with broodlac ratio of 5.35.

CONCLUSION

Lac cultivation on traditional host plants has its own advantages and constraints. Among the bushy host plants studied, *C. calothyrsus* has shown tremendous potential in lac cultivation based on broodlac ratio of 3-4 and 5.35-10.5 at Institute Research Farm and famers' fields, respectively. It was found suitable to culture *kusmi* and *rangeeni* strains of *K. lacca*. It is an indication that this host would perform better as a commercial host.

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