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Effect of population density of *Kerria lacca* Kerr. on Rangeeni lac production

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Abstract
A field trial was conducted on baisakhi production of *Cajanus cajan* with different population densities of lac insect during May 2018 to May 2019. The results revealed that the lac insect population density of 40 insects per 2.5cm^2 has highest 100 lac cell weight (3.12g) and raw lac yield (446g) per plant.

Keywords: Population density, *Kerria lacca* Kerr, Rangeeni lac, *Cajanus cajan*

Introduction
Phloem feeders exert biotic stress on the host it feeds[1], often dwarfing the plant growth and yield of the crop[2]. Lac insect (*Kerria lacca* Kerr.), is a minute insect of economic importance, as lac produced by it is a cash crop[3]. Lac production in India is a major economic activity, among forest dependants and rainfed farmers[4] in central and eastern India. Though there are over 113 host species of lac insects in India[5], in the recent year promotion of lac production on *C. cajan*[6] in gaining farmers interest. Lac production of *C. cajan* provides farmers with a pulse crop, lac crop and fuel wood, is one of the main reason its adoption.
Unlike traditional host like *Butia monosperma, Zizyphus mauritiana* and *Schleichera oleosa* which are trees, lac production on annual shrubs (*C. cajan*) exerts more biotic stress. In the present study an attempt was made to understand how much should be the density of the insects, on *C. cajan* which can produce maximum lac.

Materials and Methods
The present field trial was conducted in Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh between June 2018 to May 2019.The topography of the experimental area was fairly uniform. The Randomized Block Design experiment had seven treatments and three replication of *C. cajan* variety TJT- 501. The plant to plant and row to row spacing was 6ft x 6ft. There were three plants per replication of each of the seven treatments.

Climate
The climate of Jabalpur district is typically Sub humid, featured by hot dry summer and cool dry winter. Jabalpur is situated between 23º 09' North latitude and 79^0 58' East longitudes at an altitude of 411.78 meters above the mean sea level. Jabalpur district lies in the Agro- climatic zone VII *i.e.* Kymore Plateau and Satpura Hills and Agro-ecological region number 10 [Central Highlands (Malwa and Bundhelkhand)], Sub region number 10.1, [hot sub-humid eco-region (Malwa Plateau, Vindhyan scarp land and Narmada Valley)].
The weekly meteorological data recorded during crop season at Meteorological Observatory, College of Agriculture Engineering, Jabalpur. The weather conditions were almost favourable for the growth and development of pigeon pea. The monsoon commenced in the first week of July and terminated in the 1st week of October 2018. The total rainfall received during the crop season was 1162.90 mm, which was equally distributed in 58 rainy days from July 2018 to last week of May 2019. Minimum and maximum mean temperature ranged from 4.80 ^{0}C to 24.90 ^{0}C and 28.50 to 41.80 ^{0}C, respectively. The relative humidity ranged between 82 to 87 percent in the morning and 29 to 55 percent in the evening. The sunshine hours varied between 0.50 to 10.30 hours per day. The details of the treatments are given in table 1.

Table 1: The details of the treatments and notations used are as below

Treatments (Population density per 2.5 cm^2)
T_1 = 80 lac insects
T_2 = 100 lac insects
T_3 = 40 lac insects
T_4 = 50 lac insects
T_5 = 60 lac insects
T_6 = 0 lac insect
T_7 =Natural population density 127.39

Nursery raising of *C. cajan*

Nursery of *C. cajan* was raised in the month of May 2018 on the substrate (*Kapu* + FYM) filled polythene bag (18 x 16 cm) by sowing seeds treated with *Trichoderma viridae*, *Rhizobium* and PSB. Polythene bags were perforated to drain out excess irrigation water applied at weekly intervals. Polythene bags were kept in shade.

The seedlings were sprayed with insecticides to prevent insect pest incidence. The growing tips of the seedlings were nipped at 8-12 days interval till its transplantation Nipping was done to train the seedlings to a bush form

Layout of the field

The layout of the experiment was planned in the main field to accommodate 63 *C. cajan* plants. The spacing between plant to plant and row to row in the main field was six feet apart. The spacing between replications was maintained at a spacing of 10 feet.

Substrate

The seedlings of *C. cajan* was transplanted in used polypropylene bags(PPB) of size 93cm x 61cm filled with substrate consisting of a mixture of 45kg river bed basin soil (*Kapu*) and 20kg well rotten Farmyard manure (FYM). The *Kapu* and FYM in the above ratio were thoroughly mixed with the help of a spade to obtain a homogenized substrate. The physio-chemical property of the substrate is mentioned in the. The substrate was gradually filled into the PPB with help of a *tasala* followed by constant shaking the bag to ensure proper settlement and compactness of the substrate. The 65 kg substrate filled PPB attains a dimension of 46 cm height and 125 cm circumference. The PPB was filled with substrate on the designated spot in the layout of the experiment, such that it is not disturbed in future Table- 2.

Table 2: Physico-chemical properties of the substrate (65kg) filled in Poly propylene bag (PPB)

Constituents	Value (g/65kg substrate)	Method used
Available N	136.15	Alkaline permanganate method (Subbiah and Asija,1956)
Available P_2O_5	45	Calorimeter method (Olsen et al., 1954)
Available K_2O	304	Flame Photometer method (Chapman and Pratt, 1961)

Treatment of the substrate

PPB filled with substrate that was placed in the designated spot as per the experimental design, and was treated with microbes as per the treatments. The microbes were thoroughly mixed in the substrate.

Transplantation of *C. cajan* saplings

C. cajan saplings on attaining a height varying from 1.5 feet to 2 feet were transported to the main field. Each of the 63 saplings were place at the base of substrate filled PP. The polythene bag of the *C. cajan* saplings was carefully removed without disturbing the root system. The sapling with substrate base is carefully transplanted in the PPB and pressed tightly from all corners, followed by watering. The transplantation was done in the evening hours of 15th August 2018.

Irrigation

Each of the PPB with *C. cajan* plant was irrigated at regular intervals. Between August to October 2018, it was at 30 days interval while from November 2018 to February 2019 the interval of irrigation was 15 days, but from March 2019 to May 2019, the irrigation schedule was at 10 days interval. Approximately 10 liters water was given per plant during each irrigation with the help of polyethene pipe fitted to the tap in the field.

Nipping

The transplanted *C. cajan* was again nipped at 8-10 days interval till the last week of September, 2018.

Application of pesticides

Three sprays of pesticides on *C. cajan* pants were carried out as mentioned in Table 3.

Table 3: Spray schedule of pesticides

Spray	Pesticides	Dose	Day	Remark
First	Emamectin benzoate	1g/litre	30 DAT	To manage foliage feeders
Second	Cartap hydrochloride	1g/ litre	30 days after BLI	To manage predators and parasites of lac insect
Third	Cartap +Diethane M-45	2g/ litre	60 days after BLI	To manage predators and parasites of lac insect as well as sooty mold

* DAT = Days after transplanting, * BLI = Brood lac inoculation

Brood lac inoculation

Rangeeni brood lac purchased from Adarsh Lac Samiti, Jamankhari village, Tehsil Barghat, district Seoni, M.P. on 02.11.2018 was sorted for quality and predator free brood, before its inoculation on *C. cajan*. Brood lac stick weighing 15 g was tied at the base of each *C. cajan* in the PPB on 03.11.2018 with the help of a twine as per the treatments.

Lac insect count:

Lac insects were counted per 2.5 cm^2 (2.5cm length and 1.0cm width) space on the stem or branch as the case may be.

Marking of slot

Once lac insect inserts its stylet into the phloem, it becomes sedentary. Thirty days after BLI, branches with good lac insect settlement were selected for marking of slot of 2.5cm x 1cm size on the bark. Three slots were made on plant each of 2.5cm^2. Each slots were designated as S_1, S_2, and S_3. Later stretching a thread between the index fingers of both the hands the lac insect settlements adjacent to the boundaries of the slot is carefully removed to make the slot differentiate from the rest of the lac settlement on the branch.

Digital recording of the insects

Lac insect settlement within the slot was digitally photographed with the help of a Digital Single Lens Reflex (DSLR) camera fitted with 100 mm micro lens by settling it in manual mode with ISO 400 and shutter speed of 4.5 to 6. Several pictures of the slot was taken for clarity, finally the best click is selected and the counting was done in the Paint 3D program.

Frequency of lac insect count

Counting of lac insects within the slots were done at 65th, 70th, 95th, 125th, 155th and 185th day after BLI. On 70th day of BLI, the number of lac insects were adjusted as per treatments *i.e.*, T_1, T_2, T_3, T_4, T_5, T_6 and T_7 with 80, 100, 40, 50, 60, no lac insect (control) and natural settlement of lac insect respectively.

Emergence of male lac insects

The date of emergence of male lac insects as well as its duration was recorded.

Data analysis

Data analysis parameters are presented in the table 4.

Table 4: Skeleton of Analysis of Variance (ANOVA)

Source of variance	d.f.	S.S	M.S.S	F.cal	F. tab
Replication	(r-1)	SSR	VR	VR/VE	-
Treatments	(t-1)	SST	VT	VT/VE	F at 5% (t-1), (r-1) (t-1)
Error	(r-1) (t-1)	SSE	VE	-	-
Total	(rt – 1)	-	-	-	-

Where
r = number of replications
t = number of treatments
V = replication mean sum of square
VT = treatment mean sum of square
VE = error mean sum of square
The significance among different treatment means was judged by critical difference (C.D) at 5% level of significance for comparison among the treatments, for which the marginal means of each treatment was considered. The following formula was used for various estimations.

Standard error of mean SEm± = $\sqrt{\frac{E.ms}{r}}$

Critical difference (C.D.) = SEm± x √2 x t 0.05
Where,
Ems = error mean sum of square
t = 't' value at 5 % level at error d.f.
r = number of replications
SEm ± = standard error of any treatment mean
CD = Critical difference

Results and Discussion

Raw lac yield

Lac production is the ultimate economical goal for the enterprise. However, the economic returns depend on the level of productivity (*i.e*, production per unit area). Besides timely BLI, good lac insect settlement and nutrient status of the host, the important deciding factors for good lac productivity are: total length of branches on the host plant with lac insect (sticklac), mean weight of lac per 2.5cm^2 as well as that of 100 lac cell.

The total length of branches on the host plant with lac insect yields 'sticklac of the lac crop' from which raw Lac is scrapped. The weight of lac per 2.5cm^2 depends on growth of Lac insect and female to male ratio, more females means more lac. The weight of 100 lac cell is similar to 100 seed weight of any cultivated crop. The weight of 100 lac cell depends on the nutrient status of the host plants that promotes better growth of Lac insect and secretion of lac resin.

Weight of Lac per 2.5cm^2

The mean total length of sticklac was highest (654cm) on the *C. cajan* with natural settlement of lac insects 127.39 per 2.5 cm^2 while it was minimum (506.33cm) on *C. cajan* with population density of 60 insects per 2.5cm^2 (Tabla 5) .The mean weight of raw lac per 2.5cm^2 was 0.97, 0.96 and 0.93g on *C. cajan* with population densities of 100,127.39 and 80 insects per 2.5cm^2 while it was least 0.25g on *C. cajan* with population density of 40 insects per 2.5cm^2 closely followed by 0.30 and 0.32g on *C. cajan* with population densities of 50 and 60 insects per 2.5cm^2 respectively (Table 5).

Table 5: Details of lac yield per *C. cajan* with different population densities

Treatments (Pop^n density per 2.5 cm^2)	Total length of sticklac (cm)	Mean lac yield (g)		
		Weight per 2.5 cm^2	100 lac cell weight (g)	Yield (g) per plant
T_1 = 80 lac insects	610.00	0.93	2.91	332.33
T_2 = 100 lac insects	631.00	0.97	3.03	357.33
T_3 = 40 lac insects	590.00	0.25	3.12	446.00
T_4 = 50 lac insects	596.00	0.30	2.51	389.67
T_5 = 60 lac insects	506.33	0.32	2.91	375.67
T_6 = 0 lac insect	0.00	0.00	0.00	0.00
T_7 = 127.39 *	654.00	0.96	2.84	413.33
SE(m) ±	65.29	0.02	0.06	14.98
CD at 5%	201.17	0.06	0.19	46.14

* mean natural population density

Weight of 100 Lac cell

Lac insect secretes resinous substance from its three pair of highly specialized glands to form a protective covering over its delicate body. The continuous secretion during its lifetime dries to form the protective cell, which is termed as Lac cell. The weight of a Lac cell is the lowest individual unit of the

total Lac production. This has its own significance in terms of productivity. It is expressed as mean weight of 100 Lac cells in gram.

The variation in the mean weight of 100 Lac cell in different population densities is interesting, even when it is being grown on the same host plant under similar nutrient profile. It was highest (3.12g) in the population density of 40 insects per 2.5cm^2 closely followed by that (3.03g) in 100 insects per 2.5cm^2.The mean weight of 100 lac cell was 2.91g in population densities of 80 and 60 insects per 2.5cm^2. It was lowest (2.51g) in the population density of 50 insects per 2.5cm^2.

The mean weight of 100 lac cells was 3.12g in case of population density of 40 lac insects per 2.5cm^2. This was highest among the treatments of different population of lac insects. This indicates that with lesser lac insects are able to get better phloem sap and grow better to produce more resin per unit area.

Lac cell weight is an important factor for lac production. Hundred lac cell weight have been reported by many workers in the past. The 100 lac cells weight varies depending on the host, its nutrient status, season and strain of lac insect.

In earlier cases, the mean weight of 100 lac cell was 2.02g to 2.12g[7], 2.24g to 2.54g[8], 1.79g to 3.42g[9], 5.54g to 6.90g[10], 5.18g to 6.30g[11], 3.82g to 5.18g[12], 3.03g to 3.68g[13], 4.66g to 6.33g[14] and 4.95g to 8.21g[15]. In the present case 100 lac cell weight was maximum 3.12g in the population density of 40 insects per 2.5 cm^2.

Lac yield per plant

The study on the population density of Lac insects on fixed area of 2.5cm^2 on the branches of *C. cajan* was very good for a detail understanding of the growth, survival and lac production. The information is valid and accepted, it can translate into economic gains to the socio- economically poor lac growers. Thus, an estimation of per plant Lac production in relation to different population densities based on the length of the sticklac and weight of lac cells per 2.5cm^2 can be worked out for a realistic estimation.

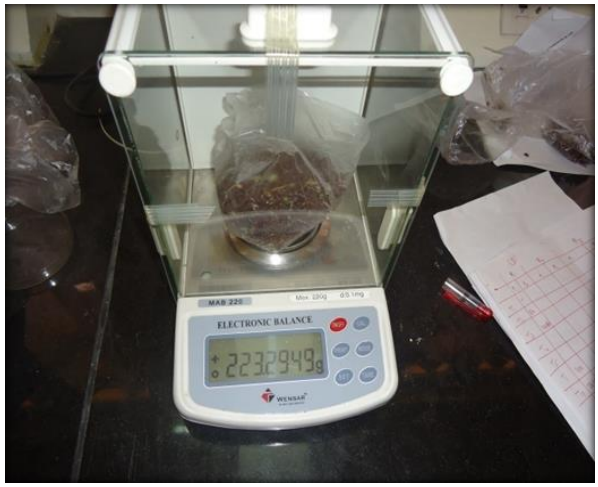
The mean estimated yield of Lac per plant was highest 446.0g on *C. cajan* with population density of 40 insects per 2.5cm^2 while it was lowest 332.33g on *C. cajan* with population density of 80 insects per 2.5cm^2. Thus the mean increase in the Lac yield per *C. cajan* of 34.20 percent can be achieved by reducing the population density of Lac insects just half from 80 to 40 insects per 2.5cm^2. This will further reduce the quantity of broodlac required to inoculate per *C. cajan*.

The mean raw lac yield per plant depends on the host, its nutrient status, season and strain of lac insects. *Rangeeni* lac yield per *B. monosperma* was 4.58kg to 7.08kg[16], 4.96kg to 6.72kg[8], 0.58kg to 2.10kg[13], 2.03kg to 4.01kg[12], 0.95kg to 1.95kg[14] and 2.80kg to 4.59kg[17], while on *Z. mauritiana* it was, 5.08kg to 8.22kg[18], 4.03kg to 5.89kg[7], 3.20kg to 4.55kg[9], 6.32kg to 10.75kg[19], 3.83 to 5.33kg[11]. The mean lac yield per *C. cajan* was 8.9g to 23.7g[20] and 3.74g to 29.45g[21]. The high lac yield in the present case was due to management of the *C. cajan* plant and its nutrient management.

Harvesting of *C. cajan* with Lac

Harvested sticklac of *C. cajan*

Scrapping of raw lac from sticklac crop



Weighing of raw lac

Plate 1: Harvesting of lac crop

Conclusions

Population density of 40 lac insects per 2.5cm^2 if maintained at the time of broodlac inoculation results in lesser intra specific competition for space to grow and food to produce lac. As the mean weight of 100 lac cell was highest (3.12g) and similarly highest mean yield (446g) per *C. cajan* plant.

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