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Productivity-linked parameters of the *Rangeeni* strain Lac Insect, *Kerria lacca* (Kerr) on Pigeonpea, *Cajanus cajan* Linn. at Rajasthan

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Abstract
The present investigation on productivity-linked parameters of lac insect on pigeonpea was carried out on *Rangeeni* strain of lac insect in *Katki* season at lac insect gene bank cum garden situated at Rajasthan College of Agriculture, MPUAT, Udaipur during 2016. The results revealed that the initial density of settlement of first instar crawlers on a plant varied in different parts of plant which ranged from 20-121 crawlers per sq.cm and with a mean initial density of settlement of 92.60, 84.10, 60.00; 86.70, 91.60, 71.00 and 67.40, 64.70, 61.00 crawlers per sq.cm at lower, middle and upper parts of plants in three plots respectively and the per cent mortality ranged from 6.46-12.57 per cent. The mean final density of settlement first instar crawlers ranged from 17-114 crawlers per sq.cm with mean of 85.50, 78.20, 53.10; 80.20, 85.90, 65.00 and 61.90, 57.30, 54.60 crawlers sq.cm on lower, middle and upper portion of plant in three plots respectively. The density of female cells during maturity ranged from 01-11 cells per sq.cm and the fecundity recorded for single female cell was 95-430 larvae per cell. The cell and resin weight ranged from 6-24 mg per cell, 4-19 mg per cell, respectively while mean sticklac and scrappedlac yield recorded were 235 g per plant, 15.63 g per plant respectively.

Keywords: Lac Insect, pigeon pea, *Rangeeni* Strain, producivity-linked parmeters

1. Introduction

Lac is one of nature's gift of immense economic importance to man. It is the only resin of animal origin, being actually the secretion of a tiny scale insect, *Kerria lacca* Kerr belonging to the family Tachardiidae (=Kerriidae), super family Coccoidea of the order Hemiptera [1]. The life cycle of lac insect starts with first instar larval stage, generally known as crawlers; and is the only mobile stage that settles and feeds on phloem sap by piercing its proboscis into phloem region of shoot and secrets the resin over the body. The crawlers after settlement undergo three successive moultings to become the adult. Lac insect basically yields three useful materials *viz*., resin, dye and wax [2]. The major constituent of lac is the resin (68%), dye (1.2%), wax (6%), others (25%) like sugar, proteins, soluble salts, sand, woody matter, and insect body debris. Its derived products are biodegradable, non toxic, environment friendly and have versatile uses and tremendous export potential [2]. In addition to this, the lac insect-host association contributes to the conservation of biodiversity *viz*., soil flora, fauna and soil microorganisms [3].

In India the lac insect is reported to be found naturally on its traditional hosts throughout the country but it is commercially cultivated mainly in the states of Jharkhand Chhattisgarh, West Bengal, Madhya Pradesh, and Maharashtra with 57.20, 17.87, 7.82, 7.26 and 5.30 percent contribution in national lac production [4]. In Rajasthan lac insect is naturally found in abundance on its natural host; peepal (*Ficus religiosa*), ber (*Ziziphus mauritiana*), palas (*Butea monosperma*), bargad (*Ficus benghalensis*) etc, indicating that agro climatic condition of region is best suited for its survival and abundance in the region [5]. In forest areas this natural resin is traditionally collected by tribal's and rurals for various uses but its commercial cultivation is not in practice due to lack of knowledge about the biology and host preference of lac insect [5]. Pigeonpea (*Cajanus cajan*) is a new host and strains of lac insect are being investigated to enhance the lac production. It is cultivated widely in different parts of state and can be better exploited for commercial production of lac in the region, despite rising on ber, palas and kusum where gestation period is 5 to 10 years [6]. Pigeonpea was identified as a favourite host for lac insect long back in 1950's, but on-farm lac production with pigeonpea has recently emerged as a result of increasing demand of lac from various parts of world [7]. Pigeonpea has been reported as promising host in North-Eastern parts of India [8]

Though its prevalence is abundant in natural condition on common lac host, ignorance and unawareness about its significance has hindered the development of lac production particularly in southern parts of Rajasthan. A complete knowledge of production-limiting parameters will bring about an impetus to the lac cultivation in the area. Hence research was carried out with the objective of evaluation of productivity-linked parameters of *Rangeeni* strain of lac insect on pigeonpea.

2. Materials and Method

The present study was carried out in the *Katki* season of *Rangeeni* strain on pigeonpea (*Cajanus cajan* L) during 2016 at lac insect gene bank cum garden situated at Department of Entomology, Rajasthan College of Agriculture, Udaipur (Rajasthan). The host plants were raised by following the all the agronomic practices. Perennial variety of pigeonpea was sown to get healthy plants of proper age for lac inoculation with broodlac sticks. The crop was sown in the last week of April 2016 with row to row spacing of 100 cm and plant to plant spacing of 40 cm in plot size measuring 2.0 × 10 sq m. There were 30 plants in each plot replicated thrice. The brood lac of *Rangeeni* strain needed for the experiment were collected from the mature crop of *Rangeeni* strain prevailing in the region on natural hosts bearing fully matured females. The brood lac were bundled and tied on host plants at 1-1.5ft above the ground level to provide succulent stem for crawlers to settle down. The nymphs were allowed to emerge from mature females for about two weeks. After the emergence of newly hatched nymphs the phunki lac stick bundles were removed from host plants. To study the productivity - linked parameters of *Rangeeni* strain lac insect on pigeonpea, the regular observations on yield attributing parameters *viz*., initial density of settlement, initial mortality, final density of settlement, density at crop maturity, weight of female lac cell, fecundity and yield were recorded on ten plants sown 45 days before the inoculation of broodlac in three sets of plots. The observations were recorded as per the standard procedure prescribed by [9] as detailed below:

2.1 Initial density of settlement (number per square cm)

The initial density of settlement were recorded 7 days after the inoculation of broodlac on 10 tagged plants in each set of plot where one square cm area was selected randomly and numbers of lac crawlers settled were counted visually by using magnifying glass by placing a graph paper with one square cm area cut window on the stem of plant and three such sites were selected at lower, middle and upper part of plant and average was taken as initial density of settlement (number per square cm).

2.2 Initial mortality (%)

Observations on initial density were repeated at 21-days after inoculation of broodlac following the same procedure as described earlier. The process of crawler emergence continues up to two weeks. The crawlers which are not able to find suitable sites for settlement die due to starvation. Observation at this stage is the true indication of the number of crawlers actually settled and that have started feeding. The initial mortality (%) was calculated by the following formula

$$\text{Initial mortality} = \frac{\text{Initial density} - \text{Density after 21 days of settlement}}{\text{Initial density}} \times 100$$

2.3 Final density of settlement (number per square cm)

The final density of settlement of crawlers was calculated by the following formula i.e.

Final density of settlement = Initial density – Initial mortality

2.4 Density at crop maturity (number of female cells per square cm)

To study the density of lac insect at crop maturity, the numbers of surviving female cells were counted at maturity when the lac crop matures with appearance of yellow spot on cell. The number of mature females per square cm was counted by following the procedure of placing of graph paper with one square cm window.

2.5 Weight (in mg) of the female cell and resin output

Weight (mg) of individual female lac insect was recorded after completion of larval emergence using electronic balance and the resin produced by an individual female cell was recorded after removing the dead insect body from cells.

2.6 Fecundity (number of young ones produced by the female insect)

To record the fecundity of lac insect, the mature female cells were placed individually into glass vials plugged with cotton for about a month and the total number of emerged larvae per female were counted and taken as fecundity of the female lac insect.

2.7 Total yield (g)

Total yield (g) of sticklac and scrappedlac were recorded at harvest per tagged plants for each set of plots.

2.8 Statistical Analysis

The data recorded on different parameters were subjected to analysis as given below.

i. Mean density

$$\text{Mean density} = \sum \frac{Xi}{N}$$

Where,
Xi = No. of insects settled per sq cm
N = Total No. of plant sampled

ii. Standard Deviation

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}$$

Where,
x_i = Number of insects settle per sq cm
N = Total number of plant sampled.
μ = Mean density of crawlers settled per sq.cm

iii. Range

Range = Lowest Value to Highest Value

iv. Standard Error

$$\text{Standard error} = \frac{\text{Standard deviation}}{\sqrt{\text{No. of Samples}}}$$

3. Results

3.1 Initial density of settlement (number per sq.cm): The data recorded on mean initial density of settlement of first instar crawlers are presented in Table 1 and showed that the initial density of crawlers ranged from 68-117, 58-121 and

54-86; 47-110, 47-110 and 54-107 and 32-107, 35-92 and 20-103 crawlers per sq.cm with a mean initial density of settlement of 92.60, 84.10 and 60.00; 86.70, 91.60 and 71.00; 67.40, 64.70 and 61.00 per sq.cm and deviation of 14.86, 23.23 and 16.29; 24.16, 15.02 and 16.08 and 22.64, 16.52 and 28.38 per sq.cm on lower, middle, upper parts of plant in plot I,II and III respectively

The data recorded on initial density of settlement of first instar crawlers from lower, middle and upper portion of pigeonpea plant in *Katki* season during 2016 were categorized into three different groups; 20-50, 50-80, 80 and above crawlers for 10 plants in each sets of plots (Table 2).The results of category wise mean of initial density from lower portion of plants reveals that under category 20-50 crawlers per sq.cm, the number of plant were minimum with least average density ranging from 32 to 47 crawlers per sq.cm whereas under category 50-80 crawlers per sq.cm the 2,3 and 7 plants with an average density of 73.50, 65.33 and 61.85 per sq.cm and 8,6 and 2 plants under category 80 and above with 97.37, 104 and 104.5 crawlers per sq.cm average density were recorded in three sets of plots, respectively. Similarly, the observations from middle parts of plant also showed that under category 20-50 crawlers per sq.cm, the number of plant were minimum with least average density ranging up to 47.00 crawlers per sq.cm whereas under category 50-80 crawlers per sq.cm the 6,2 and 7 plants with an average density of 67.00, 71.00 and 61.85 per sq.cm and 4,8 and 2 plants under category 80 and above with 109.75, 96.75 and 88.50 crawlers per sq.cm average density were recorded in three sets of plots, respectively. The observations mean initial density on upper parts of plant reveal that 3,3 and 4 plants were in the category of 20-50 with an average density of 45.66, 45.66 and 34.25 per sq.cm; 5,5 and 2 plants in the category of 50-80 with an average density of 58.40, 58.40 and 56.00 per sq.cm and 2,2 and 4 plants in the category of 80 and above with an average density of 85.00, 85.00 and 90.00 per sq.cm were recorded in three sets of plots, respectively.

3.2 Initial Mortality (%): The results on per cent initial mortality of first instar crawlers of *Rangeeni* strain of lac insect in *Katki* crop season recorded at 21-days after inoculation of broodlac on pigeonpea (Table 3) reveal that the first instar crawlers of lac insect which were not able to find suitable sites for settlement, died due to starvation and remaining population at this stage were the true number of crawlers actually settled. The results reveal 7.55%, 8.12%, 10.39%; 7.70%, 6.46%, 7.49% and 9.09%, 12.27%, 12.58% mean mortality of first instar crawlers at lower, middle and upper portion of plant in three plots respectively.

3.3 Final density of settlement (Number per sq.cm): The observations on final density of settlement of first instar crawlers on lower, middle, upper portion of 10 randomly selected plants in each set of plots presented in Table 1 and showed that the final density of crawlers ranged from 62-106, 50-114 and 40-83; 40-104, 62-102 and 42-102 and 30-101, 28-83 and 17-96 per sq.cm on lower, middle, upper portion of plant in three plots, respectively. The results show that mean final density of settlement in three plots was 85.50, 78.20 and 53.10; 80.20, 85.90 and 65.00 and 61.90, 57.30 and 54.60 per sq.cm with a deviation of 14.74, 22.70 and 17.10; 22.91, 15.66 and 18.26 and 22.26, 17.10 and 28.60 per sq.cm on lower, middle, upper portion of plant respectively.

The data recorded on final density of settlement of first instar crawlers from lower, middle and upper portion of pigeonpea plant in *Katki* season during 2016 were categorized into three different groups; 20-50, 50-80, 80 and above for 10 plants in each sets of plots (Table 2) The results of category wise mean final density of settlement reveals that in lower portion of plant 0, 2 and 3 plant were in the category group of 20-50 with an average density upto 44.00 per sq.cm, 3, 2 and 5 plants were in the category of 50-80 with an average density of 68.66, 68.50 and 60.00 per sq.cm whereas 7, 4 and 6 plants were found in the category of 80 and above with an average density of 92.71, 102.75 and 96.66 per sq.cm in plot I. Similarly the data tabulated for middle portion of plant show that 0, 0 and 3 plants were in category group of 20-50 with an average density of 57.50 per sq.cm and 6, 4 and 6 plants were in the category of 50-80 with an average density of 61.83, 68.50 and 60.00 per sq.cm whereas 4, 6 and 1 plants were found in the category of 80 and above with an average density of 102.75, 97.00 and 83.00 per sq.cm. The observations on upper portion of plant reveal that 6, 2 and 5 plants were in the category of 20-50 with an average density of 41.16, 44.50 and 30.20 per sq.cm, 2, 6 and 2 plants were in the category of 50-80 with an average density of 60.50, 62.83 and 66.00 per sq.cm and 2, 2 and 3 plants were found in the category of 80 and above with an average density of 81.50, 92.00 and 87.66 per sq.cm.

3.4 Density at crop maturity (Number of female cells per sq.cm)

The results on average number of female cells per sq.cm of *Rangeeni* strain of lac insect in *Katki* season on lower, middle, upper portion of plants in each set of plot during 2016 presented in Table 1 reveal that the mean density of female cells were 5.00, 3.80 and 4.90; 4.00, 4.20 and 4.40 and 6.40, 5.70 and 6.00 per sq.cm with a deviation of 1.63, 1.81 and 1.44; 1.63, 1.39 and 1.83 and1.34, 1.25 and 1.88 per sq.cm on lower, middle, upper portion of ten plants in three plots, respectively. The density of female cells ranged from 3-7, 1-6 and 3-7; 2-7, 2-6 and 2-8 and 4-11, 3-11 and 4-11 per sq.cm on lower, middle, upper portion of plant respectively.

3.5 Weight of cell (mg) and resin weight (mg)

The results presented in Table 4 reveal that the mean weight of randomly selected ten samples of female cells from three plots were 12.20, 12.30 and 14.70 mg respectively with an overall mean of 13.06 mg. The minimum weight of female cell recorded was 6.00 mg and maximum weight of female cell recorded was 24.00 mg. The mean resin weight recorded in three plots was 9.60, 10.10 and 12.40 mg with an overall mean of 10.70. The minimum resin weight of female cell recorded was 4.00 mg and maximum resin weight of female cell recorded was19.00 mg.

3.6 Fecundity per female cell

The mature 10 female cells from each plot were kept in separate glass vials plugged with cotton individually up to 1 month duration and emerged crawlers were counted. The results were presented in Table 4 reveal that the average number of crawlers emerged from female cells of *Rangeeni* strain of lac insect from host pigeonpea in *Katki* season during 2016 were 327.50, 258.30 and 162.90 respectively with an overall mean of 249.56 and maximum fecundity recorded was 430 whereas minimum fecundity recorded was 95 crawlers per female.

3.7 Yield of sticklac and scrappedlac in gm

The results presented in Table 4 revealed that the mean yield of sticklac recorded from 10 plants in three plots were 242.50, 210.00 and 252.20 g respectively with an overall mean of 235.00 g sticklac per plant and maximum yield of sticklac was observed as 400 g per plant and minimum yield of stick lac recorded was 125 g per plant in all the three plots.

The mean scrappedlac yield recorded from 10 plants in three plots were 11.43, 12.79 and 22.67 g respectively with an overall mean of 15.63g scraped lac per plant and maximum yield of scraped lac recorded was 29.45 g per plant and minimum yield recorded was 3.74 g per plant.

4. Discussion

The productivity of lac insect on different host depends upon the various factors governing the development of lac insect host and lac insect. The lac being the secretion of the insect is directly affected by the biotic and abiotic stresses. Besides the several developmental parameters [10] which contribute in growth, feeding, secretion and oviposition of lac insect influence the relative production of resin by lac insect. The role of developmental parameters has been discussed earlier by various workers [11, 12, 5, 1] in India the systematic work on productivity linked parameters of lac insect has started recently few years back in 2014, with the initiation of ICAR Network project on "Conservation of lac insect genetic resources" as a result of which definite guidelines for studies on this aspect were developed. In the present investigation seven different productivity-linked parameters of lac insect contributing to the productivity of *Rangeeni* strain of lac on pigeonpea in *Katki* crop were studied during 2016 to establish the resin producing efficiency and quantity of lac produce by Indian lac insect (*Kerria lacca* Kerr) on pigeonpea (*Cajanus cajan*). The different parameters linked with productivity of lac insect have been discussed in the light of the research work done by various workers as detailed below under the following subheads:

4.1 Initial density of settlement (Number per sq.cm)

The gravid female lays eggs inside encrustation and first instars larvae hatch out which crawls and settle at suitable sites of succulent stem of host plant. The settlement of the first instar larvae takes place within a period of a week or two of the hatching.

The observations of mean initial density of settlement recorded 7 days after the inoculation of broodlac and reveal that there was a difference in a mean initial density of settlement of first instar larvae on lower, middle and upper portion of plant. The observed range of initial density of settlement of first instar larvae of *Rangeeni* strain of lac insect on pigeonpea in *Katki* season during 2016 was 68-117, 58-121, 54-86; 47-110, 17-110, 54-107 and 32-107, 35-92, 20-103 per sq.cm respectively on lower, middle and upper portion of host plant in three plots. Some researchers have studied the initial density of settlement of larvae in *Kusmi* strain, but no studies on this aspect of *Rangeeni* strain have been revealed by the researchers however the results of present investigations are in alignment with the findings of [1] who reported that initial density of settlement of larvae ranged between 92.58-126.74 per sq.cm and 93.12-109.62 per sq.cm of *Kusmi* strain on Kusum and Ber trees respectively.

4.2 Initial mortality (%)

The first instar larvae which could not find suitable sites for settlement on host plant could not survive and dies due to starvation within a week or two of its emergence. The observations on per cent initial mortality of first instar larvae recorded at 21 days after inoculation of broodlac of *Rangeeni* strain of lac insect in *Katki* season on pigeonpea during 2016 shows that mean per cent initial mortality of first instar larvae varied from 6.46 per cent in middle portion to 12.57 per cent in upper portion of plants under experimental condition. The results of present investigations reveal that 7.55, 8.12, 10.39; 7.70, 6.46, 7.49 and 9.08, 12.27, 12.57 per cent mean mortality were recorded from lower, middle and upper portion of the plants in three plots respectively. The results of the present investigation confer the findings of [12] who recorded minimum per cent mortality of *Rangeeni* strain of lac insect in *C. calothyrsus* (12.48%) and *D. assamica* (22.36%) and maximum per cent mortality of *Kusmi* strain in *Jethwi* crop season in *F. semialata* (27.88%) followed by ber (24.91%) and kusum (18.75%).

4.3 Final density of settlement (Number per sq.cm)

The mean final density of settlement of first instar larvae was recorded by subtracting the density of larvae in initial and initial mortality (number). The findings of present investigation reveal that maximum final density of settlement recorded was 114 crawlers per sq.cm while minimum final density of settlement of *Rangeeni* strain of lac insect was 17 per sq.cm on pigeonpea in *Katki* season during 2016. The observations made by [12] also supports the results of present investigation who recorded maximum density (77.8 per sq.cm) of insect settlement in *F. macrophylla* as intercrop in understorey of *Dalbergia sisso* at 21 days after of inoculation of brood lac.

4.4 Density at crop maturity (number of cells per sq.cm)

The lac cells are exposed to several biotic and abiotic stresses during life period on the host hence also affect the density of female cells at crop maturity and vary widely from initial density of settlement. The female cell during their growth period increases in size and density at maturity determines the yield of lac insect at harvest and the potential of broodlac for next generation therefore can be considered as an important parameter linked with productivity of lac insect. Density of living female at crop maturity is the result of interaction between host suitability and existing environmental factors and may vary within the same host.

The results on mean of female cells per sq.cm of *Rangeeni* strain of lac insect in *Katki* season during 2016 presented in Table reveal that mean density of female cell recorded at crop maturity were 5.00, 3.80, 4.90; 4.00, 4.20, 4.40 and 6.40, 5.70, 6.00 per sq.cm respectively on lower, middle and upper portion of plant in three plots, The maximum density of female cells of *Rangeeni* strain of lac insect on pigeonpea during *Katki* season recorded during investigation was 11 cells per sq.cm and minimum density recorded was 1 cell per sq.cm. The results of present investigation are in full alignment with the findings of [1] who also recorded average density of living female cells at crop maturity were 3.38-12.67 cells per sq.cm on palas plant for *Rangeeni* strain of lac insect and as the smaller cells during growth period become large and fuse with each other which cause the observation difficult however effort were made in the present investigation to evaluate same, so as to establish density of females at maturity which greatly depends on size and growth of females. A higher growth and large size decreases the per sq.cm density of female cells at maturity. Drastic reduction in settlement density of females when compared to initial

density of settlement is caused by (i) mortality due to non feeding at initial stage, (ii) existing biotic/abiotic factors and (iii) death of male insects which die soon after fertilizing the females.

4.5 Weight of cell (mg) and resin weight (mg)

The weight of female cells of *Rangeeni* strain of lac insect on pigeonpea in *Katki* season during 2016 were recorded by electronic balance and resin weight also recorded by removing dead insect body from the female cells. The results of present investigations reveal that the mean weight of single female cell was 13.06 mg and ranges from 6-24 mg. Large quantity of lac resin is secreted by female after fertilization, which protects mother insect as well as its young-ones at later stages. It has been found that insect with high fecundity secretes more resin. As the lac insects are usually situated close together, the lac secretion from adjacent cells coalesces with each other and forms a continuous encrustation on the branches of host plant The present results are in conformity with the findings [5] who evaluated 7 host plants of lac insect with reference to the cell weight found that it ranging from 10.12-14.21 mg in ber and 9.40-13.60 mg in pigeonpea (*Baisakhi*). The results of present study are also in full alignment with the findings of [13] who also evaluated the productivity of Indian lac insect (*Kerria lacca* Kerr) on *F. semialata* and *F. macrophylla* in terms of dry cell weight and recorded 8-19 mg and 9-18.83 mg cell weight on two hosts respectively.

The mean resin weight recorded in *Rangeeni* strain of lac insect on pigeonpea in *Katki* season during 2016 was 10.70 mg per cell and ranged from 4-19 mg per cell. The results are in conformity to the findings of [14] who studied the resin producing efficiency of *Rangeeni* strain of *Kerria lacca* on different hosts and recorded resin weight on *A. auricaliformis* (9.09 mg), followed by *B. monosperma* (8.76 mg), *F. macrophylla* (7.49 mg) and *C. moschata* fruits (6.00 mg)

4.6 Fecundity (per female cell)

The eggs are laid by the female within the lac cell. Generally it lays about 200-500 eggs per female cell which may be fertilized or unfertilized. The female generally lays well developed eggs which hatch within few hours. The results of the present investigation reveal that the maximum larvae emerged per female cell were 430 while minimum 95 larvae emerged per female cell. The mean larvae emerged from single female cells of *Rangeeni* strain of lac insect on pigeonpea was 249.56. The results of present investigation gets full support from the findings of [15] who also reported that the reproductive potential of *Kerria lacca* ranged from 224-307 eggs in 1st generation and 160-240 eggs in 2nd generation. Similarly the findings of [13] who evaluated the productivity of Indian lac insect (*Kerria lacca* Kerr) on *F. semialata* and *F. macrophylla* in terms of fecundity and found that the fecundity varied from 253-565 and 297-477 larvae per female cell respectively on the two hosts under study also confers the results of present investigation. The findings of [5] are also in support of the present investigation who evaluated 7 host plants of lac insect with reference to the fecundity and found highest fecundity in Ber (525.20 & 450.60) and lowest in pigeonpea (*Baisakhi*) (409.00 & 315.40)

4.7 Yield (g)

The results on mean yield of sticklac and scrapedlac of *Rangeeni* strain of lac insect on pigeonpea in *Katki* season during 2016 reveal that mean yield of sticklac was 235.00 g per plant and ranges from 125-400 g which confer the findings of [12] who recorded 342.74 g and 219.02 g sticklac yield in *Flemengia sp* in winter and rainy season respectively per plant. The results also reveal that mean scrappedlac yield per plant was 15.63 g and ranges from 3.74-29.45 g. The similar study to record the scrapped lac yield was conducted by [12] who recorded scrapped lac yield per plant 166.64g in winter and 81.47g in rainy season. The variation of results with the findings of the present investigation in the yield may be attributed to the size, growth, length of the plants, strain of lac insect and climatic condition etc which may cause difference in the yield of scrapedlac.

5. Conclusion

On the basis of results recorded in the present investigation and the discussions in the light of the work carried out by various scientist, it could be inferred that the *Rangeeni* strain of lac insect completes all the life stages of life cycle on the pigeonpea host and thrives well till maturity. The different productivity-linked parameters studies also showed positive results; hence in order to promote the cultivation of lac insect in tribal belt of southern Rajasthan, apart from ber and palas, the traditionally growing perennial pigeonpea crop could also be better utilized as the preferred host for its cultivation. Lac cultivation for their products of economic importance, i.e. resin, dye and wax will not only provides livelihood to tribals and rural lac growers, but also helps in conserving vast stretches of forests and biodiversity associated with lac insect complex. In forest areas this natural resin is traditionally collected by tribals and rural for various uses but its commercial cultivation is not in practice due to lack of knowledge about the biology and host preference of lac insect. A complete knowledge of production-limiting parameters will bring about an impetus to the lac cultivation in the area particularly tribal belt of southern Rajasthan where tribal's can better exploit both the available traditional host plant and legume crop widely grown in the area for extra income with minimum inputs. However there is a need to carry out further investigations on the different related aspects such as effects of lac insect populations on the yield of pigeonpea, its varietal suitability, host preference, insect host interactions and its correlation with different biotic and abiotic factors. Thus the result of the present findings will not only help in understanding the life stages of lac insect during lac cultivation but will also provide an opportunity for further research in the subject.

Table 1: Mean initial density of settlement, final density of settlement and density of female cells at crop maturity of *Rangeeni* strain of lac insect on pigeonpea during *Katki* season, 2016.

Plot No	Statistical tools	Initial density of settlement (crawlers per sq.cm)			Final density of settlement (crawlers per sq.cm)			Density of female cells at maturity (cells per sq.cm)		
		L	M	U	L	M	U	L	M	U
Plot I	Mean ($\bar{x}$)	92.60	84.10	60.00	85.50	78.20	53.10	5.00	3.80	4.90
	SD (σ)	14.86	23.23	16.29	14.74	22.70	17.10	1.63	1.81	1.44
	SE	4.70	7.35	5.15	4.66	7.17	5.40	0.52	0.57	0.45
	Range (R)	68-117	58-121	54-86	62-106	50-114	40-83	3-7	1-6	3-7
Plot II	Mean($\bar{x}$)	86.70	91.60	71.00	80.20	85.90	65.00	4.00	4.20	4.40
	SD (σ)	24.16	15.02	16.08	22.91	15.66	18.26	1.63	1.39	1.83
	SE	7.64	4.75	5.08	7.27	4.95	5.77	0.51	0.44	0.58
	Range (R)	47-110	47-110	54-107	40-104	62-102	42-102	2-7	2-6	2-8
Plot III	Mean($\bar{x}$)	67.40	64.70	61.00	61.90	57.30	54.60	6.40	5.70	6.00
	SD (σ)	22.64	16.52	28.38	22.26	17.10	28.60	1.34	1.25	1.88
	SE	7.16	5.22	8.97	7.04	5.40	9.04	0.42	0.39	0.59
	Range	32-107	35-92	20-103	30-101	28-83	17-96	4-11	3-11	4-11

*L-Lower portion of plant *M-Middle portion of plant *U-Upper portion of plant

Table 3: Mean per cent mortality of crawlers of *Rangeeni* strain lac insect on pigeonpea during *Katki* season, 2016.

	Mean per cent mortality per sq.cm		
	Lower portion of plant	Middle portion of plant	Upper portion of plant
Plot I	7.55	8.12	10.40
Plot II	7.70	6.46	7.49
Plot III	9.09	12.27	12.58

Table 2: Category wise mean initial and final density of settlement (per sq.cm) of first instar crawlers of *Rangeeni* strain of lac insect on pigeonpea during *Katki* season, 2016.

Initial density of settlement per sq. cm									
	Plot I			Plot II			Plot III		
Category	L	M	U	L	M	U	L	M	U
20-50	0 (0.00)	0 (0.00)	3 (45.66)	1 (47.00)	0 (0)	3 (45.66)	1 (32.00)	1 (35.00)	4 (34.25)
50-80	2 (73.50)	6 (67.00)	5 (58.40)	3 (65.33)	2 (71.00)	5 (58.40)	7 (61.85)	7 (62.14)	2 (56.00)
80&above	8 (97.37)	4 (109.75)	2 (85.00)	6 (104.00)	8 (96.75)	2 (85.00)	2 (104.50)	2 (88.50)	4 (90.00)
Final density of settlement per sq.cm									
20-50	0 (0.00)	0 (0.00)	6 (41.16)	2 (44.00)	0 (0.00)	2 (44.50)	3 (41.00)	3 (57.50)	5 (30.20)
50-80	3 (68.66)	6 (61.83)	2 (60.50)	2 (68.50)	4 (69.25)	6 (62.83)	5 (60.00)	6 (62.50)	2 (66.00)
80&above	7 (92.71)	4 (102.75)	2 (81.50)	6 (96.66)	6 (97.00)	2 (92.00)	2 (98.00)	1 (83.00)	3 (87.66)

*L-Lower portion of plant *M-Middle portion of plant *U-Upper portion of plant
*Figures in parenthesis are average final density of settlement of crawlers (No/cm^2)

Table 4: Mean cell weight, resin weight, fecundity, sticklac yield and scrappedlac yield of *Rangeeni* strain of lac insect on pigeonpea during *Katki* season, 2016.

Plot No	Cell weight (mg)	Resin weight (mg)	Fecundity per female cell	Sticklac yield (gm)	Scrappedlac yield (gm)
Plot I	12.20	9.60	327.50	242.50	11.43
Plot II	12.30	10.10	258.30	210.00	12.79
Plot III	14.70	12.40	162.90	252.50	22.67
Mean	13.06	10.70	249.56	235	15.63
Range	6-24	4-19	95-430	125-400	3.74-29.45

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