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Survival of Lac Insects on Pigeonpea Genotypes

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A B S T R A C T

Farmers' income can be improved with crop diversification and cash crop in their production system. Pigeonpea a widely cultivated pulse crop in central India is also a good annual host of lac insect. Released variety of pigeonpea TJT-501 along with nine local tall and long duration pigeonpea genotypes were evaluated for survival of lac insects on them. The survival of lac insects from 45 days to 190 days after Brood lac inoculation varied from 24.91 to 38.13 percent. The adult male lac insects emerged from 115 to 124 days after the BLI. The male to female ratio varied from 1:1.9 to as high as 1:6.93. In general the local genotypes performed better than the released pigeonpea variety TJT-501 for the growth and survival of lac insects.

Introduction

Regular cash inflow in agriculture is the one of the major requirement for sustainable income of small and marginal farmers in India (Behera and Bussa, 2018: Dogliotti *et al.*, 2014). The mean household income of farmers in India is just Rs 6210 per month, which is insufficient for household food security. Farmer should shift from their present subsistence farming to diversified cropping with cash crop components for sustenance (Bisht *et al.*, 2014).

Lac is a cash crop generally collected or produced by forest dependents as well as tribal communities in India (Jaiswal *et al.*, 2020; Namdev *et al.*, 2015; Shah *et al.*, 2015). India is the largest producer and exporter of lac in the world (Pal, 2015; Yogi *et al.*, 2014).

Madhya Pradesh is the third largest producer after Jharkhand in Chhattisgarh (Shah *et al.*, 2018). *Butea monosperma*, *Schleichera oleosa* and *Zizyphus mauritiana* are the common woody wild tree hosts of lac insect in MP ((Namdev *et al.*, 2015; Kumar *et al.*, 2017).

Pigeonpea is also a good annual host plant of lac insect (Vajpayee *et al.*, 2019; Ghosh *et al.*, 2014). MP is the second largest producer of pigeonpea in India (Anon, 2018-19).

In the state it is grown by resource poor, small and marginal farmers (Anon, 2018-19). Majority of the pigeonpea cultivated are early to medium duration varieties (Saxena *et al.*, 2018).

In the context the present field study was conducted to evaluate a tall and long duration pigeonpea genotypes for lac production along with the variety TJT-501.

Materials and Methods

Experimental site

A field trial was conducted to study the survival of lac insect *Kerria lacca* on ten genotypes of *Cajanus cajan* (L.) Millsp. The experiment was conducted in JNKVV, Jabalpur, Madhya Pradesh from May 2019 to June 2020.

The topography of the experimental field was fairly uniform and all physical facilities were adequately available. Nine tall and long duration genotypes of *Cajanus cajan* TJT-501 (Table-1) as well as a released variety TJT-501 was replicated thrice in a RBD format with plant to plant and row to row spacing of 6 feet apart, Jabalpur lies in the Kymore plateau and Satpura hill zone. The weather is typically sub humid, featured by hot dry summer and cool dry winter (Fig. 1).

Schedule of operations

Schedule of field operation during the course of experiment are.

Nursery raising of *C. cajan*

Nursery of *C. cajan* was raised in substrate (*Kapu* + FYM) filled polythene bag of size 18 x 16 cm, were perforated to drain out excess irrigation water, applied at weekly intervals. Polythene bags and kept in shade for its germination. Seeds treated with *Trichoderma viridae*, *Rhizobium* and PSB were sown. 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.

Transplantation

The experiment was layout in plot size of 56 feet x 54 feet to accommodate 90 *C. cajan* plants maintaining spacing of 6 feet between plant to plant and row to row. The replications were 10 feet apart.

Substrate

Homogeneously mixed substrate was filled in a Polypropylene bag (PPB). Each of the empty PPB weighed 125 g and a dimension of 93 cm x 61 cm was filled were with 65 kg substrate consisted of a mixture of 45 kg river bed basin soil (*Kapu*) and 20 kg well rotten Farmyard manure (FYM), (Patent application no 201921005340 A dated 01.03.2019). The physio- chemical property of the substrate is mentioned in the Table 2.

The substrate was filled into the PPB with help of a *tasala* followed by constantly shaking the bag to ensure proper compactness of the substrate in the PPB. The PPB when filled with 65 kg substrate attained a

dimension of 46 cm height and 125 cm circumference. Availability of Nitrogen, Phosphorous and Potash in 65 kg of substrate is 136.15 g, 45 g and 304 g respectively. The PPB was filled with substrate on the designated spot in the layout of the experiment, such that it is not disturbed in future.

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 for transplantation. Each of the 90 saplings were place at adjacent to substrate filled PPB. The polythene bag of the *C. cajan* saplings was carefully removed without disturbing its root system, and carefully transplanted in the substrate filled PPB. The sapling was in the main field pressed to minimize air pockets, followed by watering. The transplantation was done in the evening hours of 05th July 2019.

Application two pesticides

Preventive sprays of pesticides on *C. cajan* plants were carried out to protect lac insects from its predator and foliage feeders. First spray of Cartap Hydrochloride 50%SP 1g/litre was at 30 days after BLI, while the second spray of Cartap hydrochloride+ Dithane M-45 75%WP was at 60 days after BLI.

The transplanted *C. cajan* was again nipped at 10-12 days interval between 12th July 2019 the last week of September 2019.

Irrigation

Each of the PPB with *C. cajan* plant was irrigated at regular intervals. There was no irrigation between August to October, due to rains, while from November to February the interval of irrigation was 15 days, but from March 2020 to June 2020, it was at 10 days interval. Approximately 10 litres of water was given per plant during each irrigation.

Brood lac inoculation (BLI)

Rangeeni brood lac was purchased from M/s Adarsh Lac Samiti, Jamankhari village, Tehsil Barghat, District Seoni, M.P. on 11.11.2019. Predator free good quality brood lac was sorted 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 with the help of a twine. *Phunki* removal pertains to the removal of left over brood lac twigs from *C. cajan* after complete emergence of lac nymphs from mother lac insect cells. *Phunki* was carefully removed from *C. cajan* plants 21 days after BLI without damaging the lac insect settlement on the plants.

Harvest of Lac crop

C. cajan with lac was harvested on 12.06.2020. The harvested *C. cajan* plant was shade dried for four days. All the branches with lac encrustation was separately kept measured and tagged. Lac was scrapped from the plant after keeping a clean polythene sheet at the base. The lac thus obtained was dried and weighed to record the data.

Observations

Lac insect count

Lac insects were counted from three fixed slots of 2.5 cm^2 (2.5 cm length and 1.0 cm width) on the branch with good lac insect settlement. Usually 30 days after BLI majority nymph of *K. lacca* leaves the brood lac and settles on the fresh branch of the host plant. Once lac insect inserts its stylet into the phloem, it becomes sedentary. Thus thirty days after BLI, 3 slots each of 1 cm width and 2.5 cm length was marked on the bark of the branch bearing good settlement of the lac

insects. Each slot was designated as S_1, S_2, and S_3. Stretching a thread between the index fingers of both the hands, the insect settlement adjacent to the boundaries of the slot was carefully removed to make the slot clearly differentiated from the rest of the lac settlement on the branch. All the insect count was recorded from the slots only.

Digital recording

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.

The digital images from the DSLR camera were transferred to the Laptop with the help of memory card reader. The live lac insects within the slot were digitally counted followed the technology developed by JNKVV Jabalpur (Patent application 201921007852 A). Counting of live lac insects within the slots were done at 45, 90, 130, 155 and 190 days after BLI during 2019-20. The date of emergence of male lac insects as well as it duration of its presence on the lac insect settlement was recorded digitally.

Results and Discussion

Live lac insects per 2.5 cm^2

Five observations of mean live lac insects per 2.5 cm^2 (MNL) on the branches of *C. cajan* were recorded on 45th, 90th, 130th, 155th and 190th days after BLI.

MNL on 45th day of BLI (30.12.2019)

MNL was significantly highest (168.72) on TJT-501 followed by Gadarwara (165.06), Korsar-3 (162.39), Rajak-2 (162), Korsar-2 (159.83), Amarkantak-2 (155.5), Amarkantak-3 (154.83), Amarkantak-4 (152.33), Saraswahi (149.83) and Amarkantak-1 (147.67) on 45th day of BLI. There was a significant difference in the MNL on TJT-501 and Gadarwara over rest of the genotypes, which were at par with each other (Table 2).

MNL on 90th day of BLI (15.02.2020)

On 90th day after BLI the MNL was significantly highest (149.39) on Lakhnadon-2 followed by TJT-501 (148.50), Korsar-3 (140.50), Korsar-2 (138.44), Gadarwara (134.00), Amarkantak-4 (131.83), Amarkantak-3 (124.39), Amarkantak-1 (121.72), Saraswahi (121.39) and Amarkantak-2 (118.39). There was significant difference in the MNL on Lakhnadon-2, TJT-501, Korsar-3, and Korsar-2. Rest of the genotypes was at par with each other.

Emergence of adult male

The adult male lac insects emerged on 115th day after BLI. It was earliest in Amarkantak-1 and Amarkantak-3 followed by Amarkantak-2 (117 days), Saraswahi (119 days), Lakhnadon-2 (122 days), Korsar-2 (122 days), TJT-501 (123 days), Korsar-3 (123 days), Amarkantak-4 (124 days) and Gadarwara (125 days). On the basis of emergence of adult male lac insects, the genotype can be categorised into two early male emergence group i.e. 115th to 119th days after BLI and late group i.e. 122th-125th days after BLI. The former category included Amarkantak-1, Amarkantak-3, Amarkantak-2, Saraswahi and the latter category included Lakhnadon-2, Korsar-2, TJT-501, Korsar-3, Amarkantak-4 and Gadarwara.

On 130th day of BLI the mean number of male lac insects per 2.5 cm^2 highest (27.33) in Gadarwara followed by Amarkantak-4 (27),

Amarkantak-3 (23.33), Saraswahi (15.33), Amarkantak-1 (15), Korsar-3 (14.67), TJT-501 (13), Amarkantak-2 (11), Korsar-2 (11) and Lakhnadon-2 (9.67).

In comparison to the MNL on 45th day of BLI, the mean percent of male lac insects was highest (34.32 %) on Amarkantak-4 followed by Gadarwara (32.67 %), Amarkantak-3 (31.25 %), Saraswahi (26.29 %), Amarkantak-1 (20.55 %), Korsar-3 (17.19 %), TJT-501 (16.60 %), Amarkantak-2 (15.07 %), Korsar-2 (14.22 %) and Lakhnadon-2 (12.61 %).

However in comparison to the MNL on 45th day of BLI, the mean percent of female lac insects was highest (87.39 %) on Lakhnadon-2 followed by Korsar-2 (85.78 %), Amarkantak-2 (84.93 %), TJT-501 (83.40 %), Korsar-3 (82.81 %), Amarkantak-1 (79.45 %), Saraswahi (73.71 %), Amarkantak-3 (68.75 %), Gadarwara (67.33 %) and Amarkantak-4 (65.68 %).

MNL on 130th day of BLI (25.03.2020)

On 130th day of BLI MNL was significantly highest (100.11) on TJT-501 followed by Lakhnadon-2 (98.00), Korsar-2 (94.83), Korsar-3 (93.50), Amarkantak-4 (90.89), Amarkantak-3 (90.39), Amarkantak-1 (88.72), Gadarwara (86.00), Amarkantak-2 (82.50) and Saraswahi (78.50).

There was significant difference in TJT-501 over rest of the genotypes. All the live lac insects counted at 130th day of BLI were fertilized female lac insects.

MNL on 155th day of BLI (20.04.2020)

On 155th day of BLI MNL was highest (90.61) on Lakhnadon-2 followed by Amarkantak-3 (86.22), TJT-501 (84.72), Korsar-3 (81.67), Gadarwara (77.00), Amarkantak-4 (73.94), Korsar-2 (73.83), Amarkantak-1 (69.11), Amarkantak-2 (68.50) and Saraswahi (64.94). There was significant difference in the MNL on Lakhnadon-2 and Amarkantak-3 genotypes over Saraswahi. Rest of the genotypes was at par with each other.

MNL on 190th day of BLI (25.05.2020)

On 190th days of BLI MNL was significantly highest (61.78) on Lakhnadon-2 followed by Korsar-3 (55.28), Amarkantak-1 (54.72), Korsar-2 (52.67), Amarkantak-2 (51.11), Amarkantak-3 (48.78), Gadarwara (48.06), TJT-501 (46.67), Saraswahi (46.22) and Amarkantak-4 (37.94). The MNL (matured female lac insects) in all the genotypes was significantly higher over Saraswahi.

Male to female ratio in lac insects

As mentioned earlier the adult male lac insects were observed in between 115th to 125th day of BLI. The male to female ratio was highest (1:6.93) in Lakhnadon-2 while it was lowest (1:1.91) in Amarkantak-4. Adult male lac insects do not produce enough lac, thus, presence of more females is a positive indication for lac productivity.

On the basis of more female to less male, Lakhnadon-2 was the best genotype for lac production.

Per cent survival of lac insects from 45th to 190th day per 2.5 cm^2

Survival of Lac insects

The per cent survival of lac insects between 45th to 190th day after BLI was highest (38.13%) on Lakhnadon-2 followed by Amarkantak-1 (37.06%), Korsar-3 (34.04%), Korsar-2 (32.95%), Amarkantak-2 (32.87%), Amarkantak-3 (31.50%), Saraswahi (30.85%), Gadarwara (29.11%), TJT-501 (27.66%) and it was lowest (24.91%) in Amarkantak-4.

Table.1 Details of the treatments

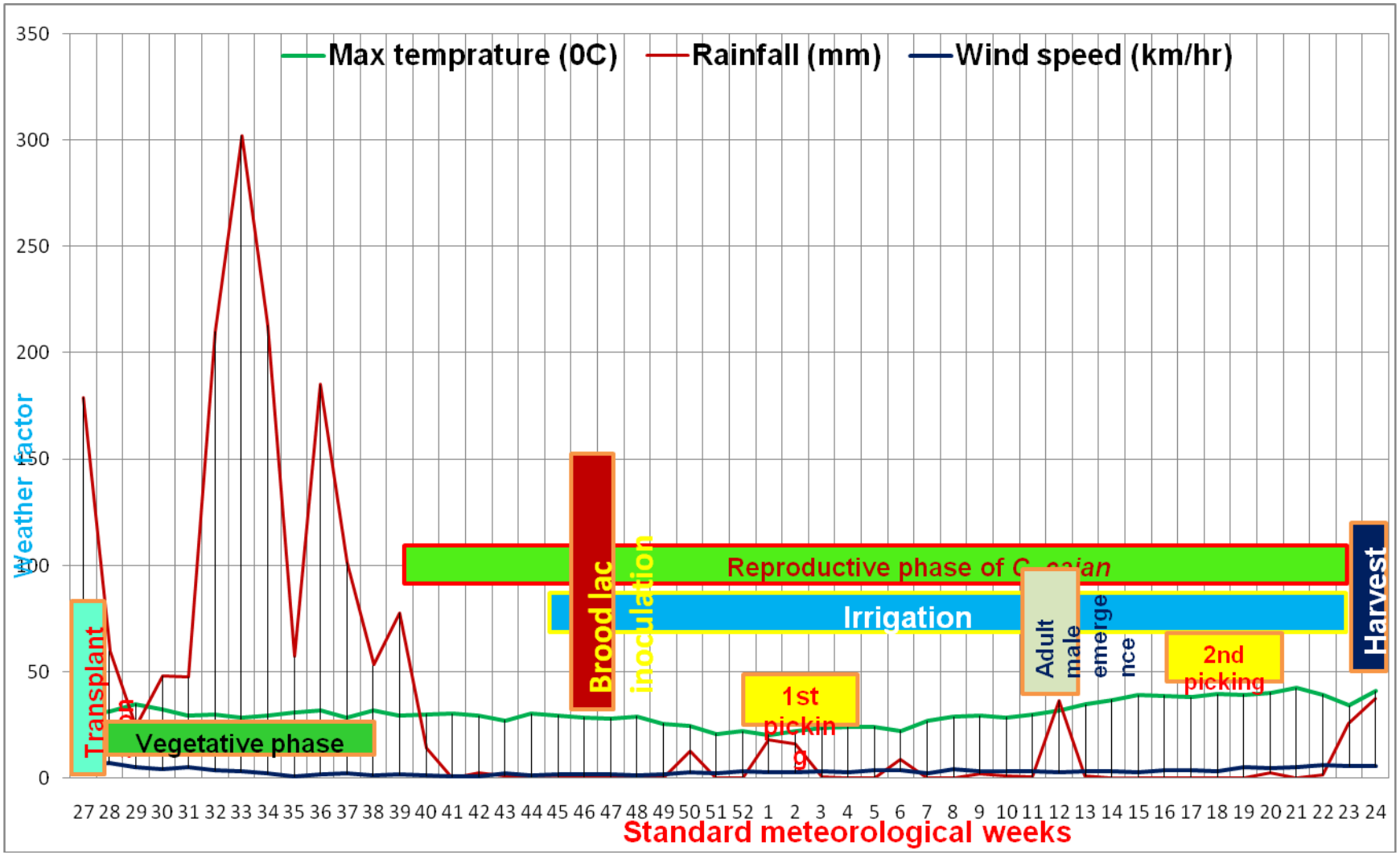
Name	Source
T_1 TJT-501	JNKVV , Jabalpur district
T_2 Lakhnadon-2	Farmer , Lakhnadon, Seoni district
T_3 Korsar-3	Farmer , Korsar, Singrauli district
T_4 Saraswahi	Farmer , Saraswahi, Jabalpur district
T_5 Gadarwara	Farmer , Gadarwara, Narsinghpur district
T_6 Amarkantak-1	Farmer , Amarkantak, Anuppur district
T_7 Amarkantak-2	Farmer , Amarkantak, Anuppur district
T_8 Amarkantak-3	Farmer , Amarkantak, Anuppur district
T_9 Korsar-2	Farmer , Korsar, Singrauli district
T_{10} Amarkantak-4	Farmer , Amarkantak, Anuppur district

Table.2 Mean number of live lac insects settled/2.5 cm^2 on branches in different treatments after BLI

Mean number of live lac insects settled per 2.5 cm^2 on days after BLI										
Genotypes	**45th**	**90th**	**Number**		**Male & female ratio**	**130th**	**155th**	**190th**	**Male emergence after BLI**	**Mean survival (%)**
			Male	**Female**						
T1 (TJT-501)	168.72	148.50	13.00	65.33	1 :5.03	100.11	84.72	46.67	123 days	27.66
	(13.00)	(12.20)	**(16.60)**	**(83.40)**		(10.03)	(9.20)	(6.86)		
T2 (Lakhnadon-2)	162.00	149.39	9.67	67.00	1 :6.93	98.00	90.61	61.78	122 days	38.13
	(12.75)	(12.24)	**(12.61)**	**(87.39)**		(9.91)	(9.49)	(7.89)		
T3 (Korsar-3)	162.39	140.50	14.67	70.67	1 :4.82	93.50	81.67	55.28	123 days	34.04
	(12.76)	(11.87)	**(17.19)**	**(82.81)**		(9.69)	(9.05)	(7.45)		
T4 (Saraswahi)	149.83	121.39	15.33	43.00	1 :2.80	78.50	64.94	46.22	119 days	30.85
	(12.25)	(11.03)	**(26.29)**	**(73.71)**		(8.87)	(8.08)	(6.83)		
T5 (Gadarwara)	165.06	134.00	27.33	56.33	1 :2.06	86.44	77.00	48.06	125 days	29.11
	(12.86)	(11.59)	**(32.67)**	**(67.33)**		(9.29)	(8.80)	(6.96)		
T6 (Amarkantak-1)	147.67	121.72	15.00	58.00	1 :3.87	88.72	69.11	54.72	115 days	37.06
	(12.17)	(11.06)	**(20.55)**	**(79.45)**		(9.44)	(8.34)	(7.42)		
T7 (Amarkantak-2)	155.50	118.39	11.00	62.00	1 :5.64	82.50	68.50	51.11	117 days	32.87
	(12.49)	(10.90)	**(15.07)**	**(84.93)**		(9.09)	(8.30)	(7.18)		
T8 (Amarkantak-3)	154.83	124.39	23.33	51.33	1 :2.20	90.39	86.22	48.78	115 days	31.50
	(12.46)	(11.15)	**(31.25)**	**(68.75)**		(9.51)	(9.24)	(7.01)		
T9 (Korsar-2)	159.83	138.44	11.00	66.33	1 :6.03	94.83	73.83	52.67	122 days	32.95
	(12.65)	(11.78)	**(14.22)**	**(85.78)**		(9.73)	(8.62)	(7.29)		
T10 (Amarkantak-4)	152.33	131.83	27.00	51.67	1 :1.91	90.89	73.94	37.94	124 days	24.91
	(12.36)	(11.49)	**(34.32)**	**(65.68)**		(9.55)	(8.61)	(6.19)		
SE(M)	0.22	0.27				0.38	0.38	0.15		
CD at 5%	0.66	0.81				1.13	1.14	0.43		

*Figure in parenthesis are transformed values & per cent of male and female

Fig.1


Max temprature (0C)
Rainfall (mm)
Wind speed (km/hr)
Weather factor
350
300
250
200
150
100
50
0
Transplant
Vegetative phase
Brood lac
inoculation
Reproductive phase of C
ian
Irrigation
1st
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g
Adult
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emerge
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Harvest
27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Standard meteorological weeks

Mean live lac insects (MNL) per 2.5cm^2 on *C. cajan*

Survival and growth of insects especially phloem feeders depends on the quantity and quality of sap access to it (Cook and Denno, 1994; Kehr, 2006) as well as protection from its natural enemies (Jhangel *et al.,* 2014, Engla, 2011). Survival of any insect on a crop or variety indicates its compatibility (Horikoshi *et al.,* 2016) and preference (McGuinness, 1987; Gogi *et al.,* 2012).

In the present study, it was observed that lac insects preferred to settle more on secondary branches over primary branches. There was reduction in the MNL from 45 days to 190 days after BLI, though the per cent varied on different *C. cajan* genotypes. There was a reduction in the MNL after BLI and last observation (190 days after BLI). In the present case the survival of lac insect varied from 24.91 to 38.13 per cent. As mentioned earlier the survival per cent of lac insect depends on the host (Ogle *et al.,* 2006, Shah *et al.,*. 2015), season of lac crop (Ghosh *et al.,* 2014), strain of the lac insect (Sharma *et al.,* 2017), nutrient management (Sharma *et al.,* 2017, Ghugal *et al.,* 2015, Namdev *et al.,* 2015), predator management (Virendra *et al.,* 2017) or even location of the host trees (Kalahal *et al.,* 2017*)*. Survival of lac insects from BLI to maturity of crop reported by many workers as 10.71 to 17.21 per cent (Shah *et al.,* 2014), 34.08 to 51.53 per cent (Gurjar, 2016), 33.53 to 41.77 per cent (Sharma *et al.,* 2015), 20.86 to 26.05 per cent (Kumar *et al.,* 2017), 19.63 to 20.58 per cent (Namdev *et al.,* 2015) and 20.47 to 23.52 per cent (Shah *et al.,* 2018), 52.13 to 81.53 per cent (Vajpayee *et al.,* 2019).

Male to female ratio in lac insects

In present study the male to female ratio observed between 1:1.91 and 1:6.93. Adult female lac insects plays a major role in lac production. In comparison to male lac insects, female insects have longer life i.e. emergence from egg to the harvest of lac crop at maturity. Adult male insect on the contrary has a very short life span of 3 to 5 days, when it aggressively mates with it adult females. Thus emergence of adult male as well as its mating with adult female lac insects has significance in terms of lac production. Unlike the sedentary female lac insects from its settlement on the host to its maturity, the adult males are either wingless or winged form and agile. Counting them in the fixed slot of 2.5 cm^2 is very difficult. The digital counting method (Patent application 201921007852 A) developed is more reliable and accurate. Each larvae of lac insects secrets a protective resin lac cells over its body. As the insect grow and attain maturity the male lac cells acquire cigar shaped protective covering over its body while female lac cell appears spherical in shape and comparatively bigger in size. Pupal and adult stages of male lac insect do not secrete lac b). Counting these cells from the digital photo of the lac insect population, one can segregate them of the basis of sex. Sex ratio of lac insects has been reported by earlier workers.

Sharma (2016) reported sex ratio of lac insect between 20-50 percent depending upon various biotic and abiotic factors. Chauhan (1988) observed that sex ratio in lac insect differs significantly on different host plants. It was observed to be 72 percent in favour of males on *F. macrophylla*, 82 per cent on *C. cajan* and 98 per cent on *Z. mauritiana*. Similarly, Sharma *et al.,* (1997) observed 39.76 and 37.28 per cent males in *Rangeeni* and *Kusmi* strains of *K. lacca* on *F. macrophylla* that increased to 70.05 and 62.65 per cent when reared on *C. moschata*. In MP, the female to male lac insect ratio has been reported to vary from 10.87:1 to 27.55:1 in different genotypes on *C. cajan* (Vajpayee *et al.,* 2019).

Male emergence

The adult male emerged between 11 to 12 standard meteorological weeks. During this period two mean temperature, rainfall and wind speed was 30.8^{0}C, 18.5 mm, 2.65 km/hr respectively. Rain and wind speed are detrimental to adult males survival and mating. Another important aspect is the date of adult male emergence.

In present study the emergence of male was observed between on 115th to 125th after BLI. The earliness of the emergence of adult male lac insects indicates early maturity of the male. One of the factors of this earliness is quality and quantity of phloem sap of the host plant available to lac insects.

The earliness at also depends on weather as well as more mating opportunities. The emergence of adult male is counted in days from the date of BLI. Similarly higher adult female means more lac production.

Thus higher female to male ratio is considered as positive trend. Early mating also leads to more days for female lac insects to produce and reproduced in comparative to those mated late. These micro factors of lac production were never captured before for analysis. Wang *et al.*, 2019 reported that adult female lac insects secrete large amount of resin, while pupal and adult male lac insects do not secrete lac.

Male emergence of lac insects has been reported by earlier workers. Patel (2013) reported that the adult male of *Kusmi* strain of *K. lacca* emerged at 70 days after BLI in winter crop on *Z. mauritiana*. Saikia *et al.*, (2019) reported male emergence of lac insect was started 45 days after inoculation which continued for 12 days. V*ajpayee et al.*, (2019) reported adult male lac insects were observed in between 129th-143th day after BLI.

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