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Survival of *Kerria lacca* (Kerr) on pigeon pea

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Abstract
Number of live lac insects (*Kerria lacca*) on the host plant till the harvest of lac crop, decides the lac yield. Survival of *K. lacca* is therefore one of the most important factors for higher lac productivity. The present study on the survival of *K. lacca* on pigeon pea was carried with eight treatments which was replicated thrice. Apart from the basal dose of DAP and MoP, biofertilizers and humic acid were also applied as per the treatments for growing pigeon pea (TJT-501). Soil, foilar and soil + foliar applications were the three types of treatments applications. The mean number of live lac insects (MNL) was maximum 69.81 to 82.29 per 2.5 cm^2 at 30 days after Brood lac inoculation (BLI). It declined in linear trend till the harvest of lac crop. At 195 days after BLI the MNL varied BLI from 34.50 to 40.85 per 2.5cm^2. It was highest in the *C. cajan* with soil applications of VAM, DAP, MoP and FYM.

Keywords: Lac insects, biofertilizers, *C. cajan*, micronutrient, treatment

Introduction
Lac is a minor forest produce (Thomas 2003, Sharma *et al*. 2006) [15, 13]. It is an important source of cash to the tribal communities and forest dependants in central and eastern part of India (Jaiswal *et al*. 2020, Namdev *et al*. 2015, Shah *et al*. 2015) [2, 7, 12]. India is the largest producer of lac in the world (Pal 2013, Yogi *et al*. 2015) [8, 17], however, the annual production of lac is declining steeply. Lac production has economically and ecological impact at the local level (Kakade *et al*. 2020) [4]. In this context, the enterprise cannot be over looked. Majority of the forest dependant are migrating to urban areas, the forest area is shrinking, as well as women collecting fuel wood from forest are also it. Thus, promotion of lac on alternative hosts plants is essentially important approach. Pigeon pea [*Cajanus cajan* (L.) Millsp.] has proved to be a good host of lac insects in India. (Thomas 2003, Vajpayee *et al* 2019, Patidar *et al*. 2019) [15, 16] In M.P. *C. cajan* is cultivated in India 3.56 m ha (Dhanalakshmi *et al*. 2017) and the state is also the third largest producer of lac in the country (Shah *et al* 2015) [12].
C. cajan being an important pulse crop in MP, lac production on it is a good option. Lac insect is a phloem feeder (Sharma *et al*. 2006, Singh *et al*. 2017, Pal 2009, Mohanta *et al*. 2014) [13, 14, 9, 5] and phloem feeders are known to reduce the yield of numerous crops. Therefore, nutrient management of *C. cajan* is very important, if lac insect is to be reared on it. In this background the present field study was conducted.

Material and Methods
The present field study was conducted during the year 2015-16 in the village Khairi, Block Shahpura, District Jabalpur, Madhya Pradesh to evaluate the effect of biological products *viz*. (PSB, Rhizobium, Mycorrhiza and Humic acid on *C. cajan* on plants for Baishakhi lac production. Geographically the village is located between $21^0$19' to $22^0$24' north latitude and $79^0$31' to $81^0$31' east longitude. The experiment in Randomized Block Design (RBD) with eight treatments and three replications was laid in the month of July 2015.
The field trial was conducted on TJT-501 variety of *C. cajan* obtained from Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur Madhya Pradesh.

Treatments
The experiment had following eight treatments in three replication.

Table 1: Details of the Experiment

Treatments combinations	
No.	**Details**
T1	Rhizobium + PSB (Soil application)
T2	Rhizobium + PSB + Mycorrhiza (Soil application)
T3	Mycorrhiza (Soil application)
T4	Rhizobium + PSB + Humic Acid (Soil + foliar application)
T5	Rhizobium + PSB + Mycorrhiza + Humic Acid (Soil + foliar application)
T6	Mycorrhiza + Humic Acid (Soil + foliar application)
T7	Humic Acid (foliar application)
T8	Control (no soil and foliar application)

Nursery raising of *C. cajan*

Black polythene bag of size 10x14 inch and 38 guage were used for the raising of *C. cajan* in the nursery. All the polythene bags were perforated with 10-12 holes before filling the substrate (medium). It was done to drain excess of irrigation water from polythene bags.

Substrate

Substrate was prepared by mixing of light soil and well rotten Farm yard manure (FYM) in the ratio of 1:1, during the first week of May. FYM was treated with *Trichoderma viride*, at the rate of 2.5kg per five quintals of FYM and kept under shade. The treated FYM was then mixed thoroughly at weekly intervals for one month for the growth of *T. viride*, prior to its filling in the polythene bag. The substrate was filled in the perforated polythene bags upto three quarters of its capacity. The substrate filled polythene bags were than arranged in 4 rows under shade to protect the growing seedling from direct sun.

C. cajan seeds after treating with *T. viride*, *Rhizobium* and Phosphorous solubulizing bacteria (PSB) culture were spread on a polythene sheet. These treated seeds were sown in the substrate filled perforated Polythene bags at the rate of 2 seeds per bag in the last week of May. Watering was done at weekly intervals, of seedling were nipped till its transplantation in the field. On attaining a height of 8 to10 inches, the growing tips at 10 to 15 days interval till its transplantation. Nipping was done to initiate side bracches.

Pit digging

Pit of dimension 1x1x1 foot was dug with a sharp iron rod. After removing the loose soil from the pit, well rotten FYM, Diammonium phosphate (DAP), Zinc and Murate of Potash (MoP) as well as *T. viride*, *Rhizobium* and PSB were added to all the pits and mixed well before transplantation. After transplantation, the plants were again nipped at 10 days interval till 1st week of October during both the years.

Transplantation

All the seedlings of *C. cajan* were transported in the field during the first week of July. Seedling in the polythene were transported to the main field and kept adjacent to the 1x1x1feet pits digged at a spacing of 6x6 foot. The polythene bag was carefully removed, keeping the *C. cajan* seedling and the soil holding it intact. The seedling was gently placed in the pit and pressed tightly all over the side.

Broodlac inoculation

Healthy Broodlac with minimum signs of predator and parasite infestation were selected for its inoculation of the *C. cajan* plants. Broodlac weighing 10-20g was inoculated per *C. cajan* plant depending on the size of the plant (Thomas *et al.* 2015) [12]. Broodlac stick was tied with a twine on the main stem about one foot above the ground.

Majority of the larvae of *K. lacca* left Broodlac to settle on branches within 21 days. The left over Broodlac on the plant without lac larvae is called *Phunki*, was removed after 21 days of Broodlac inoculation (BLI) and scrapped to recover raw lac. In this process the predators were removed from the field (Janghel, 2013) [3].

Slot preparation

On 30th day after BLI, three branches of *C. cajan* with good lac insect settlement were randomly selected per plants. On each branches five a slot of 2.5cm long and 1.0cm broad was made. The slot after measuring 2.5cm^2 dimension was marked by removing the lac insect settlement in the adjoining area. Mean live lac insects per 2.5cm^2 (MNL) was counted from five slots per branches periodically.

The MNL was recorded by counting live lac insects per 2.5cm^2 on *C. cajan* plants at five fixed spots per branch. Three branches per plant was selected and there were twelve observations on the MNL during the lac cropping season i.e. at 30, 45, 60, 75, 90, 105, 120, 135, 150, 165, 180,195 days after BLI.

Application of pesticides

The pesticides solution (Cartap hydrochloride + Mancozeb) were sprayed on the *C. cajan* plants with the help of a foot sprayer for management of predators and parasites of lac insects.

Preparation of pesticide solution

Solution of pesticide was prepared by adding Cartap hydrochloride 1g /litre of water and Mancozeb @ lg/litre of water) in two small separate containers followed by brisk stirring with a piece of stick (Rathore, 2012). Both the solutions were poured into the bucket containing 13 litre of clean water. The solution in the bucket of the spray was again stirred with the help of a stick it ensure proper mixing of the pesticides, before filling in the sprayer tank.

Spraying schedule

The first spray was done after 30 days of Broodlac inoculation (Engla, 2012). The second spray was carried out in the month of December.

Result and Discussion

Mean number of live lac per 2.5cm^2 branches (MNL) of *C. cajan*

MNL per 2.5cm^2 was recorded during observation periods. Earlier workers also recorded live lac insect count from a fixed unit space of 2.5cm^2 (Shah *et al*., 2014, Gurjar, 2016, Sharma *et al*., 2015[13] Kumar *et al*., 2017 Namdev *et al*., 2015, Shah *et al*., 2018, Vajpayee *et al*., 2019) [13, 14, 7, 11, 16], our experiments also confirms that the method is more reliable and easy to adopt. The frequency of live lac insect at 15 days intervals was also followed by many workers in the pasts.

Table 2: The mean number of live lac insects per 2.5cm^2 during growth stage of both Lac insect and *C. cajan*

Treatments	Mean no. of live lac insects settlement per 2.5cm^2 on days after BLI (2015-16)												Survival %
	30 Days	45 Days	60 Days	75 Days	90 Days	105 Days	120 Days	135 Days	150 Days	165 Days	180 Days	195 Days	
T_1	77.82 (8.85)	75.40 (8.77)	71.63 (8.49)	67.40 (8.24)	64.90 (8.09)	60.68 (7.82)	58.54 (7.68)	45.78 (6.80)	44.61 (6.72)	44.22 (6.69)	42.68 (6.57)	40.85 (6.43)	52.49%
T_2	76.66 (8.78)	73.03 (8.57)	70.48 (8.42)	66.22 (8.17)	64.70 (8.07)	60.99 (7.84)	59.75 (7.76)	44.17 (6.68)	42.89 (6.59)	42.13 (6.53)	41.67 (6.49)	39.78 (6.35)	51.89%
T_3	82.29 (9.10)	80.06 (8.98)	79.97 (8.97)	74.96 (8.45)	71.39 (8.48)	69.95 (8.39)	68.77 (8.32)	52.56 (7.28)	52.28 (7.26)	49.90 (7.12)	48.13 (7.11)	48.09 (6.97)	58.44%
T_4	74.62 (8.67)	72.93 (8.57)	70.57 (8.43)	66.73 (8.20)	65.41 (8.12)	62.03 (7.91)	61.18 (7.85)	45.73 (6.80)	45.28 (6.77)	43.35 (6.62)	42.47 (6.55)	41.22 (6.46)	55.24%
T_5	75.13 (8.70)	73.42 (8.60)	73.12 (8.58)	65.76 (8.14)	64.07 (8.03)	61.77 (7.89)	59.63 (7.75)	45.40 (6.77)	44.13 (6.68)	43.60 (6.64)	42.65 (6.57)	41.51 (6.48)	55.25%
T_6	75.50 (8.66)	72.80 (8.56)	71.77 (8.50)	66.10 (8.16)	63.14 (7.98)	60.06 (7.78)	58.82 (7.70)	44.10 (6.68)	41.37 (6.47)	40.37 (6.39)	39.17 (6.30)	38.43 (6.24)	55.90%
T_7	73.56 (8.61)	72.39 (8.54)	70.70 (8.44)	66.70 (8.20)	63.70 (8.01)	61.18 (7.85)	60.10 (7.78)	43.37 (6.70)	40.84 (6.43)	40.34 (6.39)	40.58 (6.41)	40.00 (6.36)	54.38%
T_8	69.81 (8.39)	68.42 (8.30)	65.42 (8.12)	61.55 (7.88)	57.80 (7.64)	53.47 (7.48)	53.47 (7.35)	36.06 (6.04)	38.71 (6.26)	37.35 (6.15)	36.87 (6.11)	34.50 (6.00)	49.41%
SE(m)±	0.935	0.796	0.768	0.728	0.886	0.431	0.988	0.538	0.475	0.657	0.506	0.559	
CD at 5%	2.836	2.413	2.329	2.209	2.686	2.539	2.997	1.631	1.441	1.992	1.534	1.697	

Figures in parenthesis are transformed value $\sqrt{x+0.5}$

30 days after BLI

The MNL at 30 days after BLI was significantly highest in (82.29)T_3 -*Mycorrihza* over all the treatments. The MNL was at par among (73.56), T_7-Humic acid, (75.50)T_6-*Mycorrihza* + Humic acid, (74.62) T_4-Rhizobium + PSB + Humic acid and (76.66)T_2-*Rhizobium* + PSB + *Mycorrihza*. Among (77.82)T_1 -*Rhizobium* + PSB, (76.66)T_2-*Rhizibium* + PSB + Rhizobium and T_3, the MNL was also at par.

45 days after BLI

The MNL at 45 days after BLI was again significantly highest in (80.06) T_3-*Mycorrihza* over all the treatments. The MNL was at par among (72.39) T_7-Humic acid, (72.93)T_4-*Rhizobium* + PSB + Humic acid,(73.42) T_5-*Rhizobium* + PSB + *Mycorrihza* + Humicacid and (72.80) T_6-Mycorrihza + Humic acid. Similarly, Among (75.40) T_1-*Rhizobium* + PSB, and (73.03)T_2-*Rhizobium* + PSB + *Rhizobium* in terms of MNL were also at par.

60 days after BLI

At 60 days after BLI the MNL was though highest in (79.97) T_3 -*Mycorrihza* but was at par with all the treatments. The MNL was (70.70) T_7 Humic acid, (71.63) T_1 -*Rhizobium* + PSB, (70.48) T_2 -*Rhizobium* + PSB + *Mycorrihza*, (70.57) T_4-*Rhizobium* + PSB + Humic acid and (71.77) T_6-*Mycorrihza* + Humic acid.T_3 was significantly higher than the (73.12)T_5 *Rhizobium* + PSB + *Mycorrihza* + Humic acid.

75 days after BLI

The MNL at 75 days after BLI was highest in (74.96) T_3-Mycorrihza but was at par with rest of the treatments.

90 days after BLI

At 90 days after BLI the MNL was highest in (71.39) T_3-*Mycorrihza* was over all the treatments. The MNL was (63.14) T_6-*Mycorrihza* + Humic acid, (63.70) T_7-Humic acid, (64.90) T_1-*Rhizobium* + PSB, (64.70) T_2-*Rhizobium* + PSB + Mycorrihza and (65.41) T_4 -*Rhizobium* + PSB + Humic acid.

105 days after BLI

At 105 days after BLI the MNL was significantly highest in (69.95) T_3 -*Mycorrihza* was over all the treatments. It was (60.06) T_6 –*Mycorrihza* + Humic acid, (61.18) T_7-Humic acid, (61.68) T_1-*Rhizobium* + PSB,(60.99)T_2-*Rhizobium* + PSB + Mycorrihza and (62.03) T_4-*Rhizobium* + PSB + Humic acid were also at par with each other

120 days after BLI

At 120 days after BLI was significantly highest in (68.77) T_3-*Mycorrihza* but was at par with all the treatments. The MNL of the rest of the treatments were at par with each other.

135 days after BLI

The MNL at 135 days after BLI was significantly highest in (52.56) T_3-*Mycorrihza* but it was over with all the treatments. The MNL was (44.17) T_2 -*Rhizobium* + PSB + *Mycorrihza*, (44.10) T6-*Mycorrihza* + Humic acid and (43.37) T_7 -Humic acid were at par with each other. The MNL in T_1, T_4 and T_5 were also at par with each other.

150 days after BLI

The MNL at 150 days after BLI was significantly highest in (51.28) T_3-*Mycorrihza* was over all the treatments over the control. The MNL was (41.37) T_6 -*Mycorrihza* + Humic acid, T_7 (40.84) Humic acid were at par with each other. It was T_1, T_4 and T_5 at par.

165 days after BLI

At 165 days after BLI the MNL was significantly highest in (49.90) T_3-*Mycorrihza* was over all the treatments. The MNL was (40.37) T_6-*Mycorrihza* + Humic acid, (42.13) T_2-*Rhizobium* + PSB + *Mycorrihza* and (40.34) T_7 Humic acid were at par with each other.

180 days after BLI

The MNL at 180 days after BLI was significantly highest in (48.13) T_3-*Mycorrhiza* was over all the treatments. The MNLwas (39.17) T_6 -*Mycorrihza* + Humic acid and (40.58) T_7 -Humic acid were at par. It MNL was T_4, T_1, and T_5 were at par with each other.

195 days after BLI

At 195 days after BLI the MNL was significantly highest in (48.09) T_3-*Mycorrihza* but was at par with all the treatments.

Thus the MNL was higher in T_3 but it remains at par with all the treatments throughout the observation period except at 30 abd 45 days after BLI.

A decline in the live lac insect count from BLI to the harvest of lac crop is widely acknowledged. 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) [13], 20.86 to 26.05 per cent (Kumar *et al.*, 2017) [14], 19.63 to 20.58 per cent (Namdev *et al.*, 2015) [7] and 20.47 to 23.52 per cent (Shah *et al*., 2018) [11], 52.13 to 81.53 per cent (Vajpayee *et al.*, 2019) [16].

Thus, an effort was done at shorter intervals. Maximum number of live lac insect is essentially required for higher lac products. The data revealed that the MNL declined from 30 days BLI to 195 days in all the treatments. However, the number varied according the treatments.

Soil application, foliar application and soil and foliar applications were the three methods of biofertilizers and humic acid applied either in combination or singularly for improving its nutrient status and growth. The latter two factors are very important for the growth and survival of lac insects increased substantially. It was observed that soil application of *Mycorrhiza* along with DAP and MoP had significantly higher mean number of live lac insects till the harvest of lac crop over the control. It means that *Mycorrhiza* has an important role in making the availability of soil nutrients to the plant to assimilate and growth.

The role of *Mycorrhiza* in the plant growth is reported by Sajid *et al*. (2013).This bio-agent has a significant role in making nutrient available to roots (Pandey *et al*. 2021) [10]. However, the MNL in T_3 was at par with rest of the treatments. This means instead of waste the time and cost of adding a range of biofertilizers and nutrients, just incorportion of *Mycorrhiza* will the cost effective and better in reduce the loss of live lac insects.

The survival percent of *K. lacca* at harvest of the lac crop varied in different treatments. The survival percent of *K. lacca* at maturity of the lac crop was highest in treatment T_3(58.44%) followed by T_6(55.90%), T_5(55.25%), T_4(55.24%), T_7(54.38%), T_1(52.49%), T_2(51.89%) and T_8 (49.41%).

Decline in the MNL of lac insects was evident from the data 30 days to 195 days after BLI. The loss of lac insects may be due competition for foods and spaces as the stronger in the settlement may be suppressing the neighbouring insect. Such a phenomena in any micro ecosystem and population is widely reported across the insect world. Decline in the MNL of lac insect is reported earlier by Patel (2013), Namdev (2014) [7], Gurjar (2016), Shah *et al*. (2018) [11], Pardhi (2020), Khobragade (2010), Rathore (2011), Sharma *et al*. (2015) [13], Ghugal *et al*. (2016), Vajpayee (2019) [16].

The survival percent of lac insect varied from 49.41%to 58.44%. This is very important as the lac production is decide by the number of lac insects survived during the whole process of its growth and reproduction. However, higher survival of lac insects on *C. cajan* treated with *Mycorrhiza*.

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