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Impact of Irrigation Levels and Plant Density of Annual Lac insects Host Plant *Cajanus cajan* (L.) Millsp. on the Survival of *Kerria lacca* Kerr

Gopilal Anjana[1*], Moni Thomas[2], Sahab Kumar Patel[1], Swarna Kurmi[3], Deep Kumar Pahalwan[4], Manish Bhan[5], Alok Bajpai[6] and Anil Kumar Singh[7]

[1]Department of Entomology, College of Agriculture, JNKVV, Jabalpur (Madhya Pradesh), India.
[2]Institute of Agribusiness Management, College of Agriculture, JNKVV, Jabalpur (Madhya Pradesh), India.
[3]Department of Plant Pathology, College of Agriculture, JNKVV, Jabalpur (Madhya Pradesh), India.
[4]Directorate of Farm, College of Agriculture, JNKVV, Jabalpur (Madhya Pradesh), India.
[5]Department of Physics & Agrometeorology, College of Agriculture, JNKVV, Jabalpur (Madhya Pradesh), India.
[6]Department of Soil & Water Engineering, College of Agriculture, JNKVV, Jabalpur (Madhya Pradesh), India.
[7]Department of Soil Science & Agricultural Chemistry, College of Agriculture, JNKVV, Jabalpur (Madhya Pradesh), India.

(Corresponding author: Gopilal Anjana)*
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ABSTRACT: Doubling of farmers' income is only possible if farmers diversify their crops to include high-value crops that have better market demand and can fetch higher prices. Lac is a natural resin with high commercial value. Among more than hundred hosts pigeonpea crop can be utilized as a preferred host to get more return in the form of seeds as well as lac resin from the same host. Getting high return from less resources is the fundamental concept behind the concept of Doubling of Farmers' income. Pigeonpea - a widely cultivated pulse crop in central India is alsoa good annual host of lac insect (*Kerria lacca* Kerr.). Lac insect produces lac resin which is a cash crop and export commodity. The present research work was done to evaluate the impact of irrigation levels and spacing of *C. cajan* on the survival of lac insects. The two year (2020-21 and 2021-22) pooled data analysis revealed an increase in the survival of lac insects with increasing spacing and the amount of irrigation water. The mean live lac insects on *C. cajan* with interaction of wider spacing (S_3) and higher irrigation (W_3) at BLI was 174.83 while that of at harvest of lac crop was 67.71.

Keywords: Marginal farmers, resources, survival, sustainability, income.

INTRODUCTION

Pigeonpea (*Cajanus cajan* (L.) Millsp.) is cultivated in Asian and African countries (Gwata and Shimelis 2013). Generally, the crop is cultivated as rainfed (94.81 percent) in india (Anon., 2021), but as irrigated (5.19 percent) in few areas (Anon., 2021). It is a cheap source of protein of large population in both the continents (Shirsath *et al.*, 2014). The domestic consumption of split seed of pigeonpea in India is around 44-45 lakh tonne (The Economics Time, 2023). India imports pigeonpea from Tanzania Rep (36%), Mozambique (35%), Myanmar (20%), Sudan (5%) and Uganda (2%) (Anon., 2021-22). In India, it is a widely grown crop covering more than 18 states. About 85% of the pigeonpea is grown in six states namely, Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh, Gujarat and Jharkhand (Anon., 2014-15). In Madhya Pradesh *C. cajan* is cultivated in 0.22 million hectares and production is 0.29 million tonnes (Anon., 2021). *C. cajan* is identified as an excellent annual host plant of the lac insects (Thomas, 2003). Lac insect (*Karria lacca* Kerr.) has an industrial importance because it produces lac (Sharma, 2017). It is a cash crop and export commodity (Sharma *et al.*, 1999).

Madhya Pradesh is the third largest (13.03%) producer of lac in India (Yogi *et al.*, 2020). Research of lac production on *C. cajan* is done in Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur since 2000 (Kakade *et al.*, 2020, Patidar *et al.*, 2022). The outcome is encouraging and farmers are adopting it (Thomas *et al.*, 2021). The state of MP has lots of local genotypes of *C. cajan.* Tall and long duration genotype of *C. cajan* are reported to be desirable for higher production of lac. Survival of lac insects (*K. lacca* Kerr.) is an important lac production factor (Shrivastava *et al.*, 2013, Vajpayee *et al.*, 2019). Plant density (Asghar *et al.*, 2020) and also the soil moisture (Kansman *et al.*, 2022) influence the insect population on host plants. L ac production depends on the survivability of the lac insect till the harvest of the lac crop. The present research work was done to evaluate the impact of host plant density and irrigation levels on the survival of lac insects.

MATERIALS AND METHODS

The present research work is a part of Ph.D. field work carried out in Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, India between June, 2020 to May, 2022 in Jawahar Model field (Thomas *et al.*, 2021). The model is a low input intensive and diversified field

crop production system. The bunded rice field with blacksoil is never ploughed since last three year. Crops are grown in polypropylene bag (PPBs) of size 18 × 16 cm when empty. The field experiment was laid out in Split Plot Design with nine treatments replicated thrice. Three plants of *C. cajan* were put on each treatment in each replication. Local long duration *C. cajan* plant were grown at threeplant to plant spacing viz; S_1 (6 feet), S_2 (9 feet) and S_3 (12 feet) while the row to row spacing was maintained at 10 feet. The three levels of drip irrigation per plant were viz; W_1- 2 litres/h, W_2- 4 litres/h and W_3- 8 litres/h once in seven days interval for 2 hours.

Substrate weighing 45 kg (30 kg of light soil + 15 kg of FYM) was filled in PPBs while the intercrops are raised in PPBs with 30 kg substrate (1:1). The main crop was pigeon pea (*Cajanus cajan* (L.) Millsp.) while the intercrop were tuber crop and vegetable. The substrate was treated with consortium of biofertilizers. The consortium consisted of Rhizobium, PSB, *Trichoderma viridae* and Mycorrhiza. The irrigation scheduled was initiated after the cessation of rainfall i.e. from October. The total mean rainfall from DAT to the initiation of irrigation was 672.05 mm. The mean temperature of the both year varied from 16.33 to 31.03°C.

Nursery raising. *C. cajan* raised in nursery by sowing seed treated with biofertilizers cultures and *T. viridea* on in polythene bag on size 18×16 cm filled with the light soil and FYM in the ratio of 1:1. The substrate filled polyethenebags were punctured with a sharp nail in eight to ten different places to drain out irrigation water.

Nipping. The seedlings from nursery were transplanted in the PPBs in main field at decided spacing. The growing tips of the seedling were nipped at 15 days interval from 15 DAT to 60 DAT. The plants were protected from insect pests by spraying of insecticides on *C. cajan* pants at 30 days after transplanting of seedling, 30 and 60 days after BLI. At 30 and 60 days of BLI an insecticide spray (Cartap hydrochloride) was spray to protect lac insects from its predatorsand parasitoids.

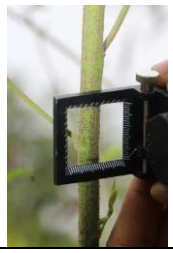
Brood lac inoculation. *Rangeeni* brood lac after shorting for quality was inoculate on the *C. cajan* on 30.10.2020 (1st year) and 24.10.2020 (2nd year). Brood lac weighing 15g per plant was tied on the main stem about one foot above the ground. The brood lac after 21 days of the brood lac inoculation (BLI) was removed from the plant. This process is referred as *Phunki* removal (Fig. 1).

Segregated for predator freegood quality brood	Brood lac stick weighing approximately 15g was tied on the stem	*Phunki* removal and scrapped

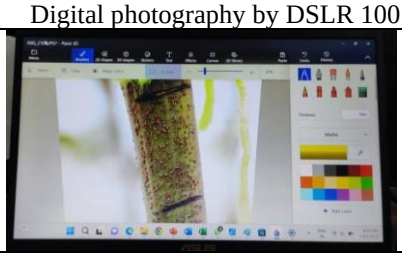
Fig. 1. Brood lac inoculation & *Phunki* removal.

Slot making. Thirty days after BLI, branches with good lac insect settlement were selected for marking of slot. Once lac insect inserts its stylet into the phloem, it becomes sedentary. A slot of 1 cm width and 2.5 cm length was marked on the bark of the branch bearing good settlement of the lac insects (Fig. 2). Four such slots were made on plant each of 2.5cm^2. Each slot was designated as S_1, S_2, S_3 and S_4. The borders of slots were made distinct by removing the lac insects settled outside the slot with the help of a thread stretching between the index fingers of both the hands. Removal of insect settlement adjacent to the boundaries of the slot clearly differentiated from the rest of the lac settlement on the branch.

Live lac insects counting. Live Lac insects were digitally counted from fixed slot space per 2.5 cm^2 on the secondary branch with good lac insect settlement. Lac insect settlement within the slot (2.5 cm^2) was digitally photographed with the help of a Digital Single Lens Reflex (DSLR) camera (Fig. 2). The digital images selected from the DSLR camera were transferred to the laptop and insects were counted with the help of Digital counting technology developed by JNKVV Jabalpur (Patent application no. 201921007852A) Counting of live lac insects within the slots were done on 45th, 90th, 130th, 155th and 190th days after BLI. The crawlers of lac insect up on inoculation (transfer from Brood lac to succulent branches) on the host plant settles after inserting there sharp and fine stylites in the process they remain sedentary for their whole life cycle thus counting from a fixed unit area i.e., slot of 2.5cm^2 at fixed intervals providesa clear comparative picture of live lac insects. The mean of such live lac insects counts from 2.5cm^2 of all the slots from the plant is referred as mean live insects count per 2.5cm^2 or MNL.



Marking and slot making | Tagging | Digital photography by DSLR 100 mm micro lens

Digital Counting by Paint 3D Microsoft App

Fig. 2. Digital method of growth analysis of lac insects.

RESULTS AND DISCUSSION

The two year pooled data analysis of the survival of lac insects from BLI to harvest of lac crop is discussed. A mentioned earlier in the present study the MNL was recorded at 30 days interval and 30 days after BLI. The data indicates (Table 1) that irrespective of treatments and interactions of treatments the MNL declined from the 1st to thelast observations. Periodic spray of contact insecticides were done to check the predators and parasitoids of lac insects, for the actual survival of lac. This insect being a phloem sap feeder (Sharma *et al.*, 2006) and gets covered itself by its own resinous secretion (Talukder *et al.*, 2022) remains protected from the contact insecticide (Mohanasundaram, 2019).

The mean number of live lac insects per 2.5cm^2 (MNL). The two year pooled MNL were recorded on 30th, 60th, 90th, 120th and 180th day after BLI. A decline in MNL from 30th to 180th BLI was observed (Table 01).

30th day after BLI

Main plot effect (Spacings). On 30th day after BLI, the MNL was varied from 173.39 (S_3), 174.28 (S_2) to 180.13 (S_1). The latter (S_1) had significantly higher MNL than all the spacing.

Sub plot effect (Levels of irrigation). The MNL on *C. cajan* at the different levels irrigation though varied from 173.15 (W_2), 175.83 (W_1) to 178.81 (W_3) but had no significant difference among the treatments. The total water was given per plant from BLI to 30th day after BLI through different levels of irrigation as 16 litres (W_1), 32 litres (W_2) and 64 litres (W_3).

Interaction effect. The MNL due to the interaction of plant spacings and levels of irrigation varied from 168.83 (S_3W_2) to 182.75 (S_1W_3) but had no significant difference in MNL all the interaction.

60th day after BLI

Main plot effect (Spacings). On 60th day after BLI, the MNL varied from 158.24 (S_2), 158.61 (S_3) to 163.19 (S_1). The latter (S_1) had significantly higher MNL than all the spacing. The percent loss in MNL during this period varied from 8.50 (S_3) to 9.39 (S_1).

Sub plot effect (Levels of irrigation). The MNL on *C. cajan* at the different levels irrigation though varied from 157.60 (W_1), 157.75 (W_2) to 164.69 (W_3).

The latter (W_3) had significantly higher MNL than all the levels of irrigation. The quantity of water per plant during period was 16 litres (W_1), 32 litres (W_2) and 64 litres (W_3), between 30th to 60th day after BLI. However, total water per plant from BLI to 60th day after BLI was 32 litres (W_1), 64 litres (W_2) and 128 litres (W_3). The percent loss in MNL varied from 7.88 (W_3) to 10.32 (W_1).

Interaction effect. The MNL due to the interaction of plant spacings and levels of irrigation varied from 153.75 (S_2W_1) to 168.04 (S_1W_3). The latter (S_1W_3) had significantly higher MNL than all the interactions. The percent loss in MNL due to the interaction of plant spacings and levels of irrigation between 30th to 60th day after BLI varied from 7.80 (S_3W_3) to 10.72 (S_2W_1).

90th day after BLI

Main plot effect (Spacings). On 90th days after BLI, the MNL varied from 135.38 (S_3), 135.63 (S_2) to 140.74 (S_1). The latter (S_1) had significantly higher MNL than both S_2 and S_3. The percent loss in MNL was varied from 13.68 (S_1) to 14.66 (S_3) at 90th day BLI over that at 60th day BLI.

Sub plot effect (Levels of irrigation). The MNL on *C. cajan* at the different levels irrigation though varied from 133.04 (W_1), 136.01 (W_2) to 142.68 (W_3). The latter (W_3) had significantly higher MNL than all the levels of irrigations. The percent loss in MNL was varied from 13.26 (W_3) to 15.48 (W_1) at 90th day BLI over that at 60th day BLI. The quantity of water per plant during period was 18 litres (W_1), 36 litres (W_2) and 72 litres (W_3), the total water per plant from BLI to 90th day after BLI was 50 litres (W_1), 100 litres (W_2) and 200 litres (W_3).

Interaction effect. The MNL on branches due to the interaction of plant spacings and levels of irrigation varied from 129.25 (S_2W_1) to 146.08 (S_1W_3). The

latter (S_1W_3) had significantly higher MNL than S_2W_1 but was at par with 138.13 (S_3W_3), 139.21 (S_1W_2) and 143.83 (S_2W_3). The rest of interactions were non-significant over. The percent loss in MNL due to the interaction of plant spacings and levels of irrigation varied from 12.76 (S_2W_3) to 15.72 (S_2W_1) at 90th day BLI over that at 60th day BLI.

120th day after BLI

Main plot effect (Spacings). On 120th day after BLI, the MNL though was varied from 119.03 (S_3), 119.71 (S_2) to 122.92 (S_1) but had no significant difference all among the spacing. The percent loss in MNL during the period varied from 11.68 (S_2) to 12.55 (S_1) at 120th day BLI over that at 90th day BLI.

Sub plot effect (Levels of irrigation). The MNL on *C. Cajan* at the different levels irrigation though varied from 114.65 (W_1), 119.32 (W_2) to 127.68 (W_3). The latter (W_3) had significantly higher MNL than all the levels of irrigation. Quantity of water per plant during period was 18 litres (W_1), 36 litres (W_2) and 72 litres (W_3). The total water per plant from BLI to 120th day after BLI was 68 litres (W_1), 136 litres (W_2) and 272 litres (W_3). The percent loss in MNL during this period varied from 10.45 (W_3) to 13.65 (W_1) at 120th day BLI over that at 90th day BLI.

Interaction effect. The MNL due to the interaction of plant spacings and levels of irrigation varied from 112.88 (S_2W_1) to 129.75 (S_1W_3). The latter (S_1W_3) had significantly higher MNL than S_2W_1 but were at par with S_1W_2 (122.13), S_3W_3 (124.00) and S_2W_3 (129.29). Rests of the interactions were non-significant. The percent loss in MNL due to the interaction of plant spacings and levels of irrigation during the period varied from 10.04 (S_2W_3) to 14.54 (S_1W_1) at 120 days BLI over that at 90 days BLI.

150th day after BLI

Main plot effect (Spacings). On 150th day after BLI, the MNL though was varied from 82.67 (S_2), 82.86 (S_1) to 84.17 (S_3) but had no significant difference. The percent loss in MNL on between 120th to 150th day after BLI varied from 29.38 (S_3) to 32.71 (S_1). At this stage the percent loss in MNL was highest in all the treatments. The adult male emergence was observed from 127.83 to 130.75 days after BLI. The reason for the loss of MNL may be due to adult male emergence (short duration life cycle 6.75 to 9.33 days after male emergence) and weather condition also influenced the loss lac insects.

Sub plot effect (Levels of irrigation). The MNL on *C. cajan* at the different levels irrigation though varied from 74.21 (W_1), 83.32 (W_2) to 92.17 (W_3). The latter (W_3) had significantly higher MNL than those of all the levels of irrigation. W_2 was also significantly higher MNL than W_1.

The percent loss in MNL In between 120th to 150th day after BLI varied from 27.76 (W_3) to 35.26 (W_1). The per plant irrigation water during period was 16 litres (W_1), 32 litres (W_2) and 64 litres (W_3). The total water per plant from BLI to 150th day after BLI was 84 litres (W_1), 168 litres (W_2) and 336 litres (W_3).

Interaction effect. The MNL due to the interaction of plant spacings and levels of irrigation varied from 72.54 (S_2W_1) to 93.29 (S_2W_3). The latter (S_2W_3) had significantly higher MNL than S_1W_1 but it was at par with S_3W_3 (91.54) and S_1W_3 (91.67). However, the MNL of interaction S_3W_2 (84.96) was significant but at par with S_2W_2 (82.17) and S_1W_2 (82.83). The MNL of S_2W_1 (72.54) was at par with S_1W_1 (74.08) and S_3W_1 (76.00). The percent loss in MNL between 120th to 150th day after BLI due to the interaction of plant spacings and levels of irrigation varied from 26.17 (S_3W_3) to 36.66(S_2W_1).

180th day after BLI

Main plot effect (Spacings). On 180th day after BLI, the MNL varied from 64.21 (S_1), 64.74 (S_2) to 67.71 (S_3). The latter (S_3) had significantly highest MNL among all the spacing. The percent loss in MNL during the period varied from 19.83 (S_3) to 22.73 (S_1).

Sub plot effect (Levels of irrigation). The MNL *C. cajan* at the different levels irrigation though varied from 56.19 (W_1), 66.33 (W_2) and 74.13 (W_3). The latter (W_3) had significantly higher MNL than W_1 and W_2. W_2 had also significant Higher MNL than W_1. The per plant quantity of water was 18 litres (W_1), 36 litres (W_2) and 72 litres (W_3). The total water per plant from BLI to 180th day after BLI was 102 litres (W_1), 204 litres (W_2) and 408 litres (W_3). The percent loss in MNL varied from 19.61 (W_3) to 24.34 (W_1). Percent loss in MNL was highest in W_1.

Interaction effect. The MNL due to the interaction of plant spacings and levels of irrigation varied from 55.29 (S_2W_1) to 76.21 (S_3W_3). The latter (S_3W_3) had significantly higher MNL than S_2W_1 but was at par with S_1W_3 (72.08) and S_2W_3 (74.08). However, the MNL of interaction S_3W_2 (69.04) was also significant higher but was at par with S_2W_2 (64.83) and S_1W_2 (65.13). The MNL of S_2W_1 (55.29) was at par with S_1W_1 (55.42) and S_3W_1 (57.87). The percent loss in MNL between 150th to 180th day after BLI due to the interaction of plant spacings and levels of irrigation varied from 16.79 (S_3W_3) to 25.34 (S_1W_1).

The percent survival in MNL in the overall lac crop period. Spacings and levels of irrigation affect the host plant growth (height), stem and branch thickness, numbers of primary and secondary branches, weather conditions and biotic factors all these parameters affect the survival of lac insects.

Main plot effect (Spacings). The percent survival of lac insects from BLI to lac harvest varied from 35.70 (S_1), 37.13 (S_2) to 39.07 (S_3).

Sub plot effect (Levels of irrigation). Between withdrawal of rain and BLI, there were 4 irrigations. Additional quantity of water per plant before BLI was 16 litres (W1), 32 litres (W2) and 64 litres (W3). The per plant total additional quantity of water from BLI to 180 days after BLI 102 litres (W_1), 204 litres (W_2) and 408 litres (W_3), there was an increase the survival of lac insects with increasing the amount of irrigation water. The percent survival of lac insects between BLI

and lac crop harvest due to different levels irrigation though varied from 32.01 (W_1), 38.35 (W_2) to 41.55 (W_3). The percent survival in MNL was lowest in W_1 and highest in W_3 irrigation level.

Interaction effect. The percent survival of lac insects due to the interaction of plant spacings and levels of irrigation varied from 31.08 (S_1W_1) to 43.59 (S_3W_3). Water availability has a significant impact on crop output. Rainfall patterns, soil moisture retention, evaporation, and runoff vary due to climate change. Rainfall is thought to be responsible for more than 80 percent of all agricultural output worldwide, hence variations in seasonal total rainfall or its patterns are crucial. The global hydrological cycle is amplified and temperature fluctuations have a significant impact on this process (Koutsoyiannis, 2020). It depends on other climate parameters including the severity and frequency of extreme weather events. Insufficient soil moisture can cause plants to lose biological processes and make them more vulnerable to diseases and pests (Zayan, 2019).

Climate change has an impact on agricultural crops (Habib-ur-Rahman *et al.*, 2022) as well as the insects (Sandra *et al.*, 2021) that afflict them both directly and indirectly. The reproduction, development, survival, and dissemination of insects are directly impacted, whilst the environment and other insect species, such as natural enemies, vectors, and mutualists, are indirectly impacted (Skendzic *et al*., 2021).

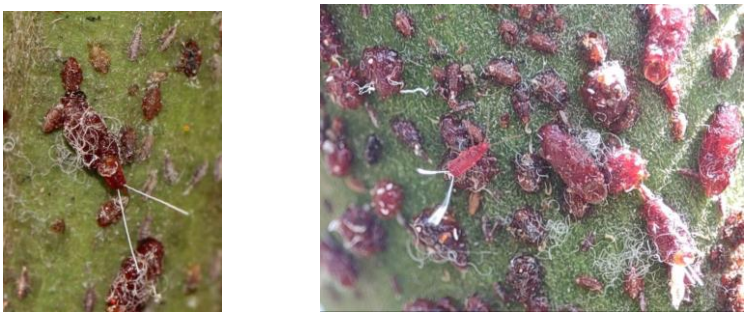
The variation in MNL have been reported earlier, the MNL at 30 days after BLI varied from 60 to 95.80 (Patel, 2013), 28.13 to 40.53 (Janghel, 2013), 51.35 to 64.08 (Namdev, 2014), 37.95 to 58.24 (Sharma *et al.*, 2015a), 38.31 to 43.37 (Sharma *et al.*, 2015), 37.05 to 39.34 (Gurjar, 2016).

The earlier data on MNL at 120 days of BLI is lacking. However, a few workers have recorded MNL at 125 days after BLI. It varied from 60.00 to 95.80 (Patel, 2013), 28.13 to 40.53 (Janghel, 2013), 51.35 to 64.08 (Namdev,2014), 38.31 to 43.37 (Gurjar, 2016). However, all these were of MNL from host trees of lac insect.

The survival percent of lac on *C. cajan* reported by earlier workers varied from 24.91 to 38.13 (Shah *et al.*, 2017), 33.53 to 41.77 (Sharma *et al.*, 2015), 34.08 to 51.53 (Gurjar, 2016), 20.86 to 26.05 at harvest. Namdev (2014) reported it to varied from 18.53 to 39.16 percent and 22.00 to 27.00 (Patel, 2013), 27 to 32 (Janghel, 2013), 21 to 25 (Vajpayee *et al.*, 2019) percent respectively. But, according to the finding of Bhalerao (2013), it was as low as 5.25% to 12.45% from BLI to maturity of lac crop.

30th	60th	90th	120th	150th	180th

Fig. 3. Growth of lac insects from 30th days after BLI (immature stage) to 180 days after BLI (maturity stage).



Emerging male	Wingless adult male

Fig. 4. Male emergence during 120th to 150th.

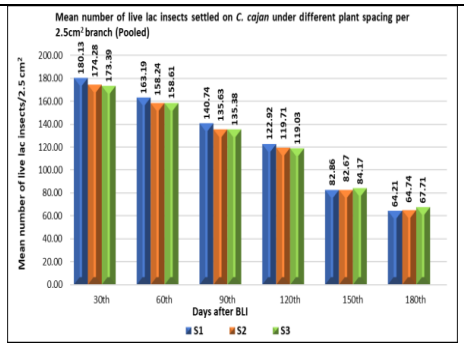
Table 1: The mean number of live lac insects settled on *C. cajan* per 2.5cm^2 branch under different plant spacings, levels of irrigation and their interactions in different periods after BLI (Pooled).

Mean number of live lac insects settled on *C. cajan* per 2.5cm^{-2} branch on difference period after BLI (Pooled)								
Treatments	**30th**	**60th**	**90th**	**120th**	**150th**	**180th**	**Total additional water (litres) per plant after BLI to 180th Days after BLI**	**Survivability (%)**
Main plot (spacings)								
S_1	180.13 (13.43)	163.19 (12.79)	140.74 (11.88)	122.92 (11.10)	82.86 (9.12)	64.21 (8.03)	238.00	35.70
S_2	174.28 (13.22)	158.24 (12.59)	135.63 (11.66)	119.71 (10.96)	82.67 (9.11)	64.74 (8.06)	238.00	37.13
S_3	173.39 (13.18)	158.61 (12.61)	135.38 (11.65)	119.03 (10.93)	84.17 (9.19)	67.71 (8.24)	238.00	39.07
SEm(±)	0.06	0.03	0.02	0.05	0.03	0.04		
CD(5%)	0.24	0.13	0.09	0.19	0.10	0.16		
Sub plot (levels of irrigation)								
W_1	175.83 (13.27)	157.60 (12.57)	133.04 (11.55)	114.65 (10.73)	74.21 (8.64)	56.19 (7.52)	102.00	32.01
W_2	173.15 (13.17)	157.75 (12.58)	136.01 (11.67)	119.32 (10.94)	83.32 (9.15)	66.33 (8.17)	204.00	38.35
W_3	178.81 (13.39)	164.69 (12.85)	142.68 (11.96)	127.68 (11.32)	92.17 (9.62)	74.13 (8.63)	408.00	41.55
SEm(±)	0.10	0.09	0.07	0.07	0.08	0.08		
CD(5%)	0.31	0.27	0.20	0.22	0.24	0.25		
Interactions (spacings × levels of irrigation)								
S_1W_1	178.58 (13.38)	159.83 (12.66)	136.92 (11.72)	116.88 (10.83)	74.08 (8.63)	55.42 (7.47)	102.00	31.08
S_1W_2	179.04 (13.40)	161.71 (12.73)	139.21 (11.81)	122.13 (11.07)	82.83 (9.12)	65.13 (8.09)	204.00	36.37
S_1W_3	182.75 (13.53)	168.04 (12.98)	146.08 (12.11)	129.75 (11.41)	91.67 (9.60)	72.08 (8.52)	408.00	39.66
S_2W_1	172.42 (13.14)	153.75 (12.41)	129.25 (11.39)	112.88 (10.64)	72.54 (8.54)	55.29 (7.47)	102.00	32.19
S_2W_2	171.58 (13.12)	156.17 (12.51)	133.79 (11.58)	116.96 (10.84)	82.17 (9.09)	64.83 (8.08)	204.00	37.81
S_2W_3	178.83 (13.39)	164.79 (12.86)	143.83 (12.01)	129.29 (11.39)	93.29 (9.68)	74.08 (8.63)	408.00	41.40
S_3W_1	176.50 (13.30)	159.21 (12.64)	132.96 (11.54)	114.21 (10.71)	76.00 (8.74)	57.87 (7.63)	102.00	32.75
S_3W_2	168.83 (13.01)	155.38 (12.48)	135.04 (11.63)	118.88 (10.92)	84.96 (9.24)	69.04 (8.33)	204.00	40.88
S_3W_3	174.83 (13.24)	161.25 (12.71)	138.13 (11.77)	124.00 (11.16)	91.54 (9.59)	76.21 (8.75)	408.00	43.59
SEm(±)	0.17	0.15	0.11	0.12	0.13	0.14		
CD(5%)	0.53	0.47	0.35	0.38	0.41	0.44		

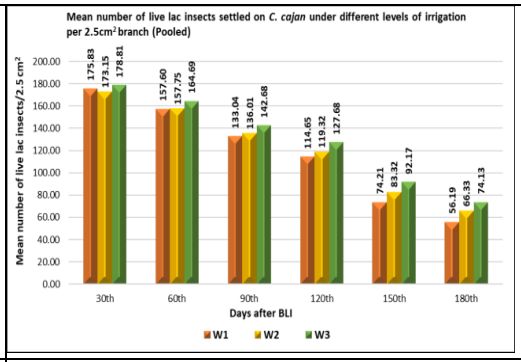
Figures in parenthesis are transformed value

Table 2: Percent survival of lac insects per 2.5cm^2 branch at different periods after BLI (Pooled).

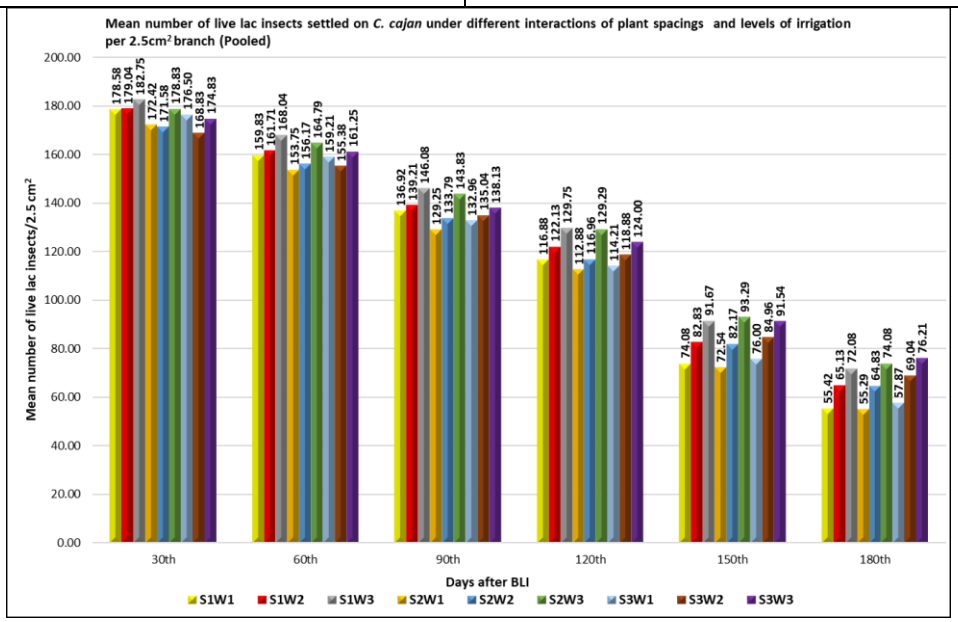
Percent survival of lac insects per 2.5cm^2 branch at different periods after BLI (Pooled)						
Treatments	**30 to 60 days**	**60 to 90 days**	**90 to 120 days**	**120 to 150 days**	**150 to 180 days**	**Overall survivability**
Main plot (spacings)						
S_1	90.61	86.32	87.45	67.29	77.27	35.70
S_2	90.82	85.76	88.32	68.93	78.14	37.13
S_3	91.50	85.34	88.15	70.62	80.17	39.07
Sub plot (levels of irrigation)						
W_1	89.68	84.52	86.35	64.74	75.66	32.01
W_2	91.13	86.16	88.01	69.85	79.53	38.35
W_3	92.12	86.74	89.55	72.24	80.39	41.55
Interactions (spacings × levels of irrigation)						
S_1W_1	89.51	85.84	85.46	63.34	74.66	31.08
S_1W_2	90.31	85.96	88.07	67.79	78.50	36.37
S_1W_3	92.02	87.16	88.81	70.73	78.65	39.66
S_2W_1	89.28	84.28	87.43	64.33	76.22	32.19
S_2W_2	91.02	85.75	87.57	70.29	78.88	37.81
S_2W_3	92.15	87.24	89.96	72.17	79.33	41.40
S_3W_1	90.24	83.44	86.17	66.56	76.09	32.75
S_3W_2	92.07	86.76	88.40	71.48	81.21	40.88
S_3W_3	92.20	85.81	89.870	73.83	83.21	43.59



Mean number of live lac insects settled on *C. cajan* under different plant spacings per 2.5cm^2 branch (Pooled)



Mean number of live lac insects settled on *C. cajan* under different levels of irrigation per 2.5cm^2 branch (Pooled)



Mean number of live lac insects settled on *C. cajan* under different interactions of plant spacings and levels of irrigation per 2.5cm^2 branch (Pooled)

Fig. 5. The mean number of live lac insects settled on *C. cajan* per 2.5cm^2 branch under different plantspacings, levels of irrigation and their interactions in different periods after BLI (Pooled).

CONCLUSIONS

Health of the host plant influences the growth and survival of the phloem feeder. Spacings between and among host plants as well as proper irrigation have positive effects on the health of plants. This may be the reason for higher percent of survival of lac insects in the plant with enough spacing and good irrigation. Irrigation helps in utilization of soil nutrients by plants due to maintenance of proper moisture level for survival of soil microorganisms. This helps to maintain the host plant in good health for the development of settled lac insect.

FUTURE SCOPE

The findings of the present study open the window to conduct future research on effects of plant densities and moisture stress on lac as well as seed production in pigeonpea. The current investigation was conducted on a pigeonpea genotype so, the future research work may be carried out on different genotypes to analyze the effects of different climatic factors on lac and seed yield.

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Conflicts of interests. None.

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