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Comparative population dynamics of major insect-pest-complex of cowpea during the summer and monsoon seasons

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Abstract
Investigations on, "Comparative population dynamics of major insect pests of *Zaid* and *Kharif* cowpea [*Vigna unguiculata* (Linnaeus) Walp.]" were carried out at the Instructional farm and Department of Entomology of Rajasthan College of Agriculture, MPUAT, Udaipur, during two summer (*Zaid*) and monsoon (*Kharif*) crop seasons in the consecutive years 2019 and 2020.During the course of investigations, the sequential infestation by the major insect pests observed on cowpea followed a more or less uniform trend in both the years of study; however, was influenced more often by the mean atmospheric temperatures and the total rainfall pattern each year. The infestation trend closely ensued the crop phenology with the following sequence of pestiferous insects: flea beetles (Coleoptera: Chrysomelidae); jassids (Heteroptera: Cicadellidae); whiteflies (Hemiptera: Aleurodidae) only during the monsoon season; leaf miner (Diptera: Agromyzidae); sap feeding bugs of Heteroptera (Hemiptera: Alydidae &Coreidae); thrips (Thysanoptera: Thripidae) only during the monsoon season; plant lice (Hemiptera: Aphididae); spotted pod borer (Lepidoptera: Crambidae); and the blue butterfly pod borer (Lepidoptera: Lycaenidae). The total rainfall had negative effect on the population of sucking pest complex; whereas gradual increase in mean atmospheric temperature supported the borer population.

Keywords: seasonal incidence, abiotic factors, pest complex, cowpea

Introduction
Pulse crops are known as an important dietary source of proteins for a major part of the vegetarian population across the globe; especially in India. Legume crops help restoration of soil fertility through symbiotic nitrogen fixation. Cowpea [*Vigna unguiculata* (L.) Walp.] is one of the principal pulse crops of the tropics and is commonly known as crowdel pea, *chala*, *chola* or *choli*, *chavli*, *lobia*, southern pea and black eyed bean. Being, an annual herbaceous legume it is a widely adapted and cultivated crop in tropical Africa, Asia, North and South America mostly for its edible seeds as a grain; besides, as a vegetable and the whole plant as fodder having high levels of proteins ensuring tolerance against several stresses. It is one of the oldest farmed crops cultivated on 12.5 million hectares, having a worldwide production of 3 million tons. In India *lobia* is grown on an area of approximately 3.9 million hectares with a production of 2.21 million tons having a national productivity of 683 kg per hectare (Kaushik, 2016) [1].
The damage by insect pests is one of the major constraints accounting for low level of yield. Cowpea crop cultivated during the summer and monsoon season, is infested by 21 insect pests from different groups (Sardana and Verma, 1986) [3]. The insects act either as vectors of diseases or as defoliators and sap feeder causing, damage to flowers and pods. Cowpea crop is infested by the legume aphid (*Aphis craccivora* Koch), foliage beetles (*Oothecas*p., *Medythias*pp.), the flower bud thrips (*Megalurothrips sjostedti* Trybom) the legume pod borer (*Marucavitrata* Fabricius) and the sucking bug complex including: *Clavigralla* spp., *Anoplocnemis* spp., *Riptortus* spp., *Mirperus* spp., *Nezaraviridula* Fab. And *Aspaviaarmigera* Linnaeus (Meena *et al.*, 2017) [5].
Cowpea is known to harbor many natural enemies of pestiferous insects, which exert a significant role in their suppression, so introduction of cowpea crop under different cropping system can result into enhanced population of natural enemies.

Materials and Methods
In order to study the comparative population dynamics of major insect pests of cowpea, a field trial was laid out during *Zaid* and *Kharif* separately at the Instructional Farm of the College.

Cowpea variety Pusa Komal was cultivated in 6 plots each of 3m x 3m with the row to row and plant to plant spacing of 50 cm and 10 cm, respectively. Weekly population data of insect peststhus obtained were correlated with the prevailing mean abiotic factors of the environment (mean atmospheric temperature, mean relative humidity and total rainfall) during both the crop seasons. Simple coefficient of correlation was worked out between the pest population and abiotic environmental factors and linear regression equations were computed. Likewise, the predator-prey association was also analysed over prey density under natural field conditions.

Statistical Analysis

Observations on the population of insect-pest-complex (pest insects and their natural enemies) were taken on a weekly basis and the prevailing abiotic conditions of the atmosphere recorded from the meteorological observatory of the farm to work out the correlation by using Karl Pearson formula of coefficient of correlation.

$$r_{xy} = \frac{\sum XY - \frac{(\sum X)(\sum Y)}{n}}{\sqrt{\left[\sum X^2 - \frac{(\sum X)^2}{n}\right]\left[\sum Y^2 - \frac{(\sum Y)^2}{n}\right]}}$$

Where,

r_{xy} = Simple correlation coefficient

X = Variable *i.e.* abiotic components. (Average temperature and relative humidity)

Y = Variable *i.e*. mean number of insect pests

n = Number of paired observations

The correlation coefficient (r) values were subjected to the test of significance using t-test:

$t = \frac{r}{\sqrt{1-r^2}} \times \sqrt{n-2}$ follows t- distribution with (n-2) degrees of freedom

Where,

r = correlation coefficient value

n = number of paired observations

Results and Discussion

Crop seasons of 2019

The seasonal incidence of major insect pest associated with cowpea crop and their simple correlation with abiotic factor *viz.* mean atmospheric temperature, mean relative humidity and total rainfall during successive seasons of 2019 have been presented in the Table (1) and Table (2).

Table 1: Seasonal incidence of major insect pests associated with the summer crop of cowpea, 2019

SMW	Mean atmospheric temperature (^{0}C)	Mean relative humidity (%)	Total Rainfall (mm)	Mean population					
				Flea beetles	Jassids	Leaf miner	Aphids	Lycaenid borer	Spotted pod borer
17	31.05	20.71	0	1.03	--	--	--	--	--
18	30.46	29.86	0	2.13	0.37	--	--	--	--
19	29.62	31.86	10.8	3.33	2.10	0.53	--	--	--
20	29.54	40.29	0	1.20	3.16	0.73	1.07	--	--
21	32.02	28.71	0	0.53	1.56	1.10	2.90	--	0.40
22	33.05	33.30	5.2	--	0.70	0.90	4.90	0.53	1.50
23	35.07	26.25	0	--	0.46	0.43	3.30	2.36	2.26
24	31.40	52.07	13.2	--	--	0.2	0.96	3.26	1.36
25	28.35	70.29	75.4	--	--	--	0.53	2.96	0.56
26	28.48	70.86	74.8	--	--	--	--	0.93	0.20
27	27.14	76.79	91.0	--	--	--	--	0.46	--
Coefficient of correlation (r) with mean atmospheric temperature				-0.68	-0.67	-0.01	0.78	0.23	0.84*
Coefficient of correlation (r) with mean relative humidity				0.18	0.77	-0.53	-0.75	-0.13	-0.61
Coefficient of correlation (r) with total rainfall				-0.64	0.16	-0.61	-0.53	-0.28	-0.64

Note: Asterisk mark * with r-value indicates significance at 5% level; (--) indicates non-occurrence of the pest

Table 2: Seasonal incidence of major insect pest associated with the monsoon crop of cowpea, 2019

SMW	Mean atmospheric temperature (^{0}C)	Mean relative humidity (%)	Total Rainfall (mm)	Mean population								
				Flea beetles	Jassids	Whiteflies	Sap sucking Bugs	Thrips	Leaf miner	Aphids	Lycaenid borer	Spotted pod borer
29	28.63	65.93	34.6	1.06	--	--	--	--	--	--	--	--
30	27.79	74.29	12.6	2.46	0.40	0.46	--	--	--	--	--	--
31	26.79	83.50	15.0	2.96	2.46	2.13	--	3.56	0.76	--	--	--
32	25.32	83.00	182.2	1.36	0.23	0.22	0.36	1.56	0.93	--	--	--
33	24.61	85.14	153.0	0.66	0.53	0.40	1.80	2.14	1.50	--	--	--
34	26.51	73.29	69.6	--	1.46	1.16	2.46	2.56	1.20	--	--	0.36
35	25.83	86.36	141.0	--	0.56	0.66	2	1.16	0.63	0.63	0.40	1.80
36	27.07	88.57	85.5	--	--	--	0.76	0.6	0.46	2.76	1.93	2.50
37	26.81	82.71	36.1	--	--	--	0.43	--	--	4.06	2.80	1.63
38	26.43	75.07	42.2	--	--	--	--	--	--	1.50	1.93	0.70
39	25.61	82.86	14.2	--	--	--	--	--	--	5.12	0.73	0.26
40	24.39	78.57	66.4	--	--	--	--	--	--	0.73	0.33	--
Coefficient of correlation (r) with mean atmospheric temperature				0.36	0.33	0.39	-0.21	0.05	-0.68	0.36	0.83*	0.53
Coefficient of correlation (r) with mean relative humidity				0.09	-0.07	-0.04	-0.45	-0.53	-0.50	0.22	-0.01	0.78
Coefficient of correlation (r) with total rainfall				-0.68	-0.61	-0.64	0.02	-0.58	0.27	-0.71	-0.38	0.57

Note: Asterisk mark * with r-value indicates significance at 5% level; (--) indicates non-occurrence of the pest

(i) Leaf/ flea beetles, *Phyllotreta* spp. and *Chaetocnema* spp.
During both the seasons, flea beetles were the pioneers to infest cowpea; their infestation began in the 17th SMW during the summer and in the 29th SMW during the monsoon. The mean population ranged from 0.53 (21st SMW) to 3.33 (19th SMW) and 0.66 (33rd SMW) to 2.96 (31st SMW) during the summer and monsoon season, respectively. During the summer, the population had a negative correlation with mean atmospheric temperature (r = -0.68) and rainfall (r = -0.64); whereas, positively correlated with mean relative humidity (r = 0.18). However, during the monsoon, the flea beetles had negative correlation with total rainfall (r = -0.68); whereas, positive correlation with mean atmospheric temperature (r = 0.36) and mean relative humidity (r = 0.09).

(ii) Jassids, *Empoasca* spp.
In a phenological sequence, jassids infestation was observed after flea beetle with their first appearance in the 18th SMW and the 30th SMW during the summer and monsoon seasons, respectively. The mean infestation ranged from 0.37 (18th SMW) to 3.16 (20th SMW) and 0.23 (32nd SMW) to 2.46 (31st SMW) during the summer and monsoon seasons, respectively. The infestation of jassids was recorded to be more in the summer than in the monsoon. Jassids were negatively correlated with mean atmospheric temperature (r = -0.67) during the summer; whereas, during the monsoon season they exhibited a negative correlation with mean relative humidity (r = -0.07) and total rainfall (r = -0.61).

(iii) Whiteflies, *Bemisia*spp.
The infestation of whiteflies was observed during the monsoon season only, which initiated in the 30th SMW coinciding with the infestation of jassids. The maximum population (2.13/ plant) was recorded during the 31st SMW and minimum (0.22/ plant) during the 32nd SMW. The mean atmospheric temperature had positive correlation (r = 0.39); while,mean relative humidity had negative correlation (r = -0.04) with the pest population. During the monsoon season the pest population evinced a statically negative correlation with total rainfall (r = -0.64).

(iv) Leaf miner
The mined leaves were observed from the 19th SMW and the 31st SMW during the summer and monsoon seasons, respectively. The infestation of leaf miner ranged from 0.2 to 1.1 (mined leaves/ plant) during the summer, and 0.46 to 1.5 (mined leaves/ plant) during monsoon season. The peak population was recorded during the 21st and 33rd SMW in the respective seasons. The coefficients of correlation between the leaf miner and mean atmospheric temperature, mean relative humidity and total rainfall were negative during the respective crop seasons; whereas, it was positively correlated with total rainfall (r = 0.27) during the monsoon season.

(v) Thrips, *Megalurothrips* spp.
Population of thrips initiated in the 31st SMW during the monsoon season after the appearance of jassids and whiteflies. There was no record of thrips during the summer season. The mean population of thrips ranged from 0.6 to 3.56 with the maximum at initial infestation. Thrips showed negative coefficient of correlation with total rainfall (r = -0.58) and mean relative humidity (r = -0.53); while positive correlation with mean atmospheric temperature (r = 0.05).

(vi) Sap sucking bugs, *Riptortus* spp. and *Clavigralla* spp.
Similar to thrips and whiteflies, the sap sucking bugs of Heteroptera were not recorded on crop during the summer season. They were observed only during the monsoon season with the mean population of 0.36 to 2.46. The maximum population was observed in the 34th SMW with initiation of infestation in the 32nd SMW. Pest population had negative correlation with mean atmospheric temperature (r = -0.21) and mean relative humidity (r = -0.45), but positive correlation with total rainfall (r = 0.02) during the season.

(vii) Legume aphid, *Aphis craccivora*
The aphid population was most dominant during both the seasons and relatively more during the monsoon season. The mean aphid population ranged from 0.53 to 4.9 and 0.63 to 5.12 during the summer and monsoon seasons, respectively. The peak incidence of aphid population was observed in the 22nd and the 37th SMW during the respective seasons. The population had positive correlation with mean atmospheric temperature (r = -0.78); whereas, negative correlation with total rainfall (r = -0.71) during the monsoon. Mean relative humidity had negative correlation (r = -0.75) with the pest during the summer; while, positive correlation (r = 0.22) during the monsoon season.

(viii) Spotted pod borer, *Maruca* spp.
The population of spotted pod borer first appeared in the 21st and the 34th SMW during both the observed seasons. The peak population of pod borer was observed in the 23rd SMW (2.26) and the 36th SMW (2.5) during the summer and monsoon, respectively. The mean pod borer population ranged from 0.2 to 2.26 and 0.26 to 2.5 during the summer and monsoon seasons, respectively. The pod borer population had significant correlation with all the abiotic factors during the summer; positively with mean atmospheric temperature (r = 0.84) and negatively with mean relative humidity (r = -0.61) and total rainfall (r = -0.64). The borer population had positive correlation with mean relative humidity (r = 0.78), total rainfall (r = 0.57) and mean atmospheric temperature (r = 0.53) during the monsoon season.

(ix) Lycaenid borer, *Lampides* spp. and *Euchrysops* spp.
As per the crop phenology, the lycaenid borer infestation was the last during both the seasons. The infestation started during the 22nd and the 35th SMW during the respective seasons. The mean population ranged from 0.46 (27th SMW) to 3.26 (24th SMW) during the summer; while, from 0.33 (40th SMW) to 2.8 (37th SMW) during the monsoon. The coefficient of correlation (r) between borer population and mean atmospheric temperature was 0.23 and 0.83; whereas, with mean relative humidity -0.13 and -0.01 and with total rainfall was -0.28 and 0.38 during the summer and monsoon seasons, respectively.

Crop seasons of 2020
The seasonal incidence of major insect pest associated with cowpea crop and their simple correlation with abiotic factor *viz.* mean atmospheric temperature, mean relative humidity and total rainfall during successive seasons of 2020 have been presented in the Table (3) and Table (4).

Table 3: Seasonal incidence of major insect pest associated with the summer crop of cowpea, 2020

SMW	Mean atmospheric temperature (^{0}C)	Mean relative humidity (%)	Total Rainfall (mm)	Mean population					
				Flea beetles	Jassids	Sap sucking Bugs	Aphids	Lycaenid borer	Spotted pod borer
10	18.40	53.14	3	0.63	--	--	--	--	--
11	17.71	42.64	0	1.07	0.53	--	--	--	--
12	23.60	40.14	2.6	3.63	1.13	--	--	--	--
13	22.14	49.71	29	2.20	2.43	0.36	--	--	--
14	24.58	36.71	0	1.20	1.13	1.60	--	--	--
15	27.39	37.14	0	--	0.66	1.96	1.93	--	0.23
16	28.32	35.21	0	--	0.23	1.90	4.66	0.46	1.26
17	29.06	36.29	8	--	--	0.66	1.26	1.93	1.83
18	30.51	33.57	0	--	--	0.26	7.93	2.13	1.06
19	30.72	31.50	0	--	--	--	7.30	2.56	0.26
20	31.11	25.64	1.2	--	--	--	2.30	0.80	0.16
21	33.29	29.86	0	--	--	--	--	0.50	--
Coefficient of correlation (r) with mean atmospheric temperature				0.58	-0.28	-0.01	0.47	-0.17	-0.24
Coefficient of correlation (r) with mean relative humidity				-0.31	0.81*	-0.34	-0.11	0.31	0.53
Coefficient of correlation (r) with total rainfall				-0.24	0.91*	-0.57	-0.57	0.24	0.68

Note: Asterisk mark * with r-value indicates significance at 5% level; (--) indicates non-occurrence of the pest

Table 4: Seasonal incidence of major insect pest associated with the monsoon crop of cowpea, 2020

SMW	Mean atmospheric temperature (^{0}C)	Mean relative humidity (%)	Total Rainfall (mm)	Mean population								
				Flea beetles	Jassids	Whiteflies	Sap sucking Bugs	Thrips	Leaf miner	Aphids	Lycaenid borer	Spotted pod borer
28	27.14	74.29	5.2	0.46	--	--	--	--	--	--	--	--
29	28.12	68.07	2.2	1.03	0.77	--	--	--	--	--	--	--
30	27.81	71.86	26.4	1.86	1.36	0.20	0.5	--	--	--	--	--
31	27.62	79.21	60	2.10	2.2	1.43	0.93	0.6	0.46	--	--	--
32	26.96	82.00	71	0.36	1.06	1.76	1.5	0.96	0.73	--	--	--
33	25.89	87.36	56.8	--	0.7	2.90	1.83	2.16	2.13	--	--	0.40
34	25.21	86.43	210.5	--	0.46	0.90	0.6	1.7	1.4	1.07	1.06	0.70
35	24.49	83.64	53	--	--	0.40	0.26	0.66	0.46	2.9	1.66	1.36
36	25.46	85.93	165.4	--	--	--	--	0.46	0.16	1.36	2.6	0.93
37	26.94	131.64	44	--	--	--	--	--	--	3.3	2.23	0.53
38	27.00	72.45	46.4	--	--	--	--	--	--	0.96	0.83	0.26
39	26.20	69.15	7.2	--	--	--	--	--	--	0.53	0.46	--
Coefficient of correlation (r) with mean atmospheric temperature				0.62	0.58	0.03	0.22	-0.13	-0.08	-0.11	-0.17	-0.85*
Coefficient of correlation (r) with mean relative humidity				-0.14	-0.26	0.57	0.38	0.62	0.57	0.78	0.64	-0.09
Coefficient of correlation (r) with total rainfall				0.14	-0.37	-0.04	-0.14	0.10	-0.01	-0.20	0.31	0.21

Note: Asterisk mark * with r-value indicates significance at 5% level; (--) indicates non-occurrence of the pest

(i) Leaf/ flea beetles, *Phyllotreta* spp. and *Chaetocnema* spp.

The infestation of flea beetles started in 10th SMW during the summer; while in 28th SMW during the monsoon. The mean population ranged from 0.63 (10st SMW) to 3.63 (12th SMW) and 0.36 (32nd SMW) to 2.10 (31st SMW) during the summer and monsoon respectively. The correlation of pest population was observed to be positive with mean atmospheric temperature (r = 0.58 and 0.62); whereas, negative with mean relative humidity (r = -0.31 and -0.14) and positive with total rainfall (r = 0.24 and 0.14) during the summer and monsoon respectively.

(ii) Jassids, *Empoasca* spp.

In Phenological sequence, jassids infestation was observed after flea beetle with the first appearance in 11th SMW and 29th SMW during the summer and monsoon season respectively. The mean infestation ranged from 0.23 (16th SMW) to 2.43 (13th SMW) and 0.46 (34th SMW) to 2.2 (31st SMW) during the summer and monsoon season, respectively. Jassids population was observed to be negatively correlated with mean atmospheric temperature (r = -0.28) and positively correlated with mean relative humidity (r = 0.81) and total rainfall (r = 0.91) during the summer season. In contrast to that population was positively correlated with mean atmospheric temperature (r = 0.58) and negatively correlated with mean relative humidity (r = -0.26) and total rainfall (r = -0.37).

(iii) Whiteflies, *Bemisia* spp.

There was no infestation of whiteflies during the summer season. The infestation of whiteflies initiated in 30th SMW one week after jassids infestation. The maximum population (2.90/ plant) was recorded during 33rd SMW and the minimum (0.20/ plant) during 30th SMW. The pest population had positive correlation with mean atmospheric temperature (r = 0.03) and mean relative humidity (r = 0.57); whereas, negative correlation with total rainfall (r = -0.04).

(iv) Leaf miner

The leaf miner infestation was observed in the monsoon season only with first appearance during 31st SMW. The infestation of leaf miner ranged from 0.16 (36th SMW) to 2.13 (33rd SMW). The correlation of mined leaves with the abiotic factors was calculated to be negative with mean atmospheric temperature (r = -0.08) and total rainfall (r = -0.01); whereas positive correlation with mean relative humidity (r = 0.57).

(v) Thrips, *Megalurothrips* spp.

The thrips population was initiated in 31st SMW during the monsoon season after the appearance of jassids and whiteflies. There was no record of thrips population during summer season. The mean population of thrips ranged from 0.6 to 2.16 (per plant), with the maximum population during 33rd SMW. The thrips had positive correlation with mean relative humidity (r = 0.62) and total rainfall (r =0.10); while negative correlation with mean atmospheric temperature (r = -0.13).

(vi) Sap sucking bugs, *Riptortus* spp. and *Clavigralla* spp.

The infestation of sap sucking bugs initiated in 13th SMW and 30th SMW during the summer and monsoon season respectively. The mean pest population ranged from 0.26 (18th SMW) to 1.96 (15th SMW) and 0.26 (35th SMW) to 1.83 (32nd SMW) during the summer and monsoon season respectively. All the abiotic factors had negative correlation with pest population during the summer season *i.e.* mean atmospheric temperature (r = -0.01), mean relative humidity (r = -0.34) and total rainfall (r = 0.57). There was no significant correlation of abiotic factors on pest population having positively correlated with mean atmospheric temperature (r = 0.22) and mean relative humidity (r = 0.38) and negatively correlated with total rainfall (r = -0.14) during the monsoon season.

(vii) Legume aphid, *Aphis craccivora*

The aphid population was most dominant during both the respective season. The aphid population was observed to be more during the summer season as compared to that of the monsoon season. The mean aphid population ranged from 1.93 (15th SMW) to 7.93 (18th SMW) and 0.53 (39th SMW) to 3.3 (37th SMW) during the summer and monsoon season respectively. The population had positive correlation with mean atmospheric temperature (r = 0.47); whereas, negative correlation with mean relative humidity (r = -0.11) and total rainfall (r = -0.57) during the summer season. Mean relative humidity had positive correlation (r = 0.78) with pest; whereas, negative correlation with mean atmospheric temperature (r = -0.11) and total rainfall (r = -0.20) during the monsoon season.

(viii) Spotted pod borer, *Maruca* spp.

The population of spotted pod borer first appeared in 15th and 33rd SMW during both the respective seasons. The peak population of pod borer infestation was observed in 17th SMW (1.83) and 35th SMW (1.36) during the summer and monsoon, respectively. The mean pod population ranged from 0.23 to 1.83 and 0.26 to 1.36 during the summer and monsoon season, respectively. The pod borer population had positive correlation with total rainfall (r = 0.68) and mean relative humidity (r = 0.53); whereas, negative correlation with mean atmospheric temperature (r = -0.24) during the summer season. The pest population had negative correlation with mean atmospheric temperature (r = -0.85) and mean relative humidity (r = -0.09); whereas, positive correlation with total rainfall (r = 0.21).

(ix) Lycaenid borer, *Lampides* spp. and *Euchrysops* spp.

The infestation of the lycaenid borer was observed to be last as per crop phenology during both of the respective seasons. The infestation of lycaenid borer initiated during 16th and 34th SMW during respective seasons. The mean population ranged from 0.46 (16th SMW) to 2.56 (19th SMW) during the summer season; while, from 0.46 (39th SMW) to 2.6 (36th SMW) during the monsoon season. The pest population had negative correlation with mean atmospheric temperature (r = -0.17 and -0.17); whereas, positive correlation with mean relative humidity (r = 0.31 and 0.64) and total rainfall (r = 0.24 and 0.31) during the summer and monsoon season, respectively.

Similar results were reported by Sardana and Verma (1986) [3] observing that insect pest population associated with cowpea showed negative correlation with minimum temperature; whereas, positive correlation with maximum temperature, relative humidity and rainfall. Likewise, Kumar *et al*. (2017) [2] also observed positive correlation of aphid population with maximum and minimum temperature and relative humidity; whereas, in contrast to our finding, he recorded a positive correlation with total rainfall.

The mean atmospheric temperature and relative humidity had a congenial effect on the lycaenid population during the second monsoon season. The present findings are supported by Singh *et al*. (2013) [4], who also observed that the lycaenid population was favoured by atmospheric temperature.

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