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Seasonal occurrence of insect pests and their natural enemies on soybean

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Abstract
The field experiments were conducted at Research Cum Instructional Farm at IGKV, Raipur (C.G.) during kharif 2018, to know the seasonal incidence of soybean insect pests and their natural enemies. Soybean is an oilseed crop of family Fabaceae. It is grown for its various purposes. During the studies observations are taken in the plot of 50 m^2 and recorded the five species of insect pests which attacked on the soybean crop at different growth stages. The insects are tobacco caterpillar, green semilooper, whitefly, thrips and jassids. Among the natural enemies lady bird beetle, *Coccinellidae septumpunctata*; spiders – *Oxyopes* and *Neoscona* species., and a pentatomid bug- *Eocanthecona furcellata* found preying on them. Observations were recorded on seasonal occurrence of insect pests of soybean and peak activity were recorded at the different Standard Meteorological week. The insect pests are correlated with different weather parameter *viz*., minimum and maximum temperature, rainfall, relative humidity (morning and evening). The correlation of insect pests is non significant to all weather parameters but jassids showed significant and negative correlation with minimum temperature (r= -0.64*). The natural enemies was found positively correlated with the sucking pests and number of defoliators (*S.litura* and *C.acuta*) in kharif, 2018. Coccinellid beetle showed significant and positive correlation with whitefly (r= 0.61 *), thrips (r= 0.64*) and jassids (r= 0.64*). Spider showed significant and positive correlation with tobacco caterpillar (r= 0.79*), green semilooper (r= 0.72 *), whitefly (r= 0.61 *), thrips (r= 0.69*) and jassids (r= 0.80*). Whereas, predatory bug showed significant and positive correlation with tobacco caterpillar (r= 0.85*) and green semilooper (r= 0.91*).

Keywords: Correlation, observations, positive, tobacco caterpillar

1. Introduction
Soybean is recognized as one of the premier crops around the world and it has been an important source of vegetable oil (>20%), protein (>40%). It contains carbohydrate, minerals and small amount of Phospholipids. It is an herbaceous oilseed crop important for food commodity. There are some environmental factors which impact for the low productivity of soybean, but injury cause by insect-pest is major problem. It is reported that Soybean is attacked by 273 species of insects (Rawat and Kapoor, 1969) [15] and there are 20 insect pest species are infesting soybean crop in India (Singh and Singh, 1990) [16]. However, in Maharashtra 16 insect pests were reported to feed on soybean (Mundhe, 1980) [11]. The major insect pests observed attacking soybean are green semilooper (*Chrysodeixis acuta*), tobacco caterpillar (*Spodoptera litura*), jassid (*Apheliona maculosa*), whitefly (*Bemicia tabaci*) and Thrips (*Thrips tabaci*).
The soybean defoliators mainly include tobacco caterpillar (*Sopdoptera litura*) and green semilooper (*Chrysodeixis acuta*). Immature stages (larva or caterpillar) of both tobacco caterpillar and green semilooper damages the crop at vegetative stage and in severe case, it completely defoliate the crop and dramatic yield loss. *S. litura* larvae even damages to soybean pods also (Singh *et al*., 2000 and Sastawa *et al*., 2004) [17, 18].

2. Material and Methods
The field experiments were conducted Seasonal occurrence of insect pests and their natural enemies on soybean at the Research Cum Instructional Farm, IGKV, Raipur, Chhattisgarh during kharif 2018-19. The seasonal occurrence of major insects-pests on soybean was recorded in the plot of size 50 m^2, the variety which were used for experiment is JS97-52 and it were sown on 30th June 2018. The observation were taken for the pest incidence in the crop was started from 25 DAS of the sowing of crop and repeated at weekly intervals, the observation continued up to ripeness of the crop using suitable methods for different insects.

To record the observations of different defoliators we had selected ten plants randomly in the plot of size 50 m^2 spots. Larval was made by shaking the plant gently over a white paper in one meter row length. The observations were recorded from the standing crop at weekly intervals from the germination of the crop till its harvest. The weekly meteorological data on Maximum and minimum temperature, relative humidity, rainfall will also be recorded for whole of the cropping season.

To record the observations of different sucking insect-pests species ten plants were randomly selected. The insect count was made on five leaves i.e. three from upper and two from middle part of the each plant. Thereafter, mean number of sucking insect pests per plant was worked out. The observations on the sucking insect-pests population were recorded from the standing crop at weekly intervals from the germination of the crop till its harvest. The time of first appearance of the each insect pest was observed and recorded. The nature of damage and feeding behaviour of the insects were carefully observed. The weekly meteorological data on Maximum and minimum temperature, relative humidity, rainfall will also be recorded for whole of the cropping season.

The data was statistically analysed by subjecting to the correlation between weather parameters and the population of insect pests which were determined using the Karl Pearson's coefficient of correlation formula:

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[\, n\sum x^2 - (\sum x)^2 \,][\, n\sum y^2 - (\sum y)^2 \,]}}$$

Where

r_{xy} = Simple correlation coefficient

X = Variable *i.e*. abiotic component. (Average temperature, relative humidity and total rainfall)

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

N = Number of observations.

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

$$t = r\sqrt{\frac{n-2}{1-r^2}}$$

with degrees of freedom equal to n – 2

Where

r = Correlation Coefficient

n = No. of observations

The calculated t-value obtained was compared with correlation coefficient table value at 5% and 1% level of significance.

3. Result and Discussion

The observations were taken on different insect pests on JS-9752 variety of soybean, the first insect pest complex happens on 24th day after sowing. The changes on pest incidence were noted from fourth week of July to first week of October. The population of insect pests were recorded as per the methods provided under "materials and methods".

There are five species of insect pests are recorded during the studies *viz*., Tobacco caterpillar (*S. litura*), Green semilooper (*C. acuta*), White fly (*B. tabaci*), Thrips (*Thrips tabaci*) and Jassids (*Apheliona maculosa*) attacked on soybean at several growth stages. Among the bio-control agents, three predators, namely lady bird beetle (*Coccinellidae septempunctata*), spiders (*Oxyopes sp* and *Neoscona sp*.) and predatory bug (*Eocanthecona furcellata*) were preying on pests of soybean. The observations were recorded in kharif, 2018.

Insect-pests studies

3.1 Defoliator's pest

The defoliators are found feeding on the foliage of the crop were observed.

a. Tobacco caterpillar (*Spodoptera litura*)

Tobacco caterpillar were appear on fifth week of July with a population of 0.20 larvae/mrl and reached at the peak in the first week of September with 1.30 larvae with a seasonal mean of 0.62 larvae/mrl. Thereafter, the population declined gradually and reached to a minimum level of 0.40 larva/plant during first week of October.

The results indicated that the tobacco caterpillar, *Spodoptera litura* population exhibited a non-significant but negative correlation with minimum temperature (r= -0.42) and non-significant but positive correlation with maximum temperature (r= 0.02), rainfall (r= 0.15), morning and evening relative humidity(r= 0.46 and r= 0.02).

Mandal (2018) [8] recorded that it were appeared on the starting week of August with a population density of 0.2 larva/meter row. The pest density increased gradually and attained the peak in the first week of September 2.2 larvae/mrl with a seasonal mean of 0.56 larvae per meter row. There were gradual declines in the population, which disappeared completely during the first week of October. Kumari (2017) [6] evaluated the correlation between number of lepidopterous larvae with maximum temperature and negative non-significant with minimum temperature and mean relative humidity of morning, rainfall were found to be positive but non-significant per meter row length whereas mean relative humidity of evening were found to be negatively correlated.

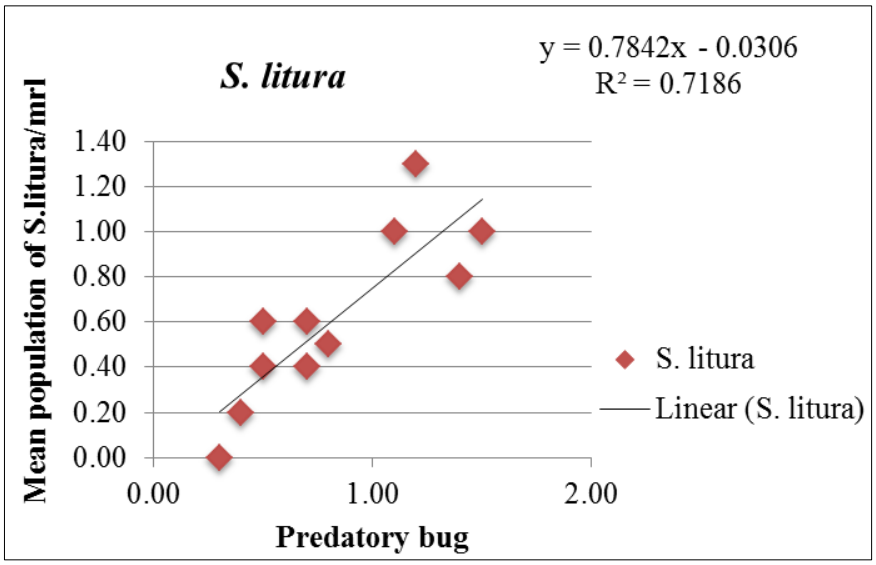

Fig 1: Regression of *S. litura* per plant on predatory bug

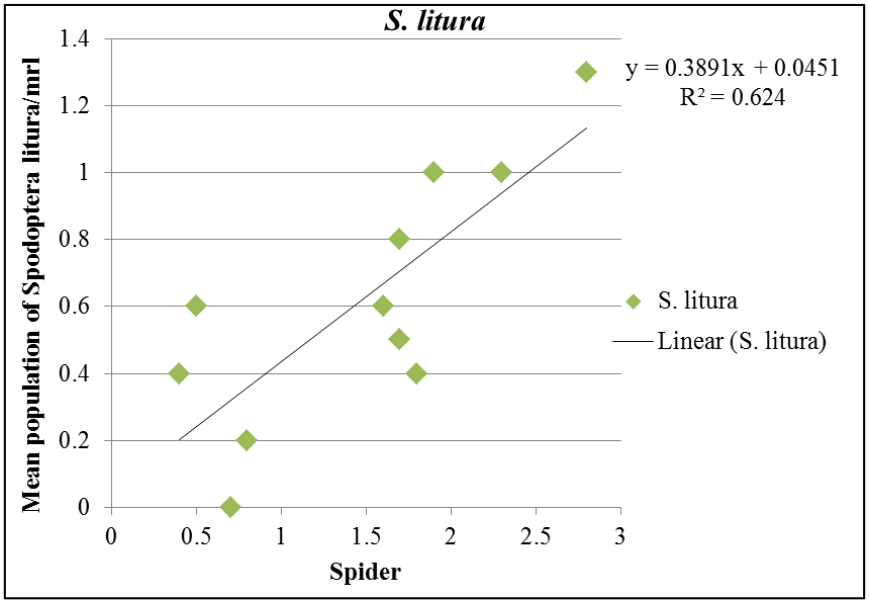

Fig 2: Regression of *S. litura* per plant on spider

b. Green semilooper (*Chrysodeixis acuta*)

Infestations of Green semilooper were firstly noted on the soybean in fifth week of July with the population of 0.30 larvae/mrl and reached the peak in the September 2nd week with 1.50 larvae with a seasonal mean of 0.58 larvae/mrl. Thereafter, the population declined gradually and reached to a minimum level of 0.30 larva/plant during first week of October.

The results indicated that the green semilooper (*Chrysodeixis acuta*) population exhibited a non-significant but negative correlation with minimum temperature (r= -0.35) and evening relative humidity(r= -0.12). Whereas, non-significant but positive correlation with maximum temperature (r= 0.00), rainfall (r= 0.08) and morning relative humidity(r= 0.19).

Kumari (2017) [6] observed that the attack of *C. acuta* was first recorded in the starting week of August with the density of 0.1 larvae/mrl. The pest density increased gradually and attained the peak in the first week of September with 2.1 larvae with a seasonal mean of 0.67 larvae/meter row. Thereafter the population of the pest decreased gradually and disappeared due to senescence of the soybean after the second week of October. Joshi and Patel (2010) [5] observed the non-significant relationship between the insect pest population and the ambient weather on soybean. Kumari (2017) [6] observed that correlation between number of lepidopterous larvae were found to be positive but non-significant per meter row length with maximum temperature, negative non-significant with minimum temperature and mean relative humidity of morning, rainfall whereas mean relative humidity of evening were found to be negatively correlated.

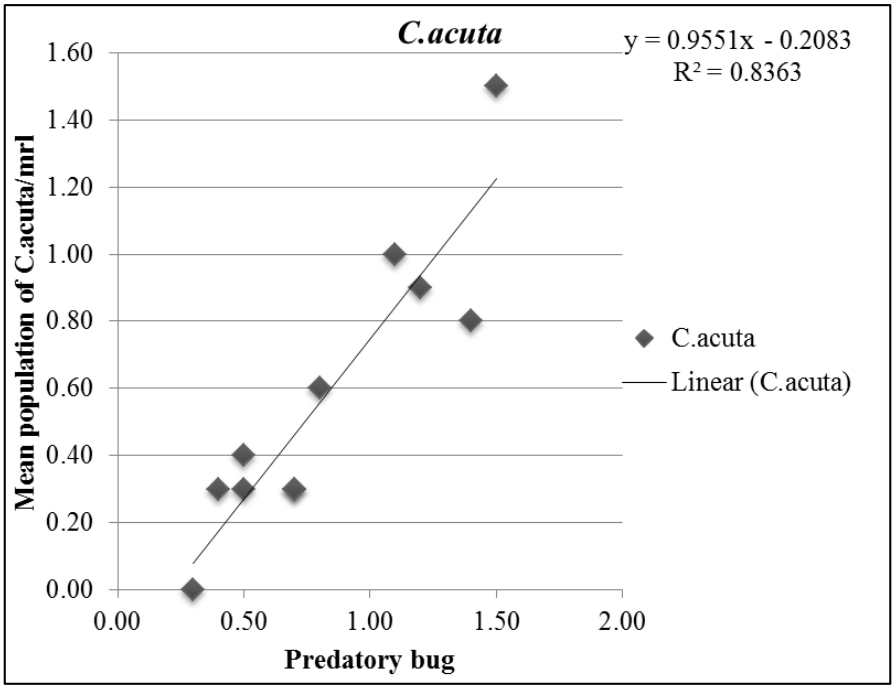

Fig 3: Regression of *C. acuta* per plant on predatory bug

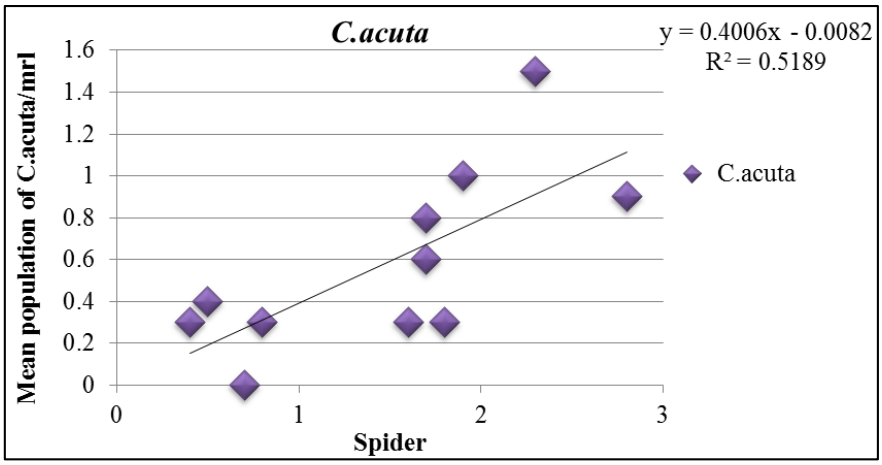

Fig 4: Regression of *C.acuta* per plant on spider

3.2 Sucking Pests

a. Whitefly (*Bemisia tabaci*)

White fly is one of the major sucking pests of soybean. It was firstly seen in the fourth week of July with a population density of 2.10. Its population ranged from 2.10 to 5.40 nymphs and adults/ three leaves/ plant with seasonal mean of 4.27 flies.

The results indicated that the whitefly (*Bemisia tabaci*) population exhibited a non-significant but negative correlation with maximum temperature (r= -0.08), minimum temperature (r= -0.32) and evening relative humidity(r= -0.01). Whereas, non-significant but positive correlation with rainfall (r= 0.04) and morning relative humidity(r= 0.51).

Netam *et al*. (2010) [12] reported that sucking pest were noticed during 3rd week of September with 4.4 seasonal mean of 3.62 white flies/plant. More or less the present findings are also agreement with the findings of Marabi *et al*. (2017) [9] who studied the correlation between the mean whitefly population and weather parameters in which maximum and minimum mean temperature (r= 0.74 and r= 0.65), and evaporation (r= 0.64) were expressed significantly positive, while morning RH has exhibited negative correlation(r= -0.66) and other parameters were found statistically non significant. Ahirwar (2010) [1] observed a significantly positive correlation among total sucking pests and minimum temperature, evening relative humidity which confirms the present finding.

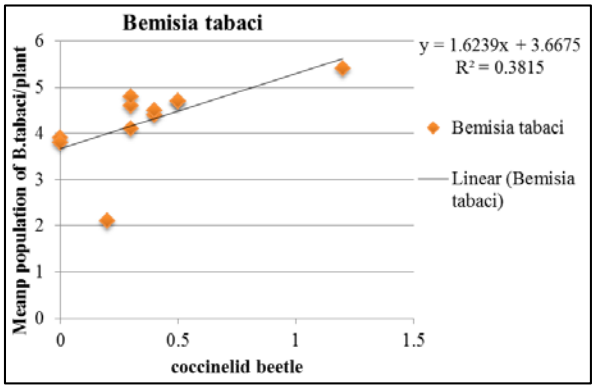

Fig 5: Regression of *Bemisia tabaci* per plant on coccinelid beetle

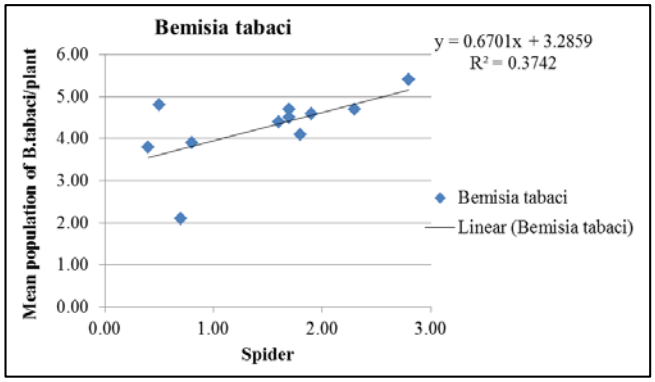

Fig 6: Regression of *Bemisia tabaci* per plant on Spider

b. Thrips (*Thrips tabaci*)

The attack of thrips started in the fourth week of July with a population density of 0.90 and its population ranged from 0.90 to 2.60 nymphs and adults/three leaves/ plant with seasonal mean of 1.68.

The results indicated that the thrips (*Thrips tabaci*) population exhibited a non-significant but negative correlation with maximum temperature (r= -0.54) and minimum temperature (r= -0.38). Whereas, non-significant but positive correlation with rainfall (r= 0.21) and morning relative humidity(r= 0.47) and evening relative humidity (r= 0.40).

Kumari (2017) [6] observed that the infestation of thrips started in the last week of July with a population density of 0.1 and its population ranged from 0.1 to 4.1 nymphs and adults/plant with seasonal mean of 1.80. Thereafter, the density of thrips decreased gradually after third week of August. More or less the present findings are also agreement with the findings of Bhamare *et.al* (2018) [3] who revealed that correlation coefficient with rainfall, maximum temperature and afternoon relative humidity exhibited direct negative effect (-1.029*, -0.617*, and -0.592*, respectively) on thrips population of sole soybean. However, minimum temperature showed direct positive effect (0.666*) on the population of thrips.

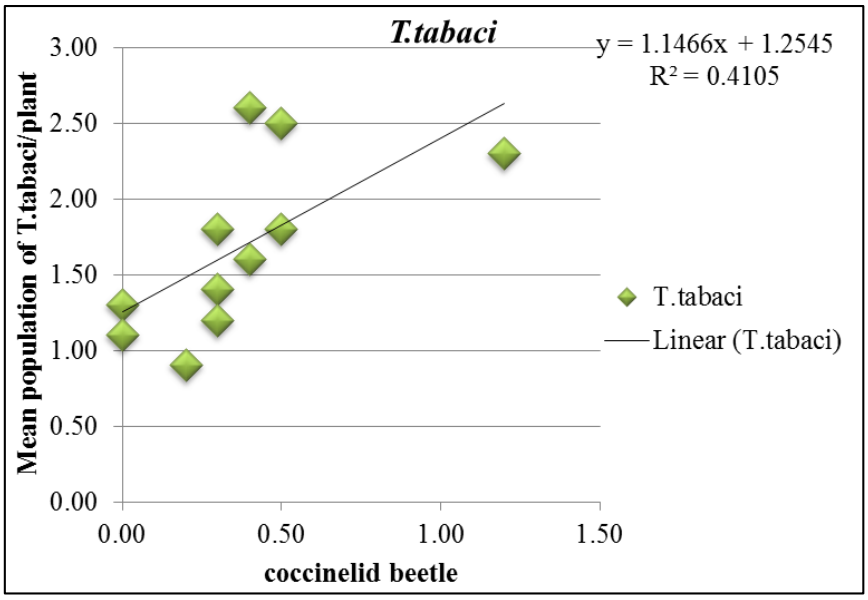

Fig 7: Regression of *T. tabaci* per plant on coccinelid beetle

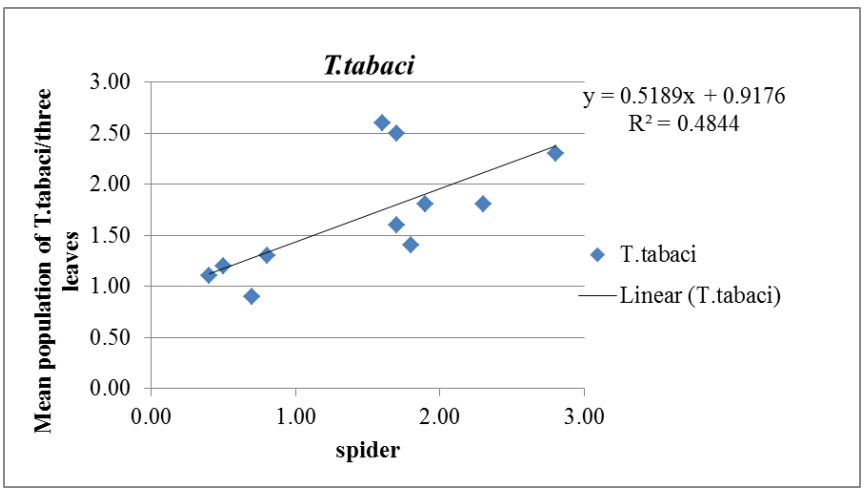

Fig 8: Regression of *T. tabaci* per plant on Spider

c. Jassids (*Apheliona maculosa*)

The pest incidence were seen in the fourth week of July with a population density of 0.70 and its population ranged from 0.70 to 1.90 nymphs and adults/three leaves/ plant with seasonal mean of 1.43.

The results indicated that the jassids (*Apheliona maculosa*)

population exhibited a non-significant but negative correlation with maximum temperature (r=-0.51). Whereas, non-significant but positive correlation with rainfall (r= 0.25) and morning relative humidity(r= 0.40) and evening relative humidity (r= 0.54). Jassids (*Apheliona maculosa*) population exhibited a significant but negative correlation with minimum temperature (r= -0.64).

Kushram (2016) [7] observed that six different insect pests damaged the soybean crop from time to time. *E.kerri* Jassid sp (0.65 jassids per plant) was observed during second week of August and Thrips tabaci (6.1 thrips/plant) in third week of August, respectively. More or less the present findings are also agreement with the findings of Bhamare *et al*. (2018) [3] who evaluated there were a significant negative correlation between the population of jassid sp. *E. kerri* infesting sole soybean and rainfall (-1.443*), maximum temperature (-1.468*) and afternoon relative humidity (-1.156*).

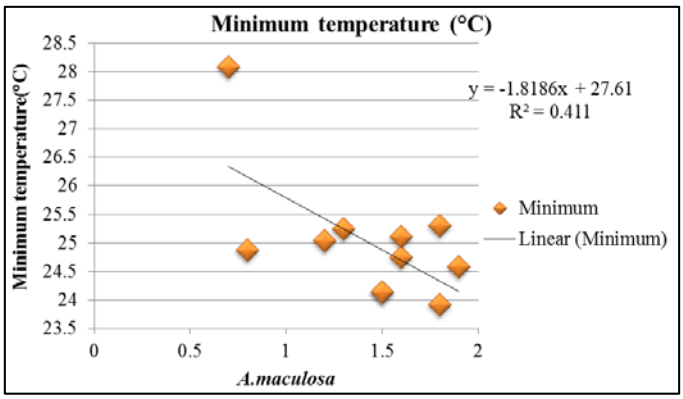

Fig 9: Regression between population of *A. maculosa* with minimum temperature

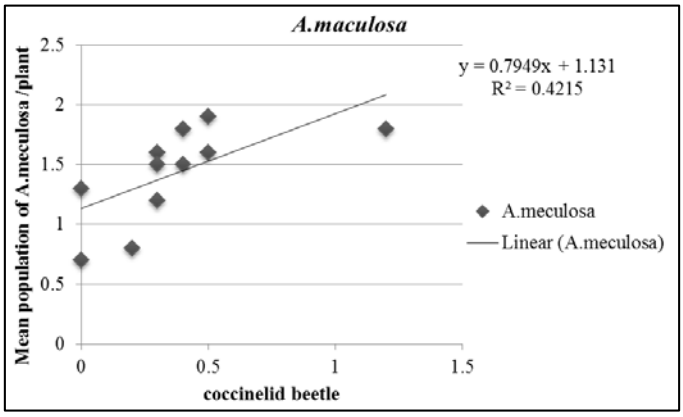

Fig 10: Regression of *A. maculosa* per plant on coccinelid beetle

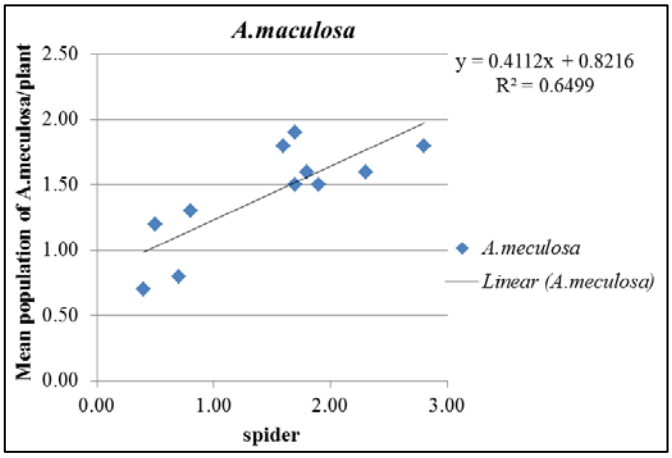

Fig 11: Regression of *A.maculosa* per plant on Spider

3.3 Predatory fauna of soybean pest

a. Lady bird beetle

The lady bird beetle (*C. Septumpunctata*) were the main predator of the sucking pests of soybean. It was firstly seen in the fourth week of July 0.20 beetles/mrl. Beetles were feeds on nymphs and adults of thrips and whiteflies. They feed continuously till the fourth week of September with the peak activity of 1.20 beetles /mrl in first week of September.

The results indicated that the lady bird beetle population exhibited a non-significant but negative correlation with

maximum temperature (r= -0.30) and minimum temperature (r= -0.58) and rainfall (r= -0.09). Whereas, non-significant but positive correlation morning relative humidity (r= 0.21) and evening relative humidity (r= 0.24).

Kumari (2017) [6] recorded the lady bird species; *M. sexmuculata* and *C. septumpunctata* are preying on the sucking pests. They appeared on the soybean in the second week of August with 0.5 grub and adult/plant. Their feeding will continued till the starting week of October and peak at last week of September. More or less the present findings are also agreement with the findings of Netam *et al*. (2010) [12] who observed lady bird species, *C. septumpunctata* and *M. sexmuculata*, predatory spiders- Lynx and golden spider were found predating mainly on jassids and whiteflies. A predatory bug, *E. furcellata* were sucking the body sap of defoliators have been observed. There existed a positive but non-significant co-relation between caterpillar pests and predators(r = 0.545) and between sucking pests and predatory fauna (r = 0.798).

b. Predatory bug

The Predatory bug, *Eocanthecona furcellata* were feeding on the body sap of caterpillars. It was firstly noticed in the fourth week of July with 0.30 bugs /mrl. Its population raised slowly with 1.50 bugs in the second week of September and a seasonal mean of 0.82 bug/mrl.

The results indicated that the predatory bug, *Eocanthecona furcellata* population exhibited a non-significant but negative correlation with minimum temperature (r= -0.31) and evening relative humidity (r= -0.13). Whereas, non-significant but positive correlation with maximum temperature (r= 0.02), rainfall (r= -0.00), morning relative humidity (r= 0.22).

Mandal (2018) [8] observed the first appearance of the bug were noticed during the August first week with an average number of 0.1 bug/plant. In subsequent observation it is evident that the population of the predatory pentatomid bug increased and reached a peak of 3.0 bugs/plant during second week of September and declined.

c. Spiders

There are two different spiders species found feeding on the caterpillars of soybean are lynx and orb weaver spider. *Oxyopes* sp is a type of hunting spider, whereas, *Neoscona* sp. is a web building spider.

These were observed in the fourth week of July with population density of 0.70 spider/mrl. It appeared along with the presence of host of the soybean. Their population ranged from 0.40 to 2.80 spiders with a seasonal mean of 1.47 spiders/mrl. The spiders vanished from the crop along with the disappearance of their host insects.

The results indicated that the spiders population exhibited a non-significant but negative correlation with maximum temperature (r= -0.31) and minimum temperature (r= -0.63*). Whereas, non-significant but positive correlation with rainfall (r= 0.22), morning relative humidity(r= 0.27) and evening relative humidity (r= 0.41).

Ahirwar (2010) [1] evaluated that spiders were observed in the starting week of August. There are 0.4 spiders/plant and correlates with the presence of soybean pests. Their population ranged from 0.4 to 1.2 spiders with a seasonal mean of 0.55 spiders/plant. More or less the present findings are also agreement with the findings of Ahirwar (2010) [1] who observed positive and significant correlation among predatory population of spider and lepidopterous pests and similarly, a positive and significant correlation among predatory population of pentatomid bugs and lepidopterous pests and correlation among coccinellid beetles and total sucking pests were found to be positive and significant. The correlation coefficient between spiders and total sucking pests were figured out to be positive but non-significant at the course of investigation.

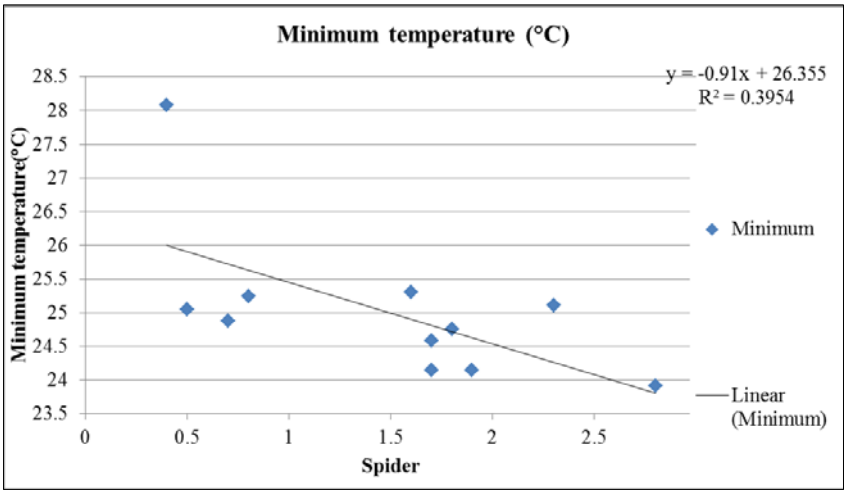

Fig 12: Regression between population of spider with minimum temperature

Table 1: Seasonal occurrence of major insect pests and predators of soybean during *kharif* 2018.

		Incidence per meter row length										
		No. of larvae/plant			No. of sucking pests/three leaves				No. of predators/plant			
Date of observation	**SMW**	***S. litura***	***C.acuta***	**total**	***Bemisia tabaci***	***T. tabaci***	***A. maculosa***	**Total**	**Coccinelid beetle**	**Predatory bug**	**spider**	**Total**
25-07-2018	30	0.00	0.00	0.00	2.10	0.90	0.80	3.80	0.20	0.30	0.70	1.20
31-07-2018	31	0.20	0.30	0.50	3.90	1.30	1.30	6.50	0.00	0.40	0.80	1.20
07-08-2018	32	0.40	0.30	0.70	4.10	1.40	1.60	7.10	0.30	0.50	1.80	2.60
14-08-2018	33	0.60	0.30	0.90	4.40	2.60	1.80	8.80	0.40	0.70	1.60	2.70
21-08-2018	34	0.50	0.60	1.10	4.70	2.50	1.90	9.10	0.50	0.80	1.70	3.00
28-08-2018	35	1.00	1.00	2.00	4.60	1.80	1.50	7.90	0.30	1.10	1.90	3.30
04-09-2018	36	1.30	0.90	2.20	5.40	2.30	1.80	9.50	1.20	1.20	2.80	5.20
11-09-2018	37	1.00	1.50	2.50	4.70	1.80	1.60	8.10	0.50	1.50	2.30	4.30
18-09-2018	38	0.80	0.80	1.60	4.50	1.60	1.50	7.60	0.40	1.40	1.70	3.50
25-09-2018	39	0.60	0.40	1.00	4.80	1.20	1.20	7.20	0.30	0.50	0.50	1.30
03-10-2018	40	0.40	0.30	0.80	3.80	1.10	0.70	5.60	0.00	0.70	0.40	1.10
Seasonal Mean		0.62	0.58	1.21	4.27	1.68	1.43	7.38	0.37	0.83	1.47	2.67

Table 2: Correlation of different weather parameters on the incidence of major insect pests and their bio-agents on soybean

Insect-pest	**Temperature (°C)**		**Rainfall (MM)**	**Relative Humidity**	
	Maximum	**Minimum**		**RH I (%)**	**RH II (%)**
Spodoptera litura	0.02	-0.42	0.15	0.46	0.02
Chrysodeixis acuta	0	-0.35	0.08	0.19	-0.12
Bemisia tabaci	-0.08	-0.32	0.04	0.51	-0.01
Thrips tabaci	-0.54	-0.38	0.21	0.47	0.4
Apheliona maculosa	-0.51	-0.64*	0.25	0.4	0.54
Natural enemies					
Coccinelid beetle	-0.3	-0.58	-0.09	0.21	0.24
Predatory bug	0.02	-0.31	0	0.22	-0.13
Spider	-0.31	-0.63*	0.22	0.27	0.41

NS= Non-significant, Significant=* Level of significance at 5% degree of freedom

Table 3: Correlation between major insect pests and their bio-agents of soybean

	No. of caterpillars/plant		**No. of sucking pests/three leaves**		
Natural enemies	***S. litura***	***C. acuta***	***Bemisia tabaci***	***T. tabaci***	***A. maculosa***
Coccinelid beetle	NS	NS	0.61*	0.64*	0.64*
spider	0.79*	0.72*	0.61*	0.69*	0.80*
Predatory bug	0.85*	0.91*	NS	NS	NS

NS= Non-significant, Significant=* Level of significance at 5% degree of freedom

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