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Population Dynamics of Sucking Pests of Soybean and their Natural Enemies in Relation to Weather Parameters

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ABSTRACT: Field experiments were carried out at research farm, Polasa, Regional Agricultural Research Station, Jagital during 2014-15 and 2015-16 on soybean variety JS-335. During the course of study at various growth stages four sucking pests namely, whitefly (*Bemisia tabaci* Gennadius), jassid (*Empoasca kerri* Pruthi), aphids (*Aphis craccivora* Koch) and thrips (*Thrips tabaci* Lindeman) and one natural enemy, namely, lady bird beetle (*Cheilomenes sexmaculata)* were observed to prey on these sucking pests. The peak activity of sucking pests that is, *B. tabaci* (5.43 whiteflies/3 leaves) was noticed during 34th std week during 2014 and for the year 2015 6.05/3 leaves during 35th std week and *E. kerri* (2.5 jassids /3 leaves) during 36th std week for the year 2014 and for the year 2015 was recorded (2.6jassid/3 leaves) during 34th std respectively. Thrips (1.8 thrips/3 leaves) during 34th std week for the year 2014 and for the year 2015 was recorded (2.9/3 leaves) during 33rd std respectively. Aphids (2.5 aphids/3 leaves) during 31th std week for the year 2014 and for the year 2015 was recorded (3.95 aphids/3 leaves) during 32nd std respectively. The biocontrol agent *i.e.* lady bird beetle, (*Cheilomenes sexmaculata)* was found predating mainly upon whiteflies and jassids. The lady bird population recorded on the crop ranged from 0.15 to 0.5/mrl during *Kharif*, 2014 and 0.15 to 0.6 during *Kharif*, 2015.

Keywords: Soybean, sucking insect pests, population dynamics, weather parameters, correlation and multiple linear regressions.

INTRODUCTION

In India, soybean (*Glycine max* (L.) Merrill) has been the number one oilseed crop in terms of both area and production since 2005. Soybean occupies 42% of India's total oilseeds and 25% of edible oil production. In India, soybean is mainly grown in the states of Madhya Pradesh, Maharashtra, Rajasthan, Karnataka and Telangana as a rainfed crop during *kharif* season. Over the years, cultivation of the crop has been instrumental in improving the socioeconomic conditions of large numbers of small and marginal farmers in the rainfed agro-ecosystems of central and peninsular India. The low productivity of soybean both at national and state level is attributed to abiotic and biotic stresses like drought, weeds, insect pests and diseases. Among these, insect pests often pose a serious threat to soybean production by increasing cost of cultivation and impairing quality of produce in many ways. Soybean crop is reported to be attacked by about 350 species of insects in many parts of the world. About 65 insect pests have been reported to attack soybean crop from cotyledon to harvesting stage (Jayappa, 2000). Vieira, (2011) noted that *Bemisia*

tabaci occurs in large populations, the plants weakened by the extraction of large amounts of sap. Netam *et al*., (2013) reported that Jassids, *Empoasca kerri* and white flies, *Bemisia tabaci* were recorded as the major sucking pests on soybean variety JS 93-05 causing damage at various stages of the crop.

MATERIALS AND METHODS

The investigations on pests succession of sucking pests on soybean (*Glycine max* L.) were carried out at research farm, Regional Agricultural Research Station, Polasa, Jagtial, Telangana during *Kharif*, 2014 and 2015. The materials used and methodology adopted during the course of investigation are described hereunder. Soybean (JS -335) was sown on during *Kharif*, 2014 and 2015 and raised by recommended agronomical practices. Experimental area was kept free from insecticidal spray throughout the crop season. Observations were recorded on the major sucking pests infesting the soybean crop *viz.*, whiteflies, aphids and leafhoppers. The population counts were recorded in three leaves (one from upper, middle and lower leaves) of each plant from randomly selected ten plants of three places of one meter row length from field. The data on bio control agents (lady bird beetle was recorded from ten plants from randomly selected three places of one meter row length from field. Later mean number of bio control agents per plant was calculated. Correlation and multiple linear regression of pest and natural enemy populations with weather factors were computed.

RESULTS AND DISCUSSION

Seasonal incidence of sucking pests and natural enemies and the influence of thermohygro parameters *viz.*, temperature (maximum and minimum), relative humidity (morning and evening), rainfall, rainy days, sunshine hrs, evaporation and wind speed on population of pests and natural enemies were assessed and presented in Tables 1-5 and represented graphically in Figs. 1-6. The crop was found to be infested by sucking pests like whiteflies, leafhoppers, aphids and thrips during *kharif*, 2014 and 2015 seasons.

Whiteflies. The occurrence of whitefly population during *Kharif*, 2014 season commenced from 4th week of July and continued to infest the soybean crop throughout the crop growth period and the number of whiteflies recorded on 3 leaves/plant ranged from 0.15 to 5.45. The initial infestation started with a whitefly population of 1.40/3 leaves during 30th std. week and it reached to peak population of 5.45/3 leaves on 4th week of August *i.e.* 34th std. week. At the time of its peak, the rainfall, maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, wind velocity, bright sun hours and evaporation were 39.6 mm, 34.67°C, 24.69°C, 84.29%, 65.43%, 3.27 km/hr, 5.06 hr/day and 3.2 mm/day respectively and there after the population declined and reached to a lowest population of 0.15 whiteflies/3leaves on 41st std. week (2nd week of October). The whitefly population during *kharif*, 2014 was highly influenced by the minimum temperature (0.665**).

During *Kharif*, 2015 season the whitefly infestation was observed from 31st std. week and continued to infest the crop till harvest *i.e* up to 42nd std. week. The appearance of the pest on the crop started with a low population of 2.2/3 leaves on 31st std. week and reached to maximum numbers (6.05/3 leaves) on first week of September i.e. 35th std. week. At the time of its peak, the rainfall, maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, wind velocity, bright sun hours and evaporation were 2 mm, 32.4^{0} C, 24.7^{0} C, 82.7%, 67.9%, 4.8 km/hr, 1.9 hr/day and 2.4 mm/day respectively and at later stages of the crop period also the pest infestation was found and at the end of the crop growth period 1.85 whiteflies/3 leaves were recorded. During *kharif*, 2015 season whitefly population was influenced by evening relative humidity (0.580*) which showed significant positive correlation, while all other parameters did not show any significant effect on whitefly population during both seasons. Ahirwar *et al.*, (2015) reported similar findings where the peak activity of sucking pests with *B.tabaci* (3.2 white flies per plant) and *E. kerri* (3.4 jassids per plant) was recorded during the last week of August and second week of August, respectively. Chaudhary *et al*., (2018) also reported similar findings relating to the activity of white flies and jassids. Netam *et al.*, (2013) reported the peak density of sucking pests on soybean was observed in the third week of September with 4.4 sucking pests /plant and a seasonal mean of 3.62 white flies and jassids per plant. Bhavasar and Kumar, (2019) also reported that the highest population of whiteflies 12.0 whiteflies/3 leaves was recorded during 44th standard week. Chaudhari *et al.*, (2020) reported similar findings where the peak incidence of white flies was recorded during the fourth week of August (2.20/3 leaves). Bhavasar and Kumar (2019) reported that the population of whitefly showed non-significant negative correlation with minimum temperature and maximum relative humidity, significant negative correlation with minimum relative humidity and rainfall. On the other hand, it showed non-significant positive correlation with maximum temperature and significant positive correlation with sunshine.

Table 1: Seasonal incidence of soybean pests at RARS, Jagtial during *kharif*, 2014.

SMW	Date of observation	Sucking pests (3 leaves/plant)				Natural enemies (mrl)	Temperature (°C)		Relative Humidity (%)		Wind velocity (Kmph)	Bright sun shine hours (hrs)	Evaporation (mm)	Rain fall (mm)	Rainy days
		Whiteflies	Leaf-hoppers	Thrips	Aphids	Coccinellid beetles	Max. temp	Min. temp	Morning RH	Evening RH					
30	28/7/14	1.40	0.50	0.45	0.00	0.00	31.2	23.6	78.14	63.00	6.59	5.59	3.3	24.1	1.0
31	4/8/14	2.10	0.75	0.55	0.20	0.00	32.14	24.07	82.14	66.14	5.71	3.11	2.7	44.0	3.0
32	11/8/14	2.65	1.20	0.75	0.30	0.20	32.60	24.14	79.57	60.00	7.89	6.16	3.63	2.6	1.0
33	18/8/14	2.80	1.80	1.10	0.30	0.30	33.67	23.59	72.86	58.00	7.00	6.01	3.7	5.0	1.0
34	25/8/14	5.45	2.05	1.80	0.40	0.30	34.67	24.69	84.29	65.43	3.27	5.06	3.2	39.6	2.0
35	1/9/14	2.20	2.40	1.55	0.60	0.40	31.30	23.71	88.71	79.86	4.36	3.46	1.17	75.0	4.0
36	8/9/14	2.05	2.55	0.40	0.40	0.60	30.99	23.80	78.43	70.71	6.53	4.81	1.8	68.6	2.0
37	15/9/14	4.50	1.70	0.40	0.45	0.20	31.79	13.66	79.43	63.14	6.14	5.34	2.59	7.0	1.0
38	22/9/14	1.55	1.00	0.25	1.00	0.15	31.80	23.87	82.86	54.51	5.14	4.97	2.97	0.0	0.0
39	29/9/14	0.80	0.15	0.10	1.20	0.00	34.51	22.04	78.29	51.71	1.37	7.70	3.43	3.6	1.0
40	6/10/14	0.45	0.05	0.05	2.50	0.00	34.77	22.13	79.43	57.57	1.29	7.23	3.51	0.0	0.0
41	13/10/14	0.15	0.05	0.00	2.05	0.00	33.69	22.14	77.00	54.57	2.26	5.03	3.43	0.0	0.0
42	20/10/14	0.00	0.00	0.00	0.00	0.00	34.59	21.73	76.71	51.71	1.79	7.80	3.63	0.0	0.0
43	27/10/14	0.00	0.00	0.00	0.00	0.00	32.43	17.63	79.00	48.71	1.14	6.51	3.29	8.0	1.0
	Mean	1.86	1.01	0.52	0.60	0.15									

SMW- Standard Metrological Week, mrl- meter row length

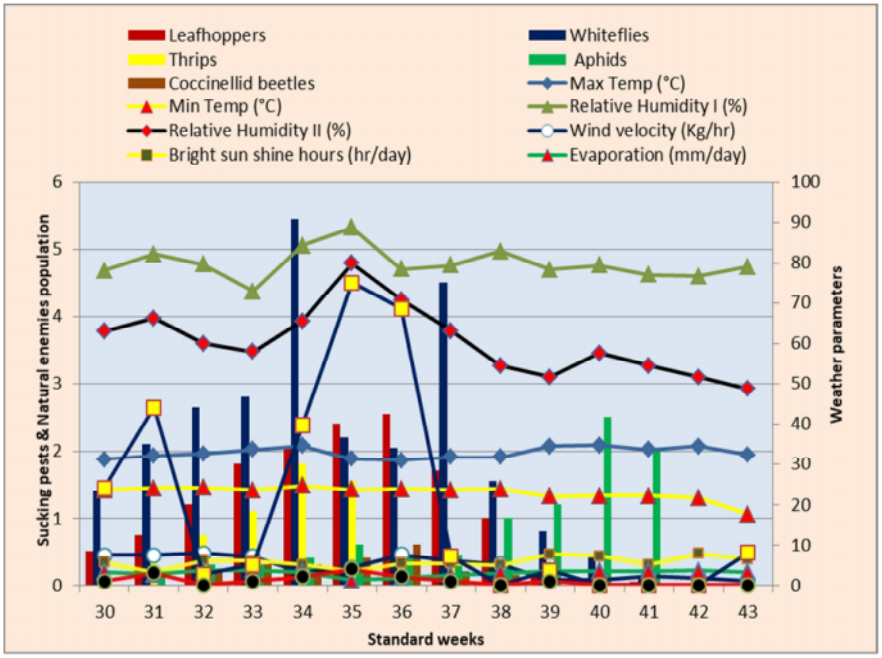

Fig. 1. Seasonal incidence of sucking pests of soybean and natural enemies in relation to weather parameters during *kharif*, 2014.

Leafhoppers. The observations recorded on seasonal incidence of leafhoppers revealed that leafhoppers have been presented in table 1 & 2. The data revealed that leafhoppers infestation was initiated in the third week of July (29th SMW) and fourth week of July (30th SMW) during the year 2014 and 2015. The population increased gradually and reached its peak population of 2.55/3 leaves was observed during 2nd week of September *i.e.* 36th std. week. At the time of its peak, the rainfall, maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, wind velocity, bright sun hours and evaporation were 68.6 mm, 30.99°C, 23.8°C, 78.43% , 70.71% , 7.5 km/hr, 5.4 hr/day and 1.81 mm/day respectively and then reached to lowest population (0.05/3 leaves) on 41st std. week. The weather parameters during *kharif* 2014 showed highly significant positive correlation with evening relative humidity (0.791**) rainfall (0.695**), while it was significant and positive with rainy days (0.631*), wind velocity (0.576*) and minimum temperature (0.629*) and was highly significant and negative with evaporation (-0.662**) More or less similar trend was observed during *Kharif*, 2015 season also and the population of leafhoppers recorded during this season ranged from 0.40 to 2.60/3 leaves. The initial infestation during *Kharif*, 2015 started with a low population of 1.1/3 leaves and reached to a maximum number of 2.60 hoppers/3 leaves on 34th std. week. At the time of its peak, the rainfall, maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, wind velocity, bright sunshine hours and evaporation were 3.2 mm, 34.1°C, 23.0°C, 87.0% , 70.9 % , 4.4 km/hr, 6.5 hr/day and 2.6

mm/day respectively and continued to remain in low numbers during the entire period up to October 3rd week. Whereas for *kharif*, 2015 the weather parameters showed highly significant and positive correlation of leaf hopper population with evening relative humidity (0.667**). Netam *et al.*, (2013) reported the peak density of sucking pests on soybean in the third week of September with 4.4 sucking pests/plant and a seasonal mean of 3.62 white flies and jassids per plant. Ahirwar *et al.*, (2015) reported similar findings where the peak activity of sucking pests, *B. tabaci* (3.2 whiteflies per plant) and *E. kerri* (3.4 leafhoppers per plant) was recorded during the last week of August and second week of August, respectively. Chaudhary *et al*., (2018) also reported similar findings relating to the activity of whiteflies and jassids. Netam *et al.*, (2013) reported the peak density of sucking pests on soybean in the third week of September with 4.4 sucking pests/plant and a seasonal mean of 3.62 white flies and jassids per plant. Bhavasar and Kumar, (2019) reported that the highest population of jassids with 3.8 jassids/3 leaves was recorded during 39th standard week. Chaudhari *et al.*, (2020) reported similar findings where the peak incidence of jassids was recorded during the second week of September (6.40/3 leaves). Earlier findings made by Vijay, (2013), Sutaria *et al.*, (2010); Yadav, (2013) corroborated with the present findings who showed that maximum temperature and evaporation had negative correlation on leafhoppers. Yadav *et al*., (2015); Patidar, (2015) also recorded negative correlation between leaf hopper population and maximum temperature and rainfall. While, Sutaria *et al.*, (2010) recorded negative correlation of leaf hopper population with evaporation and wind speed. Chaudhary *et al.*, (2018) observed that evening relative humidity showed significant positive correlation, whereas maximum temperature and sunshine hours showed non significant negative correlation with the jassid population. Pawar, (2012) observed morning and evening relative humidity, minimum temperature and rainfall had positive influence on jassid population. Bhavasar and Kumar (2019) reported that the population of leafhopper showed non-significant negative correlation with minimum relative humidity and rainfall, non-significant positive correlation with minimum temperature and sunshine while it showed significant negative correlation with maximum relative humidity and significant positive correlation with maximum temperature.

Table 2: Seasonal incidence of soybean pests at RARS, Jagtial during *kharif*, 2015.

SMW	Date of observation	Sucking pests (3 leaves/plant)				Natural enemies (mrl)	Temperature (°C)		Relative Humidity (%)		Wind velocity (Kmph)	Bright sun shine hours (hrs)	Evaporation (mm)	Rain fall (mm)	Rainy days
		Whiteflies	Leaf-hoppers	Thrips	Aphids	Coccinellid beetles	Max. temp	Min. temp	Morning RH	Evening RH					
29	16/7/15	0.00	0.00	0.00	0.00	0.00	35.7	26.3	64.3	47.7	8.8	4.4	4.0	40.4	2.0
30	25/7/15	0.00	0.00	0.80	0.00	0.00	33.8	24.9	76.0	52.9	6.6	5.6	3.2	52.2	4.0
31	1/8/15	2.20	1.10	2.15	0.30	0.00	33.1	25.2	71.3	51.3	6.6	4.8	3.2	0.0	0.0
32	8/8/15	2.65	1.45	2.45	3.95	0.20	31.1	24.0	88.9	74.6	7.3	0.8	1.8	62.6	3.0
33	15/8/15	3.55	1.75	2.90	0.35	0.30	31.6	24.6	91.6	74.6	5.5	3.9	3.5	49.1	6.0
34	22/8/15	4.65	2.60	1.95	0.25	0.25	34.1	23.0	87.0	70.9	4.4	6.5	2.6	3.2	1.0
35	29/8/15	6.05	1.80	1.55	0.00	0.30	32.4	24.7	82.7	67.9	4.8	1.9	2.4	2.0	1.0
36	5/9/15	5.05	1.75	1.40	0.00	0.40	34.6	25.2	70.7	60.1	2.5	5.9	2.7	18.6	2.0
37	12/9/15	4.10	1.30	1.10	0.25	0.50	34.5	25.3	85.7	75.9	3.3	4.4	2.7	167.9	3.0
38	19/9/15	2.65	0.60	0.95	0.35	0.15	32.1	24.5	85.1	59.0	3.8	4.7	2.3	19.2	2.0
39	26/9/15	3.10	0.85	0.85	0.20	0.15	34.9	23.7	88.9	71.4	1.5	7.1	3.5	0.0	0.0
40	3/10/15	2.65	0.50	0.85	0.00	0.00	36.4	27.9	87.9	54.1	1.0	7.3	2.7	18.0	1.0
41	10/10/15	2.35	0.65	0.45	0.00	0.00	34.9	21.3	84.1	36.4	0.8	7.9	3.4	0.0	0.0
42	17/10/15	1.85	0.40	0.00	0.00	0.00	34.4	21.7	83.6	45.1	1	7.5	3.1	0	0
	Mean	2.91	1.05	1.24	0.40	0.16									

SMW- Standard Metrological Week, mrl- meter row length

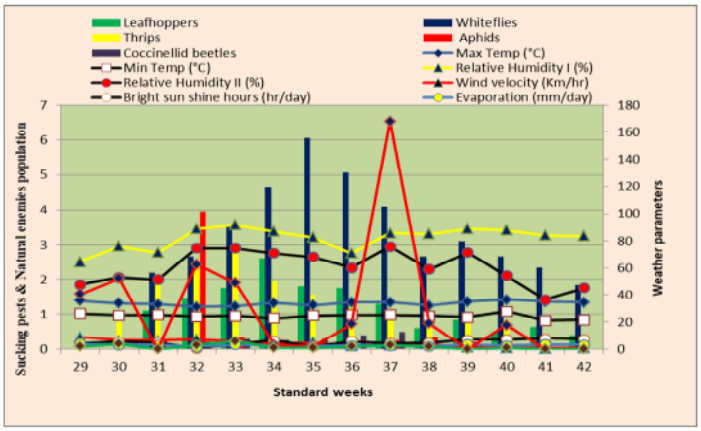

Fig. 2. Seasonal incidence of sucking pests of soybean and natural enemies in relation to weather parameters during *kharif*, 2015.

Thrips. The thrips population recorded during both seasons followed more or less similar trend as observed for leafhoppers and the population remained in low numbers and it ranged from 0.05 to 1.8/ 3 leaves during *Kharif*, 2014 by recording maximum number during 4th week of August with 1.80/3 leaves on 34th std. week. At the time of its peak, the rainfall, maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, wind velocity, bright sun hours and evaporation were 0.0 mm, 34.77°C, 22.13°C, 79.43%, 57.57%, 1.29 km/hr, 7.23 hr/day and 3.51 mm/day respectively and thereafter the population decreased to lowest number of 0.05/leaves on 41st std. week. The thrips population during *kharif*, 2014 season was mainly influenced by minimum temperature (0.581*), evening relative humidity (0.682**) and rainy days (0.674**) which showed significant positive relationship with the above weather parameters.

The thrips population was comparatively more during *Kharif*, 2015 season and it ranged from 0.45 to 2.9/3 leaves. The initial infestation (0.8 / 3 leaves) was observed during last week of July and reached to peak numbers by 33rd std. week (2.9/3 leaves). At the time of its peak, the rainfall, maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, wind velocity, bright sun shine hours and evaporation were 62.6 mm, 31.1°C, 24.0°C, 88.9%, 74.6%, 7.3 km/hr, 0.8 hr/day and 1.8 mm/day respectively and thereafter also the incidence continued till the end of the crop growth period *i.e* up to 41st std. week. During *kharif*, 2015 season evening relative humidity had highly significant and positive correlation (0.663**) with thrips population, while it was highly significant and negative with maximum temperature (-0.710*) and bright sunshine hours which also showed negative and significant relationship (-0.560*) with thrips population.

Table 3: Correlation coefficients of sucking pests and natural enemies of Soybean with weather parameters during *kharif*, 2014 and *kharif*, 2015.

Weather data	Leafhopper		Whitefly		Thrips		Aphids		Coccinellid beetle	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Maximum Temperature (°C)	-0.444	-0.402	-0.134	-0.238	-0.079	-0.710**	0.419	-0.568*	-0.402	-0.297
Minimum Temperature (°C)	0.629*	-0.148	0.665**	-0.065	0.581*	0.091	-0.052	-0.077	0.481	0.076
Morning Relative humidity (RH-I (%))	0.380	0.337	0.318	0.372	0.511	0.333	-0.010	0.293	0.255	0.253
Evening Relative humidity (RH-II(%))	0.791**	0.667**	0.524	0.580*	0.682**	0.663**	-0.185	0.401	0.689**	0.773**
Wind velocity (Km/hr)	0.576*	0.007	0.487	-0.324	0.338	0.358	-0.476	0.371	0.467	-0.036
Bright sunshine hours (hrs/day)	-0.525	-0.307	-0.416	-0.210	-0.509	-0.560*	0.161	-0.628*	-0.348	-0.396
Evaporation (mm/day)	-0.662**	-0.447	-0.242	-0.503	-0.357	-0.385	0.140	-0.571*	-0.643*	-0.407
Rainfall (mm)	0.695**	0.007	0.329	-0.015	0.570*	0.102	-0.301	0.229	0.669**	0.533*
Rainy days	0.631*	0.115	0.417	-0.067	0.674**	0.459	-0.384	0.235	0.505	0.393

***=Significant at 5% level, **=Significant at 1 % level**

Table 4: Step down multiple linear regression equations for insect pests and natural enemies of Soybean with weather parameters during *kharif*, 2014.

Insect Pests	Regression equation	Coefficient of determination R^2
Leaf hoppers	$Y= -11.61 + 0.450X_1 + 0.275X_5 - 1.1397\ X_7$	0.67
Whiteflies	$Y= -43.04 + 0.737X_1 + 0.226X_3 + 0.564X_5$	0.38
Thrips	$Y= -8.884 + 0.043X_3 + 0.060X_4 + 0.684X_7 + 0.209X_9$	0.59
Aphids	$Y= -0.812 + 0.073X_4 - 0.204X_5 - 0.204X_6 - 0.686X_9$	0.33
Coccinellids	$Y= -2.01 + 0.080X_1 + 0.044X_5 - 0.222X_7$	0.49

X_1= Maximum Temperature (°C); X_2= Minimum Temperature (°C); X_3= R.H- I (%);X_4= R.H- II (%); X_5= Wind velocity (km/hr); X_6 = Bright sunshine hours (hrs/day); X_7= Evaporation; X_8= Rainfall; X_9= Rainy days;

Table 5: Step down multiple linear regression equations for insect pests and natural enemies of Soybean during *kharif*, 2015.

Insect Pests	Regression equation	Coefficient of determination R^2
Leaf hoppers	$Y= 4.560 - 0.129X_2 - 0.033X_3 + 0.058X_4 - 0.045X_5 - 0.263X_7 + 0.004X_8$	0.36
Whiteflies	$Y= 13.57 - 0.105X_2 - 0.109X_3 + 0.114X_4 - 0.649X_5 - 0.442X_6 - 0.239X_7 - 0.010X_8$	0.52
Thrips	$Y= 9.181 - 0.286X_1 + 0.029X_3$	0.57
Aphids	$Y= -1.795 + 0.044X_3 + 0.219X_5 – 0.814X_7$	0.44
Coccinellids	$Y= 1.65 - 0.023X_2 - 0.016X_3 + 0.013X_4 - 0.063X_5 - 0.034X_6 + 0.035X_9$	0.81

X_1 = Maximum Temperature (°C); X_2 = Minimum Temperature (°C); X_3 = R.H- I (%); X_4= R.H- II (%); X_5 = Wind velocity (km/hr); X_6= Bright sunshine hours (hrs/day); X_7 = Evaporation; X_8 = Rainfall; X_9 = Rainy days

Aphids. The aphid infestation observed on the crop during *Kharif*, 2014 season started with an initial population of 0.20/3 leaves on 31st std. week and reached to peak population of 2.50 aphids/3 leaves on 40th std. week coinciding with first week of October. At the time of its peak, the rainfall, maximum temperature,

minimum temperature, morning relative humidity, evening relative humidity, wind velocity, bright sunshine hours and evaporation were 0.0 mm, 34.77°C, 22.13°C, 79.43%, 57.57%, 1.29 km/hr, 7.23 hr/day and 3.51 mm/day respectively and then they disappeared from the crop from 3rd week of October. The correlation studies carried out between aphids and weather parameters during *kharif*, 2014 season revealed that there was no significant influence of weather parameters on aphid population.

The aphid population on the crop was comparatively more during *Kharif*, 2015 season during the initial stage of the crop growth period and during this period the initial infestation started with a maximum population of 3.95/ 3 leaves during 32nd std. week. At the time of its peak, the rainfall, maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, wind velocity, bright sunshine hours and evaporation were 62.6 mm, 31.1°C, 24.0°C, 88.9 %, 74.6%, 7.3 km/hr, 0.8 hr/day and 1.8 mm/day respectively and thereafter declined suddenly to 0.35/3 leaves on 33rd std. week and continued to remain in low numbers up to 39th std. week and afterwards no incidence was recorded. While during *kharif*, 2015 season maximum temperature (-0.568*), bright sunshine hours (-0.628*) and evaporation (-0.571*) had negative and significant effect on aphid population. Chaudhari *et al.*, (2020) reported that the peak incidence of aphids was recorded during the fourth week of August (18.40/ 5cm twig).

The present results corroborates with the findings of Gaur *et al.*, (2015) who recorded positive correlation of aphids with morning and evening RH. In the present studies, maximum temperature, rainfall, rainy days, sunshine hours, wind speed and evaporation recorded negative correlation which is in line with the earlier works of Gaur *et al.*, (2015) who recorded negative correlation with maximum temperature, rainfall, wind speed and evaporation.

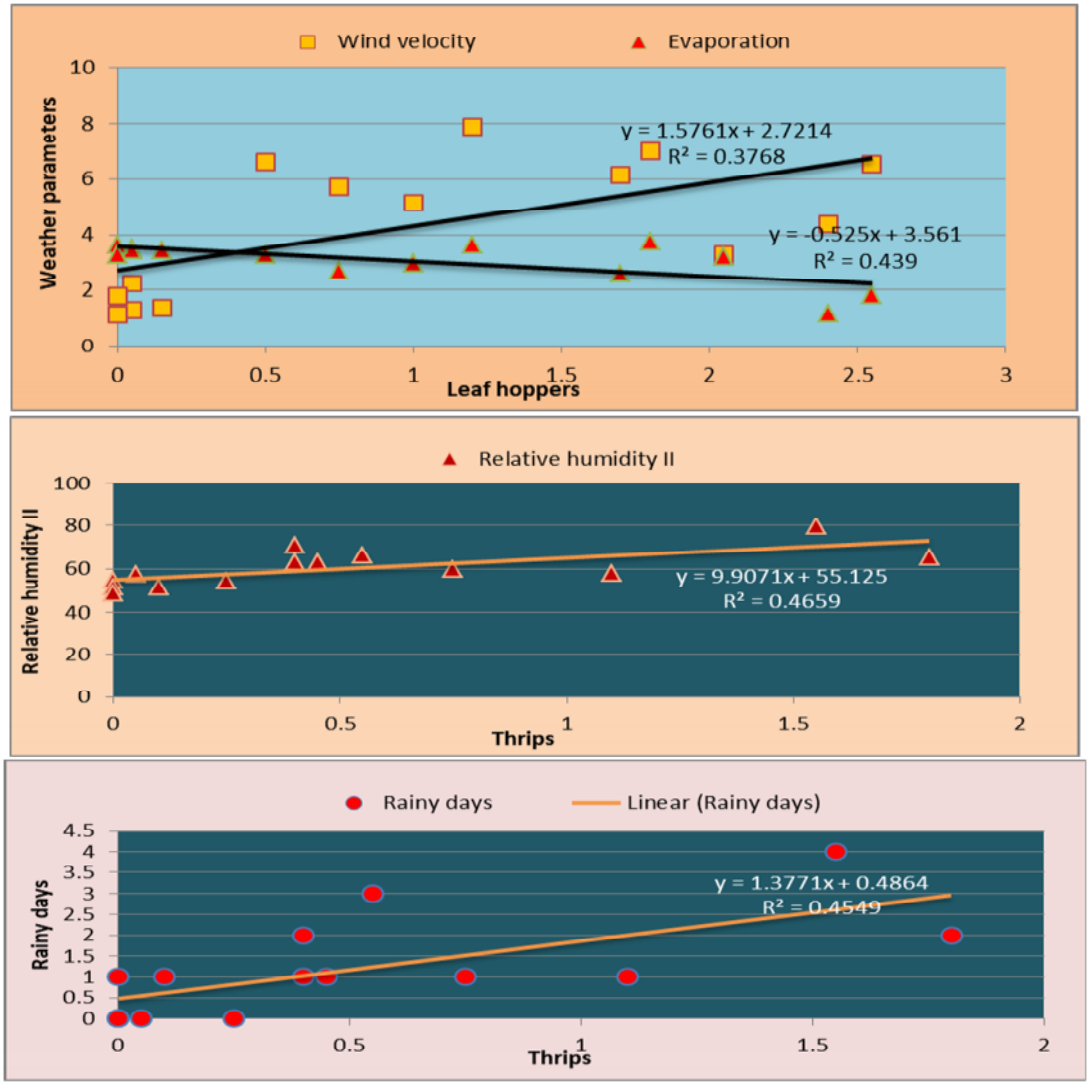

Fig. 3. Linear relationship of observatory weather parameters with sucking pests incidence during *kharif*, 2014.

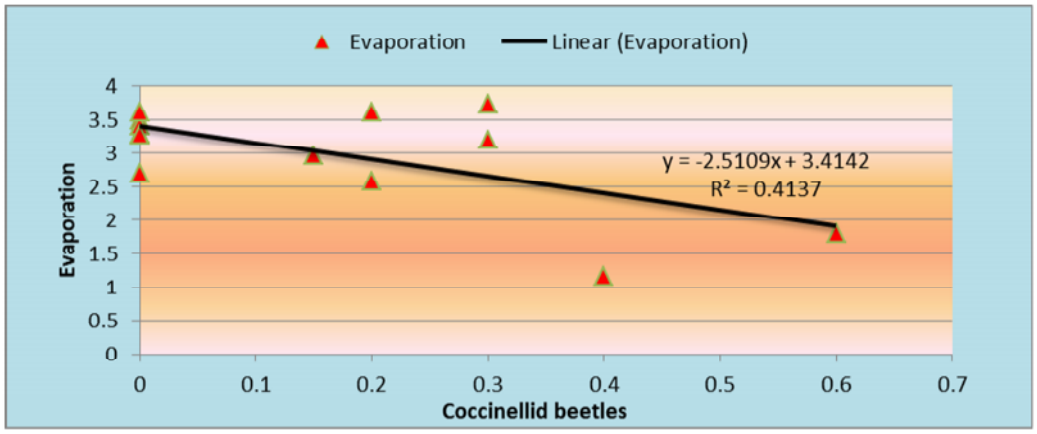

Fig. 4. Linear relationship of observatory weather parameters with coccinellids incidence during *kharif*, 2014.

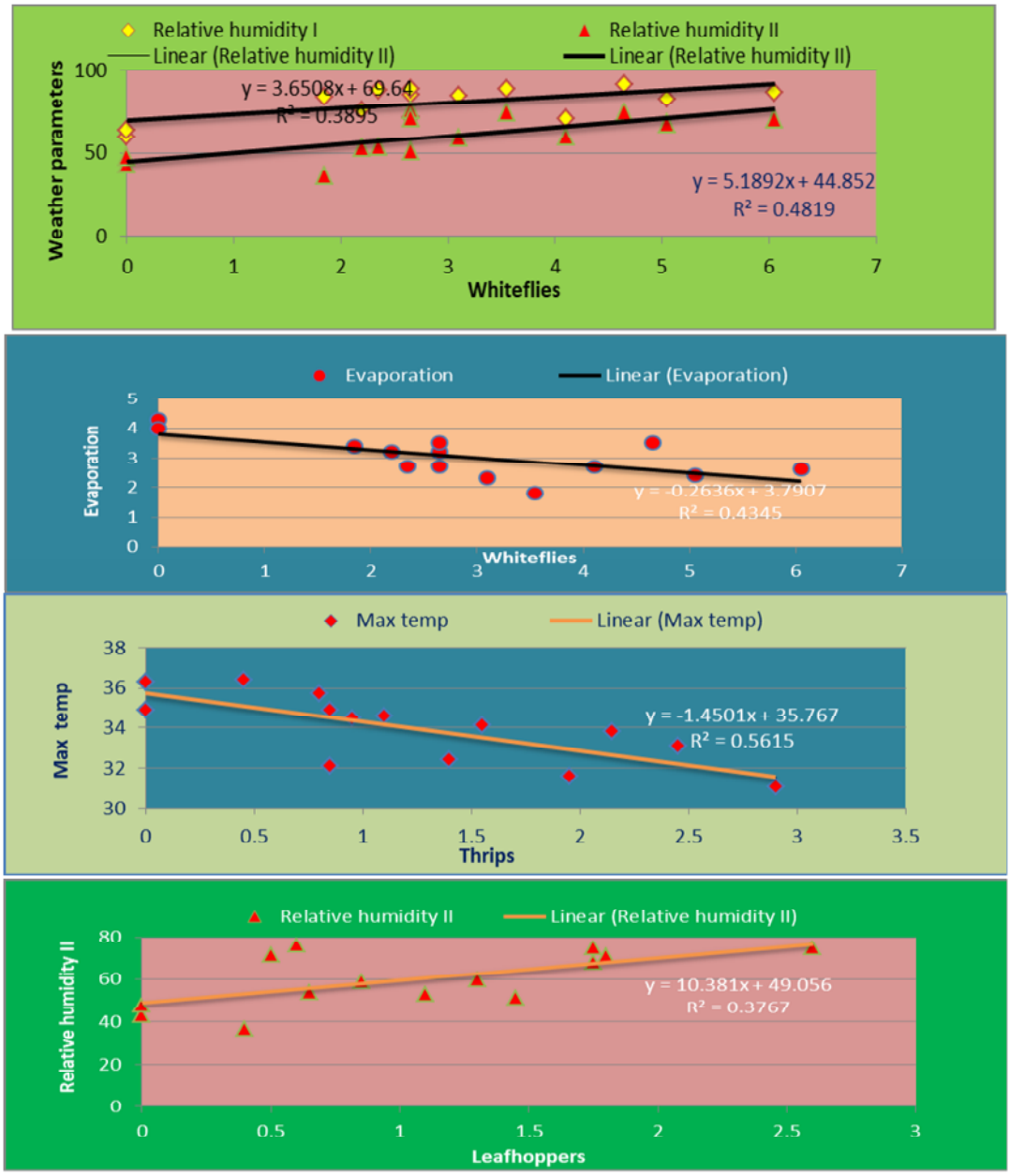

Fig. 5. Linear relationship of observatory weather parameters with sucking pests incidence during 2015.

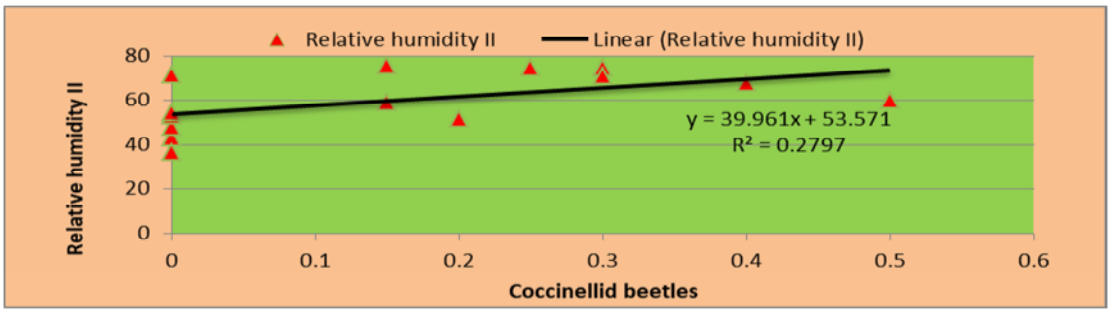

Fig. 6. Linear relationship of observatory weather parameters of coccinellids incidence during 2015.

Predators. The soybean crop pests were mainly predated in the field by the lady bird beetle (*Menochilus sexmaculata*) though the predator were found in low population. The lady bird beetle population was found mainly feeding on the sucking pests.

The lady bird population recorded on the crop ranged from 0.15 to 0.5/mrl during *Kharif*, 2014 and 0.15 to 0.6 during *Kharif*, 2015 .The peak activity of predatory fauna *i.e.* lady bird beetle was noticed in the second week of September i.e. 36th and 37th SMW with 0.6 and 0.5 adults/mrl. Ahirwar *et al.*, (2015) reported similar findings where the lady bird beetle and orb weaver spider were found predating upon whiteflies and jassids, whereas lynx spider was noticed sucking the body sap of lepidopterous larvae in soybean ecosystem where the peak activity of lady bird beetle was reported in the second week of August and September with 0.4 grub and adult per plant whereas the peak activity of spiders were reported in the last week of August with 1.2 spiders per plant. Similar results were reported by Neetam *et al*. (2013) who reported the peak activity of lady bird beetle and spiders were in the third week of September with 0.2 to 0.9 (beetles/meter row) and (02 to 0.7 spiders /meter row) which were similar to present findings. Chaudhari *et al.*, (2020) reported similar findings where the peak incidence of coccinellid predator was recorded in the fourth week of August (3.33/plant).

The results obtained from the correlation coefficient studies carried out between weather parameters and predators revealed that lady bird population was mainly influenced by evening relative humidity (0.689**) and rain fall (0.669**) which showed highly significant and positive correlation while, evaporation (-0.643*) exerted negative and significant effect during *kharif*, 2014 season while evening relative humidity (0.773**) and rainfall (0.533*) had influenced the lady bird population build up during *kharif*, 2015.

Predators population of soybean pests were also significantly influenced by weather parameters and the coccinellid species population was highly influenced by minimum temperature, morning and evening relative humidity, wind velocity, sunshine hours and rainy days which together contributed 81 per cent variation, while morning and evening relative humidity, wind velocity, sun shine hours and rain fall together resulted in 63 per cent variation in the population of spiders. The sucking pests leafhoppers, (0.67) (0.36), thrips (0.59) (0.57), aphids (0.33) (0.44) were also influenced by combined effect of weather parameters during *Kharif*, 2014 and *Kharif*, 2015.

CONCLUSION

During the course of study soybean crop was attacked at various growth stages by four sucking pests *viz.*, whitefly (*Bemisia tabaci* Gennadius), jassid (*Empoasca kerri* Pruthi), aphids (*Aphis craccivora* Koch) and thrips (*Thrips tabaci* Lindeman. The activity of whitefly and jassid was noticed right from germination whereas the activity of thrips and aphids were noticed during active vegetative and flowering stages. Among the predators, lady bird beetles, *M. sexmaculata*, was observed preying on whiteflies and jassids.

FUTURE SCOPE

Studies on seasonal incidence of insect pests and their natural enemies of soybean crop can provide basic information about seasonal occurrence of insect pest and their predators. Statistically significant correlation and regression values indicate that population of pests fluctuates with weather parameters. This provides an opportunity for the development of management strategies significant for the control of these pests. These results will support in devising the pests monitoring system and ecological sound integrated pest management modules.

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Conflict of Interest. None.

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