Original Research Article

Population Dynamics of Major Insect-pests of Rice and their Natural Enemies and its Correlation with Weather Parameters in Central U.P

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A B S T R A C T

This paper discusses the population dynamics of rice insect-pests and its correlation with abiotic factor in Kanpur district of U.P. Incidence and abundance of rice insect-pests. Paddy crop was monitored during the seasons kharif, 2015 & 2016. This investigation revealed that pest activity commenced from 34th Standard meteorological week (SMW) and continued to 49th std. week. Highest dead hearts (7.20 & 6.90%) of YSB (*Scirpophaga incertulas*) was found in the 39th std. week in both years. The 44th std. week registered the highest population of LF (Both, D% & No./5 sweeps) and GLH in kharif, 2015 & 2016. Grass Hopper's population was its peak level (4.15) at 41st std. week in kharif, 2015 whereas it was found maximum in at 42nd std. week in kharif, 2016.The maximum population (20.50 & 21.60) of GB was recorded at 43rd in both years kharif, 2015 and 2016, respectively. The 42nd std. week observed highest No. (4.95) of spider in kharif, 2015 while, it was maximum (5.75) at 39th std. week in kharif, 2016. Population of Dragon Fly was highest (1.50) at 39th std. week in kharif, 2015, whereas it was found maximum (2.25) at 41st std. week in kharif, 2016. The highest No. (3.35 & 3.10) of Damsel Fly was recorded at 42nd std. week in both the experimental years kharif, 2015 & 2016 respectively. The 44th std. week recorded the maximum No. (7.85) of LBB in kharif, 2015 while, it was observed its peak level (8.25) at 39th std. week in second year of experimental investigation kharif, 2016. Maximum temperature and relative humidity morning favours the YSB, LF, GH, GLH, GB, Spider, Drgn fly, Dmsl fly and LBB but rain fall and relative humidity evening was not ideal for insect-pests and natural enemies.

Introduction

Rice (*Oryza sativa* L.) is the most important single food crop of the world importance and staple food for nearly half of the world population. Rice belongs to genus *Oryza* of Gramineae family. Rice (*Oryza sativa* L.) is widely grown in tropical and subtropical regions (Singh *et al.,* 2012). Rice is the second most important food crop of the world feeding over one half of its population, providing 20-80 per cent of the dietary energy in the average daily intake of people in Asia (Khush, 2005 and Babu *et al.,* 2014). The rice plant is attacked by more than 100 species of insects and 20 of them can cause serious

economic loss (Pathok, 1977). Paddy crop suffers maximum damage due to wide range of insects and non-insect-pests under different ecological conditions. Insects alone cause about 30-40% yield loss in rice every year by attacking almost all the aerial parts of the crop plants as well as root system in soil (Henrich *et al.,* 1979; Dhaliwal *et al.,* 1984; Prakash and Rao, 2003 and Anonymous, 2011). Among the various insect-pests damaging the rice crop stem borer, gall midge, grass hopper, brown plant hopper and leaf folder are major pest in India (Anonymous, 2003). In addition to pest species, rice ecosystem is replete with natural enemies like predators and parasitoids, which check the pest population (Kennedy and Storer, 2000).

The seasonal effects of weather and ongoing changes in climatic conditions will directly lead to modifications in dispersal and development of insect species. The changes in surrounding temperature regimes certainly involve alterations in development rates, voltinism and survival of insects and subsequently act upon size, density and genetic composition of populations, as well as on the extent of host plant exploitation (Kennedy and Storer, 2000 and Bale *et al.,* 2002). The developmental success of insect herbivores also indirectly depends on climate, as environmental parameters impact on plant physiology. Insects and plants are exposed to complex interactions among changes in temperature, precipitation and, increased levels of CO and variations in nutrient availability. Milford and Dugdale (1990) reported temperature, day length, rainfall and relative humidity can be used as important components in forecasting and predicting the severity of insect-pests' population. Knowledge of population dynamics of insect-pests and weather parameters are essential for developing sustainable crop protection strategies, for interpreting and forecasting the response of taxonomic groups to weathers

patterns varying on a daily basis, seasonally, or as a long-term consequence of global climate change (Denholm *et al.,* 2001). Information on population dynamics of insect-pests complex in relation to abiotic factors under Kanpur (Central U.P.) conditions is lacking. Information on the seasonal incidence and management of the insect-pests is very limited. Hence, considering the importance of insect-pests of rice an attempt has been made to study the population dynamics and its correlation with weather parameters.

Materials and Methods

For recording the population dynamics of insect-pests, the study was conducted at Students Instruction Farm of Chandra Shekhar Azad University of Agriculture and Technology Kanpur -208002 (U.P.) during *Kharif*, 2015 and 2016. The total experimental plot size measured 10x10m (100m^2). The seedlings were transplanted in the experimental plot with spacing 25 cm between plant to plant and 15 cm row to row. 21 days old seedlings of Pusa Basmati-1 rice variety were transplanted as per recommended agronomic practices, the nursery sown 21 days ago, in both the experimental years (*Kharif*, 2015 and 2016).

Method of Data Collection: Data collection was started after fifteen days of transplanting and subsequent at weekly intervals, using also sweeping method as per need. For insect-pests population, visuals counts of the numbers of insects/10 hills in plot were taken. Observations on incidence of insects were taken on hill basis. Ten plants (hill) were randomly selected from plot planted with Pusa Basmati-1 for recording incidence of insects. The observations continued till harvest of the crop. The observations were recorded at morning hours.

Results and Discussion

To study the population dynamics of insect-pests of paddy crop and their natural enemies and its correlation with weather parameters in Central U.P.:

Altogether five insect-pests *viz.*, yellow stem borer, leaf folder, rice grass hopper, green leaf hopper and gundhi bug were observed attacking on rice crop in varying number at different stages of the crop and natural enemies *viz.* spider, dragon fly, damsel fly and lady bird beetle were also recorded at the time of investigation during *Kharif,* 2015 and 2016. During *Kharif*, 2015 and 2016, various insect-pests and natural enemies were recorded and presented in Table No.-1, 2, 3 and 4 and Fig-1&2, Rice Leaf folder, Stem borer, Green leaf hopper and Ear head bug were the dominating insect-pests in rice ecosystem, which have been discussed as follows:

Yellow stem borer

The population of yellow stem borer was negatively correlated with minimum temperature, relative humidity (evening) and rainfall (-0.02103, -0.00442 and -0.05886, respectively) (Table No.2). A positive correlation was with maximum temperature (0.17806) and relative humidity morning (0.14476) during *kharif*, 2015. In *kharif,* 2016, the population was negatively correlated with relative humidity (E) and rainfall (-0.16378 and -0.24981) and positive correlation was found with minimum temperature and relative humidity morning (0.06074 and 0.05000) and correlation of this pest was positive with maximum temperature (0.14552) (Table No.4).

The maximum infestation of yellow stem borer (7.20 per cent in 2015 and 6.90 per cent in 2016) during 39th std. week of both

experimental years, thereafter dead hearts declined to 6.50 and 4.20 percent during 40 and 41 std. weeks, respectively in *kharif,* 2015, (Table No.1). In *kharif,* 2016 dead hearts declined to 4.89 and 3.65 percent during 40 and 41 std. weeks, respectively (Table No.3). Similar observations were also recorded by Israel and Rao (1961) and Singh, *et al.,* (2013). Ayyanna and Hamidali (1970) also reported *S. incertulas* emergence started from second week of September, with a peak activity during the first week of October between temperatures of 30.60 ^{0}C and 21.60 ^{0}C. The damage was negatively correlated with minimum temperature. The findings of present studies are in conformity with results of (Balasubramanian *et al.,* 1982 and Lakka Vijaya Bhaskar, 1994).

Leaf folder

Results of correlation studies made on leaf folder population revealed that there were negative correlations with minimum temperature, relative humidity (E) and rainfall (-0.1665, -0.00673, and -0.08886, respectively) while the damage by leaf folder showed positive correlations with maximum temperature (0.044247) and it was found positively correlated with relative humidity morning (0.206228) during *kharif*, 2015 (Table No.2). In *kharif*, 2016 the population of leaf folder was positively correlated with maximum temperature and relative humidity (M) (0.05298 and 0.007635), while negative correlation was found between leaf folder damage and minimum temperature (-0.21408) and its population showed negative correlation with relative humidity (E) (-0.43128) and a negative correlation was found with rainfall (-0.23067) (Table No.4).

The incidence of leaf folder revealed that the pest infestation was highest at 44th std. week in the experimental year *kharif,* 2015 and 2016. Similar results were also observed by

Kumar, *et al.,* (1996) they recorded the infestation of rice leaf folder, *C. medinalis* Guen., varied from 1.4 to 33.2 per cent in rice from July to October. Singh *et al.,* (2003) rice leaf folder, *C. medinalis* has gained major pest status now a days and caused severe yield losses. Mishra and Mandal, (2003) reported the similar research. Kumar *et al.,* (2003) found that the peak activity leaf folder in the October during the *Kharif*, season. Alvi, *et al.,* (2003) found that the activity of *C. medinalis* lasted from the second week of August to the second week of October during 2000, while it lasted from the last week of August to the second week of October during *kharif,* 2001. The leaf folder infestation on leaves was noticed that peak leaf infestation was maximum (61.9%) at second week of October (Chhavi *et al.,* 2015). Kumar *et al.,* (2013) and Khan and Ramamurthy (2004) told in his research's result the rice leaf folder population were higher in the month of October, exhibiting peak activity in the first week, followed by September, they also reported that the maximum temperatures and relative humidity in the morning were highly significant and the minimum temperatures had negative impact on population build up. However, the RH in the morning had a positive impact on population build up.

The report of Khan, *et al.,* (2004) also support the present investigation, results of correlation studies made on leaf folder population revealed that there were negative correlations with minimum temperature, relative humidity (evening) and rainfall (-0.1665, -0.00673, and -0.08886) while the damage by leaf folder showed positive correlations with maximum temperature (0.044247) and it was found positively significant with relative humidity morning (0.206228)

Grass hopper

The population of GH was negatively correlated with minimum temperature and rainfall (-0.00847 and -0.02458). It was positively correlated with relative humidity (E). There was a positive correlation found with maximum temperature and relative humidity [M] (0.189706 and 0.13911) during *kharif*, 2015, (Table No.2). In *kharif*, 2016, its population had positive correlation with maximum temperature (0.189256). While, a negative correlation was found with minimum temperature (-0.02299) and relative humidity (M). A negative correlation also was found with relative humidity (E) and rainfall (-0.36752 and -0.33879) (Table No.4).

The data showed that the higher population 4.33, 4.15and 3.96 per five sweep in 41th std., 44th std. and 39th std. week, respectively in *kharif*, 2015, (Table No.1). During *kharif*, 2016 its population was highest 8.52, 6.132 and 5.90 in 42th, 43th and 37th std. weeks, respectively (Table No.3). The findings of present studies are in conformity with the results of Lanjar *et*. *al*., (2002) they reported that the maximum nymphal activity of all grasshopper species was noticed during three weeks after transplanting of crop and adults were maximally active at crop maturity. The study of Bhattacharya *et al.,* (2006), Behera *et al.,* (2007) and Ram, *et al.,* (2014) has similarity to the present investigation.

Green leaf hopper

The population of green leaf hopper showed positive correlation with relative humidity [M] (0.207518) and negative correlation with maximum temperature and relative humidity (E) [-0.04332 and -0.04021]. It showed negative correlation with minimum temperature and rainfall (-0.23824 and -0.16992) during *Kharif*, 2015 (Table No.2). In *Kharif*, 2016, its population showed positive correlation with maximum temperature (0.054658). While, negative correlations were registered with relative humidity (E), minimum temperature, relative humidity [M] and rainfall ((-0.54721, -0.28387, -0.102 and -

0.26356), respectively (Table No.4). The data of GLH revealed that higher incidence was observed at 44th, 45th, 43th and 42th std. week with 130,122, 115 and 80 per five sweeps, respectively in *kharif*, 2015 (Table No.1). However, during *Kharif*, 2016 maximum population were observed at 44th, 45th, 43th and 42th with 120, 108, 96 and 75 per five sweeps, respectively (Table No.3).

Bhatnagar (1989) also noted that peak population was observed during the late rainy season from October to November in most areas of India and also reported that hopper thrive well under weekly mean temperature of 26.9 °C, relative humidity of 66.5%, and total weekly rainfall of 0 to 2.8 mm. Pandey *et al.,* (1992); Dale (1994) and Bhatnagar and Saxena (1999) registered as the age of the crop increased, the number of GLH decreased. Bhattacharya *et al.,* (2006); (Anonymous, 2006) and Behera *et al.,* (2007) also gave the similar information. Kissimoto and Dysck, (1976) studied on climatic factors such as temperature, relative humidity, rainfall and mass air movement and their affect on the distribution, development, survival, behaviour, migration reproduction, population dynamics and outbreak of insect-pests of rice. These factors usually act in a density independent manner, influencing insects to a greater or lesser extent depending on the situation and the insect species.

Gundhi bug

The results of correlation studies showed that the population had negative correlation with minimum temperature, relative humidity (E) and rainfall (-0.2804, -0.12972 and -0.2664) in experimental year *Kharif*, 2015 (Table No.2) whereas, it was negatively correlated with maximum temperature (-0.01049).

The positive correlation of gundhi bug's population was found with relative humidity [M] (0.203846). During *Kharif*, 2016 its population showed negative correlation with minimum temperature and relative humidity [M] (-0.26738 and -0.123), whereas significant negative correlation was found with relative humidity (E) and rainfall (-0.58325 and -0.307490). A positive correlation was with maximum temperature (0.143976) (Table 4).

The data presented on the incidence of gundhi bug revealed that the pests was more active at 43th, 42th and 44th std. week with 20.50, 17.90 and 14.75 per five sweeps, respectively in *Kharif*, 2015 (Table No.1). During *Kharif*, 2016 it was higher in 43th, 42th and 44th std. week with 21.60, 17.60 and 15.25 per five sweeps, respectively (Table No.3).

The findings of present studies are in conformity with results of Rai *et al.,* (1990) they observed peak population of *Leptocorisa acuta* from 37-42th standard weeks when the crop at milky grain stage. Similar results were also observed by Sugimoto and Nugaliyadde (1995), Nudrin and Artati (2000) and Kissimoto and Dysck (1976). Bhattacharya *et al.,* (2006), Prasad and Prabhu (2010) and Behera *et al.,* (2007) observed it, as important insect-pests

Spider

There were positive correlations with relative humidity [M] (0.082223) and maximum temperature (0.18292). Correlation of spider were negatively correlated with minimum temperature, relative humidity [E] and rainfall (-0.0011, -0.0379 and -0.18255), respectively during *kharif,* 2015 (Table No.2). The population of spider was found negatively correlated with rainfall (-0.32283) and relative humidity [E] (-0.24235) in *kharif*, 2016. However, its positive correlation was found with maximum temperature (0.179281), minimum temperature (0.049984) and relative humidity (M) [0.019678] (Table 4).

Table.1 Incidence of insect-pests o rice crop and their natural during *Kharif*, 2015

SW	Insect						Natural Enemies			
	Damage (%)		Avg. No. / 5 Sweep				Avg. No. / 5 Sweep			
	YSB	LF	GH	LF	GLH	GB	Spider	Dgn. Fly	Dmsl. Fly	LBB
34	0.20	0.00	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	0.26	0.00	1.86	1.95	6.50	0.00	4.25	1.50	0.00	3.80
36	0.90	0.00	2.90	3.96	7.75	0.00	3.25	1.15	0.00	4.25
37	2.25	1.00	3.66	3.10	10.50	0.00	2.75	0.75	0.00	4.50
38	4.60	1.20	3.90	2.90	16.00	0.00	0.80	0.75	0.00	4.60
39	7.20	1.45	3.96	3.93	10.25	12.10	3.85	1.50	1.75	4.75
40	6.50	1.76	3.85	4.83	36	13.95	2.75	1.15	1.00	3.25
41	4.20	2.00	4.33	5.95	51	14.15	2.00	0.75	0.85	2.70
42	3.50	2.24	3.00	3.92	80	17.90	4.95	1.50	3.35	4.75
43	3.40	2.87	3.45	4.96	115	20.50	3.10	.95	2.45	5.80
44	2.80	3.73	4.15	6.26	130	14.75	3.65	0.20	1.85	7.85
45	2.50	1.17	2.66	3.63	122	9.35	2.45	0.00	0.00	5.35
46	0.00	0.00	0.00	0.00	0.00	5.95	0.00	0.00	0.00	3.50
47	0.00	0.00	0.00	0.00	0.00	5.25	0.00	0.00	0.00	0.00
48	0.00	0.00	0.00	0.00	0.00	4.25	0.00	0.00	0.00	0.00
49	0.00	0.00	0.00	0.00	0.00	4.40	0.00	0.00	0.00	0.00

Table.2 Correlation of insect-pests and their natural enemies with abiotic factors during *Kharif*, 2015

Serial No.	Insects	Weather Parameters				
		Temperature ^{0}C		Relative Humidity		Rainfall (mm)
		Min.	Max.	R.H. Morning	R.H. Evening	
1.	Yellow Stem Borer DH/WE	-0.02103	0.17806	0.14476	-0.00442	-0.05886
2.	Leaf Folder DL	-0.1665	0.044247	0.206228	-0.00673	-0.08886
3.	Grass Hopper	-0.00847	0.189706	0.13911	0.046005	-0.02458
4.	Leaf Folder	-0.07854	0.152932	0.104004	-0.04929	-0.13619
5.	Green Leaf Hopper	-0.23824	-0.04332	0.207518	-0.04021	-0.16992
6.	Gundhi Bug	-0.2804	-0.01049	0.203846	-0.12972	-0.2664
7.	Spider	-0.0011	0.18292	0.082223	-0.0379	-0.18255
8.	Dragon Fly	0.08751	0.241633	0.025829	-0.01078	-0.13017
9.	Damsel Fly	-0.13141	0.04839	0.124541	-0.07029	-0.19164
10.	Lady Bird Beetle	-0.11009	0.09475	0.188231	-0.01778	-0.08698

Significant at 5% level *
Significant at 1 % level **
DL: - Damaged Leaf
DH/WE: - Dead Heart/ White Ear

Table.3 Incidence of insect-pests o rice crop and their natural during *Kharif*, 2016

SW	Insect						Natural Enemies			
	Damage (%)		Avg. No. / 5 Sweep				Avg. No. / 5 Sweep			
	YSB	LF	GH	LF	GLH	GB	Spider	Dgn. Fly	Dmsl. Fly	LBB
34	0.00	0.00	1.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35	0.30	0.00	2.24	0.00	0.00	0.00	4.85	2.2	0.95	3.5
36	0.88	0.22	4.23	1.72	0.00	0.00	2.95	0.95	1.2	2.10
37	1.42	0.60	5.90	2.14	9.6	0.00	3.15	0.4	2.9	1.55
38	2.66	0.95	2.25	2.16	14.4	0.00	0.5	1.26	1.18	5.65
39	6.90	1.35	3.35	2.22	9.5	11	5.75	1.3	1.1	8.25
40	4.89	1.58	3.96	6.5	22	13.8	3.45	1.48	0.68	7.15
41	3.95	1.95	4.68	10	44.44	14.9	2.15	2.25	1.1	7.65
42	1.65	2.74	8.52	15.5	75	17.6	3.2	2.3	3.1	6.85
43	2.14	2.83	6.13	17.22	96	21.6	3.15	2.15	1.54	6.15
44	2.78	3.56	5.66	19.6	120	15.25	5.15	2.4	1.15	5.1
45	2.18	2.02	2.98	4.55	108	9.25	2.2	0	0.95	3.45
46	0.00	0.00	0.00	0.00	0.00	6.24	0.00	0.00	0.00	0.00
47	0.00	0.00	0.00	0.00	0.00	5.85	0.00	0.00	0.00	0.00
48	0.00	0.00	0.00	0.00	0.00	3.9	0.00	0.00	0.00	0.00
49	0.00	0.00	0.00	0.00	0.00	2.85	0.00	0.00	0.00	0.00

Table.4 Correlation of insect-pests and their natural enemies with abiotic factors during *Kharif*, 2016

Serial No.	Insects	Weather Parameters				
		Temperature ^{0}C		Relative Humidity		Rainfall (mm)
		Min.	Max.	R.H. Morning	R.H. Evening	
1.	Yellow Stem Borer DH/WE	0.06074	0.14552	0.05000	-0.16378	-0.24981
2.	Leaf Folder DL	-0.21408	0.05298	0.007635	-0.43128	-0.23067
3.	Grass Hopper	-0.02299	0.189256	-0.08681	-0.36752	-0.33879
4.	Leaf Folder	-0.20125	0.119707	-0.10203	-0.52282	-0.25528
5.	Green Leaf Hopper	-0.28387	0.054658	-0.102	-0.54721	-0.26356
6.	Gundhi Bug	-0.26738	0.143976	-0.123	-0.58325	-0.30749
7.	Spider	0.049984	0.179281	0.019678	-0.24235	-0.32283
8.	Dragon Fly	0.019923	0.205636	-0.03809	-03133	-0.28854
9.	Damsel Fly	0.06211	0.180693	-0.0285	-0.20617	-0.28821
10.	Lady Bird Beetle	-0.02272	0.219237	-0.00203	-0.31641	-0.29884

Significant at 5% level *
Significant at 1 % level **
DL: - Damaged Leaf DH/WE: - Dead Heart/ White Ear

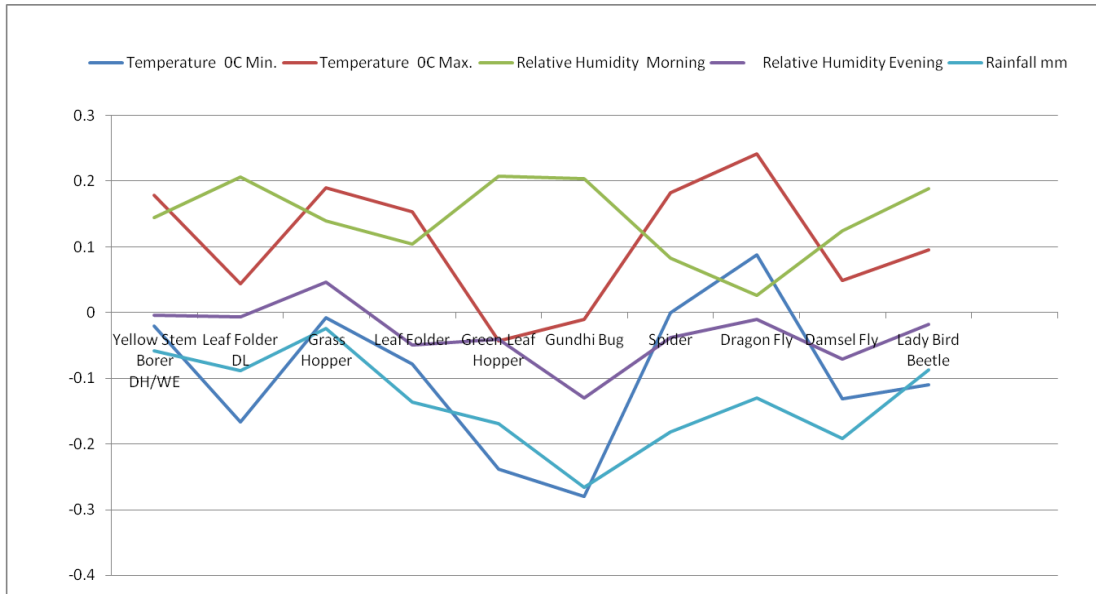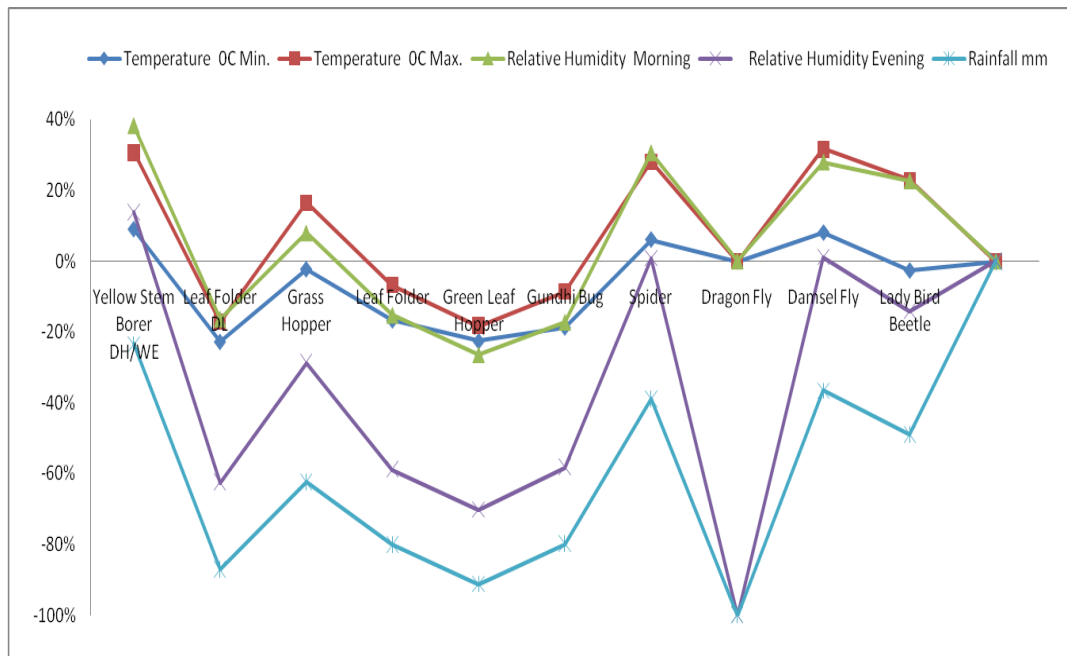**Fig.1** Correlation of insect-pests with weather parameters 2015

Fig.2 Correlation of insect-pests with weather parameters 2016

The data of spider revealed that higher incidence was observed at 42th, 35th and 39th std. week of the crop with 4.95, 4.25 and 3.85 population per five sweeps respectively in *kharif*, 2015 (Table No.1). However, during *Kharif*, 2016 higher population were observed at 39th, 44th and 35th stage of the crop with 5.75, 5.15 and 4.85 population per five sweeps, respectively (Table No.3). Singh *et al.,* (2005) recorded the highest spider population in month of September and October also which support and make conform the present investigation. Tiwari *et al.,* (2001), Zhang-Yong Jing *et al.,* (2002)

observed similar results and reported that spiders are the main predators of pests in rice fields. Venkateshalu (1996), Puspakumari and Tiwari (2005), Prasad and Prabhu (2010) and Jadhao and Madhukar (2011) reported that most of the dominant species of spiders appeared throughout the crop growth period. Mohan Reddy (2000) reported peak population of spiders during tillering stage. Chau (1987) reported highest peak of spiders at mean temperature of 23-25°C and with relative humidity of 89.94 per cent.

Dragon fly

During *Kharif*, 2015, results of correlation studies made on dragon fly population revealed that there were positive correlation with maximum temperature (0.241633), minimum temperature (0.08751) and relative humidity (M) [0.025829]. A negative correlation was found with rainfall (-0.13017) and relative humidity (E) [-0.01078] (Table No.2). In the second experimental year *Kharif*, 2016, it was evident from the data that the dragon fly's population was positively correlated with minimum temperature (0.019923), and maximum temperature (0.205636). Its population were negatively correlated with relative humidity (M), relative humidity (E) and rainfall (-0.03809, -0.3133, and -0.28854), respectively (Table No.4).

The data presented on the incidence of dragon fly revealed that, the occurrence was initiated in the month of August and remained upto last week of October in both the experimental year. Kumar, Suneel *et al.,* (2008) supported neck to neck the present findings, they also found the initiation of dragon fly's population in the month of August. Tiwari *et al.,* (2001) and Pasalu (2004) reported the dragonfly is major predator of paddy's pests. Puspakumari and Tiwari (2005) and Kumar, Suneel *et. al.* (2008) noticed the population of dragon fly occurred maximum in the month of September 1st and to 2nd week of October.

Damsel fly

The correlation of maximum temperature (0.04839) and relative humidity (M) [0.124541] were found positively non-significant with the population of damsel fly. However, its population were negatively correlated with minimum temperature and rainfall (-0.13141 and -0.19164), respectively. A negative correlation also was recorded with relative humidity [E] (-0.07029) during *Kharif*, 2015 (Table No.2). In second year of experimental observation, the minimum temperature (0.06211) and maximum temperature (0.180693) was positively correlated with damsel fly. Its population were negatively correlated with relative humidity [M] (-0.0285), relative humidity [E] (-0.20617) and rainfall (-0.28821) (Table No.4).

The higher incidence of damsel fly was recorded in the 42th, 43th and 44th std. week with 3.35, 2.45 and 1.85 population per five sweeps respectively in *kharif*, 2015 (Table No.1). Whereas, in *kharif*, 2016 its population was higher in 42th, 37th and 43th std. week with 3.10, 2.90 and 1.54 population per five sweep, respectively (Table No.3). Tiwari *et al.,* (2001) and Pasalu (2004) also support the present investigation and they recorded damselfly as major predators of paddy pests. Puspakumari and Tiwari (2005), Kumar, Suneel *et al.,* (2008) and Jadhao and Madhukar (2011) recorded damsel fly as important parasitoids of rice insect-pests. They also noticed that the maximum occurrence was seen in the month of September to October.

Lady bird beetle

The incidence of lady bird beetle on rice crop was positively correlated with maximum temperature (0.09475) and relative humidity [M] (0.188231). Its population was negatively correlated with minimum temperature (-

0.11009), relative humidity [E] (-0.01778) and rainfall (-0.08698), respectively during *Kharif*, 2015 (Table No.2). In second of investigation, *Kharif*, 2016, a positive correlation was registered with maximum temperature (0.219237). The population of lady bird beetle was recorded negatively correlated with minimum temperature (-0.02272), relative humidity [M](-0.00203), rainfall (-0.29884) and relative humidity [E](-0.31641) (Table No.4).

The incidence of lady bird beetle was started from 35th std. week in both the experimental year *kharif*, 2015 and 2016 and its last appearance was recorded in the 46th and 45th std. week of *kharif*, 2015 and 2016, respectively. The peak population was recorded in 44th std. week (7.85 per five sweep), 43rd (5.80 per five sweep) and 45th (5.35 per five sweep) in *kharif*, 2015 (Table No.1). Whereas, in *kharif*, 2016 it was 8.25 (39th std. week), 7.65 (41th std. week) and 7.15 (40th std. week) per five sweep, in descending order (Table No.3). Sasaji (1968) and Yasumatsu *et al.,* (1975) recorded coccinellids in paddy fields as most important predator. Puspakumari and Tiwari (2005) recorded lady bird beetle as important parasitoids of rice insect-pests from the field. They also noticed that the maximum presence was in the month of September to October. Bhattacharya *et al.,* (2006) and Kumar, Suneel *et al.,* (2008) evaluated that coccinellid beetles were found to be more abundant.

Statistical analysis

Correlation analysis is drawn between data recorded on pest population and weather parameters. Based on this statistical analyzed data, the results of the investigation have been interpreted and conclusions have been drawn

It can be concluded that, all 5 insects which have been discussed in this paper attacked on the crop. But, out of 6 insects, Yellow Stem Borer, Leaf Folder and Gundhi Bug may be treated as major insect-pests in paddy crop. Natural enemies have a very important role in controlling the insect-pests in rice ecosystem.

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