INTERNATIONAL JOURNAL OF PLANT PROTECTION
VOLUME 11 | ISSUE 2 | OCTOBER, 2018 | 151-157

● e ISSN-0976-6855 | Visit us : *www.researchjournal.co.in*

IJPP

RESEARCH PAPER

DOI : 10.15740/HAS/IJPP/11.2/151-157

Statistical forewarning models for insect pests and natural enemies of potato in Karnataka during *Rabi* season

■ Prashant K. Natikar* **and** R. A. Balikai

Department of Agricultural Entomology, College of Agriculture, University of Agricultural Sciences, **Dharwad (Karnataka) India**

ARITCLE INFO

Received : 26.06.2018
Revised : 06.09.2018
Accepted : 21.09.2018

KEY WORDS :
Potato, Insect pests, Forewarning model

***Corresponding author:**
shanthunatikar@gmail.com

ABSTRACT

An experiment was conducted during *Rabi* 2016-17 and 2017-18 at farmers filed of Hagaraki village, Dharwad district, Karnataka state to find out the forewarning models for insect pests and natural enemies of potato. Results revealed that, all the weather factors under consideration had a significant role on population fluctuations of insect pests *viz*., thrips, leafhoppers, whiteflies and mites while coccinellids and chrysopids with respect to natural enemies. Forecasting model for thrips depicted evening relative humidity at lead time zero (same week of observation) had negative and significant correlation with the incidence of thrips population. Based on prediction model [Y = -3.23 - 0.208X_2 (evening relative humidity)] we can forecast thrips population at zero week (during the week of its occurance) upto 41.80 per cent accuracy. Prediction model [Y = -2.58 - 0.090X_2 (evening relative humidity)] for whiteflies at lead time zero showed negative and significant correlation with evening relative humidity with accuracy of 32.10 per cent for whitefly population.

How to view point the article : Natikar, Prashant K. and Balikai, R.A. (2018). Statistical forewarning models for insect pests and natural enemies of potato in Karnataka during *Rabi* season. *Internat. J. Plant Protec.*, **11**(2) : 151-157, **DOI : 10.15740/HAS/IJPP/11.2/151-157,**

INTRODUCTION

Potato contains all the major nutrients required for good health, and there are nutritional advantages over all the major world foods. The balance of proteins to calories, the balance of the more important amino-acids, minerals and vitamins make the potato second only to eggs in nutritional value as a single food source. In Karnataka, the potato crop is cultivated over an area of 38,126 hectares with annual production of 2, 25,285 tonnes and a productivity of 6,220 kg/ha during 2015-16. The major potato growing districts of Karnataka included Hassan (18,671 ha), Belagavi (4,802 ha), Kolar (3,648 ha), Dharwad (1,160 ha) and Bengaluru - Rural (488 ha) (Anonymous, 2016). Insect pest menace is one of the major factors that destabilize potato productivity. In

Hassan district of Karnataka, about 33 species of insects and a species of mite belonging to nine orders and twenty three families infest potato crop at different stages (Nandihalli *et al*., 1996). Among the insect pests, aphids, thrips, leafhoppers, whiteflies, mites, cutworms, white grubs, epilachna beetles, defoliating caterpillars, tuber moth and stem borers were reported to be economically important causing heavy yield losses. In the present study, first time systematic attempts was made in Dharwad district of Karnataka to identify the different insect and natural enemies species associated with potato crop and their period of activity with relation to weather factors in order to develop forewarning models.

MATERIAL AND METHODS

The observations on seasonal abundance of potato insects, mites and their natural enemies were recorded at weekly interval starting from 20 days after emergence of plant till harvest. These observations were made under unprotected conditions in the absence of insecticides. Potato (variety- Kufri Pukhraj) was grown in one gunta area at Hangaraki, a village near Dharwad during *Rabi* 2016-17 and 2017-18.

For observations on shoot borer at each location, ten plants were randomly selected from the field and observed for number of shoots showing withering symptoms and total number of shoots per plant. The per cent of shoot infestation was calculated using the formula given below:

$$\text{Per cent shoot infestation} = \frac{\text{Number of infested shoots}}{\text{Total number of shoots}} \times 100$$

Incidence of aphids was recorded by selecting 34 plants at random and from each plant three compound leaves from top, middle and bottom portions/canopy of the plant was selected and aphids were counted separately with help of 10 x hand lens and expressed in terms of aphid numbers per compound leaf (Anonymous, 1995). For leafhoppers, thrips and whiteflies, ten plants were selected randomly and from each plant, three leaves representing top, middle and lower portions were selected. The total number of nymphs and adults on each leaf was counted and expressed in terms of number of insects per three leaves per plant (Bhatnagar, 2007). For sampling mites, ten plants were randomly selected and three leaves covering top, middle and bottom canopy were collected in polythene bags. These leaves were brought to the laboratory and observed under stereo binocular microscope for mites. Number of mites per leaf was worked out.

Observations on larval population of leaf eating caterpillar, *S. litura* was made on ten randomly selected spots of one meter row length. Larval counts were made by shaking the plant gently over a white cloth placed between the rows. Average number of caterpillars found per meter row length (mrl) was worked out. A total of ten plants were randomly tagged to record the observations on different natural enemies and was expressed in terms of numbers per plant.

The information on abiotic factors like maximum and minimum temperature, relative humidity (RH 1 and RH 2) and rainfall that prevailed during *Rabi* 2016-17 and 2017-18 in Dharwad were collected from Meteorological Observatory, MARS Dharwad. The pest incidence on potato during the two experimental years was correlated with the above mentioned weather parameters at 1, 2, 3 and 4 weeks lead time to get some preliminary prediction models, for each pest.

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been presented under the following heads:

Shoot borer, *Leucinodes orbonalis*:

The correlation matrix for shoot borer incidence in potato crop revealed positive and non-significant correlation with maximum temperature (r= 0.432) and minimum temperature (r= 0.031), whereas morning relative humidity (r= -0.263), evening relative humidity (r= -346) and rainfall (r= -0.086) showed negative and non-significant correlation with shoot borer population at no lead time (Table 1).

Regression analysis showed R^2 value of 0.309 indicating 30.90 per cent influence of weather parameters on shoot borer incidence at no lead time. The multiple regression equation fitted with weather parameters and shoot borer population is as follows:

$$Y = -83.74 + 0.683X_1 - 0.528X_2 + 2.928X_3 - 1.064X_4 + 0.094X_5$$ **for L_0 (Lead week 0)**

The results revealed that the decrease in 1 per cent evening relative humidity and 1 °C minimum temperature would lead to decrease in 0.528 and 1.064 shoot borer population. Whereas increase in 1 per cent morning relative humidity, 1°C maximum temperature and 1 mm

Table 1: Correlation co-efficients for insect pests and natural enemies in potato with abiotic factors during *Rabi* 2016 and 2017

Insect pests/Natural enemies	Lead week	RHm (X_1)	RHe (X_2)	MaxT (X_3)	MinT (X_4)	RF (X_5)	R^2	Regression equation
Y_1 Shoot borer	4	-0.110	-0.078	-0.031	0.174	0.245	0.164	$Y= 44.99-0.291X_1+0.097X_2-1.097X_3+0.628X_4+0.054X_5$
(% shoot	3	-0.086	-0.062	-0.101	0.186	0.022	0.188	$Y= 47.56-0.423X_1+0.212X_2-1.324X_3+1.124X_4-0.141X_5$
infestation)	2	-0.100	-0.100	0.036	0.214	0.232	0.139	$Y= 29.18-0.236X_1+0.072X_2-0.686X_3+0.696X_4+0.048X_5$
	1	-0.101	-0.176	0.068	0.157	0.039	0.118	$Y= 11.90+0.313X_1-0.336X_2-0.376X_3-0.165X_4-0.029X_5$
	0	-0.263	-0.346	0.432	0.031	-0.086	0.309	$Y= -83.74+0.683X_1-0.528X_2+2.928X_3-1.064X_4+0.094X_5$
Y_2 Aphids	4	0.121	0.074	0.034	0.268	0.180	0.088	$Y= -4.64+0.061X_1-0.042X_2+0.126X_3+0.083X_4+0.014X_5$
(No's/three	3	0.137	0.086	-0.029	0.275	0.024	0.116	$Y= -0.224+0.038X_1-0.025X_2-0.071X_3+0.233X_4-0.041X_5$
leaves)	2	0.128	0.061	0.088	0.292	0.187	0.134	$Y= -13.23+0.116X_1-0.074X_2+0.385X_3-0.004X_4+0.030X_5$
	1	0.126	0.006	0.105	0.257	0.032	0.257	$Y= -17.13+0.284X_1-0.196X_2+0.409X_3-0.131X_4-0.010X_5$
	0	-0.145	-0.210	0.350	-0.031	-0.197	0.261	$Y= -28.36+0.212X_1-0.143X_2+0.982X_3-0.364X_4+0.000X_5$
Y_3 Thrips	4	-0.280	-0.263	-0.013	0.046	0.149	0.251	$Y= 21.26-0.034X_1-0.033X_2-0.568X_3+0.118X_4+0.023X_5$
(No's/three	3	-0.258	-0.246	-0.093	0.056	-0.012	0.240	$Y=20.44-0.061X_1-0.007X_2-0.578X_3+0.225X_4-0.012X_5$
leaves)	2	-0.271	-0.282	0.044	0.081	0.197	0.238	$Y= 14.02-0.010X_1-0.044X_2-0.345X_3+0.083X_4+0.037X_5$
	1	-0.273	-0.356	0.053	0.030	-0.013	0.266	$Y= 11.17+0.140X_1-0.160X_2-0.327X_3-0.048X_4+0.024X_5$
	0	-0.433	-0.530*	0.329	-0.080	-0.194	0.418	$Y= -3.23+0.216X_1-0.208X_2+0.167X_3-0.248X_4+0.009X_5$
Y_4 Leaf hoppers	4	-0.258	-0.263	-0.167	0.202	0.116	0.223	$Y= 6.88-0.083X_1+0.017X_2-0.147X_3+0.271X_4+0.006X_5$
(No's/three	3	-0.237	-0.244	0.040	0.206	0.037	0.245	$Y= 11.11-0.089X_1+0.019X_2-0.306X_3+0.334X_4-0.015X_5$
leaves)	2	-0.250	-0.278	0.228	0.223	0.226	0.298	$Y= -3.86-0.018X_1-0.022X_2+0.228X_3+0.079X_4+0.057X_5$
	1	-0.252	-0.353	0.206	0.189	0.007	0.256	$Y= 3.72+0.106X_1-0.127X_2-0.118X_3+0.072X_4+0.009X_5$
	0	-0.503*	-0.582**	0.486*	-0.090	-0.153	0.464	$Y= -15.80+0.190X_1-0.177X_2+0.627X_3-0.318X_4+0.031X_5$
Y_5 Whiteflies	4	-0.214	-0.171	-0.066	0.160	0.243	0.302	$Y= 11.88-0.063X_1+0.015X_2-0.323X_3+0.137X_4+0.008X_5$
(No's/three	3	-0.188	-0.152	-0.161	0.171	0.097	0.311	$Y= 11.47-0.072X_1+0.026X_2-0.325X_3+0.178X_4-0.005X_5$
leaves)	2	-0.203	-0.191	0.000	0.198	0.334	0.301	$Y= 7.18-0.046X_1+0.007X_2-0.169X_3+0.094X_4+0.024X_5$
	1	-0.205	-0.276	0.010	0.143	0.084	0.226	$Y= 8.24+0.026X_1-0.050X_2-0.256X_3+0.067X_4+0.012X_5$
	0	-0.395	-0.485*	0.353	0.008	-0.109	0.321	$Y= -2.58+0.088X_1-0.090X_2+0.108X_3-0.076X_4+0.007X_5$
Y_6 Mites (No's/leaf)	4	-0.110	-0.096	-0.029	0.195	0.154	0.148	$Y= 25.44-0.147X_1+0.041X_2-0.711X_3+0.464X_4+0.000X_5$
	3	-0.088	-0.077	-0.143	0.202	0.027	0.212	$Y= 29.06-0.166X_1+0.054X_2-0.886X_3+0.617X_4-0.072X_5$
	2	-0.101	-0.111	0.035	0.224	0.293	0.170	$Y= 8.07-0.045X_1-0.021X_2-0.137X_3+0.221X_4+0.069X_5$
	1	-0.103	-0.190	0.026	0.179	0.003	0.158	$Y= 13.28+0.138X_1-0.169X_2-0.473X_3+0.235X_4-0.012X_5$
	0	-0.301	-0.383	0.511*	0.111	-0.136	0.322	$Y= -43.19+0.237X_1-0.195X_2+1.460X_3-0.213X_4-0.002X_5$
Y_7 Defoliator, *S. litura* ((No. of larvae/mrl)	4	0.056	0.000	0.051	0.343	0.170	0.137	$Y= -0.672+0.047X_1-0.048X_2-0.027X_3+0.217X_4+0.007X_5$
	3	0.076	0.015	-0.025	0.350	-0.028	0.228	$Y= 3.88+0.020X_1-0.029X_2-0.243X_3+0.404X_4-0.074X_5$
	2	0.065	-0.016	0.112	0.368	0.178	0.182	$Y= -7.84+0.103X_1-0.083X_2+0.173X_3+0.159X_4+0.014X_5$
	1	0.063	-0.083	0.130	0.331	-0.016	0.334	$Y= -14.15+0.284X_1-0.213X_2+0.268X_3+0.014X_4-0.027X_5$
	0	-0.221	-0.306	0.414	0.074	-0.175	0.266	$Y= -23.97+0.187X_1-0.144X_2+0.812X_3-0.188X_4-0.011X_5$
Y_8 Coccinellids (No's/plant)	4	0.201	0.229	-0.159	0.401	0.458*	0.274	$Y= 0.398-0.022X_1+0.016X_2-0.011X_3+0.057X_4+0.004X_5$
	3	0.224	0.243	-0.216	0.413	0.325	0.260	$Y= 0.870-0.029X_1+0.021X_2-0.031X_3+0.077X_4+0.000X_5$

Table 1: Count………

Table 1 : Contd…………….

	2	0.211	0.210	-0.091	0.439*	0.487*	0.292	$Y= -1.49-0.017X_1+0.014X_2+0.050X_3+0.040X_4+0.010X_5$
	1	0.209	0.136	-0.047	0.385	0.324	0.174	$Y= 0.122+0.012X_1-0.010X_2-0.020X_3+0.028X_4+0.006X_5$
	0	-0.093	-0.164	0.145	-0.010	0.010	0.160	$Y= -2.80+0.049X_1-0.003X_2+0.096X_3+0.079X_4+0.009X_5$
Y_9 Chrysopids (No's/plant)	4	0.091	0.066	0.006	0.413	0378	0.224	$Y= -0.330+0.001X_1 0.003X_2+0.002X_3+0.035X_4+0.005X_5$
	3	0.116	0.083	-0.073	0.424	0.207	0.200	$Y= 0.531-0.006X_1+0.001X_2-0.033X_3+0.065X_4-0.003X_5$
	2	0.139	0.072	0.209	0.470*	0.256	0.270	$Y= -3.68+0.009X_1-0.004X_2+0.097X_3+0.035X_4+0.002X_5$
	1	0.100	-0.038	0.117	0.398	0.212	0.300	$Y= -2.35+0.043X_1-0.033X_2+0.044X_3-0.002X_4+0.004X_5$
	0	-0.251	-0.314	0.455*	0.077	0.038	0.292	$Y= -5.53+0.029X_1-0.021X_2+0.192X_3-0.056X_4+0.010X_5$
Y_{10} Spiders (No's/plant)	4	0.063	0.051	0.063	0.258	0.332	0.144	$Y= 2.30+0.012X_1-0.017X_2-0.063X_3+0.022X_4+0.014X_5$
	3	0.084	0.063	-0.105	0.270	0.138	0.098	$Y= 2.72-0.003X_1-0.002X_2-0.098X_3+0.089X_4-0.005X_5$
	2	0.073	0.030	-0.001	0.295	0.281	0.123	$Y= -0.28+0.016X_1-0.017X_2+0.009X_3+0.029X_4+0.013X_5$
	1	-0.083	-0.188	0.028	0.086	-0.118	0.211	$Y= 1.35-0.073X_1-0.065X_2-0.063X_3-0.024X_4-0.005X_5$
	0	-0.144	-0.247	0.165	0.001	-0.145	0.249	$Y= -2.49+0.099X_1-0.082X_2+0.075X_3-0.101X_4-0.000X_5$

* and ** indicate significane of values at P=0.05 and P=0.01, respectively

rainfall would lead to increase in 0.683, 2.928 and 0.094 shoot borer population, respectively at no lead time.

The relationship between moth trapping and minimum temperature was positive (r=0.3893) suggesting that minimum temperature has a major role to play in moth population build up as reported by Shukla and Khatri (2010). The correlation studies made by Kumar and Singh (2013) in brinjal revealed a positive role of morning relative humidity, rainfall and temperature on pest infestation. Similarly, as per report of Kumar *et al*. (2017) the weather factors like maximum temperature, minimum temperature, morning relative humidity and sunshine hours exhibited a positive correlation with the build up of pest incidence.

Aphid, *Myzus persicae*:

The incidence of aphid showed non-significant negative correlation with morning relative humidity (r= -0.145), evening relative humidity (r= -0.210), minimum temperature (r= -0.031) and rainfall (r= -0.197) and non-significant positive correlation with maximum temperature (r= 0.350) at no lead time (Table 1). The overall impact of abiotic factors on aphid population was 26.10 per cent at no lead time. The multiple regression equation fitted with weather parameters and aphid population is as follows:

$Y = -28.36 + 0.212X_1 - 0.143X_2 + 0.982X_3 - 0.364X_4 + 0.000X_5$ for L_0 (Lead week 0)

The results indicated that the decrease in 1 per cent evening relative humidity and 1°C minimum temperature would lead to decrease in 0.143 and 0.364 aphid population. Whereas increase in 1 per cent morning relative humidity, 1°C maximum temperature and 1 mm rainfall would lead to increase in 0.212, 0.982 and 0.000, respectively at no lead time. . In a similar study by Biswas *et al*. (2004) who concluded that, by multiple correlation studies the temperature and relative humidity were the most important ones among all the other weather parameters as they were directly responsible for increase of 71.3-88.40 per cent of *M. persicae* population.

Thrips (*Scirtothrips dorsalis*, *Thrips palmi* and *Bathrips melanicornis*):

Correlation studies for incidence of thrips showed negative and significant correlation with evening relative humidity (r= -0.530) whereas, a negative and non-significant correlation was exhibited with morning relative humidity (r= -0. 433), minimum temperature (r= -0.080) and rainfall (r= -0.194) at no lead time. All the weather factors together influenced the pest to the tune of 41.80 per cent at no lead time (Table 1). The multiple regression equation fitted with weather parameters and thrips population is as follows:

$Y = -3.23 + 0.216X_1 - 0.208X_2 + 0.167X_3 - 0.248X_4 + 0.009X_5$ for L_0 (Lead week 0)

The results indicated that the decrease in 1 per cent evening relative humidity and 1°C minimum temperature would lead to decrease in 0.208 and 0.248 thrips population. Whereas increase in morning relative humidity, 1°C minimum temperature and 1 mm rainfall would lead to increase in 0.216, 0.167 and 0.009 thrips population, respectively at no lead time. The work done on the correlation studies with respect to thrips population is very scanty. However, Thakur (2017) reported that the thrips population in potato was negatively correlated with minimum temperature, morning and evening relative humidity and rainfall.

Leafhoppers (*Empoasca* sp., *Empoascarana indica* and *Amrasca biguttula biguttula*):

The morning relative humidity (r= -0.503) and maximum temperature (r= -0.486) had significant negative correlation with pest incidence whereas, evening relative humidity (r= -0.582), showed highly significant and negative correlation with leafhopper population at no lead time. The overall impact of weather factors on pest incidence was 46.40 per cent at no lead time (Table 1). The multiple regression equation fitted with weather parameters and leafhopper population is as follows:

$Y = -15.80 + 0.190X_1 - 0.177X_2 + 0.627X_3 - 0.318X_4 + 0.031X_5$ for L_0 (Lead week 0)

The results indicated that the decrease in 1 per cent evening relative humidity and 1°C minimum temperature would lead to decrease in 0.177 and 0.318 leafhopper population. Whereas increase in 1 per cent morning relative humidity, 1°C maximum temperature and 1 mm rainfall would lead to increase in 0.190, 0.627 and 0.031 leafhopper population, respectively at no lead time. Similarly, as per the report of Sajjan (2014) significantly negative correlation with evening relative humidity (r = -0.500*) was noticed in relation to leafhopper activity.

Whitefly, *Bemisia tabaci*:

Correlation studies for incidence of whitefly showed negative and non-significant correlation with morning relative humidity (r= -0.395) and rainfall (r= -0.109) whereas, a negative and significant correlation was exhibited with evening relative humidity (r= -0.485), (Table 1). The maximum (r= 0.353) and minimum temperature (r= 0.008) had non-significant positive correlation with pest incidence at no lead time (Table 1).

Regression analysis showed R^2 value of 0.321 indicating 32.10 per cent influence of weather parameters on whitefly incidence at no lead time. The multiple regression equation fitted with weather parameters and whitefly population is as follows:

$Y = -2.58 + 0.088X_1 - 0.090X_2 + 0.108X_3 - 0.076X_4 + 0.007X_5$ for L_0 (Lead week 0)

The results indicated that the increase in 1 per cent morning relative humidity, 1°C maximum temperature and 1 mm rainfall would lead to increase in 0.088, 0.108 and 0.007 whitefly population. Whereas decrease in 1 per cent evening relative humidity and 1°C minimum temperature would lead to decrease in 0.090 and 0.076 whitefly population, respectively at no lead time. Pandey *et al*. (2008) revealed that relative humidity and whitefly population exhibited a significant and negative correlation (-0.944) on Kufri Badshah variety of potato. Naik *et al*. (2009) reported that a non-significant relationship existed between whitefly incidence and abiotic factors.

Mite, *Polyphagotarsonemus latus:*

The incidence of mite showed non-significant negative correlation with morning relative humidity (r= -0.301), evening relative humidity (r= -0.383) and rainfall (r= -0.136) and significant positive correlation with maximum temperature (r= 0.511) at no lead time (Table 1). The overall impact of abiotic factors on mite population was 32.20 per cent at no lead time. The multiple regression equation fitted with weather parameters and mite population is as follows:

$Y = - 43.19 + 0.237X_1 - 0.195X_2 + 1.460X_3 - 0.213X_4 - 0.002X_5$ for L_0 (Lead week 0)

The results indicated that the decrease in 1 per cent evening relative humidity, 1°C minimum temperature and 1 mm rainfall would lead to decrease in 0.195, 0.213 and 0.002 mite population. Whereas increase in 1 per cent morning relative humidity and 1°C maximum temperature would lead to increase in 0.237 and 1.460 mite population, respectively at no lead time. The studies in Hassan also in concord with the present study wherein the rainfall and lower temperature could minimize the mites load on plant (Basavaraju *et al*., 2010).

Defoliator, *Spodoptera litura*:

The incidence of defoliator showed positive and non-significant correlation with morning relative humidity (r= 0.063), maximum temperature (r= 0.130) and minimum temperature (r= 0.331), whereas evening relative humidity (r= -0.083) and rainfall (r= -0.016) showed negative and non-significant correlation with defoliator population at 1 weeks lead time (Table 1).

Regression analysis showed R^2 value of 0.334

indicating 33.40 per cent influence of weather parameters on defoliator incidence at 1 weeks lead time. The multiple regression equation fitted with weather parameters and defoliator population is as follows:

$Y = -14.15 + 0.284X_1 - 0.213X_2 + 0.268X_3 + 0.014X_4 - 0.027X_5$ for L_1 (Lead week 1)

The results indicated that the decrease in 1 per cent evening relative humidity and 1 mm rainfall would lead to decrease in 0.123 and 0.027 defoliator population. Whereas increase in 1 per cent morning relative humidity, 1°C maximum and minimum temperature would lead to increase in 0.284, 0.268 and 0.014 defoliator population, respectively at 1 weeks lead time. There are no earlier works pertaining to correlation studies with respect to *S. litura* in potato. However, Shakya *et al*. (2015) reported that, the incidence of *S. litura* in tomato exhibited a positive correlation with relative humidity.

Coccinellid, *Cheilomenes sexmaculata:*

The minimum temperature (r= 0.439) and rainfall (r= 0.487) had significant positive correlation with coccinellid incidence whereas, morning relative humidity (r= 0.211) and evening relative humidity (r= 0.210), showed non-significant and positive correlation with coccinellid population at 2 weeks lead time. The overall impact of weather factors on pest incidence was 29.20 per cent at 2 weeks lead time (Table 1). The multiple regression equation fitted with weather parameters and coccinellid population is as follows:

$Y = -1.49 - 0.017X_1 + 0.014X_2 + 0.050X_3 + 0.040X_4 + 0.010X_5$ for L_2 (Lead week 2)

The results indicated that the decrease in 1 per cent morning relative humidity would lead to decrease in 0.017 coccinellid population. Whereas increase in 1 per cent evening relative humidity, 1°C maximum and minimum temperature and 1 mm rainfall would lead to increase in 0.014, 0.050, 0.040 and 0.010 coccinellid population, respectively at 2 weeks lead time. The literature on this particular aspect is lacking to discuss present findings.

Chrysopids, *Chrysoperla* sp.:

The morning relative humidity (r= 0.100), maximum temperature (r= 0.117), minimum temperature (r= 0.398) and rainfall (r= 0.212) had non-significant positive correlation with chrysopid incidence whereas evening relative humidity (r= -0.038) showed non-significant negative correlation at 1 weeks lead time. The overall impact of abiotic factors on chrysopid population was 30.00 per cent at 1 weeks lead time. The multiple regression equation fitted with weather parameters and mite population is as follows:

$Y = -2.35 + 0.043X_1 - 0.033X_2 + 0.044X_3 - 0.002X_4 + 0.004X_5$ for L_1 (Lead week 1)

The results revealed that the decrease in 1 per cent evening relative humidity and 1°C minimum temperature would lead to decrease in 0.033 and 0.002 chrysopid population, respectively. Whereas, increase in 1 per cent morning relative humidity, 1°C increase in maximum temperature and 1 mm rainfall would lead to increase in 0.043, 0.044 and 0.004 chrysopid population, respectively at 1 weeks lead time. The literature on this particular aspect is lacking to discuss present findings.

Spiders (*Cyclosa hexatuberculata*, *Neoscona* sp. and *Neoscona theisi*):

The incidence of spiders showed non-significant negative correlation with morning relative humidity (r= -0.144), evening relative humidity (r= -0.247) and rainfall (r= -0.145) whereas positive and non-significant correlation was exhibited with maximum temperature (r= 0.165) and minimum temperature (r= 0.001) at no lead time (Table 1).

Regression analysis showed R^2 value of 0.249 indicating 24.90 per cent influence of weather parameters on spider incidence at no lead time. The multiple regression equation fitted with weather parameters and spider population is as follows:

$Y = -2.49 + 0.099X_1 - 0.082X_2 + 0.075X_3 - 0.101X_4 - 0.000X_5$ for L_0 (Lead week 0)

The results revealed that the decrease in 1 per cent evening relative humidity, 1°C minimum temperature and 1 mm rainfall would lead to decrease in 0.082, 0.101 and 0.000 spider population. Whereas increase in 1 per cent morning relative humidity and 1°C maximum temperature would lead to increase in 0.099 and 0.075 spider population, respectively at no lead time. The literature on this particular aspect is lacking to discuss present findings.

During *Rabi* season in general, the correlation between insect pests, natural enemies and weather parameters revealed that all the weather factors under consideration had a significant role on population fluctuations of insect pests *viz*., thrips, leafhoppers, whiteflies and mites while coccinellids and chrysopids with respect to natural enemies.

Acknowledgement:

The authors are thankful to Mr. Dayanand Pujar, a farmer at Hangaraki village of Dharwad district for providing field and the necessary facilities to conduct the experiment.

REFERENCES

Anonymous (1995). *Surveillance of potato aphids and incidence of virus diseases*. AICRP, 24th Annual Report, pp. 118-119.

Anonymous (2016). *Directorate of economics and statistics*, Bengaluru. p. 110.

Basavaraju, B.S., Doddabasappa, B., Shashank, P.R. and Channakesava, R. (2010). Seasonal incidence of mite, *Polyphagotarsonemus latus* Banks (Tarsonemidae: Acarina) on potato in southern transitional zone of Karnataka. *Curr. Biotica*, **4** (2) : 261-266.

Bhatnagar, A. (2007). Insects associated with potato in Madhya Pradesh. *Pest Manag. Hortic. Ecosyst.*, **13** (2) : 172-175.

Biswas, M.K., De, B.K., Nath, P.S. and Mohasin, M. (2004). Influence of different weather factors on the population build up of vectors of potato virus. *Ann. Pl. Protec. Sci*., **12** (2) : 352-355.

Kumar, K.R., Singh, N.N., Raju, S.V.S. and Mishra, V.K. (2017). Influence of abiotic factors on seasonal incidence of brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen. in Varanasi Region. *Int. J. Curr. Microbiol.& Appl. Sci*., **6** (4) : 1513-1518.

Kumar, S. and Singh, D. (2013). Seasonal incidence and economic losses of brinjal shoot and fruit borer *Leucinodes orbonalis* Guen. *Agric. Sci. Digest*., **33** (2) : 98-103.

Naik, C.V., Arjuna R., Krishnayya, P.V. and Chalam, M.S.V. (2009). Seasonal incidence and management of *Bemisia tabaci* Gennadius and *Amrasca biguttula biguttula* Ishida of brinjal. *Ann. Pl. Protec. Sci*., **17** : 9-13.

Nandihalli, B.S., Kuberappa, G.C. and Viswanathappa, K.R. (1996). Survey of insects pests of potato in Hassan, Karnataka. *Mysore J. Agric. Sci*., **30** (2) : 138-141.

Pandey, R., Sharma, K., Chaudhari, D. and Rai, M. (2008). Effect of weather parameters on incidence of *Bemisia tabaci* and *Myzus persicae* on potato. *Ann. Pl. Protec. Sci*., **16** (1) : 78-80.

Sajjan, A.A. (2014). Seasonal incidence and management of brinjal pests with special reference to shoot and fruit borer, *Leucinodes orbonalis* (Guen.). M.Sc. (Ag.) Thesis, University of Agricultural Sciences, Dharwad, Karnataka (India).

Shakya, P.K., Haseeb, M. and Manzoor, U. (2015). Seasonal incidence of *Spodoptera litura* infesting tomato (*Lycopersicum esculentum*). *Biotic environ*., **21** (2&3) : 49-51.

Shukla, A. and Khatri, S.N. (2010). Incidence and abundance of brinjal shoot and fruit borer *Leucinodes orbonalis* Guenee. *The Bioscan*, **5** (2) : 305-308.

Thakur, D. (2017). Seasonal incidence of major insect pests and their management through particle film technology on *Rabi* potato at Raipur. M.Sc. (Ag.) Thesis, Indira Gandhi Krishi Vishwa Vidyalaya, Raipur, Chhattisgarh (India).