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Prediction models for insect pests of potato and their natural enemies based on abiotic factors in Karnataka

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Abstract

Prediction models for insect pests of potato and their natural enemies was studied during *kharif* 2016 and 2017 at AICRP on Potato, MARS, Dharwad in relation to the prevailing as well as the previous (antecedent) four weeks (one/two/three/four lead weeks) weather. The correlation and regression studies between insect pests, natural enemies and weather parameters during *kharif* season indicated that all the weather factors under consideration had no significant role on population fluctuations of insect pests and natural enemies except mites and spiders. Forecasting model for mites depicted that maximum temperature at one week lead time had negative and significant association with the incidence of mites population. Based on prediction model [$Y = 77.81 - 3.205X_3$ (maximum temperature)] we can forecast mite population at one week before incidence upto 35.50 per cent accuracy.

Keywords: Prediction models, potato, insect pests, lead week and mites

1. Introduction

The potato (*Solanum tuberosum* L.) is one of the most important nutritive and staple food crops, which ranks fourth in the production i.e., after rice, wheat and maize and provides whole some food. Because of its high matter, protein content and its versatility to adopt a wide range of climates it holds great potential as food for the millions in the world. Considering the world scenario, potato is being grown in more than 100 countries. China holds the credit of first rank followed by Russia and India. The potato crop is grown under diverse agro-climatic conditions over an area of 20.85 lakh ha with production of 480.96 lakh metric tonnes and productivity of 23.07 t/ha (Anon., 2016) [2]. In North India, about 85 per cent of potatoes are cultivated in Indo-Gangetic plains and 80 per cent of the total production is shared by Uttar Pradesh, West Bengal, Punjab, Bihar and Gujarat states. 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 (Anon., 2016a) [3].

Insect pest menace is one of the major factors that destabilize potato productivity. In India, the potato crop is attacked by a wide diversity of insect pests. The potato crop is damaged by more than 100 arthropod pests (Simpson, 1977) [12] out of which, 80 have been reported from India. The sucking pest's *viz.,* aphids, thrips and leaf hoppers are considered as a major group of sucking pests because of their role as vectors of viral diseases. The specimens collected from potato field were identified as, aphid, *Myzus persicae* (Sulzer), leaf hopper, *Empoasca* spp, whitefly, *Bemisia tabaci* (Gennadius) and thrips, *Scirtothrips dorsalis* Hood, *Thrips palmi* Karny and a new report of thrips, *Bathrips melaniconis* (Shumsher) was identified as a new report of sucking pest on potato in Dharwad district of Northern Karnataka (India) (Natikar *et al*., 2018) [10]. The shoot borer, *Leucinodes orbonalis* (Guenee) has become the most destructive and ubiquitous pest in the recent years causing heavy yield losses in potato crop. The pest was reported from Karnataka as early as 1965 (Nair, 1967) [9]. The larva of *L. orbonalis* attacks the shoots of potato causing withering and wilting of the stem ultimately resulting in retardation of the plant growth. The changing scenario of insect pest problems in agriculture as a consequence of green revolution technology has been well documented. There has been further shift in the status of several insect pests after the introduction of transgenic crops and the current scenario of climate change. Generally the pest build up at any time is the result of interaction between pest and weather during previous 1-4 weeks. The correlation studies carried out using such data will help to predict the pest population at least 1-4 weeks in

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advance based on the weather parameters. This will help to adopt control measures in time and suppress it before it causes economic damage. Hence, a study was conducted for two years to know the seasonal incidence of insect pests of potato and to analyze the prevailing weather as well as the weather during the previous (antecedent) four weeks (one/two/three/four lead (previous) weeks).

2. Materials 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 AICRP on Potato, MARS, dharwad with a spacing of 60 × 20 cm during *kharif* 2016 and 2017, respectively.

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

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

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 (Anon., 1995)[1]. 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)[4]. 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 *kharif* 2016 and 2017 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.

3. Results and Discussion

Potato shoot borer, *Leucinodes orbonalis*

Correlation for shoot borer in potato showed a positive and non-significant association with morning relative humidity (r= 0.043), evening relative humidity (r= 0.114), minimum temperature (r= 0.068) and rainfall (r= 0.293) whereas, a negative and non-significant correlation was exhibited with maximum temperature (r= -0.264) at 2 weeks lead time (Table 1).

The regression analysis showed R^2 value of 0.166 indicating 16.60 per cent influence of abiotic factors on shoot borer incidence at 2 weeks lead time. The multiple regression equation fitted with weather parameters and shoot infestation is as follows:

$Y = 50.01 - 0.715X_1 + 0.254X_2 - 1.626X_3 + 2.459X_4 + 0.079X_5$ for L_2 (Lead week 2)

The results indicated that the decrease in 1 per cent morning relative humidity and 1 °C maximum temperature would lead to decrease in 0.715 and 1.626 per cent shoot infestation.

The present findings are in conformity with Patel *et al*. (1988) [11] who reported, that the high relative humidity, heavy rainfall and variation in maximum and minimum temperature provided congenial conditions for the build-up of *L. orbonalis* population on brinjal. Naik *et al*., 2008[8] reported non-significant relationship between the shoot damage in brinjal and abiotic factors like relative humidity, temperature and rainfall. Further, the coefficient of determination (R^2) for shoot borer incidence was 0.4569, which shows that the abiotic and biotic factors together were able to explain the variation in the incidence of *L. orbonalis* to the extent of 45 per cent at Bapatla.

Aphid, *Myzus persicae*

Correlation matrix for aphid (number per compound leaf) exhibited a positive and non-significant association with minimum temperature (r= 0.160) and rainfall (r = 0.095) whereas, a negative and non-significant correlation was exhibited with morning relative humidity (r= -0.107), evening relative humidity (r= -0.164) and maximum temperature (r= -0.269) at 2 weeks lead time (Table 1).

Regression analysis showed R^2 value of 0.214 indicating 21.40 per cent influence of weather parameters on aphid incidence at 2 weeks lead time. The multiple regression equation fitted with weather parameters and aphid population is as follows:

$Y = 8.4 - 0.160X_1 - 0.114X_2 - 1.061X_3 + 2.466X_4 + 0.013X_5$ for L_2 (Lead week 2)

The results indicated that the decrease in 1 per cent morning relative humidity, evening relative humidity and 1 °C maximum temperature would lead to decrease in 0.160, 0.114 and 1.061 aphid population. Whereas increase in 1 °C minimum temperature and 1 mm rainfall would lead to increase in 2.466 and 0.013 aphid population, respectively at 2 weeks lead time. The present findings are in agreement with the report of Ebwongu *et al*. (2001) [5] who reported that, the correlation studies registered negative correlation of relative humidity with the aphid incidence.

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

The incidence of thrips was non-significantly and negatively correlated with evening relative humidity (r= -0.027) and maximum temperature (r= -0.408) and positively correlated with morning relative humidity (r= 0.019), minimum temperature (r= 0.073) and rainfall (r= 0.160) at 2 weeks lead time (Table 1). The incidence of thrips was influenced to an extent of 24.00 per cent by all-weather parameters at 2 weeks lead time. The multiple regression equation fitted with weather parameters and thrips population is as follows:

$Y = 2.90 + 0.361X_1 - 0.219X_2 - 1.000X_3 + 0.651X_4 + 0.010X_5$

for L_2 (Lead week 2) The results indicated that the decrease in 1 per cent evening relative humidity and 1 °C maximum temperature would lead to decrease in 0.219 and 1.00 thrips population. The work done on the correlation studies with respect to thrips population is very scanty and hence cannot be compared.

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

The morning relative humidity (r= -0.143), evening relative humidity (r= -0.006), minimum temperature (r= -0.262) and rainfall (r= -0.175) had non-significant negative correlation with pest incidence whereas maximum temperature (r= 0.287) showed non-significant positive correlation with leafhopper population at no lead time. The overall impact of weather factors on pest incidence was 36.40 per cent at no lead time (Table 1). The multiple regression equation fitted with weather parameters and leafhopper population is as follows:

$Y = 38.66 - 0.161X_1 + 0.171X_2 + 1.580X_3 - 3.692X_4 - 0.040X_5$

for L_0 (Lead week 0) The results revealed that the decrease in 1 per cent morning relative humidity, 1 °C minimum temperature and 1 mm rainfall would lead to decrease in 0.161, 3.692 and 0.040 leafhopper population. The present results are in accordance with Naik *et al.* (2009) [7] who opined that, leafhopper had negative and non-significant correlation with relative humidity (morning and evening) and rainfall.

Whitefly, *Bemisia tabaci*

Correlation studies for incidence of whitefly showed negative and non-significant correlation with morning relative humidity (r= -0.288), evening relative humidity (r= -0.132), maximum temperature (r= -0.063) and rainfall (r= -0.047) whereas, a positive and non-significant correlation was exhibited with minimum temperature (r= 0.018) at 3 weeks lead time (Table 1).

Regression analysis showed R^2 value of 0.199 indicating 19.90 per cent influence of weather parameters on whitefly incidence at 3 weeks lead time. The multiple regression equation fitted with weather parameters and whitefly population is as follows:

$Y = 16.97 - 0.620X_1 + 0.259X_2 - 0.174X_3 + 1.231X_4 - 0.012X_5$

for L_3 (Lead week 3) The results indicated that the decrease in 1 per cent morning relative humidity, 1 ºC maximum temperature and 1 mm rainfall would lead to decrease in 0.620, 0.174 and 0.012 whitefly population. The results of present investigations are comparable with the work of Ghosh *et al.* (2004) [6] who concluded by correlation studies and revealed that there existed a non-significant and negative correlation with average humidity and weekly rainfall.

Mite, *Polyphagotarsonemus latus*

The incidence of mite showed significantly negative correlation with maximum temperature (r= -0.508) and non-significant negative correlation with morning relative humidity (r= -0.195), evening relative humidity (r= -0.205), minimum temperature (r= -0.078) and rainfall (r= -0.025) at 1 weeks lead time (Table 1). The overall impact of abiotic factors on mite population was 35.30 per cent at 1 weeks lead time. The multiple regression equation fitted with weather parameters and mite population is as follows:

$Y = 77.81 - 0.460X_1 - 0.126X_2 - 3.205X_3 + 3.622X_4 + 0.016X_5$

for L_1 (Lead week 1)

The results indicated that the decrease in 1 per cent morning relative humidity, evening relative humidity and 1 °C maximum temperature would lead to decrease in 0.460, 0.126 and 3.205 mite population. Whereas increase in 1 °C minimum temperature and 1 mm rainfall would lead to increase in 3.622 and 0.016 mite population, respectively at 2 weeks lead time. These results are in agreement with the findings of Sontakke *et al.* (1989) [13] who reported that the variation in the incidence of *P. latus* on potato crop grown in different seasons in Orissa was due to climatic factors, especially the atmospheric humidity.

Defoliator, *Spodoptera litura*

Correlation matrix for *S. litura* (larvae/mrl) incidence in potato crop revealed positive and non-significant correlation with evening relative humidity (r= 0.050), minimum temperature (r= 0.140) and rainfall (r= 0.288), whereas morning relative humidity (r= -0.025), maximum temperature (r= -0.305) showed negative and non-significant correlation with defoliator population at 2 weeks lead time (Table 1).

Regression analysis showed R^2 value of 0.249 indicating 24.90 per cent influence of weather parameters on defoliator incidence at 2 weeks lead time. The multiple regression equation fitted with weather parameters and defoliator population is as follows:

$Y = 16.14 - 0.453X_1 + 0.148X_2 - 0.724X_3 + 1.799X_4 + 0.020X_5$

for L_2 (Lead week 2) The results indicated that the decrease in 1 per cent morning relative humidity and 1 °C maximum temperature would lead to decrease in 0.453 and 0.724 defoliator population. There are no earlier works pertaining to correlation studies with respect to *S. litura* in potato.

Coccinellid, *Cheilomenes sexmaculata*

Correlation studies for incidence of coccinellids showed positive and non-significant correlation with morning relative humidity (r= 0.043), evening relative humidity (r= 0.030), minimum temperature (r= 0.286) and rainfall (r= 0.371) whereas, a negative and non-significant correlation was exhibited with maximum temperature (r= -0.318) at 2 weeks lead time. All the weather factors together influenced the coccinellids to the tune of 35.90 per cent at 2 weeks lead time (Table 1). The multiple regression equation fitted with weather parameters and coccinellid population is as follows:

$Y = -0.02 - 0.030X_1 - 0.004X_2 - 0.145X_3 + 0.362X_4 + 0.006X_5$

for L_2 (Lead week 2) The results indicated that the decrease in 1 per cent morning relative humidity, evening relative humidity and 1 °C maximum temperature would lead to decrease in 0.030, 0.004 and 0.145 coccinellid population. The literature on this particular aspect is lacking to discuss present findings.

Chrysopids, *Chrysoperla* sp.

The incidence of chrysopids showed non-significant positive correlation with morning relative humidity (r= 0.087), evening relative humidity (r= 0.031), minimum temperature (r= 0.367) and rainfall (r= 0.303) whereas, a negative and non-significant correlation was exhibited with maximum temperature (r= -0.361) at 2 weeks lead time (Table 1).

Regression analysis showed R^2 value of 0.399 indicating 39.90 per cent influence of weather parameters on chrysopid incidence at 2 weeks lead time. The multiple regression equation fitted with weather parameters and chrysopid population is as follows:

$Y = -2.37 - 0.025X_1 - 0.004X_2 - 0.134X_3 + 0.401X_4 - 0.001X_5$

for L_2 (Lead week 2) The results revealed that the decrease in

1 per cent morning relative humidity, evening relative humidity and 1 °C maximum temperature would lead to decrease in 0.025, 0.004 and 0.134 chrysopid population. The literature on this particular aspect is lacking to discuss present findings.

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

The morning relative humidity (r= -0.174), evening relative humidity (r = -0.227) and rainfall (r= -0.311) had non-significant negative correlation with pest incidence whereas maximum temperature (r= 0.426) showed significant positive correlation with spider population at 4 weeks lead time (Table 1). The overall impact of abiotic factors on spider population was 26.60 per cent at 4 weeks lead time. The multiple regression equation fitted with weather parameters and spider population is as follows:

$$Y = -3.84 - 0.010X_1 + 0.000X_2 + 0.209X_3 - 0.009X_4 - 0.010X_5$$

for L_4 (Lead week 4) The results revealed that the decrease in 1 per cent morning relative humidity, 1 mm rainfall and 1 °C minimum temperature would lead to decrease in 0.010 each and 0.009 of spider population, respectively. Whereas, 1 °C increase in maximum temperature would lead to increase in 0.209 spider population at 4 weeks lead time. The literature on this particular aspect is lacking to discuss present findings.

Table 1: Correlation coefficients for insect pests and natural enemies in potato with abiotic factors during *kharif* 2016 and 2017

Insect pests/Natural enemies	Lead week	RHm (X_1)	RHe (X_2)	MaxT (X_3)	Min T (X_4)	RF (X_5)	R^2	Regression equation
Y_1 Shoot borer (% shoot infestation)	4	-0.145	-0.090	-0.046	-0.018	0.034	0.046	Y= 61.14-1.024X_1+0.254X_2-0.723X3+2.138X_4+0.039X_5
	3	-0.144	-0.017	-0.167	0.017	0.093	0.131	Y= 69.40-1.489X_1+0.555X_2-1.397X_3+3.465X_4+0.044X_5
	2	0.043	0.114	-0.264	0.068	0.293	0.166	Y= 50.01-0.715X_1+0.254X_2-1.626X_3+2.459X_4+0.079X_5
	1	-0.039	0.023	-0.225	0.020	0.212	0.126	Y= 56.15-0.710X_1+0.158X_2-1.620X_3+2.523X_4+0.083X_5
	0	0.034	0.033	-0.153	-0.118	0.040	0.042	Y= -48.53+0.761X_1-0.334X_2-0.512X_3-3.059X_4+0.049X_5
Y_2 Aphids (No’s/three leaves)	4	-0.281	-0.345	-0.047	0.077	-0.199	0.159	Y= 10.45-0.238X_1-0.105X_2-0.615X_3+2.110X_4-0.010X_5
	3	-0.276	-0.281	-0.172	0.113	-0.142	0.205	Y= 14.26-0.422X_1-0.002X_2-0.900X_3+2.701X_4-0.010X_5
	2	-0.107	-0.164	-0.269	0.160	0.095	0.214	Y= 8.41-0.160X_1-0.114X_2-1.061X_3+2.466X_4+0.013X_5
	1	-0.185	-0.246	-0.231	0.114	0.002	0.202	Y= 11.16-0.176X_1-0.128X_2-1.038X_3+2.434X_4+0.012X_5
	0	-0.138	-0.243	-0.171	0.023	-0.170	0.124	Y= 2.74+0.158X_1-0.222X_2-0.717X_3+1.339X_4-0.010X_5
Y_3 Thrips (No’s/three leaves)	4	-0.197	-0.255	-0.152	-0.035	0.221	0.137	Y= 17.21+0.347X_1-0.277X_2-0.409X_3-0.494X_4-0.025X_5
	3	-0.195	-0.175	-0.295	0.009	-0.143	0.165	Y= 16.58-0.141X_1-0.015X_2-0.797X_3+1.155X_4-0.018X_5
	2	0.019	-0.027	-0.408	0.073	0.160	0.240	Y= 2.90+0.361X_1-0.219X_2-1.000X_3+0.651X_4+0.010X_5
	1	-0.077	-0.131	-0.363	0.013	0.039	0.206	Y= 8.85+0.359X_1-0.252X_2-0.953X_3+0.447X_4-0.006X_5
	0	-0.171	-0.138	-0.184	-0.224	-0.028	0.079	Y= 35.42+0.084X_1-0.117X_2-0.189X_3-1.197X_4-0.018X_5
Y_4 Leaf hoppers (No’s/three leaves)	4	-0.271	-0.135	0.400	-0.012	-0.043	0.323	Y= 32.54-0.654X_1+0.270X_2+1.371X_3-1.341X_4-0.036X_5
	3	-0.266	-0.042	0.243	0.036	-0.069	0.292	Y= 25.52-1.126X_1+0.547X_2+0.696X_3+0.884X_4-0.042X_5
	2	-0.015	0.130	0.105	0.0105	0.222	0.127	Y= 11.76-0.758X_1+0.358X_2+0.207X_3+1.279X_4+0.015X_5
	1	-0.131	0.010	0.165	0.040	0.099	0.114	Y= 22.53-0.818X_1+0.338X_2+0.393X_3+0.871X_4+0.001X_5
	0	-0.143	-0.006	0.287	-0.262	-0.175	0.364	Y= 38.66-0.161X_1+0.171X_2+1.580X_3-3.692X_4-0.040X_5
Y_5 Whiteflies (No’s/three leaves)	4	-0.310	-0.233	0.113	-0.055	-0.131	0.123	Y= 18.09-0.405X_1+0.126X_2+0.137X_3+0.343X_4-0.009X_5
	3	-0.288	-0.132	-0.063	0.018	-0.047	0.199	Y= 16.97-0.620X_1+0.259X_2-0.174X_3+1.231X_4-0.012X_5
	2	-0.091	-0.001	-0.156	0.007	0.178	0.129	Y= 13.16-0.454X_1+0.170X_2-0.312X_3+1.208X_4+0.005X_5
	1	-0.179	-0.086	-0.132	-0.001	0.136	0.118	Y= 18.67-0.394X_1+0.111X_2-0.271X_3+0.847X_4+0.012X_5
	0	-0.035	-0.064	-0.015	-0.168	-0.016	0.096	Y= 14.35+0.436X_1-0.220X_2+0.283X_3-2.024X_4-0.016X_5
Y_6 Mites (No’s/leaf)	4	-0.286	-0.305	-0.332	-0.119	-0.233	0.253	Y= 76.35-0.793X1-0.012X2-2.617X3+3.977X4-0.028X5
	3	-0.269	-0.236	-0.461*	-0.063	-0.172	0.348	Y= 81.65-0.871X1+0.073X2-3.052X3+4.275X4-0.014X5
	2	-0.132	-0.145	-0.517*	-0.020	0.019	0.351	Y= 67.84-0.512X1-0.049X2-3.155X3+3.975X4-0.006X5
	1	-0.195	-0.205	-0.508*	-0.078	-0.025	0.353	Y= 77.81-0.460X1-0.126X2-3.205X3+3.622X4+0.016X5
	0	-0.173	-0.224	-0.460*	-0.170	-0.202	0.276	Y= 62.49-0.020X1-0.243X2-2.814X3+2.428X4-0.021X5
Y_7 Defoliator, *S. litura* ((No. of larvae/mrl)	4	-0.235	-0.180	-0.057	0.050	-0.021	0.123	Y= 18.06-0.592X1+0.172X2-0.470X3+1.912X4+0.003X5
	3	-0.235	-0.102	-0.189	0.083	0.042	0.223	Y= 21.80-0.644X1+0.221X2-0.601X3+1.925X4+0.008X5
	2	-0.025	0.050	-0.305	0.140	0.288	0.249	Y= 16.14-0.453X1+0.148X2-0.724X3+1.799X4+0.020X5
	1	-0.121	-0.057	-0.255	0.091	0.177	0.204	Y= 16.38-0.480X1+0.138X2-0.731X3+1.969X4+0.017X5
	0	-0.025	-0.031	-0.176	-0.060	-0.015	0.034	Y= 12.32-0.002X1-0.020X2-0.405X3+0.275X4+0.003X5
Y_8 Coccinellids (No’s/plant)	4	-0.197	-0.232	-0.035	0.216	-0.005	0.186	Y= -0.31-0.073X1+0.009X2-0.110X3+0.475X4+0.001X5
	3	-0.217	-0.165	-0.154	0.219	0.051	0.249	Y= 0.98-0.085X1+0.017X2-0.118X3+0.438X4+0.002X5
	2	0.043	0.030	-0.318	0.286	0.371	0.359	Y= -0.02-0.030X1-0.004X2-0.145X3+0.362X4+0.006X5
	1	-0.076	-0.113	-0.232	0.253	0.172	0.271	Y= -0.79-0.045X1+0.001X2-0.146X3+0.454X4+0.003X5
	0	-0.197	-0.232	-0.035	0.216	-0.005	0.082	Y= -1.97+0.034X1-0.020X2-0.094X3+0.177X4+0.001X5
Y_9 Chrysopids (No’s/plant)	4	-0.184	-0.274	-0.011	0.266	-0.197	0.218	Y= -2.31-0.046X1+0.007X2-0.082X3+0.412X4+0.003X5
	3	-0.194	-0.180	-0.183	0.293	-0.107	0.320	Y= -1.55-0.074X1+0.025X2-0.101X3+0.455X4+0.002X5
	2	0.087	0.031	-0.361	0.367	0.303	0.399	Y= -2.37-0.025X1-0.004X2-0.134X3+0.401X4-0.001X5
	1	-0.038	-0.120	-0.278	0.316	0.098	0.330	Y= -2.52-0.033X1+0.005X2-0.136X3+0.448X4+0.000X5
	0	-0.011	-0.062	-0.055	0.169	0.119	0.091	Y= -1.16-0.013X1-0.005X2-0.064X3+0.235X4+0.002X5
Y_{10} Spiders (No’s/plant)	4	-0.174	-0.227	0.426*	0.162	-0.311	0.266	Y= -3.84-0.010X1+0.000X2+0.209X3-0.009X4-0.010X5
	3	-0.186	-0.142	0.266	0.184	-0.229	0.250	Y= -3.22-0.189X1+0.095X2+0.116X3+0.497X4-0.011X5
	2	0.080	0.056	0.080	0.258	0.193	0.101	Y= -4.26-0.097X1+0.045X2+0.028X3+0.447X4+0.003X5
	1	-0.039	-0.086	0.173	0.209	-0.026	0.076	Y= -4.16-0.104X1+0.043X2+0.046X3+0.460X4-0.002X5
	0	0.068	0.024	0.391	0.090	0.108	0.230	Y= -2.15+0.136X1-0.062X2+0.279X3-0.601X4+0.006X5

* - Significant at P=0.05

4. Conclusion

In general, the correlation between insect pests, natural enemies and weather parameters during *kharif* season in potato crop indicated that all the weather factors under consideration had no significant role on population fluctuations of insect pests and natural enemies except for mites and spiders, respectively.

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