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Population dynamics of insect pests and influence of weather parameters on their population in cabbage crop

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ABSTRACT: An investigation was carried out to study the population dynamics of some cabbage pests, viz., cabbage aphid (*Brevicoryne brassicae*), tobacco caterpillar (*Spodoptera litura*) and gram pod borer (*Helicoverpa armigera*) and the effect of weather parameters on them at Vegetable Research Centre of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar during *Rabi* 2020. During the crop season aphid population marked its appearance in the 46th MSW (2nd week of November) with 1.05 aphids per plant, which progressively touched its peak in the 2nd MSW (2nd week of January) with 111.97 aphids per plant. Tobacco caterpillar and Gram-pod borer were both recorded first time in the 47th MSW (0.46 and 0.39 larvae/ plant, respectively) that gradually reached its peak in the 4th MSW (2.96 and 2.64 larvae/plant, respectively). Correlation studies revealed that aphid population was positively affected by morning and evening humidity (r = 0.778 and 0.853, respectively), wind velocity (r = 0.607) and rainfall (r = 0.277) whereas a negative impact was observed with minimum and maximum temperature, i.e., r = -0.527 and -0.832, evaporation and sunshine hours (r = -0.702). In case of Tobacco caterpillar rainfall (r = 0.303), wind velocity (r = 0.369) and morning relative humidity (r = 0.813) had a positive correlation with the pest population whereas minimum temperature (r = -0.588), maximum temperature (r = -0.802), evaporation (r = -0.658) and sunshine hours (r = -0.677) have had a negative correlation. Gram-pod borer population was positively associated with morning relative humidity (r = 0.825), evening relative humidity (r = 0.771), wind velocity (r = 0.381) and rainfall (r = 0.344) whereas maximum temperature (r = -0.768), minimum temperature (r = -0.556), evaporation (r = -0.627) and sunshine hours (r = -0.647) were in a negative correlation.

Key words: Abiotic parameter, cabbage, correlation, population dynamics, regression equation

Cabbage (*Brassica oleracea* var. *capitata*) is one of the most important cruciferous vegetables in India as well as globally. It would probably be due to the richness of minerals and vitamins A, B1, B2 and C (Anonymous, 2014). The plant develops in about 90-120 days to form 'head' which is a compact globular mass of soft and crumpled leaves draped over one another enclosing the cabbage inflorescence in between them. India is ranked 2nd among the cabbage producers with a production of 9.207 million tonnes (Mt) from 0.397 million hectares of area under cabbage cultivation. West Bengal, Orissa, Madhya Pradesh, Bihar and Assam are the top cabbage producer states in India with 2.288, 1.059, 0.687, 0.673 and 0.640 Mt of production respectively, whereas Uttarakhand has a very low (0.067 Mt) production status in comparison to these cabbage growing states (Anonymous, 2018). This difference may be due to several limiting factors ranking insect pests as the major factor in reducing the production of cabbage. Various insect pests of cabbage, viz. cabbage aphid, tobacco caterpillar, gram pod borer etc. causes a considerable loss to cabbage (Pandey *et al.,* 2006; Dhawan and Matharu, 2011; Pal and Singh, 2013; Gautam *et al.,* 2018; Tran and Nguyen, 2019), i.e., up-to 40% of the total yield of vegetables and nearly 60-80% on an average yield loss in crucifer crops. Measures to reduce the crop damage should be taken before the insect population reaches the economic injury level, which could be well achieved when the pest incidence time, population dynamics and its correlation with weather factors are already known. This is because both abiotic and biotic factors greatly influence the seasonal variations in pest population.

MATERIALS AND METHODS

The experiments on population dynamics of cabbage

aphid (*B. brassicae*), tobacco caterpillar (*S. litura*), gram pod borer (*H. armigera*) and their relation to abiotic parameter were performed at Vegetable Research Centre (VRC) of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand during *Rabi* 2020. The experiment was laid out in three replications/plots (each of size, 5m × 5m = 25m^2). Observations on the population of sucking pests as well as foliage eating pests were recorded from outer, middle and inner leaves of the five plants selected randomly in each replication (Mane *et al.*, 2020). The meteorological data were also collected throughout the crop season from the meteorological observatory of Department of Agro-meteorology, College of Agriculture, G. B. Pant University of Agriculture and Technology, Pantnagar.

Population dynamics of cabbage aphid, tobacco caterpillar and gram pod borer were represented by taking weekly mean pest population against weekly weather data whereas for the calculation of correlation coefficient, daily insect population data was plotted against daily weather data. Multiple linear regression was also performed on the daily data in Microsoft Excel software to establish predictive relationship between insect population and weather parameters. The following is a standard multiple linear regression equation:

$$Y = B_0 + B_1X_1 + ...+ B_nX_n$$

Where,

Y = Predicted or expected value of the dependent variable,

X_1 to X_n = n distinct independent or predictor variables,

B_0 = value of Y when all of the independent variables (X_1 through X_n) are equal to zero,

B_1 to B_n = estimated regression coefficients.

RESULTS AND DISCUSSION

Population dynamics of cabbage aphid during the observation period

The weekly mean population of cabbage aphid (*B. brassicae*) on cabbage crop along with meteorological observation during *Rabi* 2020 has been presented with the help of Table 1 and Figure 1. The data showed that the population of *B. brassicae* appeared first on the second week of November i.e., 46th Metrological Standard Week (MSW) with a scanty population of 1.05 aphids/plant which gradually increased and reached at its peak in the 2nd week of January (2nd MSW), i.e., 111.97 aphids/plant at 18.7°C maximum and 8.7°C minimum temperatures, 84.1% relative humidity and 3.89 sunshine hours per day. However, it decreased up to 86.97 aphids/plant during 3rd MSW which was followed by gradual increase of population i.e., up to 99.05 aphids/plant in the month of February (6th MSW), prior to harvesting of the crop. The above found results were in accordance with Sain *et al.* (2017) who reported the peak of cabbage aphid during 3rd week of December (95.40 aphid/plant) in 2012. Raut (2020) recorded the aphid population on cabbage from 2nd week of December (50th MSW) of 2017 followed by its peak in January (1st MSW) 2018 and drop down in population at the end of January (4th MSW) 2018, however its 2nd peak was also recorded during mid of March (10th MSW) 2018 at the instructional farm of Uttar Banga Krishi Vishwavidyalaya, Pundibari, Cooch Behar.

Population dynamics of tobacco caterpillar during observation period

The data recorded on seasonal incidence of foliage feeding insect pests on cabbage (Table 1 and Figure 1) showed that among the defoliators, Tobacco caterpillar (*S. litura*) was first appeared in the 47th MSW (19th to 25th November) with a minimum population of 0.46 larvae/plant which gradually increased to 2.49 larvae/plant in the 1st MSW of 2021. However, the *S. litura* larvae sustained up to 6th MSW (5th to 11th February) into the cabbage field. Overall its peak was recorded in 4th MSW (2.96 larvae/plant) of 2021. These results were in agreement with the findings of Reddy *et al.* (2016) who reported that the incidence of *S. litura* was first noted in 47th MSW of *Rabi* 2013 while in *Rabi* 2014 the first appearance was recorded in 48th MSW, however a maximum population was recorded in the 5th MSW (3.34 larvae/plant) and 6th MSW (3.41 larvae/plant) respectively. Lal *et al.* (2020) recorded

the infestation of *S. litura* in cabbage crop during 1st MSW of 2017 which reached its peak population in the last week of February 2017 (4.25 larvae per five plant).

Population dynamics of gram pod borer during observation period

The first appearance of Gram pod borer, *H. armigera* (0.39 larvae/plant) in cabbage experimental plot was observed (Table 1 and Figure 1) during 47th MSW (19th to 25th November) and afterwards a gradual increase was perceived and a population of 2.13 larvae/plant was attained by the 1st MSW (1st to 7th January). However a sudden decrease in *H. armigera* population (1.89 larvae/plant) was observed in the 2nd MSW (8th to 14th January) which again increased and reached its peak population i.e. 2.64 larvae per plant recorded in 4th MSW. The results were in conformity with the findings of Sahu *et al.* (2019) where *H. armigera* caterpillars were first observed in 3rd week of December (51st MSW) at the head formation stage and remained up-to mid of February (6th MSW). Patel (2004) noticed the incidence of *H. armigera* on cabbage crop with a larval population of 0.10 and 0.08 larvae per plant in 48th MSW (26th November – 2nd December) during 2000 and in 45th MSW (5th to 11th November) during 2001, respectively, in Anand Agricultural University, Anand (Gujarat).

Relationship of cabbage aphid population with weather parameters

Correlation was worked out (Table 2 and Figure 2) between the *B. brassicae* population and weather parameters, recorded on daily basis, revealed that there was a significant positive association between aphid incidence and evening humidity (r = 0.853**), wind velocity (r = 0.607**) and rainfall (r = 0.277**) whereas a significant negative correlation was obtained with minimum temperature (r = -0.527**) and sunshine hours (r = -0.702**). However, there was non-significant positive correlation of *B. brassicae* with morning relative humidity (r = 0.778) and non-significant negative correlation with maximum temperature (r = -0.832) and evaporation (r = -0.638). The studies done by Atwal *et al.* (1971) found that aphid population was adversely affected

Table 1: Seasonal incidence of some insect pests on cabbage at VRC, Pantnagar during *Rabi* 2020

(**MSW** = Meteorological Standard Week, **Max.** = Maximum, **Min.** = Minimum.)

Date	MSW	Temperature (°C))		Relative Humidity (%)		Rainfall (in mm)	Evaporation (in mm)	Wind velocity (Km/hr.)	Sun-shine Hours	Mean number of aphids/ plants	Mean number of larvae/plant	
		Max.	Min.	Morning (at 07:12 AM)	Evening (at 02:12 PM)						Tobacco caterpillar	Gram pod borer
5th-11th Nov	45	28.5	12.3	88.6	37.1	0.00	3.46	1.26	6.29	0.00	0.00	0
12th-18th Nov	46	28.5	11.3	92.1	36.3	0.00	2.99	1.89	8.14	1.05	0.00	0
19th-25th Nov	47	25.1	8.7	92.9	43.1	0.00	2.87	2.19	7.49	4.31	0.46	0.39
26th Nov-2nd Dec	48	25.0	8.6	93.9	42.4	0.00	2.20	0.99	6.06	5.98	0.98	0.87
3rd-9th Dec	49	25.7	10.1	94.0	50.0	0.00	2.71	1.31	6.44	17.94	1.02	0.99
10th-16th Dec	50	20.8	9.7	93.4	66.6	0.36	1.71	3.40	3.31	52.23	1.31	1.01
17th-23rd Dec	51	16.0	4.1	95.3	65.4	0.00	1.01	2.54	3.11	67.83	1.72	1.18
24th-31st Dec	52	21.2	4.4	96.3	51.9	0.00	1.49	1.80	5.47	68.12	2.06	1.82
1st-7th Jan	1	20.3	9.2	94.3	62.0	2.66	2.10	2.76	3.07	86.01	2.49	2.13
8th-14th Jan	2	18.7	8.7	96.7	71.6	0.00	2.04	5.64	3.89	111.97	2.11	1.89
15th-21st Jan	3	18.2	7.5	95.9	69.3	0.00	1.70	2.70	3.69	86.97	2.16	2.04
22nd-28th Jan	4	16.6	8.8	96.4	75.3	0.00	1.54	2.77	1.60	87.25	2.96	2.64
29th Jan-4th Feb	5	18.8	6.1	95.7	60.6	0.00	1.84	1.06	4.53	90.21	2.63	2.24
5th-11th Feb	6	23.7	7.8	94.3	53.0	0.66	2.71	2.80	6.69	99.05	2.84	2.46

Table 2: Correlation coefficients between pest population and various weather parameters

Correlation coefficients	Temperature (^{0}C)		Relative Humidity (%)		Rainfall (in mm)	Evaporation (in mm)	Wind velocity (Km/hr.)	Sun-shine Hours
	Maximum	Minimum	Morning (at 07:12 AM)	Evening (at 02:12 PM)				
Mean number of aphids/plants	-0.811	-0.523	0.766	0.835	0.282	-0.615	0.603	-0.676
Mean number of tobacco caterpillar/plant	-0.785	-0.566	0.794	0.774	0.318	-0.633	0.354	-0.667
Mean number of gram pod borer/plant	-0.744	-0.512	0.794	0.755	0.299	-0.582	0.347	-0.633

Table 3: Regression equations for insect pests recorded from cabbage crop at VRC during *Rabi* 2020

Sl. No.	Name of the pest	Regression equation	R^2 value
1	Cabbage aphid	$Y = 9.237 - 4.309X_1 - 0.637X_2 + 1.078X_3 + 0.611X_4 + 4.357X_5 + 2.584X_6 + 1.174X_7 - 3.340X_8$	0.584
2	Tobacco caterpillar	$Y = (-0.022) - 0.091X_1 - 0.027X_2 + 0.029X_3 + 0.017X_4 + 0.142X_5 + 0.062X_6 - 0.020X_7 - 0.088X_8$	0.561
3	Gram pod borer	$Y = (-0.940) - 0.065X_1 - 0.008X_2 + 0.032X_3 + 0.014X_4 + 0.146X_5 + 0.052X_6 - 0.026X_7 - 0.136X_8$	0.529

Where,
X_1 = Maximum temperature, X_2 = Minimum temperature, X_3 = Maximum relative humidity, X_4 = Minimum relative humidity, X_5 = Rainfall, X_6 = Evaporation, X_7 = Wind velocity and X_8 = Sunshine hours.

by the rising temperature, however Sachan and Srivastava (1972) reported positive effect of temperature on aphid population after the end of winter season. Kulat *et al.* (1996) noticed that the aphid activity increases with the maintenance of ambient temperature with high humidity in the month of January. Choudhuri *et al.* (2001) observed a positive correlation of aphid population with average relative humidity. Bana *et al.* (2012) noted a significant negative correlation of aphid population with maximum and minimum temperature.

Relationship of tobacco caterpillar population with weather parameters

The correlation studies between incidence of *S. litura* and the weather parameters (Table 2 and Figure 3) revealed that there was a significant positive association of the larval population with rainfall ($r = 0.303^{**}$) and wind velocity ($r = 0.369^{**}$) whereas a significant negative correlation was observed with minimum temperature ($r = -0.588^{**}$) and sunshine hours ($r = -0.677^{**}$). However, the population of *S. litura* was in non-significantly positive and negative correlation with morning relative humidity (r = 0.813), maximum temperature (r = -0.802) and evaporation (r = -0.658) respectively. A significant negative correlation of larval population of tobacco caterpillar with maximum temperature and sunshine hours has also been recorded by Reddy *et al.* (2016) However, there was a significant positive correlation of *S. litura* with minimum temperature, while with relative humidity; it was having a non-significant positive correlation. However, in another study conducted by Khan and Talukder (2017), it was observed that there was a positive correlation of *S. litura* population with maximum and minimum temperature.

Relationship between gram pod borer populations and weather parameters

The correlation worked out between the incidence of *H. armigera* and weather parameters (Table 2 and Figure 4) discovered that there was a significant positive association of *H. armigera* with evening relative humidity ($r = 0.771^{**}$), wind velocity ($r = 0.381^{**}$) and rainfall ($r = 0.344^{**}$) whereas a significant negative correlation was recorded with maximum temperature ($r = -0.768^{**}$) and sunshine hours ($r = -0.647^{**}$). Furthermore, incidence of pest showed a non-significant positive correlation with morning relative humidity (r = 0.825) but non-significant negative correlation with minimum

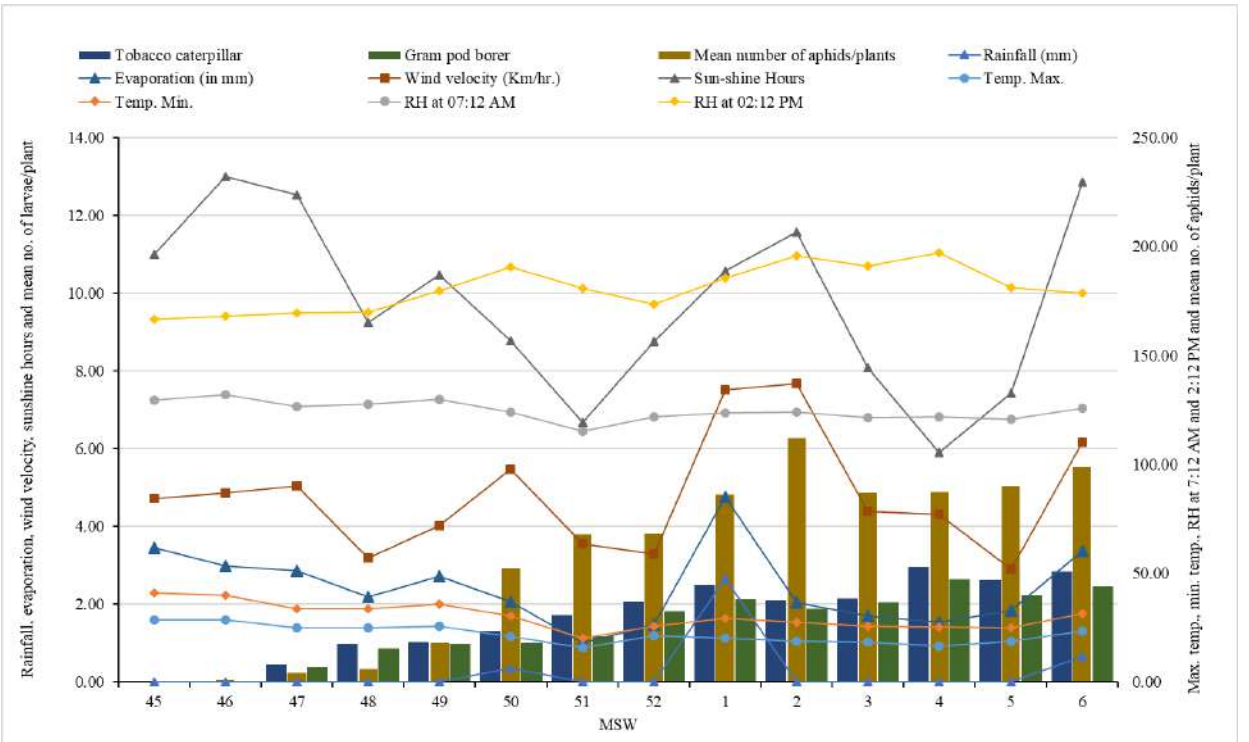

Fig. 1: Dynamics of insect pest during *Rabi* 2020 at Vegetable Research Centre, Pantnagar

temperature (r = -0.556) and evaporation (r = -0.627). Above results were confirmed with the works of Bhure *et al.* (2015) who reported a non-significant negative correlation of *H. armigera* larval population with maximum temperature, minimum temperature, average temperature and sunshine hours, while a non-significant correlation was seen with morning relative humidity, evening relative humidity and average relative humidity, whereas wind velocity had a significant positive correlation with cabbage head eating caterpillar population on cabbage.

Regression equations for estimating the dependency of pest population on weather parameters

Multiple linear regression was worked out for population of cabbage aphid, tobacco caterpillar and gram pod borer with the weather parameters to establish following equations (Table 3)

After performing regression analysis on the daily data, R^2 value thus obtained for the population of different pests suggested that 58.4% values of cabbage aphid, 56.1% values of tobacco caterpillar and 52.9 % values of gram pod borer population could be predicted for any new set of values of weather parameters by substituting the values in the regression equations obtained after following the multiple regression protocol.

CONCLUSION

In the present study it was found that all the three pest viz., cabbage aphid, tobacco caterpillar and gram pod borer, populations were negatively affected by both maximum as well as minimum temperature along with evaporation and sunshine hours while relative humidity, rainfall, and wind velocity were positively affecting the pest population during the period of observation (Figure 2, Figure 3 and Figure 4). The correlation data generated in the experiment could be helpful in formulating pest population prediction models that could be useful for farmers in order to prepare for timely management of pest in their field.

ACKNOWLEDGEMENTS

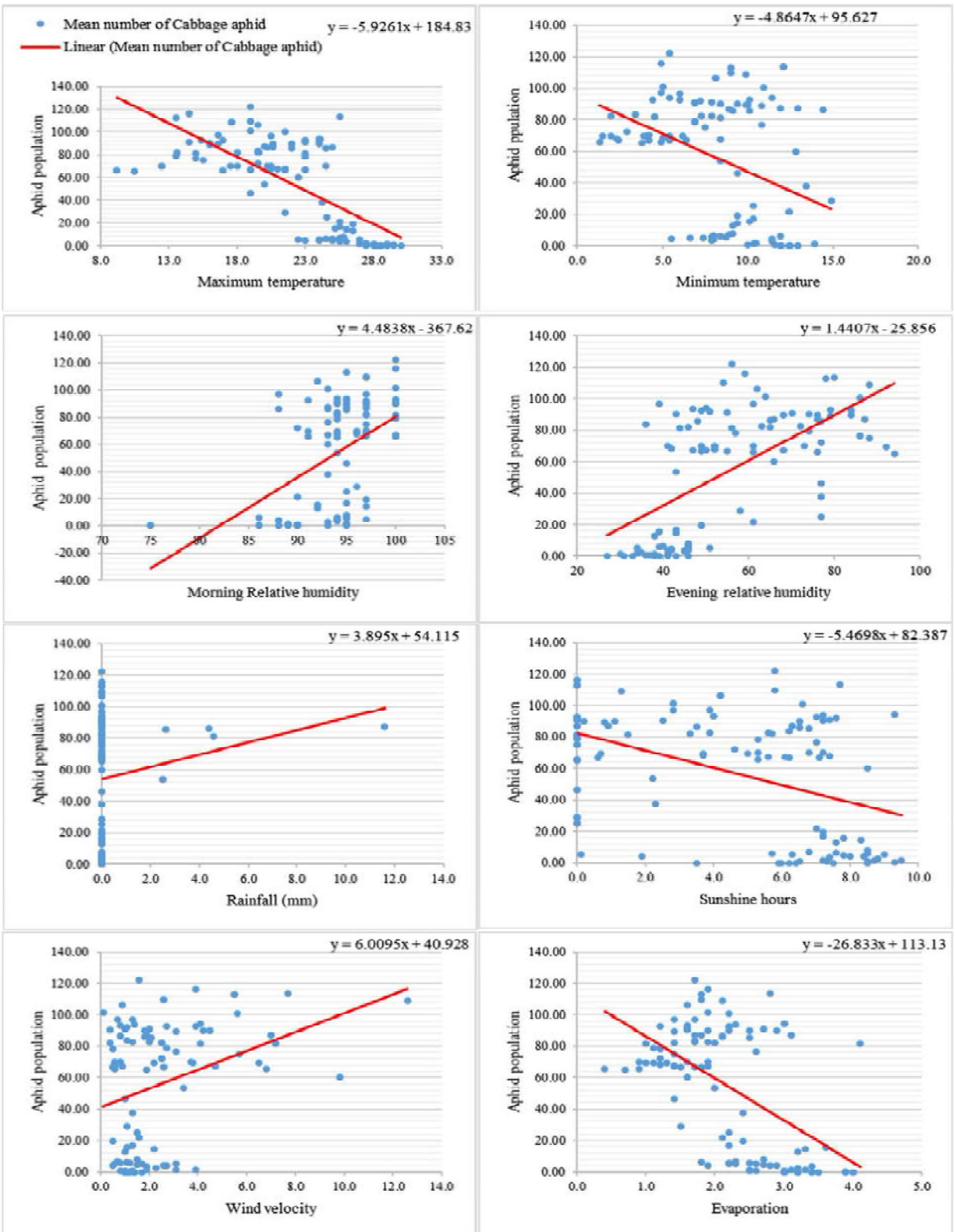

Fig. 2: Graphical representation of relationship between aphid population and various weather parameters

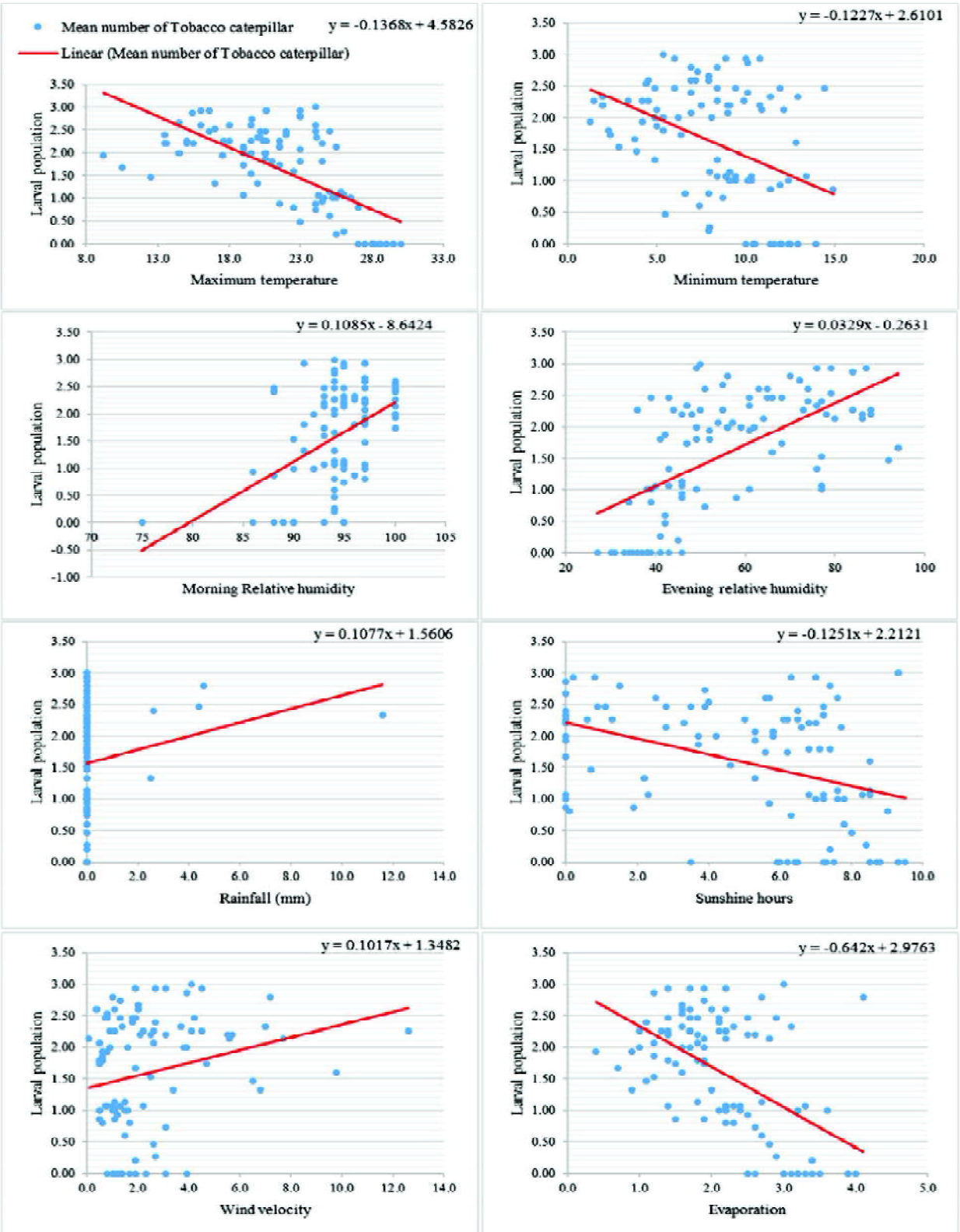

Fig. 3: Graphical representation of relationship between tobacco caterpillar population and different weather parameters

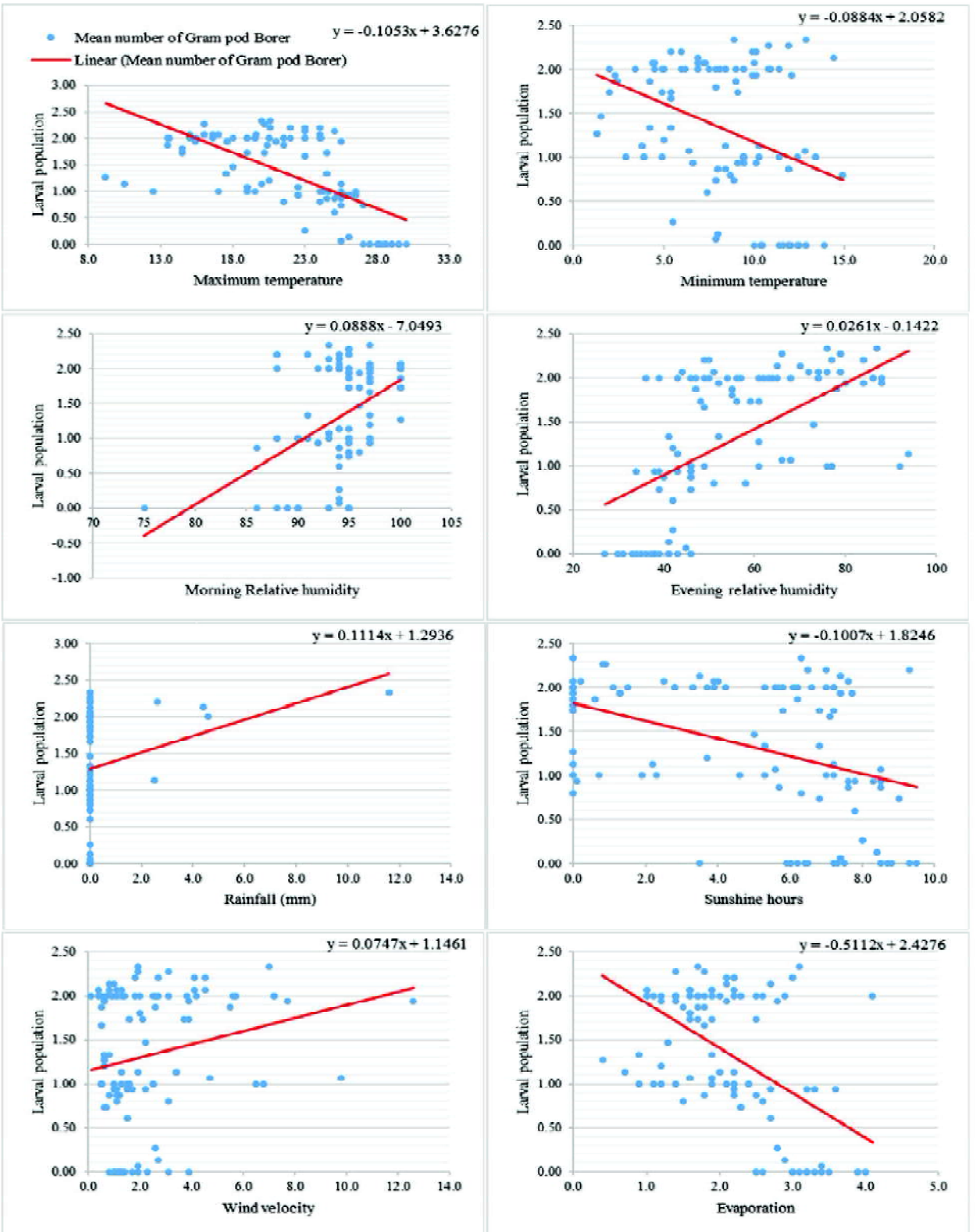

Fig. 4: Graphical representation of relationship between gram pod borer population and different weather parameters

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