Modeling of aphid complex and its associated natural enemies in rapeseed-mustard in relation to climatic factors

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ABSTRACT

Effect of climatic factors on population build-up of aphid complex of rapeseed-mustard *viz.* mustard aphid, *Lipaphis erysimi* (Kaltenbach), cabbage aphid, *Brevicoryne brassicae* (Linnaeus), and green peach aphid, *Myzus persicae* (Sulzer) and associated natural enemies (coccinellids, syrphids and a parasitoid, *Diaeretiella rapae* M'Intosh) was studied at Experimental Farm of CSK HPKV Palampur over a period of three years. Correlation coefficients indicated that the temperature favoured build-up of aphid population and their natural enemies while rainfall exerted negative impact. The population of coccinellids was negatively correlated with the population of *L. erysimi* and *M. persicae* while, positive correlation with *B. brassicae* was observed. On the other hand, population of syrphids was found to be positively correlated with aphid population. Predictive model using step-up regression analysis revealed that a weak relation in aphid population was attributed by weather parameters particularly minimum, maximum temperature and bright sunshine hours. Regression analysis revealed that 89 per cent variation in parasitization by *D. rapae* was attributed by minimum and maximum temperature, rainfall, relative humidity and bright sunshine hours.

Key words: Lipaphis erysimi, Brevicoryne brassicae, Myzus persicae, correlation, regression

The rapeseed-mustard group broadly includes, Indian mustard (*Brassica juncea* L. Czernj. & Cosson), *toria* (*B. rapa* var. *toria*), yellow sarson (*B. rapa* var. *yellow sarson*), brown sarson (*B. rapa* var. *brown sarson*) and *gobhi sarson* (*B. napus* L.). Bakhetia and Sekhon (1989) documented about 40 insect-pests harboured on the rapeseed-mustard, where about half a dozen are serious threats to cultivation of these crops. Among various insects, aphid complex comprising mustard aphid, *Lipaphis erysimi* (Kaltenbach), cabbage aphid, *Brevicoryne brassicae* (Linnaeus), and green peach aphid, *Myzus persicae* (Sulzer) are serious pests and one of the important limiting factors in the production of rapeseed-mustard. Climatic factors like temperature, relative humidity, sunshine hours and rainfall play vital role in multiplication and distribution of insect-pests. Predictive model for pest forecast is an important tool for effective integrated pest management strategy. Therefore, a good understanding of pest population dynamics is of vital importance for crop protection. Climatic factors play an important role on the aphid appearance, multiplication and disappearance (Vekaria and Patel, 2000). Keeping in view the importance of the crop and the damage caused by these species of aphids, the present investigations were initiated to study the population build-up of aphid complex i.e. *L. erysimi, B. brassicae* and *M. persicae* on rapeseed-mustard, and the population dynamics of associated natural enemies (Coccinellids, syrphids and a parasitoid, *Diaeretiella rapae* McIntosh) in relation to climatic factors under natural field conditions.

MATERIALS AND METHODS

The present investigation was conducted during 2015-16 to 2017-18 in the Experimental Farm of the Department of Entomology, CSK HPKV Palampur, Himachal Pradesh, India (32.1003° N latitudes, 76.5465° E longitudes).

For this purpose, mustard variety RCC-4 was raised in the experimental farm of the Department of Entomology following recommended package of practices during *rabi* 2015-16, 2016-17 and 2017-18. Data were recorded on the population of different aphid species and their natural enemies (NE's) following standard sampling methodology. Observations were recorded in the following manner:

Aphids

The population of aphids at initial stage mostly remains low and thus count was made on leaves and shoots as well. After the stem elongation, terminal 10 cm of the main

shoot formed the sampling unit. Samples were randomly collected from 150 plants at weekly intervals from the time of appearance of the aphids till the harvest of the crop and counts were made separately for *L. erysimi*, *B. brassicae* and *M. persicae* by using the method of Mathur and Singh, (1986).

Predators

Observations on the population of coccinellids (total number of adults and grubs/plant) and syrphids (total number of maggots/10 cm apical twig) were recorded simultaneously while recording population of aphids on randomly selected 50 plants at weekly intervals as per the sampling method used by earlier workers (Lakhanpal, 1994) with some modifications.

Parasitoid

Parasitization (%) by *D. rapae* was worked out by taking direct counts on number of mummified and healthy aphids at the time of recording aphid population as per the formula given by Root and Skelsey (1969):

$$\text{Per cent parasitization} = \frac{\text{Number of parasitized aphids}}{\text{Total number of aphids (healthy and parasitized)}} \times 100$$

Statistical analysis

To study the impact of climatic factors on the population build-up of aphids and their natural enemies, the meteorological data (weekly means) for temperature (minimum and maximum), relative humidity (%), rainfall (mm) and bright sunshine (hrs) recorded during the observation period were obtained from the Department of Agronomy, CSK HPKV, Palampur. Correlation coefficients were worked out for the population build-up (means of pooled data of three cropping seasons) of three aphid species and their natural enemies in relation to climatic factors. Further, step-wise linear regression model was developed for estimating aphid and their natural enemy population with the climatic parameters namely, temperature (minimum and maximum), relative humidity (%), rainfall (mm) and bright sunshine hours (hrs).

RESULTS AND DISCUSSION

Population build-up of aphids and their natural enemies

The perusal of pooled data (based on three cropping seasons) revealed that among the three aphid species, *L. erysimi* was the first to appear on the crop in the month of December (49th SMW) and remained active for a longer duration followed by *B. brassicae* and *M. persicae* (Table 1,

Fig. 1). The infestation of *M. persicae* was noted in the third week of January (3rd SMW) and it continued up to the last week of March (12th SMW). *B. brassicae* appeared on the crop late in last week of January (4th SMW) as compared to the other two aphid species but its infestation continued up to the harvesting of the crop in the third week of April (15th SMW). Observations recorded on the NE's associated with the aphids revealed the prevalence of two groups of predatory species *viz*. coccinellids, syrphids and one parasitoid, *Diaeretiella rapae* (McIntosh). Among coccinellids, *Coccinella septempunctata* was the predominant species. *Cheilomenes sexmaculata* (Fab), *Hippodamia variegata* (Goeze) and *Harmonia dimidiata* Fab were also observed but their population was low. *Ischiodon scutellaris* (Fab) and *Episyrphus balteatus* (De Geer) were found to be the predominant syrphid species. The pooled data showed that the coccinellids and syrphids started appearing in second and first week of February (6th and 5th SMW), respectively. The parasitization by *D. rapae* was first noted in the second week of January (2nd SMW) (Table 1). Our results are in agreement to Mehnaj *et al.* (2017), who reported the appearance of *L. erysimi* and its peak activity in 51st SMW and 8th SMW, respectively. Prasad *et al.* (2013) reported that *B. brassicae*, *M. persicae* and *L. erysimi* have been observed to be the most important aphids to cause economic damage on oilseed *Brassicas* although, population of the *B. brassicae* remains always greater than other species.

Effects of abiotic factors on population build-up

The data revealed that maximum temperature had a significant negative correlation with *L. erysimi* population (r= -0.33) (Table 2). However, a significant positive relationship of *B. brassicae* population was recorded with maximum and minimum temperature (r= 0.72 and 0.73), whereas, RH showed a significant negative correlation (r= -0.67). The population of *M. persicae* was found to be significantly negatively correlated to rainfall (r= -0.56), while BSS showed a significant positive correlation (r= 0.44). The correlation coefficients between pooled average population of NE's with pooled means of meteorological parameters were worked out which have been given in table 2. Maximum and minimum temperature showed a significant positive correlation (r= 0.94 and 0.94) with population of coccinellids. The correlation coefficients worked out for population of syrphids indicated a significant negative correlation with maximum temperature (r= -0.46) and a significant positive correlation with RH (r= 0.76). Data revealed that pararsitization by *D. rapae* showed

Table 1: Population build-up of aphids on rapeseed-mustard at Palampur (based on pooled data of 2015-16 to 2017-18)

SMW	Dates of observation	Aphid population*¥			Population of natural enemies €£		
		L. erysimi	*B. brassicae*	*M. persicae*	Coccinellids	Syrphids	*D. rapae*
49	Dec-9	0.23	0.00	0.00	0.00	0.00	0.00
50	Dec-16	0.26	0.00	0.00	0.00	0.00	0.00
51	Dec-23	1.82	0.00	0.00	0.00	0.00	0.00
52	Dec-31	3.38	0.00	0.00	0.00	0.00	0.00
1	Jan-7	8.56	0.00	0.00	0.00	0.00	0.00
2	Jan-14	12.35	0.00	0.00	0.00	0.00	0.14
3	Jan-21	15.96	0.00	0.04	0.00	0.00	2.96
4	Jan-28	17.80	0.54	0.09	0.00	0.00	2.99
5	Feb-4	21.05	2.69	0.64	0.00	0.02	6.98
6	Feb-11	19.28	3.85	1.18	0.14	0.13	13.16
7	Feb-18	18.67	8.99	1.00	0.36	0.16	25.26
8	Feb-25	13.86	14.28	0.93	0.68	0.19	32.28
9	March-4	13.14	25.88	0.76	0.94	0.19	36.53
10	March-11	8.90	21.65	0.20	0.76	0.06	41.57
11	March-18	9.35	20.94	0.34	1.36	0.05	48.16
12	March-25	2.87	20.42	0.15	1.69	0.03	45.46
13	April-1	0.94	25.34	0.00	1.59	0.00	50.42
14	April-8	0.00	19.55	0.00	1.67	0.00	26.94
15	April-15	0.00	15.49	0.00	0.95	0.00	9.55

*Average of 150 observations; SMW - Standard meteorological week; ¥ At initial stage of crop growth, counts were made on whole plant, whereas, after stem elongation, terminal 10 cm of the apical shoot formed the sampling unit.; € Average of 50 observations £ Coccinellids = number of adults and grubs per plant; Syrphids = number of larvae per 10 cm apical twig; *D. rapae* = per cent parasitization

a significant positive correlation with maximum (r= 0.83) and minimum temperature (r= 0.86), while a significant negative correlation with RH (r= -0.73) was observed. The findings of present investigation are supported by Ali and Rizvi (2012) who observed that population of *L. erysimi* was negatively correlated with minimum, maximum temperature, rainfall and sunshine hours. In similar study, Kumar and Paul (2017) reported that maximum temperature was negatively correlated with the *M. persicae* population. On the other hand, Raja *et al.* (2014) reported a positive correlation between population of *B. brassicae* and maximum, minimum temperature and bright sunshine hours, whereas negative correlation with RH and rainfall. Coccinellids and *D. rapae* exhibited positive correlation with maximum, minimum temperature and sunshine hours. Our findings are in support with Yadav and Agrawal (2018) who reported that the population of coccinellids was highly affected by maximum and minimum temperature. The sunshine also had a positive correlation with build-up of coccinellids, whereas RH showed a negative correlation. Akhtar *et al.* (2010) showed that relative humidity had a negative correlation with parasitization by *D. rapae*, while a positive correlation with temperature was observed. The reason for this negative correlation could

possibly be due to the fact that population of natural enemies did not synchronize with respective weather parameters. The study revealed that the temperature and sunshine hours showed negative correlation with syrphid population. Similar observations were also reported by Paul and Konar (2005).

Correlation (r) between aphids and their natural enemies

The perusal of data in table 3 revealed that the population of coccinellids had a significant negative correlation with *L. erysimi* (r=-0.91) and *M. persicae* (r= 0.89) population, whereas, significant positive correlation with population of *B. brassicae* (r= 0.50). It is clear from data that the population of coccinellids increased gradually with the increase of aphid population and then resulting in gradual decrease in aphid population. The syrphids had a significant positive correlation with the population of *L. erysimi.*. The data reveal similar results for correlation studies between coccinellids and *M. persicae*, depicting negative correlation as a result of asynchronizaton. However, appearance of coccinellids at later stage of the crop with maximum population of *B. brassicae* was favourable for coccinellid predators. Talpur and Khuhro (2004) also reported that coccinellid beetles appeared at later stage of the crop when
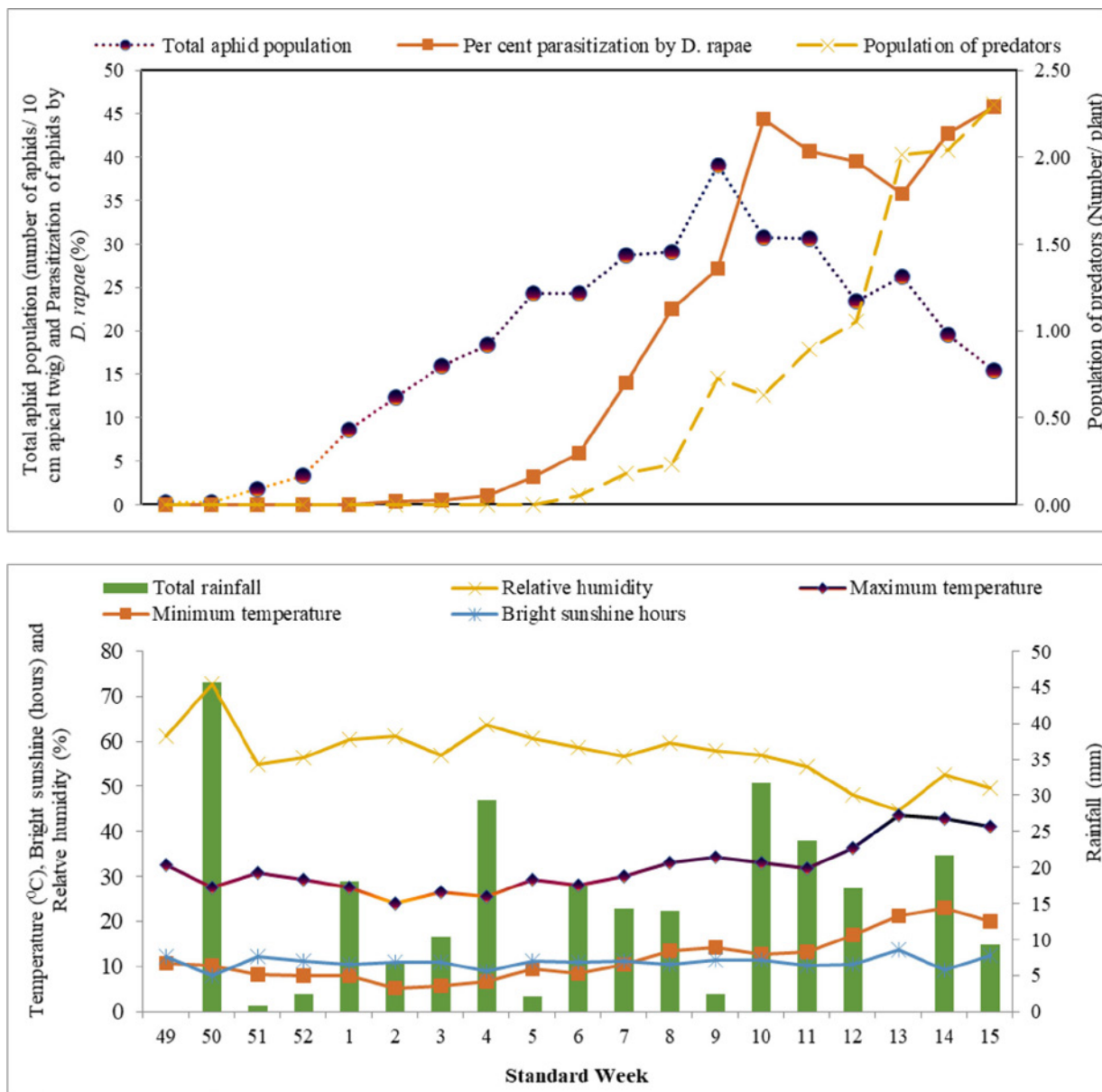
Fig. 1: Population build-up of aphids and their natural enemies (based on the pooled data from 2015-16 to 2017-18) at Palampur

there was maximum population of aphids on the crop. Data presented in table 1 revealed that peak activity of aphids and syrphids fall in the first week of March and then gradually decreased with decrease in aphid population revealing a positive correlation between aphid population and syrphids. This indicated the positive role of syrphids in suppressing the aphid population in the field. In conformity with our findings, Devi *et al.* (2011) observed similar results. The data on the relationship between aphid population and per cent parasitization revealed that the activity of *D. rapae* was directly influenced by the presence of aphid population in the field. These results are in corroboration with the findings of Nieto *et al.* (2006) who reported that the presence of

mummified aphids was positively correlated to *B. brassicae* infestation at cabbage harvest.

Regression analysis

Based on the data clubbed for three cropping seasons, it was evident that maximum, minimum temperature and sunshine hours contributed 41 per cent variation in aphid population (Table 4) and was depicted in predictive model. In case of natural enemies, it was evident from data that minimum temperature and relative humidity was found to influence predator population significantly and contributed to the extent of 90 per cent variation. Whereas, in case of parasitization by *D. rapae*, minimum and maximum

Table 2: Correlation (r) between various abiotic factors and population of aphids and their natural enemies on rapeseed-mustard

Factor	Population of aphids				Natural enemies		
	L. erysimi (n=46)	*B. brassicae* (n=34)	*M. persicae* (n=21)	Total aphid population	Coccinellids (n=27)	Syrphids (n=21)	Parasitization (%) (n=37)
Maximum temperature	-0.33*	0.72*	-0.14	0.30	0.94*	-0.46*	0.83*
Minimum temperature	-0.24	0.73*	-0.20	0.37	0.94*	-0.43	0.86*
RH	0.01	-0.67*	0.23	-0.36	-0.80*	0.76*	-0.73*
Rainfall	-0.07	-0.15	-0.56*	-0.17	-0.28	0.21	0.21
Bright sunshine hours	-0.03	0.41	0.44*	0.12	0.31	-0.43	0.26

* Significant at 5% level

Table 3: Correlation (r) between aphids and their natural enemies on rapeseed-mustard

Aphid	Population of coccinellids	Population of syrphids	Parasitization by *D. rapae* (%)
L. erysimi	-0.91*	0.46*	-
B. brassicae	0.50*	0.09	-
M. persicae	-0.89*	0.11	-
Total aphid population	-0.59*	0.81*	-0.23

* Significant at 5% level

Table 4: Regression model for aphids and their associated natural enemy population build-up on rapeseed-mustard

Regression equations	R^2
Population of aphids	
$Y = 95.37 + 4.13\ T_{Min}* - 4.1\ T_{Max}* + 0.85\ BSS*$	0.41
Population of predators (coccinellids and syrphids)	
$Y = 0.79\ T_{Min}* - 0.21\ RH$	0.90
Parasitization by *D. rapae*	
$Y = 90.86 + 2.12\ T_{Min}* + 0.38\ RF* - 0.38\ RH* - 1.7\ T_{Max}* + 0.46\ BSS*$	0.89

*Significant at 5% level; T_{Max}: Maximum temperature, T_{Min}: Minimum temperature (^{O}C); BSS: Bright sunshine hours, RH: Relative humidity, RF: Rainfall (mm)

temperature, rainfall, relative humidity and sunshine hours were found to be the major contributing factors and the equation obtained by stepwise multiple regression depicted that these factors significantly resulted in 89 per cent variation. It is evident from the stepwise regression equations that climatic factors greatly influenced the population dynamics of aphids and associated natural enemies. Seasonal variations of the weather factors play a vital role in multiplication, growth, development and distribution of insects, and have influence on their population dynamics (Dhaliwal and Arora, 2001). Sahoo (2013) from the stepwise regression analysis observed that the combined influence of rainfall, temperature and RH resulted in 70, 62 and 41 per cent variation in *L. erysimi* population during 2009-10, 2010-11 and 2011-12. Sahoo and Saha (2018) observed the impact of rainfall, temperature, relative humidity and wind speed on incidence of *L. erysimi* through stepwise regression analysis and it was noted that the combined influence of these weather parameters was 54 per cent. Mandal *et al.* (2018) reported that temperature individually exerted 77.9 per cent effect on

population abundance of aphid in mustard. The temperature with combination of light intensity provided 81.3 per cent abundance. The combined effect of temperature, light intensity and relative humidity depicted 81.7 per cent abundance. The multiple linear regression analysis showed that the three weather parameters together contributed on the abundance of mustard aphid, but the temperature had the greater effect than others.

CONCLUSIONS

Based on the investigations, it is concluded that three aphid species viz. *L. erysimi, B. brassicae* and *M. persicae* were found to infest rapeseed-mustard at Palampur. Among climatic factors, temperature exhibited negative correlation with *M. persicae* and *L. erysimi* population whereas positive relationship with population of *B. brassicae*. Rainfall exerted negative influence on aphid population. Coccinellids and parasitoid, *D. rapae* showed a strong positive correlation with temperature and sunshine hours whereas, syrphids showed negative correlation with temperature. Parasitization and predation of aphids was also observed to increase with rise in maximum and minimum temperature.

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