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Research Article

Influence of environmental factors on the population dynamics of *Diaeretiella rapae* (Hymenoptera: Braconidae) parasitizing *Brevicoryne brassicae* (Hemiptera: Aphididae) in cauliflower cultivars

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ABSTRACT: The experiment was conducted on five different cauliflower cultivars viz. Early London, PSBK-1, PSBK-25, Pusa Himjyoti and Snowball Super to study the influence of weather factors viz., temperature, relative humidity and rainfall on the population of cabbage aphid, *Brevicoryne brassicae* (Linnaeus) and its parasitoid, *Diaeretiella rapae* (MacIntosh) at Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh during the year 2021-2022. The incidence of *B. brassicae* was first recorded on cv. Early London, Pusa Himjyoti and Snowball Super during 52nd Standard Meteorological Week (SMW) followed by PSBK-1 and PSBK-25 during 1st SMW while the parasitoid was first noticed in 8th SMW on cv. Early London followed by PSBK-1 (9th SMW), Snowball Super (10th SMW), PSBK-25 and Pusa Himjyoti (11th SMW). The aphid population was maximum (177 aphids/plant) during 10th SMW whereas, the population of parasitoids was maximum (4.90 mummified aphids/plant) during 11th SMW on Early London. Among all the cultivars, the per cent parasitism by *D. rapae* was highest (17.31%) on Pusa Himjyoti during 13th SMW. The populations of cabbage aphid and its parasitoids exhibited positive correlation with the temperature and negative correlation with relative humidity and rainfall.

KEYWORDS: *Brevicoryne brassicae,* correlation, *Diaeretiella rapae,* per cent parasitism

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INTRODUCTION

One of the most significant cruciferous vegetable crops is cauliflower (*Brassica oleracea* var. *botrytis*), which is grown in many countries, including India. The cauliflower crop in India covers an area of 458 thousand hectares and yields 9283 thousand metric tonnes (Anonymous, 2022). However, a number of insects- pests *viz*. the cabbage butterfly (*Pieris brassicae* L.), the white cabbage butterfly (*Pieris rapae* L.), the diamondback moth (*Plutella xylostella* L.), the tobacco caterpillar (*Spodoptera litura* Fabricius), the cutworm (*Agrotis ipsilon* Hufnagel), the cabbage aphid (*Brevicoryne brassicae* L.), green peach aphid (*Myzus persicae* Sulzer), greenhouse whitefly (*Trialeurodes vaporariorum* Westwood) affects the production of the crop (Verma *et al.,* 2019). Among these, the cabbage aphid, *B. brassicae*, is a major insect pest with a wide host range that includes cruciferous plants (Jahan *et al.,* 2012). Cabbage aphids feed on the underside of the leaves, inflorescence, and the center of the cabbage head (Halder *et al.,* 2014; Eyidozehi *et al.,* 2014). This pest reduces crucifer crop yield up to 75 per cent and also causes indirect crop damage by transmitting 30 known viruses and has the potential to cause 82 per cent yield loss if insecticides are not used (Gazmer *et al.,* 2015; Razaq *et al.,* 2011).

Chemical pesticides are the most commonly used method for controlling this aphid species, but their harmful effects on both humans and the environment have increased the importance of biological control. As a result, aphid parasitoids play an important role in the natural control of their host populations. Among the various parasitoids, *Diaeretiella rapae* (McIntosh) (Hymenoptera: Braconidae) has been identified as the primary parasitoid of the cabbage aphid, *B. brassicae* (Mussury & Fernandes, 2002; Vaz *et al.,* 2004; Stary *et al.,* 2007). This tiny wasp is a solitary, cosmopolitan endoparasitoid of aphids on a variety of host plants (Pramanik *et al.,* 2012) and parasitizes more than 60 aphid species, of which many are important agricultural pests (Pike *et al.,* 1999; Jankowska & Wiech, 2003).

Pest control does not solely rely solely on chemical or biological methods, but its environment also plays an important role in controlling pest populations (Abbasi *et al.,* 2018). Hence, proper management practices can be implemented by understanding abiotic factors and their effects on a specific pest and its biocontrol agent. The population dynamics of the aphid and its parasitoid differ in relation to climatic conditions and host plant species. Weather parameters viz. temperature, relative humidity, and rainfall were highly correlated with aphid population density (Mandal *et al.,* 2018; Singh *et al.,* 2018). The temperature has a positive effect on the building-up of the aphid population up to an extent (30-35°C) while relative humidity and rainfall have a negative effect on the growth of the aphid population (Patel & Singh, 2018). Parasitoid population depends on the density of aphid and plant species along with abiotic factors including temperature, relative humidity and rainfall (Weisser *et al.,* 1997; Pradhan *et al.,* 2019).

Synchrony between environmental factors, parasitoids, and hosts is required for effective management of aphid population. Host stage preference is an important behavioural trait to evaluate parasitoid effectiveness in aphid control (Luck, 1990). The morphological traits (waxy coating, leaf colour, texture) and chemical constituents (volatiles) of different cauliflower cultivars may also influence pest and parasitoid population dynamics. As a result, the current study was undertaken to investigate the influence of meteorological parameters on cabbage aphids and their parasitoid, *D. rapae*, in five different cauliflower cultivars.

MATERIALS AND METHODS

Raising of the crop

- Five cultivars of cauliflower (*Brassica oleracea* L. var. *botrytis*) viz. PSBK-1, PSBK-25, Pusa Himjyoti, Snowball Super and Early London were raised by transplanting one-month-old seedlings. The planting distance was 60 X 45 cm, i.e., 60 cm between rows and 45 cm between plants.
- The crop was grown as per the recommended package of practices of vegetable crops, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan for except the application of insecticides.

Sampling of *D. rapae*

- The sampling of *D. rapae* was initiated 20 days after transplanting seedlings of cauliflower cultivars and sampling of mummified aphids was done at weekly intervals on 50 randomly selected plants. Sampling was done as per the method of Krishnaiah *et al.* (1979) on three leaves (outer, middle and inner leaves) of cauliflower.
- Mummified aphids were collected and placed inside the glass tube, covered with muslin cloth tied with rubber band, and kept under laboratory conditions at 25±0.5°C, 70±5 per cent relative humidity for the emergence of parasitoid adults.

Parasitism of *D. rapae*

The cabbage aphid nymphs and parasitized aphids were recorded on five cultivars of cauliflower. The parasitized host nymphs were brought to the laboratory and reared till the emergence of the parasitoid and data on the number of parasitoid adults that emerged were recorded. The data thus used to calculate the mean per cent parasitism of cabbage aphid.

Per cent parasitism – The per cent parasitism of aphids by its parasitoid is calculated by using the equation of Root and Skelsey (1969):

$$\text{Per cent parasitism} = \frac{\text{Parasitized aphids (mummies)}}{\text{Total aphid population}} \times 100$$

RESULTS AND DISCUSSION

Population dynamics of *D. rapae* against *B. brassicae* infesting five cauliflower cultivars

The data on the seasonal abundance of cabbage aphids as well as their parasitoids were recorded on five cauliflower cultivars viz. Early London, PSBK-1, PSBK-25, Pusa Himjyoti and Snowball Super. Data were recorded from the 52nd SMW of 2021 to the 13th SMW of 2022 with respect to weather parameters, on each cultivar. The cabbage aphid population persisted in the field throughout the cropping period of cauliflower while the parasitoid emerged eight weeks later than the cabbage aphid and then persisted throughout the cropping period. Data presented in Table 1 revealed that the incidence of *B. brassicae* was first recorded on cv. Early London, Pusa Himjyoti and Snowball Super in 52nd SMW during which the maximum and minimum temperature was 17.7 and 0.9°C, respectively, relative humidity was 58 per cent and there was no rainfall whereas on cv. PSBK-1 and PSBK-25, its incidence was first observed in 1st SMW of 2022 during which the maximum and minimum temperature was 16.9 and 4.0°C, respectively, and relative humidity was 53 per cent with 3.70 mm rainfall. Aphid population was noticed maximum during 11-12th SMW in all the cultivars which may be due to favourable environmental conditions prevailing during this period. In the present study, the per cent parasitism by the parasitoid, *D. rapae* was also maximum

during 11-13th SMW. During this period, the maximum and minimum temperature ranged between 30.7-32.7°C and 10.1-11.3°C, respectively and relative humidity was 32-46 per cent while there was no rainfall.

The present study showed that the cauliflower cvs. Early London and Snowball Super harboured maximum population of *B. brassicae* indicating susceptibility to cabbage aphids. While the cv. PSBK-25 showed tolerance towards cabbage aphids by harbouring less population of aphids. The results indicated that the occurrence of *D. rapae* was initiated in the 8th SMW on cv. Early London followed by PSBK-1 (9th SMW), Snowball Super (10th SMW), PSBK-25 and Pusa Himjyoti (11th SMW) which coincided with the increase in

Table 1. Population dynamics of *B. brassicae* and its parasitoid *D. rapae* on five cauliflower cultivars during 2021-22 cropping season

Standard Meteorological Week (SMW)	EARLY LONDON			PSBK-1			PSBK-25			PUSA HIMJYOTI			SNOWBALL SUPER			WEATHER PARAMETERS			
	Mean no. of aphids/ plant	Mean no. of parasitoids/ plant	Parasitization (%)	Mean no. of aphids/plant	Mean no. of parasitoids/ plant	Parasitization (%)	Mean no. of aphids/plant	Mean no. of parasitoids/ Plant	Parasitization (%)	Mean no. of aphids/plant	Mean no. of parasitoids/ Plant	Parasitization (%)	Mean no. of aphids/plant	Mean no. of parasitoids/ plant	Parasitization (%)	Tmax (°C)	Tmin (°C)	RH (%) (Mean)	RF (mm)
52	11.10	00	00	0.00	00	00	0.00	00	00	8.50	00	00	3.50	00	00	17.7	0.9	58	0.00
1	1.70	00	00	3.40	00	00	3.10	00	00	1.80	00	00	22.30	00	00	16.9	4.0	53	3.70
2	2.80	00	00	0.20	00	00	3.80	00	00	4.70	00	00	0.80	00	00	15.2	2.8	54	21.90
3	1.20	00	00	0.50	00	00	1.00	00	00	0.00	00	00	1.10	00	00	18.4	3.4	62	0.10
4	5.30	00	00	1.90	00	00	2.10	00	00	1.40	00	00	11.80	00	00	12.0	2.9	67	11.30
5	79.60	00	00	0.00	00	00	0.00	00	00	0.70	00	00	16.60	00	00	15.4	2.3	58	4.70
6	27.50	00	00	1.90	00	00	0.00	00	00	0.00	00	00	10.70	00	00	18.8	2.3	57	3.60
7	87.50	00	00	0.80	00	00	0.00	00	00	7.70	00	00	18.40	00	00	20.8	1.2	45	0.00
8	172.20	0.20	0.11	0.30	00	00	1.20	00	00	3.50	00	00	78.90	00	00	20.8	4.3	48	2.20
9	104.00	1.70	1.63	1.50	0.10	6.67	1.20	00	00	6.30	00	00	29.00	00	00	20.5	5.0	56	1.30
10	177.00	2.50	1.41	10.00	0.30	3.00	2.90	00	00	3.80	00	00	141.90	0.40	0.23	25.8	7.5	48	00
11	152.90	4.90	3.20	18.00	0.80	4.44	11.80	0.30	2.54	20.20	0.40	1.98	172.90	2.40	1.69	30.7	10.1	46	00
12	91.80	3.10	3.38	25.00	1.40	5.60	2.50	0.10	4.00	44.50	1.10	2.47	61.80	1.60	3.59	30.2	11.0	42	00
13	56.90	2.90	5.10	16.90	1.10	6.51	10.60	0.60	5.66	15.60	2.70	17.31	44.60	3.00	4.85	32.1	11.3	32	00

temperature. Thus, the major activity of this parasitoid was observed in the month of March with the increase in the maximum temperature (20.8-32.1°C) while the maximum temperature prevailing during December, January and February was comparatively low, i.e., <20°C which might be responsible for non-occurrence of this parasitoid in these months. These findings corroborate the findings of Halder *et al.* (2014) who reported that low-temperature resulted in no incidence of this braconid endoparasitoid, *D. rapae* and its population is directly proportional to the temperature, i.e., an increase in temperature results in an increase in parasitoid population and vice-versa.

Correlation of *Brevicoryne brassicae* population with weather parameters

The correlation matrix was worked out between cabbage aphid and weather parameters on five cauliflower cultivars. The results in Table 2 revealed that in the case of cultivar Early London, there was a significantly positive correlation of cabbage aphid population with the maximum (r = 0.57) and minimum temperature (r = 0.46) which means the population of the cabbage aphid increased with the increase in temperature. Similarly, the cabbage aphid population was found to be positively correlated with maximum and minimum temperatures on other cultivars. Cultivar PBSK-1 showed a highly significant correlation with maximum temperature (r = 0.88) and minimum temperature (r = 0.94). These findings were in accordance with the findings of Pal and Singh (2013) who observed that aphid population was positively correlated with the maximum and minimum temperature as the incidence of cabbage aphids was observed in the second week of February and then reached at peak during the second week of March. In the present study, the aphid population exhibited a significantly negative correlation with relative humidity on all the five cultivars viz. Early London (r = -0.48), PSBK-1 (r = -0.70), PSBK-25 (r = -0.59), Pusa Himjyoti (r = -0.59) and Snowball Super (r = -0.47). On the other hand, the cabbage aphid population had a non-significant negative correlation with the rainfall. The present findings also corroborate the findings of Raja *et al.,* (2014) who reported that aphid population was negatively correlated with relative humidity and rainfall.

Correlation of *Diaeretiella rapae* population with *Brevicoryne brassicae* and weather parameters

It is evident from Table 3 that there was a significant positive correlation between parasitoid population with the cabbage aphid population in early London (r = 0.58), PSBK-1 (r = 0.97), PSBK-25 (r = 0.86), Pusa Himjyoti (r = 0.54) and Snowball Super (r = 0.54). Parasitoid population was significantly positively correlated with the maximum and minimum temperature among all the cultivars whereas a significant negative correlation was observed with respect to relative humidity on early London (r = -0.63), PSBK-1 (r = -0.74), PSBK-25 (r = -0.72), Pusa Himjyoti (r = -0.75) and Snowball Super (r = -0.76). The present findings also indicated that the rainfall had no significant effect on the parasitoid population among all the cultivars. These findings were in accordance with the findings of Akhtar *et al.,* (2010) who reported that the parasitoid population showed significant positive correlation with temperature and significant negative correlation with relative humidity. Similarly, the present findings corroborate the findings of Pradhan *et al.,* (2019) who also reported that the parasitoid exhibited significant positive correlation with maximum and minimum temperatures and negative correlation with relative humidity

Table 2. Correlation of *Brevicoryne brassicae* population with weather parameters on five different cauliflower cultivars

Cultivars	Correlation coefficient (r)			
	T_{max}(°C)	T_{min}(°C)	RH(%)	RF(mm)
Early London	0.57*	0.46*	-0.48*	-0.44
PSBK-1	0.88**	0.94**	-0.70**	-0.35
PSBK-25	0.68**	0.76**	-0.59*	-0.06
Pusa Himjyoti	0.72**	0.72**	-0.59*	-0.28
Snowball Super	0.69**	0.67**	-0.47**	-0.37

**Correlation is significant at the 0.01 level.
*Correlation is significant at the 0.05 level.

Table 3. Correlation between the population of *D. rapae* and *B. brassicae* as well weather parameters on five different cauliflower cultivars

Cultivars	Correlation coefficient (r)				
	Aphid Population/ Plant	T_{max} (°C)	T_{min} (°C)	RH (%)	RF (mm)
Early London	0.58*	0.89**	0.91**	-0.63**	-0.389
PSBK-1	0.97**	0.88**	0.92**	-0.74**	-0.336
PSBK-25	0.86**	0.74**	0.74**	-0.72**	-0.252
Pusa Himjyoti	0.54*	0.71**	0.74**	-0.75**	-0.24
Snowball Super	0.53*	0.87**	0.89**	-0.76**	-0.31

**Correlation is significant at the 0.01 level.
*Correlation is significant at the 0.05 level.

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