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Effect of various cauliflower cultivars on population density fluctuations of the cabbage aphid, Brevicoryne brassicae (L.) (Hom.: Aphididae) and its parasitoid Diaeretiella rapae (McIntosh) (Hymenoptera: Braconidae)

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In this study, population density changes of the cabbage aphid, *Brevicoryne brassica* (L.), were tested in the field during 2011 under natural infestation at research field of the Shahed University (South of Tehran). This investigation was conducted on the eight cauliflower cultivars including Smilla, Snow mystique, White cloud, Buris, Galiblanka, Snow crown, SG and Tokita in randomised complete block design with five replications. Sampling was done after starting of aphid activity in the field every week and the total number of adult aphids and nymphs were counted in three leaves of the upper, middle and lower parts of the plant. In addition, the percentage of parasitism of the cabbage aphid by *Diaeretiella rapae* was evaluated. Results of the sampling showed that peak of the aphid population were at the first half of November. The parasitism percent of the cabbage aphid by *D. rapae* was significantly different among studied cultivars ($p < 0.05$). Therefore, it can be concluded that using of Smilla, Buris and SG cultivars probably increases the efficiency of *D. rapae* in the control of the *B. brassica* (L.).

Keywords: cabbage aphid; population; fluctuation; *Diaeretiella rapae*; cauliflower cultivars

Introduction

The Cauliflower *Brassica oleracae* var. *botrytis* is one of the most important cruciferous plants (Singh et al. 1997). Due to the abundant amount of vitamins it is particularly important. Several aphids attack these plants, including; *Brevicoryne brassicae* (L.), *Myzus persicae* Sulzer and *Lipaphis erysimi* Kalt. (Trumble 1982) and the most important one is the cabbage aphid, *B. brassicae.* This aphid causes direct damage to the supply of sap and indirect damage by transmitting plant viruses (Blackman & Eastop 2000). The cabbage aphid, *B. brassicae* is scattered in many parts of the world (Rivnay 1962). Also, in Iran it is active in most areas, especially in central areas (Khanjani 2006). Some researchers suggested biological control methods and the use of resistant varieties to overcome the problem of the cabbage aphid. These methods are low-cost, environmentally friendly and reconcilable with other methods of combat (Maurya 1998; Kumar & Sharma 1999; Yue & Liu 2000; Sarwar et al. 2002).

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Diaeretiella rapae (McIntosh) is one of the polyphagous parasitoid of aphids, especially the cabbage aphid, and this parasitoid is of Aphidiidae family (Farid et al. 1998). *D. rapae* is active in most parts of the world, including Central Asia, Western and Eastern Europe, the Mediterranean, North Africa, South America and North America (Feng et al. 1992; Bernel et al. 2001). Modarres-Najafabadi et al. (2004) identified two parasitoids of *D. rapae* and *Pachyneuron aphidis* Bouche from infested fields of canola to cabbage aphid in Sistan region of Iran. Based on the obtained results, performance of *D. rapae* is more than *P. aphidis.*

Kazemzadeh-Arjas (2003) reported two parasitoid species from the cabbage aphid in canola fields of Khuzestan (Iran). Lotfalizadeh (2002) introduced two parasitoids of *D. rapae* and *P. aphidis to* the cabbage aphid in Moghan region (Iran). Parasitoids of *D. rapae* and *P. aphidis* were introduced as most important natural enemies from infested fields to the cabbage aphid in India (Thakhur et al. 1998). Based on studies by Kxdamshoev (1983), *D. rapae* wasp is one of the most important parasitoids of the cabbage aphid in Tajikistan. In the studies on parasitism of canola aphids in France, parasitoid wasp of *D. rapae* on the cabbage aphid was reported (Desneux et al. 2006).

Several cultivars of cauliflower are known in the world, each of them with its specific characteristics and investigation of their resistance to pests is of special importance. Due to rear information on resistance of different cauliflower cultivars to the cabbage aphid in Iran, Therefore, the aim of this study was to compare the infestion of the eight cauliflower cultivars to the cabbage aphid and identify the resistant cultivars in order to use them in integrated management of the aphid cabbage.

Materials and methods

The experimental cultivars including eight cultivars of cauliflower (Smilla, Snow mystique, White cloud, Buris, Galiblanka, Snow crown, SG and Tokita) were planted at the Shahed University research field during 2011. For investigating population fluctuations of the aphid, sampling was done from September to November. Cauliflower cultivars were planted in field in randomised complete-block design with five replications. No chemical control was performed during the developmental period of plant. Weeds were controlled by hand weeding method. Three pots per each experimental plot were evaluated. Three upper leaves, middle leaves and the lower leaves (totally 45 leaves for each cultivar) of each plant were randomly selected. Then, all samples were placed in plastic bag and were transported to the laboratory for counting. Total numbers of aphids on the leaves were counted. When weather conditions were inclement and rainy, sampling was done with delaing. To determine the parasitism percent in each cultivar, 50 adult aphids were randomly collected from leaves of each cultivar (by a triple zero brush) and they were put into clear plastic containers ($5 \times 13 \times 15$ cm) withits lid embedded with a piece of net (for air conditioning). And, then they were placed under controlled conditions (25 ± 2 °C and 65 ± 5% RH and 16:8 L:D). Five replicates were considered for each cultivar and after five days, the number of parasitoids and mummification aphids were counted and the parasitism percent was calculated by the following formula:

$$\text{Parasitism } \% = \frac{\text{Number of mummification aphid}}{\text{Total number of aphids per each leaves}} \times 100$$

Statistical analyses

Analyses of variance (ANOVA) (PROC GLM) for a randomised complete-block design were performed to test the differences among treatments and means were compared at the 5% level of significance using Duncan multiple range test (Littell et al. 2002, SAS Institute 2004). For analysis and mean comparison, mean of different developmental stages in each sampling date was considered as a replicate.

Results and discussion

Seasonal population fluctuations of cabbage aphid based on density of aphid in leaves

Infested rate to the cabbage aphid in different cultivars in total upper leaves, middle leaves and the lower leaves is shown in Figure 1. In this study, in Smilla cultivar, density of aphid per leaf was more than other cultivars. So, the average numbers of aphids for five sampling times were 2.13 aphid/leave. Density of aphid per leaf on Galiblanka cultivar was less than other cultivars and average number of aphids for this cultivar was calculated to be 0.48 aphids/ leaf.

Hasanshahi and Jahan (2012) examined resistance of eight cauliflower cultivars to the damage of three important pests of cruciferous plants in field. Based on this study, Snow crown and White cloud cultivars were introduced as most resistant cultivars to damage of different pests in field conditions.

Hasanshahi (2012) studied density of diamondback moth larva on eight cauliflower cultivar and calculated the highest density of larvae on Snow mystique (0.05 ± 0.008) and Tokita (0.05 ± 0.002) cultivars and the lowest density of larvae on Buris (0.02 ± 0.001) and Snow crown (0.02 ± 0.001) cultivars (larvae per plant). Density of the cabbage white butterfly, *Pieris rapae* (L.) on different cultivars of cauliflower has been studied by Hasanshahi, Yazdanpanah et al. (2012) and it was found that White cloud and Tokita cultivars have more resistant to *P. rapae* than other cultivars and these cultivars will reduce damage of pest to crop.

Mousavi-Anzabi et al. (2009) examined sensitivity and resistance of 21 different genotypes of *Brassica* to the cabbage aphid under field infestation conditions and

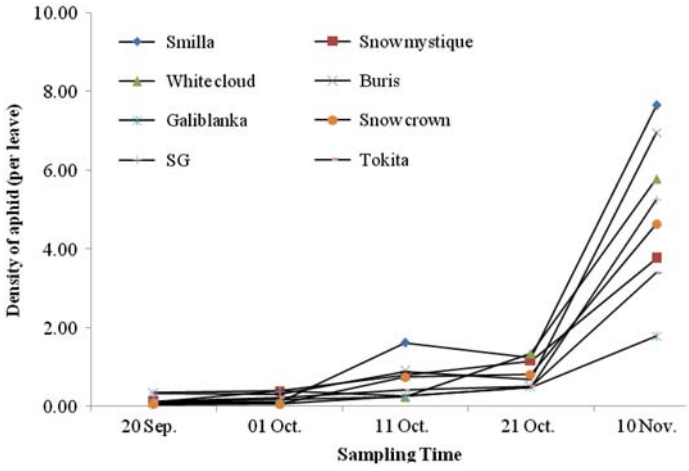

Figure 1. Seasonal fluctuations of cabbage aphid based on density of aphid per leave on eight cauliflower cultivars during 2011.

showed that there were significant differences among infestion intensity to the cabbage aphid in different cultivars and six genotypes (Sahara, Opera, ARC-2, Sintara, Okapi and Sunday) have been introduced as resistant cultivars. Monfared et al.(2003) evaluated resistance of 27 lines, hybrids and varieties of canola to the cabbage aphid under field infestation conditions and seven varieties (Shiralee, Hyola 330, Okapi, PF, Eurol, Hyola 401 and Hyola 308) have been found with lowest rates of infestion and wild mustard (resistant control) with no significant difference. Therefore, they were introduced as resistant cultivars. Based on studies by Zandi-Sohani et al. 2004 on different canola cultivars, three cultivars were introduced as resistant variety.

Jahan et al. (2013) showed that different cauliflower cultivars have a significant effect on life table parameters of *B. brassicae*. They reported that Smilla cultivar is most suitable cultivar for cabbage aphid population. According to report Hasanshahi et al. (2012), survival rates of the cabbage aphid was significantly ranged from 74.27% on Smilla cultivar to 95.44% on SG cultivar.

In this study, the highest density of aphid in total cultivars was in the fifth sampling on 10 November, recorded number of aphid was 39.15 aphids/ leaf, the highest density of aphid per leaf was on Smilla cultivar and the lowest density of aphid was on Galiblanka cultivar this time. The lowest density of aphid observed was 1.34 aphids/ leaf on September 20, the highest density of aphid in leaves was observed on SG cultivar and the lowest density of aphid was on Galiblanka and Snow crown cultivars this time. The first peak of density was observed on cultivars on Sep 20 and the highest density of aphid was on Smilla cultivar. Density of aphid per leaf was on White cloud cultivar in South of Tehran in this time. Based on the results of Table 1, there was not significant difference between densities of aphid per leaf in different cultivars. So, studied cultivars were in a groups (Table 2).

Table 1. Comparison of measured traits on eight cauliflower cultivars (mean of aphids density in each sampling date was considered as a replicate).

Cultivars	Density of aphid (per leave)
Smilla	0.87 ± 2.13
Snow mystique	0.40 ± 1.25
White cloud	0.54 ± 1.38
Buris	0.59 ± 1.61
Galiblanka	0.18 ± 0.48
Snow crown	0.38 ± 0.96
SG	0.46 ± 1.00
Tokita	0.29 ± 0.93

Table 2. Analysis of variance of measured traits on eight cauliflower cultivars.

Traits	Source	d*f*	Mean of square	*F*
Density of aphid (per leave)	Treatments	7	5.446	1.609^{ns}
	Sampling	4	131.553	38.865^{**}
	Replicate	4	5.692	1.682^{ns}
	Error	177	3.385	
	Total	193		

**Significant at 1% probability level.
^{ns}Non significant.

Parasitism rate of cabbage aphid by Diaeretiella rapae on different cauliflower cultivars

Parasitism rate of cabbage aphid by *D. rapae* on different cauliflower cultivars are shown in Table 3. The results showed that there was significant difference between parasitism percent by *D. rapae* in studied cultivars ($p < 0.05$). The highest parasitism percent of cabbage aphid by *D. rapae* was observed on Smilla cultivar (37.6 ± 9.00).

The highest parasitism percent by *D. rapae* was reported to be 32% in the first half of March and average total parasitism percent was 13%in canola fields in Ahvaz (Iran) (Farsi et al. 2009).

Duchovskiene and Raudonis (2008) observed the highest parasitism percent of the cabbage aphid by *D. rapae* at the end of July (2003) and at the beginning of August (2004) and *D. rapae* reduced populations of cabbage aphid 23.9–26.2% during both experimental years.

Based on studies by Mosadegh (1993), parasitism rate of this parasitoid on cabbage aphid was 25% on cabbage and traditional radish in Ahvaz (Iran). The mean of percentage of parasite *B. brassicae* by *D. rapae* that emerged from mummies collected during 1973–74 were 31.3% and the cabbage aphid had two population peak in UK (Chua 1977). Hasanshahi et al. (2013), were studied parasitism percent of *Plutella xylostella* (L.) by three parasitoids on eight cauliflower cultivars and the highest parasitism percent of the diamondback moth were obtained on Buris, Snow mystique and White cloud cultivars. The lowest parasitism percent by this parasitoid was observed on Snow crown, SG and Galiblanka cultivars. Bayhan et al. (2007), were studied parasitism rate of the cabbage aphid by *D. rapae* on different *Brassica* cultivars and was recorded the highest parasitism percent on cabbage (40.20%), and the lowest was recorded on turnip (32.64%).

These results showed that *D. rapae* wasp has important role in reducing populations of the cabbage aphid. Table 4.

Table 3. Comparison of mean (±SE) parasitism rate of cabbage aphid by *D. rapae* on eight cauliflower cultivars.

Cultivars	Mean of parasitism rate
Smilla	37.6 ± 9.00 a
Snow mystique	18.4 ± 7.30 b
White cloud	15.2 ± 6.37 b
Buris	23.2 ± 5.85 ab
Galiblanka	8.00 ± 2.82 b
Snow crown	16.00 ± 2.82 b
SG	22.4 ± 4.11 ab
Tokita	17.6 ± 4.11 b

*The same letters in each row are not significant different at 5% level.

Table 4. Results of analysis of variance of parasitism rate of cabbage aphid by *D. rapae* on eight cauliflower cultivars.

	Sum of squares	df	Mean square	*F*
Treatment	0.29	7	0.04	2.32*
Error	0.58	32	0.01	
Total	0.87	39		

*Significant at 5% probability level.

Several factors are effective on population fluctuations of *B. brassicae* that most important of these factors are climatic conditions, natural enemies (parasitoids and predators), host plant quality and aphid species characteristics (Dixon 1998; Awmack & Leather 2002).

Modarres-Najafabadi et al. (2004), were reported population peak of cabbage aphid in canola fields of Sistan region (Iran) from second half of March to late April. Peak of cabbage aphid density were reported from late April or early May in 2002–2003 in canola fields of Varamin (Iran) (Keyhanian & Taghaddosi 2010).

In conducted research by Khajezadeh (2004), population peak of cabbage aphid was in the second half of March in canola fields of Behbahan (Iran). Khan and Rabbani (1992), were studied population fluctuations of *B. brassicae* in canola fields of Pakistan and were reported population peak this aphid from March to April and from September to November. Population peak this aphid were reported from late of March to early April in Ahvaz region of Iran (Kazemzadeh-Arjas 2003). In this researches by increasing temperature, population density of the cabbage aphid was decreased and can be said that climatic conditions has large impact on population density of this pest.

In this study, pest population has fluctuations of increasing and decreasing throughout time. But population was increased with reducing temperature in South of Tehran almost in the beginning of October and population reach to its maximum at the end of the season. The mean of daily temperature is reduced with approached to end of the season. Parasitism rate by parasitoid of this pest on different cultivars was increased with decreasing daily temperature during the season.

Therefore can be conserving this parasitoid when the peak population of this pest and with releasing this parasitoid reduced pest damage. The temperature reducing role is well represented in increasing of population of the cabbage aphid. According to results of this study, despite of the increasing activity of *D. rapae*, temperature reducing role in increasing of population of *B. brassicae* is more prominent than parasitoids role of this pest

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