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Variation in aphid complex influx and predatory dynamics in wild crucifers

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ABSTRACT

The present study was carried out during the winter (*rabi*) season of 2019–20 and 2020–21 at ICAR-Indian Agricultural Research Institute, New Delhi to examine the population densities of different aphid species and predatory beetle, *Coccinella septempunctata* on various wild crucifer. The experiment followed a randomized complete block design (RBD) with four replications. Significant variation in aphid infestation and predatory activity of *C. septempunctata* was observed across test genotypes. *Brassica chinensis* exhibited highest susceptibility to aphid infestation, while *B. fruticulosa*, *B. tournefortii*, *Camelina sativa* and *Crambe abyssinica* had lower aphid population. Both grub and adult stages of *C. septempunctata* showed a strong presence in genotypes with high aphid infestation, indicating its role in biological control. Positive correlation was found between *C. septempunctata* and aphid species like *Lipaphis erysimi*, *Myzus persicae*, and *Brevicoryne brassicae*, suggesting that these aphids attract the predator, contributing to natural pest management. However, the correlation coefficients were non-significant with *Lipaphis pseudobrassicae* and *Aphis craccivora*. The results suggested that the predatory abundance is linked to aphid density, and introgression of aphid resistance from *B. tournefortii*, *Crambe abyssinica* and *Camelina sativa* in breeding programme could further help in reducing the aphid infestation in mustard.

Keywords: Aphid, *Coccinella septempunctata*, Population, Predator, Wild crucifers

Oilseeds, particularly rapeseed-mustard [*Brassica juncea* (L.) Czern & Coss], are globally significant due to their high nutritional and economic value (Singh *et al.* 2022). In India, mustard is a major oilseed crop, contributing 25–30% of the country's total oilseed production and serving as a critical source of edible oil (Trivedi *et al.* 2023). Its adaptability to diverse agro-climatic conditions makes it favourable for cultivation across various regions (Verma *et al.* 1975). However, mustard cultivation faces considerable challenges, particularly from aphid infestations, which can lead to severe yield losses if not managed (Dhillon *et al.* 2018). Aphids, such as the mustard/turnip aphid (*Lipaphis erysimi*), green peach aphid (*Myzus persicae*), and cabbage aphid (*Brevicoryne brassicae*), form a damaging aphid complex in crucifer crops (Sarwar *et al.* 2009, Samal *et al.* 2021, Dhillon *et al.* 2022, Chandrakumara *et al.* 2023). These sap-sucking insects weaken plants by reducing photosynthetic capacity, stunting growth, and lowering seed yields, while also transmitting viral diseases (Dhillon *et al.* 2022, Chandrakumara *et al.* 2024). Chemical insecticides have traditionally been the main control method, but their overuse has led to development of resistance in aphid populations, resurgence of secondary pests, and environmental concerns.

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Biological control through *Coccinella septempunctata* Linnaeus, offers a sustainable alternative for aphid management (Sahito *et al.* 2019). Both the grubs and adults of this predator feed on aphids, significantly reducing the pest population (Murahwi 2015). Despite its ecological importance, limited research exists on the interaction between aphid complex and their natural enemies in mustard. Wild crucifers on the other hand, are rich in genetic diversity and serve as potential sources of pest and disease resistance (Bandopadhyay *et al.* 2024). Aphid infested mustard plants emit herbivore-induced plant volatiles like (E)-β-ocimene and (Z)-3-hexenyl acetate, which attract natural predators such as ladybird beetles, lacewings, and parasitic wasps (War *et al.* 2011). However, the aphid complex associated with wild crucifers and its interaction with natural enemies like *C. septempunctata* remains unexplored. This research aims to investigate the diversity of aphid species on wild crucifers and their association with *C. septempunctata*, contributing to the development of sustainable pest management strategies.

MATERIALS AND METHODS

The present study was carried out during winter (*rabi*) season of 2019–20 and 2020–21 at ICAR-Indian Agricultural Research Institute, New Delhi. A total of 29 wild crucifer species were grown in the experimental fields of ICAR-Indian Agricultural Research Institute, New Delhi (28.08°N, 77.12°E). The experiment followed a randomized complete block design (RCBD) with four replications. Each genotype was planted in four-row plots, with each row measuring 5 m in length. Row spacing was maintained at 30 cm, and individual plants were spaced 15 cm apart within the rows. A 60 cm buffer gap was provided between adjacent four-row plots of different genotypes to minimize interference. All recommended agronomic practices were implemented throughout the experiment, except for the application of insecticides.

For data collection, five plants from each genotype were randomly selected and tagged for monitoring, ensuring that the selection covered all four rows within each plot and thus making five replications. The numbers of different species of aphids and the predatory beetle, *C. septempunctata,* were counted from the top 10 cm main shoot of test wild crucifer genotypes. The data on aphid population and *C. septempunctata* in the test wild crucifer genotypes were analyzed using R software (version 4.1.1). The Shapiro-Wilk test confirmed the normality of the data, allowing for the application of one-way analysis of variance. Treatment means were compared using the least significant differences at p=0.05. The relationship between aphid species and *C. septempunctata* population was assessed using Pearson correlation analysis by SPSS software (version 22).

RESULTS AND DISCUSSION

A total of five different species of aphids have been reported to inhabit wild crucifer species, viz. *L. erysimi*, *M. persicae*, *B. brassicae*, *Lipaphis pseudobrassicae* and *Aphis craccivora*. The data on aphid populations, as well as the population of *C. septempunctata* in both grub and adult stages across various genotypes during the cropping seasons of 2019–20 and 2020–21, exhibited significant variations among the test genotypes (Table 1). These variations highlight the differential susceptibility of the genotypes to aphid infestation and the varying levels of predatory activity by *C. septempunctata*. The result revealed that in both the season, aphid population ranged from 4.2–173.0 for *L. erysimi* (F=3.12 in 2019–20, F= 4.10 in 2020–21; df=28,144; p<0.001), 0.6–153.2 for *M. persicae* (F=4.35 in 2019–20, F= 3.01 in 2020–21; df=28,144; p<0.001), 0.2–82.0 for *B. brassicae* (F=3.98 in 2019–20, F= 3.80 in 2020–21; df=28,144; p<0.001), 0.2–24.0 for *L. pseudobrassicae* (F=5.56 in 2019–20, F= 4.22 in 2020–21; df=28,144; p<0.001) and 0.1–19.4 for *A. craccivora* (F=5.06 in 2019–20, F= 4.56 in 2020–21; df=28,144; p<0.001). *C. septempunctata* grub (F=6.02 in 2019–20, F= 5.25 in 2020–21; df= 28,144; p<0.001) and adult (F=5.11 in 2019–20, F= 3.89 in 2020–21; df=28,144; p<0.001) stages across both seasons ranged from 0.8–4.4 and 1.7–6.6, respectively. *Brassica chinensis* exhibited the highest aphid infestations among the genotypes, with significant populations of aphid complex across both seasons. The persistent high levels of infestation highlight its susceptibility to aphid attack. In contrast, *B. fruticulosa* and its Spanish variant showed lower aphid populations, demonstrating a degree of resistance compared to *B. chinensis*. Other genotypes such as *B. tournefortii*, *Lepidium sativum*, and *Sisimbrium* (BWMR) displayed remarkably low aphid infestations. These genotypes, especially *B. tournefortii* (RBT 2003), had minimal populations of aphids, indicating high aphid resistance. *Camelina sativa, Eruca sativa* (IC57705, IC60468, and IC62597) also exhibited low aphid infestations, further emphasizing its potential as a resistant genotype. Moderate levels of infestation were observed in genotypes like *Capsella bursapastoris* and species from the *Diplotaxis* species, indicating varying susceptibility to aphids. Notably, *Crambe abyssinica* variants (EC400058, EC694069, EC694071, EC694075, EC694090, and EC694125) were the least affected by aphids, with minimal infestations of aphids. This makes *Crambe abyssinica* one of the most aphid-resistant genotypes studied as compared to other test wild crucifers. The present study, in line with Dwivedi and Singh (2019), evaluated eight varieties of *Brassica juncea* for resistance against mustard aphids, revealing that the Varuna variety harbour highest aphid population, averaging 285.7 aphids/10 cm top shoot, while the Rohini variety exhibited the lowest infestation with 110.5 aphids. Similarly, Kumari *et al.* (2018) assessed 77 mustard germplasm lines and identified IC491089 as a tolerant line, supporting 21.3–30.7 aphids/10 cm, while IC385703 was found to be highly susceptible, with aphid counts ranging from 87.0–195.3/10 cm. Genetic variation within plant species plays a significant role in influencing herbivore acceptance and suitability, with this relationship effectively assessed by studying herbivore population dynamics across different host plant genotypes. Barker *et al.* (2018) emphasized that such variations substantially affect a plant's ability to either resist or support insect herbivores. In the case of *Brassica juncea* (Indian mustard), Chandrakumara *et al.* (2024) observed significant differences in aphid populations, resistance indices, and aphid multiplication rates across different mustard genotypes. Under both natural and artificially induced infestation conditions, genotypes like DRMR 150-35, RH 0406, NRCHB 101, Pusa Mustard 27, and RLC 3 exhibited significantly lower aphid populations and reduced multiplication rates, suggesting a higher level of resistance to aphids. Chaudhary and Patel (2016) also conducted a comprehensive screening of 60 mustard lines, identifying NRCM 120, NRCM 353, and Ryad 9602 as highly resistant, based on their low aphid resistance indices, while varieties such as GM-2, HYOLA-401, GM-3, and GM-1 were categorized as susceptible. These susceptible lines exhibited high aphid multiplication rates, resulting in higher levels of aphid infestation and plant damage. Agarwala *et al.* (2009) studied the genetic and morphological differentiation of *L. pseudobrassicae* on cruciferous host plants, noting that aphids from *B. juncea*, were larger and exhibited higher growth rates and fecundity compared to those from wild herbs like *Rorippa indica*. In the current study, legume aphid, *A. craccivora* was observed to occasionally inhabit wild crucifers. However, it failed to establish a rapid infestation on these plants, indicating its limited ability to thrive on non-legume hosts. These

Table 1 Population of aphid complex and the predatory beetle, *Coccinella septempunctata* in wild crucifer genotypes under natural conditions (2019–20 and 2020–21)

Genotypes	Aphid complex (Nos.)										*Coccinella septempunctata* (Nos.)			
	Lipaphis erysimi		*Myzus persicae*		*Brevicoryne brassicae*		*Lipaphis pseudobrassicae*		*Aphis craccivora*		Grubs		Adults	
	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21	2019–20	2020–21
Brassica chinensis	135.0	173.0	106.0	153.2	82.0	70.0	24.0	19.0	19.4	16.0	2.2	0.8	3.4	1.7
Brassica fruticulosa	91.0	118.0	59.0	97.9	35.0	24.4	3.0	2.0	16.8	14.5	2.2	1.2	2.4	2.1
Brassica fruticulosa (Spain)	100.0	115.0	48.0	79.7	24.0	17.4	4.0	2.5	16.0	13.0	2.0	0.8	3.4	1.7
Sisimbrium (BWMR)	50.8	65.8	22.0	36.5	17.0	15.6	1.4	1.2	2.0	6.0	3.6	2.6	6.0	5.3
Brassica tournefortii (RBT 2002)	26.0	41.0	25.2	41.8	20.2	12.6	1.8	1.4	3.2	6.6	3.0	2.0	4.6	3.9
Brassica tournefortii (RBT 2003)	27.6	42.6	1.2	2.0	1.2	1.0	0.8	0.9	0.4	0.7	3.4	2.0	4.2	3.5
Camelina sativa	12.8	27.8	2.6	4.3	2.6	8.6	0.8	0.9	0.8	0.9	3.8	2.6	3.4	2.7
Capsella bursapastoris (Early)	70.8	85.8	13.8	22.9	12.8	5.3	1.0	1.0	1.0	1.0	3.8	2.8	3.6	2.9
Capsella bursapastoris (Late)	63.4	78.4	9.8	16.3	8.8	4.6	1.2	1.1	1.4	1.2	4.4	3.4	2.8	3.1
Diplotaxis assurgens	55.8	70.8	16.8	27.9	15.8	8.2	0.8	0.9	1.6	1.3	2.6	1.6	3.4	2.7
Diplotaxis erucoides	57.4	60.4	14.8	24.6	13.8	11.2	0.0	0.5	0.8	1.3	2.6	1.2	3.4	2.1
Diplotaxis gomez-campoi	45.4	66.4	7.0	11.6	6.0	3.8	0.8	0.9	1.6	0.9	2.2	1.2	2.8	2.5
Diplotaxis muralis	51.4	80.0	18.6	30.9	17.6	10.4	1.4	1.2	1.6	1.3	2.2	1.2	3.2	2.9
Diplotaxis siettiana	65.0	71.4	22.0	36.5	21.0	15.2	1.2	1.1	2.2	1.3	2.2	1.4	3.6	3.3
Diplotaxis tenuisilique	56.4	66.0	7.8	12.9	6.8	5.2	2.0	1.5	1.0	1.6	2.4	1.4	3.2	2.1
Diplotaxis viminea	51.0	74.8	10.0	16.6	9.0	4.8	1.4	1.2	1.4	1.0	2.4	1.4	2.8	3.3
Enarthrocarpus lyratus	58.2	73.2	16.6	27.6	15.6	11.2	1.2	1.1	1.8	1.4	2.8	1.8	3.6	2.9
Erucastrum canariense	46.6	61.6	15.2	25.2	14.2	9.5	1.4	1.2	1.8	1.4	2.2	1.2	3.6	2.9
Lepidium sativum	12.4	27.4	6.4	10.6	5.4	3.8	1.2	1.1	1.2	1.1	2.2	1.2	3.2	3.3
Sisimbrium spp.	4.2	4.2	0.8	1.3	0.6	0.4	0.4	0.7	0.8	0.9	3.2	2.2	2.8	2.1
Crambe abyssinica (EC400058)	4.6	5.8	0.6	1.0	0.6	0.6	0.0	0.5	0.6	1.1	2.0	1.0	2.2	2.7
Crambe abyssinica (EC694069)	6.0	4.6	1.0	1.7	0.8	0.2	0.6	0.8	1.2	0.6	2.0	1.0	2.4	1.5
Crambe abyssinica (EC694071)	6.8	6.8	0.8	1.3	0.8	0.6	0.2	0.6	1.0	1.0	2.2	1.2	3.0	2.3
Crambe abyssinica (EC694075)	5.8	6.2	1.0	1.7	1.0	0.5	0.2	0.6	0.1	1.0	2.8	1.2	2.8	2.3
Crambe abyssinica (EC694090)	6.2	6.6	1.0	1.7	0.8	0.8	0.4	0.7	0.2	0.5	2.2	1.6	3.0	2.3
Crambe abyssinica (EC694125)	5.4	5.6	0.8	1.3	0.6	0.2	0.2	0.6	0.1	0.7	2.0	2.2	2.4	2.1
Eruca sativa (IC57705)	18.8	15.8	2.2	3.7	1.2	0.4	1.0	1.0	0.2	0.6	2.0	1.6	2.8	1.9
Eruca sativa (IC60468)	22.0	22.0	2.4	3.5	1.4	0.6	0.8	0.9	0.4	0.7	2.2	1.2	2.4	1.7
Eruca sativa (IC62597)	19.2	19.2	2.4	4.0	1.4	0.8	1.4	1.2	0.8	0.9	1.8	0.8	1.6	1.7
F-probability	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
LSD (p=0.05)	1.66	0.82	0.26	1.01	0.14	0.09	0.07	0.21	0.05	0.01	0.85	0.45	1.34	1.12

Table 2 Association between aphid complex and *Coccinella septempunctata* population in wild crucifers

Aphid complex	Correlation coefficients (r)	
	Coccinella septempunctata	
	Grubs	Adults
Lipaphis erysimi	0.83**	0.96**
Myzus persicae	0.65**	0.83**
Brevicoryne brassicae	0.75**	0.93**
Lipaphis pseudobrassicae	-0.01	-0.18
Aphis craccivora	0.17	0.07

*,**Correlation coefficients significant at the p=0.05, 0.001, respectively.

findings underscore the importance of genetic variation in plant resistance to insect herbivores and provide valuable insights for breeding programmes focused on developing insect-resistant crop varieties.

The population of *C. septempunctata*, an important aphid predator, was also studied across these genotypes in both its grub and adult stages (Table 2). The presence of *C. septempunctata* grubs and adults is an indicator of the biological control potential exerted on aphid populations, as these beetles are highly effective in reducing aphid numbers. Across the test genotypes, significant variations in the population of *C. septempunctata* were observed. In genotypes with high aphid infestations, such as *B. chinensis*, the presence of *C. septempunctata* was relatively higher. For instance, the population of grubs was 2.2 in 2019–20 and 0.8 in 2020–21, while the adult population was 3.4 in 2019–20 and 1.7 in 2020–21. These numbers suggested a natural response of *C. septempunctata* to the high aphid populations in these genotypes, although the numbers of both aphids and *C. septempunctata* declined in the second year. In genotypes such as *B. fruticulosa* and *B. fruticulosa* (Spain), which had moderate aphid infestations, the population of *C. septempunctata* was also moderate. For example, in *Brassica fruticulosa*, the grub population was 2.2 in 2019–20 and 1.2 in 2020–21, while the adult population was 2.4 in 2019–20 and 2.1 in 2020–21. This indicates that while the aphid infestations were not as high as in *B. chinensis*, the presence of *C. septempunctata* was sufficient to exert biological control. Genotypes with low aphid infestations, such as *B. tournefortii* (RBT 2003), *Camelina sativa*, and *Crambe abyssinica*, also exhibited relatively low populations of *C. septempunctata*. In *B. tournefortii* (RBT 2003), the population of grubs was 3.4 in 2019–20 and 2.0 in 2020–21, while adults were 4.2 in 2019–20 and 3.5 in 2020–21. Despite the low aphid infestations, the presence of *C. septempunctata* suggests that these genotypes still attract predators, potentially maintaining a natural balance that prevents aphid outbreaks. Conversely, some genotypes such as *Sisimbrium* (BWMR) and *Diplotaxis siettiana* exhibited higher populations of *C. septempunctata* despite moderate aphid infestations. *Sisimbrium* (BWMR) recorded grub populations of 3.6 in 2019–20 and 2.6 in 2020–21, with adult populations of 6.0 in 2019–20 and 5.3 in 2020–21. Similarly, *Diplotaxis siettiana* had grub populations of 2.2 in both years, with adult populations of 3.6 in 2019–20 and 3.3 in 2020–21. The relatively high presence of *C. septempunctata* in these genotypes indicates a robust natural enemy response, possibly due to environmental factors or the availability of alternative prey. Rana (2006) found that *C. septempunctata* and *Menochilus sexmaculatus* ladybird populations were influenced by aphid density, with eggs and larvae positively correlated to aphid numbers, and *C. septempunctata* being more abundant and lasting longer than *M. sexmaculatus*. Similarly, Sahito *et al.* (2019) reported that *C. septempunctata* grubs and adults showed significant aphid predation, consuming up to 48 aphids/day in the fourth larval stage and 40 aphids/day as an adult, making it an effective biological control agent for mustard pests.

A strong positive correlation was observed between *C. septempunctata* and *Lipaphis erysimi*, with correlation coefficients of 0.83 for grubs and 0.96 for adults, indicating that higher populations of this aphid are associated with increased numbers of ladybird beetles. Similarly, *Myzus persicae* showed positive correlations of 0.65 for grubs and 0.83 for adults, suggesting a substantial relationship between this aphid species and *C. septempunctata*. *Brevicoryne brassicae* also exhibited significant positive correlations (0.75 for grubs and 0.93 for adults), reinforcing the trend. *C. septempunctata*, is a well-documented predator of aphids, particularly effective in controlling populations of species such as *L. erysimi*, *M. persicae*, and *B. brassicae.* In contrast, the correlations with *Lipaphis pseudobrassicae* (-0.01 for grubs and -0.18 for adults) and *Aphis craccivora* (0.17 for grubs and 0.07 for adults) were not statistically significant. These findings suggested that *C. septempunctata* is more strongly associated with specific aphid species, particularly *Lipaphis erysimi*, *Myzus persicae*, and *Brevicoryne brassicae*, which may serve as important prey for this ladybird beetle. The lack of significant associations with other aphid complexes indicated that *C. septempunctata* may selectively target certain aphid species, which could have implications for biological control strategies in managing aphid populations in crucifer crops. The findings of current study were also in line with earlier studies conducted by Norkute *et al.* (2020), Hamid *et al.* (2021), Meseguer *et al.* (2021) and Manimala *et al.* (2024).

The findings revealed significant differences in aphid susceptibility, with *Brassica chinensis* being highly susceptible, while genotypes like *B. fruticulosa, B. tournefortii, Camelina sativa,* and *Crambe abyssinica* exhibit notable resistance. The consistent presence of *C. septempunctata* in high-aphid-infested genotypes underscores its potential as a biological control agent. The positive correlation with specific aphid species indicated that these pests can effectively attract natural predators, and incorporation of resistant genotypes into crop breeding programme also help in reducing aphid infestation, and minimize insecticide use and promoting sustainable agricultural practices. Future research should further explore the aphid complex dynamics to optimize pest management in cruciferous crops.

REFERENCES

Agarwala B K, Das K and Raychoudhury P. 2009. Morphological, ecological and biological variations in the mustard aphid, *Lipaphis pseudobrassicae* (Kaltenbach) (Hemiptera: Aphididae) from different host plants. *Journal of Asia-Pacific Entomology* **12**(3): 169–73.

Bandopadhyay L, Basu D and Ranjan Sikdar S. 2024. *De novo* transcriptome assembly and global analysis of differential gene expression of aphid tolerant wild mustard *Rorippa indica* (L.) Hiern infested by mustard aphid *Lipaphis erysimi* (L.) Kaltenbach. *Functional and Integrative Genomics* **24**(2): 65.

Barker H L, Holeski L M and Lindroth R L. 2018. Genotypic variation in plant traits shapes herbivorous insect and ant communities on a foundation tree species. *PLOS One* **13**(7): e0200954.

Chandrakumara K, Dhillon M K, Tanwar A K and Singh N. 2023. Phytochemicals in *Brassica juncea* distressing developmental and reproductive biology of mustard aphid *(Lipaphis erysimi)*. *The Indian Journal of Agricultural Sciences* **93**(10): 1139–43.

Chandrakumara K, Dhillon M K and Singh N. 2024. Tolerance in *Brassica juncea* cultivars vis-a-vis population buildup of mustard aphid *Lipaphis erysimi* (Kalt.). *Indian Journal of Entomology* **86**(2): 409–13.

Chaudhary R I and Patel C C. 2016. Screening of Brassica germplasm for resistance to mustard aphid, *Lipaphis erysimi* (Kalt.). *International Journal of Plant Protection* **9**(1): 62–67.

Dhillon M K, Singh N, Tanwar A K, Yadava D K and Vasudeva S. 2018. Standardization of screening techniques for resistance to *Lipaphis erysimi* (Kalt.) in rapeseed-mustard under field conditions. *Indian Journal of Experimental Biology* **56**: 674–85.

Dhillon M K, Singh N and Yadava D K. 2022. Preventable yield losses and management of mustard aphid, *Lipaphis erysimi* (Kaltenbach) in different cultivars of *Brassica juncea* (L.) Czern and Coss. *Crop Protection* **161**: 106070.

Dwivedi S A and Singh R S. 2019. Evaluation of the new molecular insecticides and biopesticides against mustard aphid *Lipaphis erysimi* (Kalt.) on yield parameter in mustard. *Journal of Biopesticides* **12**(2): 203–14.

Hamid M F, Hameed Y, Sarmad M, Abbas K, Shahzaib M, Zakria M and Zaka S M. 2021. Functional response of *Coccinella septempunctata* (Coleoptera: Coccinellidae) to different species of aphids (Hemiptera: Aphididae). *Journal of the Kansas Entomological Society* **93**(4): 313–26.

Kumari A, Goswami T N, Vishwakarma R and Kishore C. 2018. Evaluation of mustard germplasm against aphid *Lipaphis erysimi* (Kalt.). *Indian Journal of Entomology* **80**(4): 1456–59.

Manimala R N, Shashikala M, Lakshmi K S I, Jayanth B V, Vireesha P and Rajareddy G. 2024. Behavioural response of seven-spotted ladybird beetle, *Coccinella septempunctata* (L.) (Coleoptera: Coccinellidae) towards different aphids and their host plants. *International Journal of Environment and Climate Change* **14**(9): 448–53.

Meseguer R, Levi-Mourao A and Pons X. 2021. Species complex and temporal associations between coccinellids and aphids in alfalfa stands in Spain. *Insects* **12**(11): 971.

Murahwi D K. 2015. 'Feeding performance and effectiveness of ladybird beetles (Coleoptera: Coccinellidae) for cowpea aphids (*Aphis craccivora*) control'. PhD Thesis, University of Zimbabwe.

Norkute M, Olsson U and Ninkovic V. 2020. Aphids-induced plant volatiles affect diel foraging behavior of a ladybird beetle *Coccinella septempunctata*. *Insect Science* **27**(6): 1266–75.

Rana J S. 2006. Response of *Coccinella septempunctata* and *Menochilus sexmaculatus* (Coleoptera: Coccinellidae) to their aphid prey, *Lipaphis erysimi* (Hemiptera: Aphididae) in rapeseed-mustard. *European Journal of Entomology* **103**(1): 81.

Sahito H A, Solangi R, Kousar T, Shah Z H, Mangrio W M and Rind M M. 2019. Biological control of mustard aphid, *Lipaphis erysimi* (Kaltenbach) through seven-spotted ladybird beetle *Coccinella septempunctata* under laboratory conditions. *Pure and Applied Biology* **8**(2): 1707–17.

Samal I, Dhillon M K and Singh N. 2021. Biological performance and biochemical interactions of mustard aphid (*Lipaphis erysimi*) in *Brassica juncea. The Indian Journal of Agricultural Sciences* **91**(9):1347–52.

Sarwar M, Ahmad N, Khan G Z and Tofique M. 2009. Varietals resistance and susceptibility in mustard (*Brassica campestris* L.) genotypes against aphid *Myzus persicae* (Sulzer) (Homoptera: Aphididae). *The Nucleus* **46**(4): 507–12.

Singh K H, Singh L, Parmar N, Kumar S, Nanjundan J, Singh G and Thakur A K. 2022. Molecular characterization and genetic diversity analysis in Indian mustard (*Brassica juncea* L.) varieties using SSR markers. *PLOS One* **17**(8): e0272914.

Trivedi R K, Tripathi R K, Pandey D and Sharma P. 2023. An overview of oilseeds seed industry. *Journal of Oilseeds Research* **40**(4): 169–75.

Verma P R, Harding H, Petrie G A and Williams P H. 1975. Infection and temporal development of mycelium of *Albugo candida* in cotyledons of four *Brassica* species. *Canadian Journal of Botany* **53**:1016–20.

War A R, Sharma H C, Paulraj M G, War M Y and Ignacimuthu S. 2011. Herbivore induced plant volatiles: Their role in plant defense for pest management. *Plant Signaling and Behavior* **6**(12): 1973–78.