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PLANT–APHID INTERACTIONS IN BRASSICACEAE: ROLES OF GLUCOSINOLATES, VIRUSES, AND BACTERIAL SYMBIONT ASSOCIATIONS

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ABSTRACT

The family Brassicaceae, which includes economically important crops like mustard, cabbage, and rapeseed, is a host to a diverse range of sap-sucking insects, with aphids being among the most damaging. These pests, including *Lipaphis erysimi*, *Brevicoryne brassicae*, and *Myzus persicae*, inflict significant damage by extracting phloem sap, leading to stunted growth, reduced yield, and the transmission of plant viruses. This review paper synthesizes current knowledge on the multifaceted interactions between Brassicaceae plants and aphids, focusing on the key roles of plant chemical defences, aphid-associated viruses, and symbiotic relationships. Glucosinolates (GSLs) and their hydrolysis products, such as isothiocyanates (ITCs), are a primary line of plant defence, influencing aphid feeding behaviour and the effectiveness of natural predators. Furthermore, the intricate relationship between aphids and the viruses they transmit can alter host plant physiology and vector behaviour, often promoting conditions favourable for virus spread. Finally, the paper highlights the critical role of aphid endosymbionts, particularly *Buchnera aphidicola*, in providing essential nutrients that enable aphids to thrive on nutrient-poor phloem sap. A comprehensive understanding of these complex interactions is crucial for developing integrated pest management strategies and breeding resistant *Brassica* cultivars.

Introduction

Brassicas are globally cultivated due to their vegetable as well as edible oil utilization (Singh *et al.*, 2022). Commonly dubbed as crucifers, the crops are used globally as food, oil seed production and also animal feed. The extensive array of their utilization may be due to the family's high diversity with a total of over 321 genera and also 3,660 species (Raza *et al.*, 2020). Genomes of over 20 species of the Brassicaceae family are already available (Chen *et al.*, 2022). These species cover traditionally cultivated indigenous varieties like toria (*Brassica rapa L. var. toria*), brown sarson (*B. rapa L. var. brown sarson*), yellow sarson (*B. rapa L. var. yellow sarson*), Indian mustard (*B. juncea L.*), black mustard (B. nigra Koch), and taramira (*Eruca sativa*), as well as non-traditional varieties like gobhi sarson (*B. napus L.*) and Ethiopian mustard, or otherwise referred to as karan rai (*B. carinata Braun*) (Kumar *et al.*, 2020). Members of the cultivated Brassicaceae family also include rapeseed, mustard, cabbage, cauliflower, broccoli, turnip, and other leafy vegetable types. Of particular interest are *B. oleracea, B. napus, and B. rapa* cultivated worldwide (Jabeen, 2020; Raza *et al.*, 2020). Brassica oleracea acts as a vegetable (i.e., cabbage, kale, Brussels sprout, broccoli, and cauliflower), as well as an oil and fodder crop. Indian cultivations of rapeseed and mustard constitute three chief cruciferous members of the genus *Brassica*. Of these, *B. juncea* (Indian mustard, locally known as rai) remains the chief oilseed crop while *B. campestris ssp. Oleifera*-consisting of three varieties of ecotypes, i.e., brown sarson, yellow sarson, toria and *B. napus* are cultivated to a minimal level. These generally produce fruits of the type of siliques or siliqua types (Jabeen, 2020). *Brassica* oilseeds are susceptible to infestation with the green peach aphid

(*Myzus persicae* Sulzer), the cabbage aphid (*Brevicoryne brassicae* L.), and the turnip aphid (*Lipaphis erysimi* Kalt.). Most severely, B. juncea (Indian mustard) has highest infestation from *L. erysimi*, though there are cases of *B. brassicae* and *M. persicae* infestations as well (Bhatia *et al.*, 2011). These aphids are also provided with specific piercing-sucking mouthparts with which they tap the host plant's phloem sap and thus rob the host of vital nutrients and cause significant direct and indirect damages in agricultural productivity (Bhattacharya, 2019).

Species Complex of Aphids on *Brassicaceae* Plants

Aphids or greenflies/plant lice are minute, soft-bodied arthropods and constitute a leading group of herbivorous insects of the order Hemiptera and the superfamily Aphidoidea (Blackman & Eastop, 1994). With their feeding habit as sap feeders, aphids are globally famous as major pests of agriculture (Vennila, 2008). Out of the approximately 4,000 to 5,000 aphid species documented, approximately 250 are documented as major agricultural pests with host specificity variation among species (Kumar, 2019). In northern Europe and India, aphids are major insect pests of agriculture. They also seriously threaten horticultural production in both greenhouse and field production through the direct damage of crops through feeding and infesting and transmitting plant viral pathogens (Dawson *et al.*, 1990; Sekhon, 1999). Aphids cause high global agricultural damages through removal of plant nutrients, injection of elicitors, and viral transmission of pathogenic viruses (Ng & Perry, 2004). In addition, aphid honeydew stimulates the growth of sooty molds on leaves that disrupts photosynthetic activity and plant health (Dedryver *et al.*, 2010). Brassicaceae family members are good hosts of a high number of aphid species. Most prominent of all are *B. brassicae*, *L. erysimi*, and *M. persicae* because they are especially notable for extensive damage among a wide variety of Brassica crops throughout much.

Table 1 : Key aphid pests of *Brassica* species and their economic significance

Aphid species	**Common name**	**Host Brassica crops**	**Biology / Reproduction**	**Yield loss reported**	**ETL (Economic Threshold Level)**	**References**
Lipaphis erysimi	Mustard/ Turnip aphid	Mustard, cabbage, cauliflower, toria	Nymphs and adults suck sap during vegetative, flowering, and pod formation stages	11–83%	40 aphids per 10 cm twig	Atwal (1976); Bakhetia (1990); Mandal *et al.* (1994); Dhillon *et al.* (2018, 2022); Dwivedi *et al.* (2019)
Brevicoryne brassicae	Cabbage aphid	Cabbage, broccoli, cauliflower	Highly host-specific; parthenogenetic viviparous females throughout year; overwinter on horticultural Brassicas and forage crops (rape, swede)	Moderate to severe	Variable, control mainly with insecticides	Kumar *et al.* (2011); Kift *et al.* (2000); Cole (1997); Schroeder & Dumbleton (2001)
Myzus persicae	Green peach aphid/ Potato aphid	Cabbage, Chinese cabbage, potato	Polyphagous; parthenogenetic reproduction with a single sexual generation; life cycle ~15 days; adult winged forms up to 2.1 mm	13% in Chinese cabbage	20 aphids per plant	Francis *et al.* (2001); Ali *et al.* (2023); Vorburger *et al.* (2003); Hemming *et al.* (2022); Jeon *et al.* (2008

Role of Glucosinolates in Aphid–Plant Interaction

Glucosinolates (GSLs) represent a substantial category of non-volatile, sulfur-containing secondary metabolites that are present in all economically significant Brassica crops (Tripathi & Mishra, 2007). Over 140 different glucosinolates have been identified from various plant sources, with roughly 30 of these found specifically in Brassica species (Bellostas *et al.*, 2007). The hydrolytic degradation products of GSLs, particularly isothiocyanates (ITCs), manifest a range of biological activities (Prieto *et al.*, 2019). The enzymes that facilitate the hydrolysis of GSLs into ITCs and additional compounds are known as myrosinases, which commence the bioactivation process of GSLs by severing their thioglycosidic bond. Myrosinases are classified as thioglucosidases (thioglucoside glucohydrolases, EC 3.2.1.147) and fall within glycoside hydrolase family I, alongside other β-glycosidases (Wittstock *et al.*, 2016). Syntheses of glucosinolates (GSLs) and plant reactions toward aphid herbivore feeding both possess both quantitative and qualitative variations (Kempema *et al.*, 2007). Sucking herbivores such as aphids generally cause fewer variations of GSL contents and correspondingly similar gene expressions as opposed to chewing insects such as beetles and caterpillars (Barth & Jander, 2006; Sato *et al.*, 2019). Aphids preferred feeding off of chinese cabbage as opposed to radish or cabbage because of low sulfur-GSL and high amino acid contents of leaves. However, high GSL contents of cabbage and radish triggered suboptimal feeding of aphids and restricted their growth (Ahmed *et al.*, 2022). Contrasting results were observed in *B. juncea fruticulosa* introgressed lines infested with *L. erysimi* with varying effects on GSL content (Palia *et al.*, 2018). Biosynthetic pathway transcripts of GSLs were upregulated during a B. juncea response to infestation with *Aphis craccivora* but were downregulated by infestation with *L. erysimi* (Duhlian *et al.*, 2020). Total GSL content increased in *B. rapa* infested with *L. erysimi* but decreased with infestation with *M. persicae* (Blande *et al.*, 2007). Light infestation with *B. brassicae* also triggered a growth of leaves and an increase of GSL emission from the bulb, *B. rapa's* major store organ (Sotelo *et al.*, 2014). Glucosinolates also affect the survival and fitness of *M. persicae* and the efficacy of the predators of the aphids (Kos *et al.*, 2011). A particular type of one of the glucosinolate variants, known as sinigrin, has a destructive effect on apterous aphids (Mazumder *et al.*, 2016).

Host plants (*Brassica* spp.) – aphids – parasitoids/ predators (Tritrophic interaction)

Glucosinolates serve as a defensive mechanism against herbivory by repelling herbivores while concurrently supporting parasitoids and predators (Hopkins *et al.*, 2009). Francis *et al.* (2001) studied tritrophic interactions in Brassica crops with varying glucosinolate profiles, involving *Myzus persicae* and *Brevicoryne brassicae* as herbivores and *Adalia bipunctata* as a predator. They emphasized that pest management must consider both herbivore and plant trophic levels to evaluate plant allelochemical effects on beneficial insects, noting that semiochemicals, from plants or herbivores, can act as toxins or informative cues. *Brassica nigra* plants with high sinigrin contents and a modified aphid diet supplemented with sinigrin were used to rear the specialist *B. brassicae*. These aphids were then presented as prey items to two generalist coccinellid beetles, *A. bipunctata* and *Coccinella septempunctata* (Pratt *et al.*, 2008). Results showed that feeding *B. brassicae* with sinigrin rendered such aphids unsuitable as a prey item for *A. bipunctata*, while they were still acceptable to *C. septempunctata*. However, *C. septempunctata* still incurred certain disadvantages with prey aphids that were laced with the chemical. Blande *et al.* (2007) examined the direction of the parasitoid *Diaeretiella rapae* orientation towards the semiochemicals of two aphids, *Lipaphis* erysimi (specialist) and *M.* persicae (generalist), feeding on turnips. Isothiocyanates were among the volatiles from the family Brassicaceae emitted as a defense response of the plant to insect feeding damages, including aphid infestations. Both *L. erysimi* and *M. persicae* could use the same cues during host location, and acceptance of the host and host suitability could rely also on the non-volatile aphid chemistry. Furthermore, Pope *et al.* (2008) investigated the olfactory perception and orientation behaviour of *B. brassicae* and the parasitoid *D. rapae* in response to alkenyl glucosinolate hydrolysis products. Electroantennogram recordings showed that *D. rapae* females could perceive all 3-butenylglucosinolate hydrolysis products. Interestingly, rearing *D. rapae* either on *B. nigra* (which accumulates 2-propenylglucosinolate) or *B. rapa* (which accumulates 3-butenylglucosinolate) altered the parasitoids' response to 3-isothiocyanatoprop-1-ene and 4-isothiocyanatobut-1-ene.

Modulation of Plant–Aphid Interaction by Aphid-Associated Viruses

Aphid-associated viruses influence both host plant physiology and vector behavior, with transmission strategies broadly classified into non-circulative and circulative types. These distinct mechanisms result in contrasting effects on host quality, aphid feeding behavior, and virus epidemiology.

Table 2: Modes of Aphid-Transmitted Plant Viruses and Their Effects on Plant–Aphid Interactions

Transmission Type	Mechanism	Effect on Vector Behaviour	Plant/Virus Interaction	References
Non-circulative	Virus acquired within seconds; attaches to aphid mouthparts; released when aphid feeds on a different healthy plant	Reduces host plant quality to promote rapid vector dispersion	Virus retained externally; transmission does not involve internal circulation	Watson *et al.* (1939); Mauck *et al.* (2012)
Circulative	Virus is ingested, crosses the gut lining to enter the hemolymph, circulates in the body, and reaches the salivary glands, from where it is released into saliva and transmitted to the plant	Improves host quality to promote long-term feeding and increases chance of virus acquisition	Involves systemic circulation and sometimes replication inside vector	Mauck *et al.* (2012)
General effect of plant viruses	—	Alters vector settling, performance, and feeding preferences	Induces morphological, physiological, biochemical, and molecular changes in host plants	Blanc *et al.* (2016)

Aphid Symbionts in Aphid–Plant Interactions

Endosymbionts are symbiotic bacteria that form obligate or facultative intracellular associations with insects and are of significant evolutionary significance since acquisition and retention often results in a new structure or host physiology and metabolic changes. These symbionts are of crucial importance in insect–plant ecology with a significant impact on insect ecology and resulting diversification among insect lineages (Janson *et al.*, 2008). Two types of bacterial endosymbionts are found in aphids: the obligate endosymbiont *Buchnera aphidicola* present in almost all aphids and facultative endosymbionts that are non-essential for survival and yet present in individuals of a particular population (Douglas, 1998; Moran *et al.*, 2005; Brady *et al.*, 2014). Coexistence of *Buchnera* and aphids goes back 80–150 million years (von Dohlen *et al.*, 2000), and *Buchnera* has a major responsibility of producing basic amino acids of their aphid hosts (Douglas, 1998). Because aphids are mostly fed with phloem sap, they are confronted with two hurdles: the high sugar level that needs conversion into long-chain oligosaccharides in order to avoid osmotic stress (the surplus sugars are excreted as honeydew attracting the ant offering protection but simultaneously exploited as food resource and honey bee food and attractant), and the low and imbalanced amino acid content of the phloem. In order to cope with the latter one, aphids rely upon *B. aphidicola* with an α-proteobacterium closely resembling *Escherichia coli* as a housing bacterium residing in special cells called bacteriocytes. Here we witness the co-evolution of aphids and their endosymbionts with *Buchnera* changing from a free-living one into an obligate partner (Buchner, 1965; Douglas, 1989; Fukatsu, 1994; Baumann *et al.*, 1997; Moran, 2007; Hogervorst *et al.*, 2007).

Conclusion

This review has highlighted the complex and dynamic nature of the interactions between aphids and Brassicaceae plants. The relationship is not merely a simple predator–prey dynamic but a sophisticated network influenced by plant-derived defense compounds, viral infections, and symbiotic microbial associations. The presence of glucosinolates acts as a double-edged sword, serving as a deterrent to some herbivores while simultaneously providing host recognition cues for specialized aphids and their natural enemies. Aphid-vectored viruses further manipulate this interaction by altering plant physiology to facilitate their own transmission, often to the detriment of the host plant. Moreover, the obligate relationship between aphids and their symbionts allows them to overcome nutritional deficiencies, solidifying their status as highly successful pests. Future research should focus on a more holistic understanding of these interactions at the molecular level, including the specific salivary effectors that aphids use to manipulate plant defenses and the precise mechanisms by which viruses and symbionts modify aphid behavior. Such insights will be vital for developing next-generation, sustainable pest control methods, such as breeding for enhanced glucosinolate profiles or disrupting the critical symbiotic relationships that underpin aphid survival. Ultimately, a multi-faceted approach that considers the full spectrum of these interactions will be required to ensure the long-term protection and productivity of Brassicaceae crops.

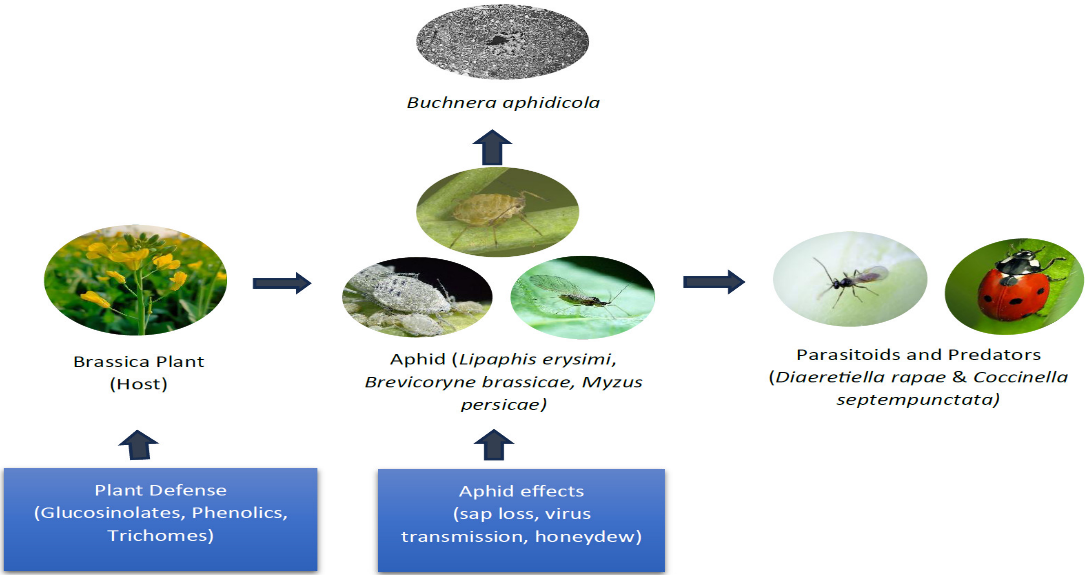

Fig. 1 : Schematic of Plant–Aphid Interactions in Brassicaceae

References

Ahmed, M.A. *et al*. (2022). Preference and performance of the green peach aphid, *Myzus persicae*, on three *Brassicaceae* vegetable plants and its association with amino acids and glucosinolates. *PLoS ONE* **17**, e0269736.

Ali, J. *et al*. (2023). Peach–potato aphid *Myzus persicae*, current management strategies, challenges, and proposed solutions. *Sustainability,* **15**, 11150.

Atwal, A.S. (1976). Pests of oilseed crops. In, *Agricultural pests of India and South-east Asia*. Kalyani Publishers, New Delhi, pp. 296–298.

Bakhetia, D.R.C. (1990). Insect pests. In, Chopra, V.L. and Parkash, S. (eds), *Oil Seed Brassicas in Indian Agriculture*. Vikas Publishing House, New Delhi, pp. 211–240.

Bari, R. *et al*. (2009). Role of plant hormones in plant defence responses. *Plant Mol. Biol.* **69**, 473–488.

Baumann, P. *et al.* (1995) Genetics, physiology, and evolutionary relationships of the genus *Buchnera*, intracellular symbionts of aphids. *Annu. Rev. Microbiol.* **49**, 55–94.

Bellostas, N. *et al*. (2007) Genetic variation and metabolism of glucosinolates. *Adv. Bot. Res.,* **45**, 369–415.

Bhatia, V. *et al*. (2011) Aphid resistance in *Brassica* crops, challenges, biotechnological progress and emerging possibilities. *Biotechnol. Adv.* **29**(6), 879–888.

Bhattacharya, S. (2019) *Physiol. Mol. Plant Pathol.* 101442.

Blackman, R.L. *et al*. (1994). *Aphids on the world's trees, an identification and information guide*. CAB International, Wallingford, UK.

Blanc, S. *et al*. (2016). Manipulation of hosts and vectors by plant viruses and impact of the environment. *Curr. Opin. Insect Sci.* **16**, 36–43.

Blande, J.D. *et al*. (2007). A comparison of semiochemically mediated interactions involving specialist and generalist *Brassica*-feeding aphids and the braconid parasitoid *Diaeretiella rapae*. *J. Chem. Ecol.* **33**, 767–779.

Brady, C.M. *et al*. (2014). Worldwide populations of the aphid *Aphis craccivora* are infected with diverse facultative bacterial symbionts. *Microb. Ecol.* **67**, 195–204.

Buchner, P. (1965). Endosymbiosis of animals with plant microorganisms. Interscience, New York.

Burke, G.R. *et al*. (2009). Evolution and diversity of facultative symbionts from the aphid subfamily Lachninae. *Appl. Environ. Microbiol.* **75**, 5328–5335.

Chen, H. *et al*. (2022). BRAD V3.0, an upgraded *Brassicaceae* database. *Nucleic Acids Res.* **50**, D1432–D1441.

Cole, R.A. (1997) Comparison of feeding behaviour of two *Brassica* pests *Brevicoryne brassicae* and *Myzus persicae* on wild and cultivated *Brassica* species. *Entomol. Exp. Appl.* **85**, 135–143.

Dawson, G.W. *et al*. (1990). Aphid semiochemicals – a review, and recent advances on the sex pheromone. *J. Chem. Ecol.* **16**, 3019–3030.

Dedryver, C.A. *et al*. (2010). The conflicting relationships between aphids and men, a review of aphid damage and control strategies. *C. R. Biol.* **333**, 539–553.

Dhillon, M.K. *et al*. (2018). Standardization of screening techniques for resistance to *Lipaphis erysimi* (Kalt.) in rapeseed–mustard under field conditions. *Indian J. Exp. Biol.* **56**, 674–685.

Dhillon, M.K. *et al*. (2022). Preventable yield losses and management of mustard aphid, *L. erysimi* (Kaltenbach) in different cultivars of *B. juncea* (L.) Czern. & Coss. *Crop Prot.* **161**, 106070.

Douglas, A.E. (1989). Mycetocyte symbiosis in insects. *Biol. Rev.* **64**, 409–434.

Douglas, A.E. (1998). Nutritional interactions in insect-microbial symbioses, aphids and their symbiotic bacteria *Buchnera*. *Annu. Rev. Entomol.* **43**, 17–37.

Duhlian, L. *et al*. (2020). Comparative transcriptomics revealed differential regulation of defense-related genes in *Brassica juncea* leading to successful and unsuccessful infestation by aphid species. *Sci. Rep.* **10**, 10583.

Dwivedi, S.A. *et al*. (2019). The occurrence and intensity of mustard aphid *Lipaphis erysimi* (Kalt.) on dates of sowing in different varieties with respect to yield parameters. *J. Entomol. Res.* **43**(4), 491–498.

Francis, F. *et al*. (2001). Effect of allelochemicals from first (Brassicaceae) and second (*Myzus persicae* and *Brevicoryne brassicae*) trophic levels on *Adalia bipunctata*. *J. Chem. Ecol.* **27**, 243–256.

Fukatsu, T. *et al*. (2000). The secondary endosymbiotic bacterium of the pea aphid *Acyrthosiphon pisum* (Insecta, Homoptera). *Appl. Environ. Microbiol.* **66**, 2748–2758.

Hemming, D. *et al*. (2022). Likelihood of extreme early flight of *Myzus persicae* (Hemiptera, Aphididae) across the UK. *J. Econ. Entomol.* **115**, 1342–1349.

Hogervorst, P.A.M. *et al*. (2007). Effects of honeydew sugar composition on the longevity of *Aphidius ervi*. *Entomol. Exp. Appl.* **122**, 223–232.

Hopkins, R.J. *et al*. (2009). Role of glucosinolates in insect–plant relationships and multitrophic interactions. *Annu. Rev. Entomol.* **54**, 57–83.

Jabeen, N. (2020) Agricultural, economic and societal importance of *Brassicaceae* plants. *Plant Fam. Brassicaceae* 2020, 45–128.

Janson, E.M. *et al*. (2008). Phytophagous insect–microbe mutualisms and adaptive evolutionary diversification. *Evolution* **62**(5), 997–1012.

Jeon, H.Y. *et al*. (2008). Economic injury level of *Myzus persicae* (Homoptera, Aphididae) at Chinese cabbage. *Korean J. Appl. Entomol.* **47**(4), 407–411.

Kempema, L.A. *et al*. (2007). Arabidopsis transcriptome changes in response to phloem-feeding silverleaf whitefly nymphs, similarities and distinctions in responses to aphids. *Plant Physiol.* **143**, 849–865.

Kift, N.B. *et al*. (2000). The influence of genetic background on resistance to the cabbage aphid (*Brevicoryne brassicae*) in kale (*Brassica oleracea* var. *acephala*). *Ann. Appl. Biol.* **136**, 189–195.

Kos, M. *et al*. (2011). Prey-mediated effects of glucosinolates on aphid predators. *Ecol. Entomol.* **36**, 377–388.

Kumar, A. *et al*. (2020). Biochemical basis of resistance to mustard aphid *Lipaphis erysimi* (Kaltenbach). *Indian J. Entomol.* **82**(4), 875–879.

Kumar, S. (2019). Aphid–plant interactions, implications for pest management. In, *Vegetation – Natural and Cultivated Vegetation in a Changing World*. Intech Open, s.l., pp. 1–10.

Kumar, S. *et al*. (2011). Screening of wild crucifers for resistance to mustard aphid, *Lipaphis erysimi* (Kaltenbach) and attempt at introgression of resistance gene(s) from *Brassica fruticulosa* to *Brassica juncea*. *Euphytica* **179**, 461–470.

Li, G.L. *et al.* (2019). TuMV management for *Brassica* crops through host resistance, retrospect and prospects. *Plant Pathol.* **68**, 1035–1044.

Mandal, S.M.A. *et al.* (1994). Yield loss in rapeseed and mustard due to aphid infestation in respect of different cultivars and dates of sowing. *Orissa J. Agric. Res.* **7**, 58–62.

Mauck, K. *et al.* (2012). Transmission mechanisms shape pathogen effects on host–vector interactions, evidence from plant viruses. *Funct. Ecol.* **26**, 1162–1175.

Mazumder, A. *et al.* (2016). Sinigrin and its therapeutic benefits. *Molecules* **21**, 416.

Moran, N.A. (2007). Symbiosis as an adaptive process and source of phenotypic complexity. *Proc. Natl. Acad. Sci. USA* **104**, 8627–8633

Moran, N.A. *et al.* (2005). Regulation of transcription in a reduced bacterial genome, nutrient-provisioning genes of the obligate symbiont *Buchnera aphidicola*. *J. Bacteriol.* **187**, 4229–4237.

Kumar Ng, J.C.K. *et al.* (2004). Transmission of plant viruses by aphid vectors. *Mol. Plant Pathol.* **5**, 505–511.

Palial, S. *et al.* (2018). Biochemical changes in the *Brassica juncea–fruticulosa* introgression lines after *Lipaphis erysimi* (Kaltenbach) infestation. *Phytoparasitica* **46**, 499–509.

Pope, T.W. *et al.* (2008). Comparative innate responses of the aphid parasitoid *Diaeretiella rapae* to alkenyl glucosinolate-derived isothiocyanates, nitriles and epithionitriles. *J. Chem. Ecol.* **34**, 1302–1310.

Tjallingii Pratt, C. *et al.* (2008). Accumulation of glucosinolates by the cabbage aphid *Brevicoryne brassicae* as a defense against two coccinellid species. *J. Chem. Ecol.* **34**, 323–329.

Prieto, M.A. *et al.* (2019). Glucosinolates, molecular structure, breakdown, genetics, bioavailability, properties and health effects. *Adv. Food Nutr. Res.* **90**, 305–350.

Raza, A. *et al.* (2020). The plant family *Brassicaceae*, introduction, biology, and importance. *Plant Fam. Brassicaceae* 2020, 1–43.

Sato, Y. *et al.* (2019). Transcriptional variation in glucosinolate biosynthetic genes and inducible responses to aphid herbivory on field-grown *Arabidopsis thaliana*. *Front. Genet.* **10**, 787.

Schmidtberg, H. *et al.* (2016). The ontogenesis of the pea aphid *Acyrthosiphon pisum*. In, Vilcinskas, A. (ed), *Biology and Ecology of Aphids*. CRC Press, Boca Raton, FL, pp. 14–51.

Schroeder, N.C. *et al.* (2001). Thiamethoxam seed coating on rape seed for the control of cabbage aphid *Brevicoryne brassicae* (L.). *N. Z. Plant Protect.* **54**, 240–243

Sekhon, B.S. (1999). Population dynamics of *Lipaphis erysimi* and *Myzus persicae* on different species of *Brassica*. 10th International Rapeseed Congress, Canberra, Australia.

Singh, N. *et al.* (2022). Achieving genetic gain for yield, quality and stress resistance in oilseed *Brassicas* through accelerated breeding. In, Gosal, S.S. and Wani, S.H. (eds), *Accelerated Plant Breeding*, Volume 4. Springer, Cham.

Sotelo, P. *et al.* (2014). *Brassica* plant responses to mild herbivore stress elicited by two specialist insects from different feeding guilds. *J. Chem. Ecol.* **40**, 136–149.

Srinivasan, D.G. *et al.* (2014). Gene expression analysis of parthenogenetic embryonic development of the pea aphid, *Acyrthosiphon pisum*, suggests that aphid parthenogenesis evolved from meiotic oogenesis. *PLoS One* **9**(12), e115099.

Tripathi, M.K. *et al.* (2007). Glucosinolates in animal nutrition, a review. *Anim. Feed Sci. Tech.* **132**, 1–27.

Vennila, S. (2008). Pest management for cotton ecosystems or ecosystem management for cotton production. *Curr. Sci.* **94**(11), 1351–1352.

von Dohlen, C.D. *et al.* (2000). Molecular data support a rapid radiation of aphids in the Cretaceous and multiple origins of host alternation. *Biol. J. Linn. Soc.* **71**, 689–717.

Vorburger, C. *et al.* (2003). Environmentally related patterns of reproductive modes in the aphid *Myzus persicae* and the predominance of two 'superclones' in Victoria, Australia. *Mol. Ecol.* **12**, 3493–3504.

Watson, M.A. *et al.* (1939). A comparative study of the transmission of *Hyoscyamus virus 3*, potato virus Y and cucumber virus 1 by the vectors *Myzus persicae* (Sulz), *M. circumflexus* (Buckton), and *Macrosiphum gei* (Koch). *Proc. R. Soc. Lond. B Biol. Sci.*, 543–576.

Wittstock, U. *et al.* (2016). Glucosinolate breakdown. *Adv. Bot. Res.* **80**, 125–169.