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A COMPREHENSIVE REVIEW ON HOLISTIC APPROACHES FOR MANAGING MUSTARD APHID, *LIPAPHIS ERYSIMI* (KALT.)

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ABSTRACT

Mustard, a crucial oilseed crop among brassica crops, is predominantly cultivated during the rabi season in temperate and some tropical regions worldwide. With its bright yellow flowers belonging to the Brassicaceae family, mustard is susceptible to attack by the mustard aphid *Lipaphis erysimi* (Kalt), a significant sucking pest affecting mustard and other Brassicaceae crops. Both nymphs and adults of this pest suck the cell-sap from plant parts, leading to stunted plant growth, wilting flowers and impaired pod development. Additionally, their feeding activity introduces toxic substances into the plants, causing chlorosis at feeding sites, yellowing of veins, and leaf curling. Numerous cost-effective control methods, including cultural, biological, botanical, push-pull and integrated approaches, have been identified to manage mustard aphids effectively. These strategies are particularly relevant for smallholder farmers in the region who often lack the financial resources to invest in chemical pesticides or other expensive control measures. This review explores various mustard aphid management options, encompassing prevention, monitoring, cultural practices, mechanical interventions, botanical remedies, biological management, biotechnological approaches, chemical methods and other integrated management approaches, tailored to the needs of smallholder farmers.

Key words : Mustard, Aphid, Sap sucking, Chlorosis, Integrated management, Smallholder farmers.

Introduction

Among the various insect pests affecting agriculture globally, Aphids (Hemiptera; Aphididae) stand out as particularly significant. There are approximately 4,700 species of Aphididae worldwide, with about 450 species documented on crop plants (Blackman, 2000). Most herbivorous aphid species belong to the largest subfamily, Aphidinae (Blackman, 2006). These pests feed on plant sap, hindering plant growth, excreting honeydew and causing a decrease in photosynthesis due to sooty mold, ultimately leading to yield reduction. Aphids infest nearly all parts of plants, from roots to tender shoots. Moreover, aphids are vectors for over 200 plant viruses (Hogenhout, 2008), resulting in secondary diseases in agriculture, horticulture, and related professions. In India, aphid infestations have been reported to cause yield losses ranging from 10% to 90%, depending on the severity of infestation and crop stage (Razaq, 2011).

Mustard, a significant oilseed crop among brassica crops, is primarily cultivated during the *rabi* season in temperate and certain tropical regions worldwide. Characterized by bright yellow flowers, this crop belongs to the Brassicaceae family and boasts approximately 40-45% oil content and 24% protein (Das, 2014). However, the mustard aphid *Lipaphis erysimi* (Kalt), a sucking pest, poses a severe threat to mustard and other Brassicaceae crops. According to the Central Organization for Oil Industry & Trade (COOIT), mustard seed production was estimated at 109.5 million tonnes in 2021-22, with area coverage of 87.44 million hectares and an average yield of 1270 kg per hectare. Mustard serves as a crucial cash crop for farmers in states like Rajasthan, Haryana, Madhya Pradesh and Uttar Pradesh, with Rajasthan being the leading producer in the country. India heavily relies on imports, accounting for about 60-65% of its total domestic demand for edible oils. COOIT

has stressed the imperative to boost domestic mustard seed production, given its high oil content ranging from 38-43%. This initiative aims not only to reduce India's dependence on imported edible oils but also to support small millers in utilizing their production capacities.

L. erysimi represents a significant threat, capable of causing yield losses ranging from 35.4% to 96% under favourable conditions (Sahoo, 2012), with a potential reduction of 5-6% in oil content (Shylesha, 2006). In certain mustard-growing regions, these losses can escalate to 100% (Singh, 1999). Both nymphs and adults of this pest feed on cell sap from various parts of the plant, including leaves, petioles, tender stems, inflorescences and pods, resulting in significant economic damage (Srivastava, 2002). Additionally, aphids excrete honeydew, promoting the growth of sooty mold and giving leaves a dirty black appearance. Cloudy and cold weather conditions (20°C or below) with high relative humidity (70-75%) are particularly conducive to aphid multiplication (Awasthi, 2002).

Eventhough, various approaches available for pest management, many farmers predominantly rely on chemical management options, overlooking the drawbacks such as insecticide residues, insect resistance development, environmental risks and collateral damage to non-targeted insects like parasites, predators and pollinators. This inclination towards chemical methods may stem from a lack of awareness about alternative eco-friendly approaches or a preference for quicker results, as non-chemical management methods typically yield outcomes over the long term. Therefore, there is an urgent need to implement an integrated approach to aphid management, incorporating cultural, biological, mechanical and physical methods alongside chemical control, while simultaneously educating farmers to achieve more effective results.

Management methods

Cultural methods

Changing the sowing dates of mustard crops can potentially help evade aphid infestation, aligning with the hop and fly hypothesis of aphid migration. However, solely cultivating mustard in reverse order may not completely avoid aphid attacks. A more effective strategy could involve reversing the cultivation of all cruciferous crops (Ghosh, 2019). Utilizing resistant varieties like Varuna can also aid in controlling aphid infestations (Dwivedi, 2019). Early sowing before October 20th has been observed to prevent infestations, as plants become hardened before the peak infestation period due to such timing (Ghosh, 1981; Kular, 2012; Singh, 1984; Singh, 1987). Additionally, light rainfall during the peak period can negatively impact aphid populations. (Hasan, 2009). Aphids feeding on host plants receiving higher nitrogen doses exhibit shorter nymphal periods, longer adult longevity and increased fecundity (Fallahpour, 2015). Consequently, higher nitrogen doses or nitrogen application alone tend to boost aphid populations, while the application of phosphorus and potash, with or without nitrogen, can suppress population growth. Thus, judicious fertilizer application serves as a significant tool for aphid management (Pandey, 2010). Intercropping mustard with fennel (Singh, 1997) or two rows of coriander (Noman, 2013) has shown promising results in mustard aphid management. This not only enhances mustard yields but also increases predator availability, such as ladybird beetles.

Mechanical control

Clipping the infested portions of mustard plants during the early stages of infestation and subsequently disposing of them has proven to be an effective method for aphid control. The implementation of yellow sticky traps has also demonstrated effectiveness in managing aphid populations (Khanzada, 2016).

Botanical plant extracts

Altineem, a neem-based insecticide, has shown efficacy in combating mustard aphid infections (Adhikari, 2019). Neem oil has been found to be highly effective, resulting in maximum mortality of mustard aphids (Aziz, 2014). Additionally, neem leaf extract (5%) and neem seed kernel extract (5%) have demonstrated effectiveness against mustard aphids (Singh, 2007). Thermo and photo stable tetrahydro azadirachtin-A has been identified as a highly effective compound for controlling mustard aphids, surpassing azadirachtin, and it is also safe for natural enemies (Dhingra, 2006). Following the clipping of infested twigs, both neem oil and neem seed kernel extract at 5% each have shown effectiveness in mustard aphid control (Yadav, 2020). Ardusa leaf extract (10%) is deemed safe for natural enemies of aphids, including coccinellids, chrysopids, syrphid flies and *Diaeretiella rapae*, as well as pollinators like honey bees (Khedkar, 2012). Eucalyptus and papaya leaf extracts have also proven effective in controlling aphid pests (Mandal, 2019). Derisom, a botanical insecticide derived from the Pongamia or Karanj plant, has been identified as causing minimal harm to the environment, honey bees and natural enemies (Kafle, 2015). A combination of neem, Bakaino, Hattibar, Khirro, and Bojho leaves with cow urine presents an eco-friendly approach to aphid management (Pal, 2018). Aak

(*Calotropis*) and Gul-e-Daudi plant extracts have been suggested for mustard aphid management (Akbar, 2016). Tobacco leaf extract, particularly from pattay wala tobacco, has demonstrated effectiveness in mustard aphid management (Udin, 2019). Seed oil at a 4% concentration from bottle gourd and small bitter gourd has been shown to cause 100% mortality in mustard aphids within 24 hours (Mishra, 2006). Spraying Jholmol, a plant and animal-based product, has provided desirable results in controlling mustard aphids while being environmentally sustainable (Malla, 2021).

Microbial pesticides

Biopesticides such as *Beauveria bassiana* and *Metarhizium anisopliae* have demonstrated effectiveness in managing mustard aphids, specifically *Lipaphis erysimi* (Shinde, 2021). Among entomopathogenic biopesticides, *M. anisopliae* has been identified as particularly effective against mustard aphids, followed by *B. bassiana* and *B. thuringiensis* (Sajid, 2017; Muhammad, 2017). *M. anisopliae* stands out as one of the most effective biopesticides against mustard aphids (Sajid, 2017; Muhammad, 2017). Furthermore, microbial agents and bio products, such as plant extracts, have been deemed safe for natural enemies of mustard aphids and pollinators like honey bees, without causing any phytotoxic effects (Meena, 2013).

Use of predatory beetles

To achieve maximum mustard yield, it is recommended to release *Coccinella septempunctata* at a rate of 5,000 beetles per hectare, followed by spraying *Verticillium lecanii* at a concentration of 10^8 CS/ml and then reintroducing *C. septempunctata* at a reduced rate of 3,000 beetles per hectare (Singh, 2010). *Chrysoperla carnea* has been identified as an effective bio agent for successful aphid management in mustard crops (Singh, 2000). *Coccinella septempunctata*, known for its high feeding efficacy, can also be employed for mustard aphid management (Sahito, 2019). The predatory larvae of *Chrysoperla carnea* have been recognized as an efficient biocontrol agent for mustard aphid management (Rana, 2017). *Coccinella septempunctata* grubs prey on a greater number of mustard aphids compared to other predators like *Syrphid confrater* and *Ischiodon scutellaris*, with the last juvenile stage being the most voracious against mustard aphids (Singh, 2013). It is advisable to apply insecticides three days after spraying water (blank spray) to allow time for aphid population build up and sustain. Additionally, releasing predators like *Chrysoperla carnea* and *Coccinella septempunctata* after a tap water (blank) spray has been found to be effective (Farooq, 2008).

Plate 1 : Mustard aphid infestation on terminal inflorescence, stems and siliqua.

Coccinella septumpunctata **(Red coloured)**

Coccinella transversalis

Coccinella septumpunctata **(Orange coloured)**

Grub preying on aphids

Plate 2 : Different species of Coccinellid predators and grubs observed in the field.

Use of chemicals

Seed treatment with Imidacloprid has been found to be effective in suppressing mustard aphid populations, resulting in decreased survival and reduced fecundity in survivors (Huang, 2019). Spot application of Imidacloprid after 30 days of sowing can also be advantageous in suppressing initial aphid populations while reducing the environmental hazards associated with chemical use (Dey, 2020). Imidacloprid is a safe and effective chemical option for managing mustard aphids without adverse effects on natural enemies (Dotasara, 2017). Additionally, the use of Acephate 75 SP at a rate of 350 g a.i./ha has been shown to improve yields while managing mustard aphids (Singh, 2019). Emamectin benzoate insecticide has also demonstrated effectiveness in aphid management (Yadav, 2018). Combining the spraying of two insecticides, Chlorpyriphos and Cypermethrin, has been found to yield better results (Mandal, 2012). Spinosad, as a biopesticide, is effective in integrated pest management for mustard aphids, promoting overall plant growth and enhancing yields (Aktar, 2021).

Biotechnological approaches

Lectins, which are plant defense proteins extracted from lentil and soybean seeds, possess entomotoxic properties that can shield the crop from mustard aphids (Deeksha, 2021). RiHSPRO2, a nematode resistance protein homolog found in wild crucifers, has been shown to confer tolerance against mustard aphids when expressed in transgenic *Brassica juncea* (Bose, 2019). Wild crucifer species such as *Brassica fructiculosa* are naturally resistant to mustard aphids. Therefore, the development and characterization of *Brassica juncea*-fructiculosa introgression lines exhibiting resistance to mustard aphids (*Lipaphis erysimi* Kalt.) warrant further investigation (Atri, 2012).

Future prospects

Further research on transgenic lines of Indian mustard containing SUC1-specific siRNA molecules (Dhatwalia, 2022) should be prioritized for enhancement. Additionally, deeper investigations into the efficacy of the monocot mannose-binding lectin *Allium sativum* (garlic) leaf lectin (ASAL) for aphid management and its potential in reducing viral attacks are warranted (Banerjee, 2004). A new study focuses on compliance with new drift legislation, improved application technology to reduce spray drift, and increased spray efficacy, as well as the dynamics of mustard aphid movement among crucifer vegetables and forage crops in India (Gautam, 2019). KS-75, a canola variety, exhibits resistance to aphids through antixenosis and antibiosis (Muhammad, 2022) and efforts should be directed towards developing similar varieties with host plant resistance to aphids in mustard crops.

Conflict of interest

The author declares no conflict of interest.

Author contribution

Written the manuscript by analysing different references-Lingutla Geethanjali; Checked the references—Bhupendra Singh, Arunima Tiwari.

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