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MP Gautam
Department of Entomology, Sardar Vallabhbhai Patel University of Agriculture and Technology Meerut, Uttar Pradesh, India

SN Singh
Subject Matter Specialist (Agriculture Extension), KVK Sohana, Siddharthnagar, Narendra Deva University of Agriculture and Technology, Faizabad, Uttar Pradesh, India

Pardeep Kumar
Subject Matter Specialist (Plant Protection), KVK Sohana, Siddharthnagar, Narendra Deva University of Agriculture and Technology, Faizabad, Uttar Pradesh, India

PK Misra
Senior Scientist (Agroforestry), KVK, Sohana, Siddharthnagar, Narendra Deva University of Agriculture and Technology, Faizabad, Uttar Pradesh, India

SK Yadav
Department of Entomology, Narendra Deva University of Agriculture and Technology, Faizabad, Uttar Pradesh, India

DP Singh
Senior Scientist (Animal Science), KVK Sohana, Siddharthnagar, Narendra Deva University of Agriculture and Technology, Faizabad, Uttar Pradesh, India

MK Pandey
Senior Scientist & Head, KVK Sohana, Siddharthnagar, Narendra Deva University of Agriculture and Technology, Faizabad, Uttar Pradesh, India

Correspondence
MP Gautam
Department of Entomology, Sardar Vallabhbhai Patel University of Agriculture and Technology Meerut, Uttar Pradesh, India

Mustard aphid, *Lipaphis erysimi* (Kalt) (Hemiptera: Aphididae): A review

MP Gautam, SN Singh, Pardeep Kumar, PK Misra, SK Yadav, DP Singh and MK Pandey

Abstract
The mustard crop is more vulnerable to a wide variety of insect pests from sowing till harvest than other oil seed crops. The invasion by insect pests are one of the important factors responsible for low yield such as; mustard aphid, *L. erysimi* (Kalt), cabbage aphid, *B. brassica* (L), mustard sawfly, *A. proxima* (Klug), cabbage butterfly, *P. brassicae* (Linn), painted bug, *B.picta* (K), mustard leaf eater, *S. litura*(F), leaf miner, *Ch. Horticola* (Goureau) thrips, *T. tabaci* and whitefly, *B. tabaci* (Gennedius). Among them, *L. erysimi* Kalt enbach, (Aphididae: Homoptera) is the most devastating pest in India and is distributed in many other countries also found most preferred crop to sucking complex and six varieties of mustard. Aphids are small, soft-bodied, pearl-shaped insects that have a pair of cornicles (honey tubes) projecting out from the fifth or sixth abdominal segment. There are four nymphal stages (instars). The winged, female, adult aphids have a dusky green abdomen with dark lateral stripes separating the body segments and dusky wing veins. Male aphids are olive-green to brown in color. The aphid attacks generally during December and continues till March. The most favorable temperature is 200C or below. Cloudy and cold weather help in accelerating the growth of insects. About 45 generations are completed in a year.

Keywords: Mustard aphid, *Lipaphis erysimi*, identification, life cycle, host crop and management

1. Introduction
Mustard crop attacked by painted bug, mustard Saw fly, mustard aphid potato aphid, leaf miner, flea beetle, diamond-back moth, bihar hairy catterpiller, cabbage buter fly and tobacco caterpillar Among them, Mustard aphid. *Lipaphis erysimi* (Kalt) is the most destructive pest. It is not only causes heavy seed yield losses up to 73.3 per cent but also negatively affects the oil content up to 66.9 percent (Bakhetia and Sekhon, 1989).

The mustard is the major oilseed crop of north-west Madhya Pradesh and Mustard aphid, *Lipaphis erysimi* (Kalt) (Hemiptera: Aphididae) is the key pest of mustard which causes severe losses to the crop. It causes severe damage to the plants by sucking plant sap from the tender shoots and flowers of the plant in the beginning and later sucks the sap from tender pods. The infested plant becomes weak and stunted. The excessive excretion of honey dew by the aphid on the leaves results in the growth of black sooty mould, which interferes the photosynthetic activity of the leaves. The management of the pest with systemic insecticides is quite effective but it adversely affects the predators and parasitoids of the pest. However, in addition to the high cost of insecticide, several other drawbacks of chemical control viz. development of resistance to commonly used insecticides, pest resurgence, secondary pest out break, build up of insecticide residue in oil and cake beyond the permissible limit and the degradation of the environment (Singh and Sharma, 2009) [43]. Among all the insect pests, the mustard aphid, *Lipaphis erysimi* (Kaltenbach) (Homoptera: Aphididae) has gained the statusof key pest of rapeseed-mustard in India. It feeds by sucking sapfrom its host and damage to the crop ranging from 9 to 96% in different agroclimatic conditions of India (Singh and Sharma, 2002; Bakhetia, 1984; Chorbandi and Bakhetia, 1987; Singh and sachan, 1994; Singh and Sachan, 1995; Parmar *et al*., 2007) [7, 36, 37, 23]. The loss may go upto 100% in certain mustard growing. regions (Singh and Sachan, 1999) [35]. Large colonies of the aphid could cause the plant to become deformed due to curling and shriveling of leaves (Metcalf, 1962) [20]. Under severe infestation, both sides of leaves are attacked (Yadav *et al*., 1988). On mustard, *Lipaphis erysimi* prefers to feed on flowers as well as foliage of mustard (Singh *et al*., 1965) [42].

2. Identification
Adult apterae of *Lipaphis erysimi* are small to medium sized yellowish green, grey green or olive green aphids, with a faint white wax bloom.

In humid conditions they may be more densely coated with wax. The aptera (see first picture below) has two rows of dark bands on the thorax and abdomen which unite into a single band near the tip of the abdomen. The siphunculi are pale with dark tips. The body length of adult *Lipaphis erysimi* apterae is 1.4-2.4 mm.

3. Symptom of damage

Due to heavy infestation, the symptoms of yellowing, curling and then drying of leaves appear, resulting in development of feeble pods and small seeds in the pods. It also secretes the honeydew which is responsible for development of sooty mould and reduces the photosynthetic rate Sekhon (1989) [31]. Thus, it is mandatory to monitor mustard crop regularly during the favorable period of aphid breeding. At severe attack, the chemical control is the only choice to deal with the outbreak of the mustard aphid. Therefore, the present investigation was undertaken to evaluate the bio-efficacy of some insecticides against mustard aphid, *Lipaphis erysimi* Kalt.

4. Population dynamics of *Lipaphis erysimi.*

Maximum relative humidity three days prior to observation was the most important factor in increasing the aphid population (Singh and Rai, 1994). Similar results were also obtained by Singh *et al.* (1986) [40], Jaglan *et al*. (1988) and Rossi (1990) [26]. Narang *et al*. (1983) [22] rainfall as an ecological factor reduced the mustard aphid population significantly and suddenly as simulated rainfall of 1.0 to2.0 cm reduced population by 45.47 to 66.43%. Tomar and Yadav (2009) [46] the aphid infestation began in the fourth week of December and reached its peak in the 3rd week of February when the temperature ranged from 10.5 to 25.70 C and the relative humidity was 68%. Debjani-Dey and Akhtar (2008) [8] showed that aphid distribution was aggregated based on variance/mean (from 0.005 to 0.605) relationship and dispersion parameter, K. The aphid count indicated a positive correlation with temperature and a negative correlation with relative humidity. Rumki *et al.,* (2018) [27] The lowest mean population of 6.03 aphids (mean of thirty plants) was recorded during 17th Standard week in April and highest population was recorded in 48 Standard week with a mean population of 94.7 aphids, respectively.

5. Life Cycleof *Lipaphis erysimi*

This aphid has two modes producing young: fertilization of females by males resulting in the production of eggs (sexual reproduction), and the birthing of live female nymphs by adult females without fertilization by males (parthenogenesis). Reproduction through parthenogenesis seems to be the norm as males are very rare and females are almost exclusively viviparous (birth live young) throughout the year and males have only been observed in the cooler months (Kawada and Murai, 1979) [15].

5.1 Eggs

Eggs are laid along the veins of leaves (Kawada and Murai, 1979) [15]. Eggs of this aphid have not been found in Hawaii.

5.2 Nymphs

There are four nymphal stages (instars). The general appearance of each stage is similar except for increase in size during subsequent instars. The first, second, third and fourth nymphal stages last 1-2 and 3 days respectfully (Sachan and Bansal, 1975) [28], giving the nymphal stage a length of 8-9 days total. Minor variations in these durations occur between winged and wingless forms when raised on cabbage, cauliflower, mustard and radish (Sachan and Bansal, 1975) [28]. Refer to Sidhu and Singh (1964) [34] for a shaded drawing of the first and fourth instars.

5.3 Adults

Wingless, female, aphids (called apterae) are yellowish green, gray green or olive green with a white waxy bloom covering the body (Blackman and Eastop, 1984) [5]. The waxy coating is more dense under humid conditions. The winged female and adult aphids (called alate) have a dusky green abdomen with dark lateral stripes separating the body segments and dusky wing veins (Blackman and Eastop, 1984) [5]. Antennae are dark in color except at the base (Deshpande, 1937) [9]. The apterae females are about 3/50-1/10 inch (1.2-2.4 mm) long and the alate forms are about 3/50-1/12 inch (1.4-2.2 mm) long (Blackman and Eastop, 1984) [5]. Refer to Sidhu and Singh (1964) [34] for a shaded drawing of the apterous and alate adults.

6. Economic Thresholds Level (ETL)

Bath and Singh (1989) [3] Field trials were carried out in Punjab, India, in 1983-84 to determine the economic threshold of *Lipaphis erysimi* on a radish seed crop of the variety Punjab Sufed. Sprays of oxydemeton-methyl at 300 g a.i./ha were applied at arbitrary set aphid population levels from 25 to 150 aphids/plant. The maximum cost-benefit ratio was obtained at a level of 50 aphids/plant, requiring 3 sprays. The concepts of EIL and ETL are defined respectively as the "lowest population of pests that will cause economic damage", and as the "population density (number of pests) at which control measures should be determined to prevent an increasing pest population from reaching the economic injury level".

7. Host crop

Brassicas are the members of the family Cruciferae. In India They are mainly grown in *rabi* season as oilseed condiment and medicinal crop. They occupy a unique position in agriculture world as the source of vegetable, oilseed, forage and fodder, green manure and condiment. Brassica seed oil is used in food, lubricant and polymer industries whereas its cake is used as organic manure and as source of protein in agriculture and animal feeds, respectively. Rapeseed-mustard seeds are the good source of oil and the oil content in seeds ranges from 32- 42 percent. Its oil is used for edible purpose. The green leaves and stems of mustard are good source of oil (Jat *et al*., 2007) [14].

8. Effect of abiotic factor on population buildup of *Lipaphis erysimi*

The infestation of mustard aphid occurs in the field from December to February. Both the adults and nymphs of this aphid cause damage to mustard plants from seedling to maturity, but maximum damage is caused at flowering stage (Ahmed and Jalil, 1993) [1]. The aphids suck sap from leaves, flower-buds, flowers, pod and twigs of the plants. They also secrete sticky honey dew which act as a medium for sooty mold development and reduce the photosynthetic efficiency of the plants. In case of severe infestation, leaves become curled, plant fails to develop pods, the young pods when developed fail to become mature and cannot produce healthy

seeds. As a result, plants lose their vigour and growth becomes stunted (Morzia and Huq, 1991) [21]. Ali and Rizvi (2012) [2] reducing *L. erysimi* population to an extent of 35.63, 15.14 and 4.83%, respectively on early shown *B. juncea* (October 25). Whereas, on late (November 10 and 25) seeded cultivars, the maximum temperature, maximum relative humidity and evaporation are the key factors responsible in reducing the population of 3.06, 5.00 and 1.74%, respectively.

9. Screening of mustard variety against mustard aphid

Rohilla *et al.* (1990) [25] reported varieties RL-18, RLM-198, RLM-514, Vardan, RH-819, RH- 7859, Vaibhav, B-85 and RH-8113 as less susceptible to aphid. Bhadauria *et al.* (1991) [4] reported varieties RKV-24 and RKV-47 as less susceptible to mustard aphid on the basis of aphid count and multiplication index. Lal (2009) [17] The Rai varieties Laha 101 and *B. juncea* 6105 were found most highly resistant probably due to cumulative effect of preference, antibiosis and tolerance. Rai culture 294. R.T. 11 *B. juncea* 5976 and *B. juncea* B.R. 13 are also comparatively resistant particularly due to their tolerance. Rana (2005) [24] revealed that rapeseed (*B. campestris* var. BSH-1, *B. campestris* var. YSPB-9) and mustard (*B. juncea* RH-30) were better hosts for this aphid than other *Brassica* species (*B. napus, B. nigra, Eruca sativa, B. carinata*). Chaudhary and Patel (2017) [6] Variety Vardan (1.42) also showed lower aphid index and grouped into resistant (R), whereas varieties GM-2 (1.78), HYOLA-401 (1.69), GM-3 (1.83) and GM-1 (1.80) were categorized as susceptible and highly susceptible.

10. Natural enemies of on mustrd crop

Tajwar, *et al.,* (2016) [45] Results showed that weekly mean population per leaf of thrips, whitefly and their predator, *Geocoris* varied with different dates and phenology of mustard localities. predator *Geocoris* remained maximum (15.33+0.31) in 3rd week of February and minimum (4.50+0.25) in 1st week of January at Tando Allahyar**.**

11. Damage caused by *Lipaphis erysimi*

Aphids feed by sucking sap from their hosts. Large colonies can cause the plants to become deformed and the leaves curled, shriveled and yellowed (Metcalf, 1962) [20]. The turnip aphid can sometimes be found in large numbers on the undersides of outer open leaves or in the inflorescences (flowers) (Blackman and Eastop, 1984) [5]. In severe infestations, both sides of leaves are infested (Yadav *et. al*., 1988) [48]. On cabbage, large populations can affect leaf size (Deshpande, 1937) [9] and yield (Jagan Mohan *et al.*, 1981) [13]. On mustard, these aphids prefer flowers to leaves (Singh, *et al*., 1965) [42]. Like other soft bodied insects such as leafhoppers, mealybugs and scales, aphids produce honeydew. This sweet and watery excrement is fed on by bees, wasps, ants and other insects. The honeydew serves as a medium on which a sooty fungus, called sooty mold, grows. Honeydew gives cabbage plants a dirty appearance that reduces their market value (Deshpande, 1937) [9]. Aphids vector many plant diseases that cause greater losses than caused by direct feeding injury. This is often the greatest impact of an aphid infestation. The turnip aphid is a vector of about 10 non-persistent plant viruses, including cabbage black ring spot and mosaic diseases of cauliflower, radish and turnip (Blackman and Eastop, 1984) [5]. In non persistent transmission the virus reproduces in the plant and aphids simply aid in dissemination of the virus and the infection process.

12. Management of *Lipaphis erysimi*

12.1 Agronomic manipulations in disease/pest management: cultural control

Considerable experimental evidences are available in Indian literature on the usefulness of cultural and agronomic practices such as timely sowing, sanitation, ploughing, crop rotation, intercropping, spacing and nutrient management in minimizing the losses due topests in mustard. Early October sowing (Kolte, 1985) [16] balanced NPK application – N100 P40 K40 (Sharma and Kolte, 1994) [33] and sanitation are the important top priority practices in management of most aphid infestation. The increase in infection rate of AB, WR and SSR infestation rate of aphid attack is directly proportional to delay in planting of the crop in most mustard-growing areas in the country.

12.2 Inter-culture operation

Optimum plant population was maintained by thinning operations keeping healthy seedling in both the years. The hand weeding was done one month after sowing. After the hand weeding the field remained free and clean from weeds throughout the season**.**

12.3 Biological

Mari, *et al.*, (2016) [19] revealed that both adult and grubs of *C. undecimpunctata* (L) had significant feeding potential on all aphid species but highest feeding potential was recorded on alfalfa aphid than mustard and maize aphids respectively period under studied, because of its higher survivorship comparatively than on other aphid species. Hakim, *et al*, (2016) [11] predators' activities were recorded on the varieties having maximum pest activities. Overall data suggested that the population of insect pest and predators remained constant on all varieties. Sajid *et al.*, (2017) [30] Among entomopathogenic biopesticides *M. anisopliae* (83.23%) found most effective against mustard aphid followed by *B. bassiana* (78.33%) and *B. thuringiensis* (73%). Bio-pesticides can be used as a potential candidate for integrated pest management against mustard aphid after field efficacy. Liz, *et al.*, (2017) [18] Biological control of crop pests and diseases has found to play significant role in reducing the over reliance on chemical pesticides.

12.4 Botanical

Kumar and Patel. (2017) The crude aqueous extracts from *Ageratum conyzoides* (L.), *Parthenium hysterophorus* (L.), *Lantana camera* (L.), *Solanum nigrum* (L.), *Cannabis sativa* (L.), *Calotropis gigantean* (L.), *Livistona chinensis* (Jacq.), *Cassia angustifolia* (Mill.) were tested for their insecticidal and repellent activity against *Myzus persicae* (Sulzer) and *Brevicoryne brassicae* (Linnaeus). Repellent activity was inversely related to concentration of plant extract. Inayat, *et al.*, (2017) [12]. The antioxidant activities of different fraction of the methanolic extracts were indicated in the range of 69.08-84.89%. From the current study, it may be concluded that the selected plants have the potential of antimicrobial and antioxidant properties, which play a key role in controlling a variety of diseases caused by various pathogens of bacteria and by the oxidation of free radical in the body.

Table 1: Wild edible plants and pattern of local use

Plant Name	Family Name	Local Name	Parts used	Status
Amaranthus thunbergii	Amaranthaceae	Ranzakka	Areal Parts	Wild
Caralluma edulis	Asclepiadaceae	Pamankai	Areal Parts	Wild
Allium astrosanguineum	Alliaceae	Shezyee	Areal Parts	Wild
Rumexpatientia	Polygonaceae	Zundaa	Areal Parts	Wild
Portulaca oleracea	Potulacaceae	Terwikai	Areal Parts	Wild

Source: Inayat, *et al.*, (2017) [12]

12.5 Chamical

Effective control of mustard aphid *Lipaphis erysimi* (Kalt) is possible by the use of systemic insecticide but it could not be permanent solution as it's population again attains the same level within a fortnight after spray of chemical (Singh *et al*., 1984) [39]. Effective control of mustard aphid *Lipaphis erysimi* (Kalt) is possible by the use of systemic insecticide but it could not be permanent solution as it's population again attains the same level within a fortnight after spray of chemical (Singh *et al*., 1984) [38]. Among the various insecticides evaluated against the mustard aphid, *Lipaphis erysimi* Kalt, imidacloprid 17.8 SL @ 0.2 g/litre showed highest reduction. Imidacloprid 17.8 SL @ 0.2 g/litre reduce the 87.53% incidence of mustard aphid followed by fipronil 5 SC @ 1.0 ml/litre 83.56% reduction at 7 days after Ist spray, respectively. Similarly same trend was noticed after 15 days of spraying in which both the chemicals registered 83.86% and 78.90%. The experiment was repeated after 15 days to check the aphid population and it was observed that imidacloprid 17.8 SL @ 0.2 g/litre was found best followed by fipronil 5 SC @ 1.0 ml/litre and neem oil 2% @ 2.0 ml/litre, when the data was recorded after 7 and 15 DAS. Dotasara, *et al.*, (2017) [10] Among the various insecticides evaluated against the mustard aphid, *Lipaphis erysimi* Kalt, imidacloprid 17.8 SL @ 0.2 g/litre showed highest reduction. Imidacloprid 17.8 SL @ 0.2 g/litre reduce the 87.53% incidence of mustard aphid followed by fipronil 5 SC @ 1.0 ml/litre 83.56% reduction at 7 days after Ist spray, respectively.

13. Conclusion

The major concern in chemical control is the development of insecticidal resistance, resurgence, pest outbreak etc., against most of the commonly used broad spectrum insecticides in the field. This has necessitated the use of alternative eco-friendly insecticides to sustain the management of insect-pests and the development of resistance against these traditional insecticides can be easily breakdown by using the newer group of molecules. The substitution of older recommendations or other conventional insecticides with newer safer insecticidal molecules have reduced the hazards effect on natural enemies. In this context, the present study was carried out to the efficacy of few newer insecticides under field condition for their comparative efficacy against mustard aphid. On the other hand, plants are rich sources of natural substances and have great potential to be formulated as botanical pesticides that can be utilized in the development of environmentally safe alternative methods for insect control in the place of synthetic insecticides Kumar and Patel (2017). Plants contain secondary metabolites that are deleterious to insect and other herbivores in diverse ways; through acute toxicity, enzyme inhibition and interference with the consumption and/or utilization of food. Therefore, the present study was conducted to evaluate the insecticidal and repellent activity

14. Future strategy

If we know when the population is reach peek period (Month), in case of mustard aphid maximum population present in first week of March to middle march, then we apply control measures and with knowing the biology of insect most susceptible stage control of insect pest is easy. The management practices are adopted which is most affected and give most cost benefits. Strong industry stewardship to ensure residue compliance. Compliance with new drift legislation, Improved application technology required to reduce spray drift and increase spray efficacy and The dynamics of mustered aphid movement between India, crucifer vegetable and forage crops is the focus of a new Ph.D study.

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