IJCRT.ORG ISSN : 2320-2882
INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)
An International Open Access, Peer-reviewed, Refereed Journal

A STUDY OF CLIMATIC CONDITIONS OF MUSTARD BRASSICA APHIDS FOR LIPAPHIS KALTENBACH

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Abstract: Mustard is the common name for several herbaceous plants in the genera Brassica and *Sinapis* of the Brassicaceae family, and in particular *Sinapis hirta* or *Sinapis alba* (White or yellow mustard; sometimes classified in Brassica), *Brassica juncea* (Brown or Indian mustard), and *Brassica nigra* (Black mustard), all three of which produce small mustard seeds that can be used as a spice and, by grinding and mixing them with water, vinegar, or other liquids be turned into a condiment also known as mustard. The seeds are also pressed to make mustard oil, and the edible leaves can be eaten as mustard greens. The term mustard sometimes is used as a collective name for all members of the genus Brassica (a taxon that also includes cabbage, turnip, reddish and other well-known vegetables) and Brassicaceae is sometimes known as the "mustard family." Mustard has been called the third most important spice after salt and pepper. With a use dating to prehistoric times, the plants have been spread by spice traders and conquering armies and have spawned an industry in many nations. The sharp stimulating flavor of products made from the seeds offers a unique joy to humans, who have used their creativity to develop many varieties to suit different tastes and uses.
***Index Terms* - Mustard Brassica Aphids, Lipaphis Kaltenbach, Climatic conditions, Brassicaceae family.**

I. INTRODUCTION

Oilseeds play an important role in the agricultural economy of India as they second to cereals. Oilseed sector also has a significant role in international trade and become a net foreign exchange earner from the export of oilseed extract and the oil cakes. It supplies over 1.5 million tons of oil and 3-3.2 million tons of meal. India holds a premium position in the global oilseed scenario accounting for 19% of the total area and 9% of the production.

Important annual oilseeds grown in India are groundnut (*Arachis hypogaea* L.), rapeseed- mustard (*Brassica campestris* L., *B. napus* L., *B. juncea* L., Crem and Coss and *Eruca sativa* L.), sunflower (*Helianthus annus* L.), sesame (*Sesamum indicum* L.), niger seeds (*Guizotia abyssinica* Cass.), soyabean (*Glycine max* L.) and linseed (*Linum usitatissimum* L.).

Rapeseed-mustard crops are cultivated in 53 countries spreading over the 6 continents covering an area of 24.2 million ha with an average yield of 1451kg/ha ranging from 411kg/ha (Russian Federation) to 6250 (Algeria) and netted the total production of 35.1 million tones. The Asia alone accounts for 59.1% of the hectare but contribute only 48.6% to the world production. Europe contributes 29.7% to the global production while, its share is only 16.32% of cultivated area in the world. The yield is variable from 411 to 3528kg/ha (France). China and India together account for 95.4% of the total cultivated area and 96.7% of the rapeseed-mustard production in Asia.

Mustard is the major oilseed crop after groundnut in India contributing 26.1 and 29.1% of total oilseed cultivation and production in India, respectively. The area and production under rapeseed-mustard is 7.00 million ha and 7.10 million tones, respectively during 2008-09 with a productivity of 1060kg/ha (Anonymous, 2009) being the second highest in the world after China. It is a rich source of oil (46-48%) and protein (43.6%) in whole seed meal (Frank, 1990). Moreover, their green leaves are used both for human food and animal fodder (Nasir et al, 1998).

The major areas of its cultivation are concentrated in North Western to North Eastern parts of India. The rapeseed-mustard crops are highly vulnerable to attack of insect pests that resulted heavy losses in the yield. It is attacked by 43 insect species; the most important being mustard aphid, as it can inflict losses up to 100% in severe conditions and varied with varieties, environmental factors and ago-technological practices.

The mustard aphid, *Lipaphis erysimi* (Kaltenbach) (Homoptera: *Aphididae*) is a key pest distributed in all the agro-climatic zones of India. The adults and nymphs suck the sap from the stem, leaves, inflorescence and pods and often aerial parts of plant is covered over by a large number of aphids (Srivastava, 2002) and also reported to infest roots of mustard plants (Singh and Singh, 1987). In early stage of infestation, the development of the plant is adversely affected. Buds do not bloom to flowers. Colonization of aphid leads to partial or complete failure of silique formation. Siliques become thin and seedless. They also attack on set pods that resulted in shriveled seeds (Zaman, 1990) and even the plant may die due to excessive sucking of sap (Aslam and Ahmad,2001).

L. erysimi is a soft bodied, minute, light green and pear shaped having a pair of short tubes called cornicles on 5'^-6" ^ posterodistal region of abdomen. The adults could be winged or wingless. The wingless are predominantly in early stage of infestation. The wings when present are long and held vertically up over the body. The insect breeds sexually and parthenogenetically. A single female gives birth to 25-133 nymphs, which will become adult in 7-10 days. There are about 25 generations in a year. The insect remains most active from December to March in plains and the peak season of its activity is at flowering and pod formation stages of Brassica. At the onset of summer, they migrate back to hills.

L. erysimi has caused severe reduction to rapeseed-mustard up to 66-96% in yield (Singh and Sachan,1997) to 75.70% (Sekhon et al,1996) and 66-96% and 27-68% on *B. campestris* and *B. juncea*, respectively (Bakhetia, 1979). Later on, Singh and Sachan (1994) reported seed yield of described crop could go down up to 91.35% during severe infestation. However, in different agro-climatic zones seed yield reduction is about 11-96% (Phadke, 1985). This pest coincides with the general growing season of Brassica crop from October to April. The cloudy weather is the most favorable for its rapid multiplication. In case of severe infestation, the attacked plants become yellowish and full of honeydew with black fungus. Prevailing weather conditions play an important role in the appearance and intensity of aphid infestation. Normally elate forms appeared and become established on the mustard crops in the month of November to 3rd week of December. Population peak reached in the end of February to mid-March (Sekhon, 2007). The ambient maximum (21.7-23.5°C) and minimum (7.2-9.4°C) temperature with maximum-minimum humidity (39.7-89.0%), rainfall and sunshine is 1.8mm and 5.5hr in January-February, respectively appeared to be highly conducive for rapid multiplication. Whereas, the population of *Coccinella spp* was found zero at the time of appearance of the aphid till reached to peak. The populations of parasites and predators are composed of 4-5 species and are also influenced by environmental factors (Kumar et al. 1996). So, it was observed that the populations of parasites and predators could not synchronize with the abundance of *L. erysimi* and hence were found unable to control the aphid. Activity of the pest is ceased at below 50.9% relative humidity. A frequent rain during the phase of the population increases adversely affected the aphids and kept it low throughout the period of highest abundance (Sinha et al. 1989).

Life tables provide an ecological tool to measure survivorship, mortality of an organism under natural conditions (Morris and Miller, 1954, Harcourt, 1969). Multiple sets of life table data can be analyzed to identify key mortality factors or critical life stages or periods, which can increase understanding of the dynamics of an insect population and at the same time, reveal the most appropriate period for management (Harcourt, 1969, Southwood, 1978). It was extensively studied by Deevy (1947) on natural population of animals. Subsequently, the concept of life table was extended to study the life expectancy of laboratory cultured insects (Birch, 1948). Life table has also been used for the study of natural population of insect pests and has been discussed comprehensively by various workers (Morris, 1963, Harcourt, 1969).

Construction of life tables in relation to temperature is an important component in the understanding of population dynamics of a species (Carey, 1993). Although the insects are not always subjected to constant temperatures in nature, a controlled study can provide valuable insight into population dynamics of a particular species (Summers et al., 1984). It may also provide assessment of incidence of damage and guide the application of control measures.

CLIMATIC CONDITIONS

Weather variables influence the appearance, multiplication and disappearance of mustard aphid (Vekaria and Patel, 2000). Multiplication of *L. erysimi* is thrived by cool, wet and cloudy weather (Hasan et al., 2009). Several climatic attributes like fog, frost, rain and high temperatures have been realized as main mortality factors of, mustard aphid.

Temperature

The peak incidence of *L. erysimi* takes place at a mean temperature of 17-18°C (Bishnoi et al., 1992). Severe cold during December and increasing temperature onward March preclude its multiplication, its incidence during the flowering stage was positively correlated to a maximum temperature in the range of 20-29°C in the preceding week (Chatopadhyay et al., 2005). Specifically the aphids exhibited higher prolific multiplication, net reproductive rate, and longer average generation time at 25°C than to a range of other temperatures tested (Hsiao, 1999). Kulat et al., 1997uncovered that maximum temperature and minimum temperatures in the range of 26.4-29.0°C and 8.4-12.6°C coupled with relative humidity (RH) of 75-85% in January rendered the congenial conditions for aphid multiplication but its population began to decline at RH ≤ 65%.

Humidity

Relative humidity ranging from 65-89-3% positivity correlated with the fecundity of mustard aphid. Although, its response on aphid progeny during the crop season, i.e. mid-January to mid-March, was proved to be statistically insignificant. The incidence of mustard aphid on the inflorescence of plants was positively correlated to RH (Samdur et al., 1997; Chattopadhyay et al., 2005; Narjary et al., 2013) With morning RH>92% and daily average RH>75% favorable for population multiplication.

Rainfall

However, heavy rainfall has a profound effect on the mustard aphid population declining, build up within 1 week during the spring season. Bakhetia and Sidhu (1983) found that the endure rainfall for 4-5 days towards the end of February outcome rapid mortality of this pest, which halt population development in the following weeks. Even mild rainfall was reported lethal effect on population built-up (Hasan et al., 2009).

MANAGEMENT

I. Cultural practices

Time of Sowing

Aphid progeny and the rate of infestation are directly positively relying on sowing time (Islam et al., 1991). Alteration time in crop sowing can eschew phonological synchrony between the most sensitive stages of species with the peak period of insect infestation. This asynchrony can also be realized through genetic engineering by inserting genes for earliness and lateness in the crop. The flowering period (end of December, the first fortnight of January to mid-February) is the critical period for aphid infestation. Hence, the crop is sown early before 20 October predominately eludes aphid infestation (Ghosh and Ghosh, 1981; Kular et al., 2012) since plants become hardy before the peak period of infestation (Singh et al., 1984; Singh and Bakhetia, 1987). Pal et al., 1976, also reported that the aphid infestation was the main reason for yield loss in late sown crops.

Nutrient application

Heavily fertilizer crops are often susceptive to the incidence of the population of *L. erysimi*. Hence, aphids feeding on host plants obtained higher nitrogen doses certainly had shorter nymphal developmental time, longer adult longevity, and higher fecundity (Fallahpour et al., 2015). Pandey (2010) reported that the aphid population to surge dramatically with the application of sole nitrogen or higher levels of nitrogen. While the application of phosphorus and potash whether or not with a combination of nitrogen limits the population incidence. Hence, Balanced and judicious plant nitrogen fertilization for crops to some degree serves as a pest management tool.

Resistant varieties

Genetic resistance against mustard aphid can be realized through breeding techniques and tools by incorporating resistance genes from sexually compatible germplasms. For instance, S.P.ray (1998) reported that toria lines namely, ICT-9135, TS-72, TL-15, Acc-12-31637, Acc-17-31642 and Acc-32-31893; Sarson line LSS-9305, while mustard varieties including Krishna, Kranti, Varuna, Pusa Bold and BR-40 were found to tolerant against mustard aphid.

II. Botanical Control

Several plant materials as extracts have been assessed against mustard aphid, namely nicotine sulfate, rotenone and pyrethrins. All these have shown variable toxicity. Plant extracts of *Azadirachta indica. Lantana camara*, *Ipomoea carnea*, *Acorus sp.*, *Solanum xanthocarpum*, *Swertia chirata*, *Melia azedarach* and *Argemone mexicana* found to be toxic against mustard aphid (Pandey et al., 1977). In a field trial on the mustard crop (*B. juncea*), thermo and photostable tetrahydroazadirachtin-A proved an effective control of mustard aphid as compared to azadirachtin, apart from being safe to natural predatory arthropods (Dhingra et al., 2006). Singh (2007) found that neem seed kernel extract (5%) and neem leaf extract (5%) superior control against mustard aphid.

III. Use of natural enemies

Bakhetia and Sekhon (1989) noted six species of coccinellids, 16 syrphids, one chamaemyiid, hemerobiid (predators), four species of hymenopterous parasitoids, four species of entomogenous fungi, and one predatory bird to be correlated with mustard aphid as natural enemies. coccinellids are the chief predators of mustard aphid with a couple of species including *Coccinella septempunctata*, *C. repanda*, *C. trannsversalis*, *Brumoides saturalis*, *Menochilus sexmaculatus* and *Hippodamia variegate*, realized to be copious in the brassica agroecosystem. Even with their abundance, these natural enemies fall short in satisfactory control of mustaerd aphid. As the matter of fact that aphids thrive at temperatures below 20°C, while coccinellids thrive above 20°C, eventually lead to phonological asynchrony in their peak periods of activity, perhaps, considered as one crucial reason is even supported by Sarwar (2009), who concluded a lack of synchronization between populations of mustard aphid and its predators on canola rape. *Coccinella septempunctata* at 5000 beetles/ha and *Verticillium lecanii* at 108 conidial spores/ml were proved significantly superior in declining aphids number on Indian mustard 10 days after release (Singh and Meghwal, 2009). Syrphids also found predating upon the mustard aphid. Despite this, abundance is comparatively low and has a constraint for the control of mustard aphid. Moreover, it is reported that syrphids oviposit mainly when their prey population reaches a certain threshold level for instance; Luna and Jepson (2003) found that syrphids do not oviposit before aphid infestations surpass 50 aphids per broccoli plant. Besides that, the green lacewings *Chrysopa scaslastes* and *Chrysoperla carnea* also reported effectively prey on the mustard aphid. Even through, their scope in population control of insects is very confined. Among the parasitoids, *Diaeretiella rapae* and *Encyrtus sp.* have also been observed parasitizing the mustard aphid. *D. rapae* had been reported to be an effective parasitoid of aphid, which showed in more than 70% parasitization (Atwal et al., 1969).

Insecticide	**Dose/acre**	**Water required in liter/acre**
Chlorpyrifos 20% EC	200ml	200-400L
Dimethoate 30% EC	264ml	200-400L
Malathion 50% EC	400ml	200-400L
Methylparathion 2% DP	6000g	
Monocrotophos 36% SL	150ml	200-400L
Oxydemeton-methyl 25% EC	400ml	200-400L
Phorate 10% CG	4000g	
Phosphamion 40% SL	200ml	200L
Thiamethoxam 25% WG	20-40g	200-400L

Table1. A recommended insecticide with dose and water required liter/acre

IV. Chemical control

Admittedly, if the aphid population surpassed through action thresholds r the natural enemies unable to cope with the rapid intensify aphid population, then different insecticide treatments are mandatory for effective control. Injudicious spraying of chemical insecticides dire warning of agro-ecosystem vulnerability, which is a leading concern about their use. That's why selective insecticidal treatments have been studied and recommended by several workers every so often against mustard aphid in various regions of global (Table1).

The chemical pesticides are found in two forms, i.e. contact and systemic insecticides. Since they frequently infest the abaxial surface of the leaves and sucking trough inserting stylets directly from the phloem sap, aphids are barely succumbing with contact insecticides. Importantly, systemic insecticides which are directly assimilated by the plants are primarily used and well known to control aphids, as it is sucked phloem sap and kill the aphids regardless of their shelter and feeding even if under the leaf. The predominate agrochemicals employed in the control of aphids such as carbamates, organo-phosphates, pyrethroids, cyclodienes etc. group of insecticide (Bahlai et al., 2010, Cameron et al., 2005). Aphid's progeny builds up resistance against the normally sprayed organophosphate group of insecticides (Gould, 1996).

CONCLUSION

The expectancy is highest in beginning of age and decreased slowly to the end of life. Among ten treatments evaluated for their efficacy in field condition against mustard aphid during rabi season (2012-2015), the minimum infestation of aphid was recorded in treatment dimethoate (43.90) which was also statistically at par with Malathion (46.48). Similarly treatment Neem oil (51.87) were also found statistically at par with NSKE (54.19) and Tabacco leaf extract (56.82). Tobacco leaf extract (56.82) were also statistically at par with *Bacillus thuringiensis* (61.36) and *Beauveria bassiana* (63.99). Similarly treatment *Beauveria bassiana* (63.99) was also found statistically at par with *Metarhizium anisopliae* (66.50) and least effective treatment *Verticillium lecanii* (67.72). Maximum infestation was recorded in control (83.46). Based on the results obtained in the present investigations it is concluded that Dimethoate. Malathion and Neem products could be utilized as a component in Integrated Pest Management for effective management of *Lipaphis erysimi* Kalt. on mustard (*Brassica compestris* L.). Regarding yields, Dimethoate recorded highest yield of 14.42 q/ha followed by Malathion 13.36 q/ha and Neem oil 11.93 q/ha Straw yield recorded highest in Dimthoate 26.75 q/ha followed by Malathion 25.60 q/ha and Neem oil 23.71 q/ha Subsequently highest cost benefit ratio obtained with Dimethoate 18.09 followed by Malathion 14.41 and NSKE 12.45.

ACKNOWLEDGMENT

I am most grateful to thanks Dr. R.A.S. Chauhan, Mr. Dinesh Kumar Sharma Sir for his helpful and kind assistance in this paper. I am sincerely grateful to Dr. Shivraj Singh Tomar for his kindly advising. Thanks to friends and colleagues for support.

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