Comparative efficacy and cost benefit ratio of newer insecticides and bio-pesticides against mustard aphid, *Lipaphis erysimi* (Kaltenbach) on Indian mustard in Trans Yamuna region of Prayagraj (U.P.)

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**Abstract**

The present study was conducted at the Central Research Field (CRF), Department of Entomology, SHUATS, Prayagraj during Rabi 2021-2022. Seven treatments were evaluated against *Lipaphis erysimi*, i.e., Control (T0), *Verticillium lecanii (2x10^8 spores/ml) (T1)*, Beta cyfluthrin 8.49% w/w + Imidacloprid 19.81% w/w (T2), Imidacloprid 17.8 SL + Cypermethrin 25% EC (T3), Neem oil 5% EC (T4), Nisco Bio 5% (T5), *Metarhizium anisopliae 106-108 spore load/ml 5 g/lit (T6)*, Imidacloprid 17.8 SL (T7) were evaluated against mustard aphid (*Lipaphis erysimi*). Result revealed that, among the different treatments, the highest per cent population reduction of mustard aphid was recorded in Imidacloprid 17.8 SL + Cypermethrin 25% EC (75.67%), followed by Beta cyfluthrin 8.49% w/w + Imidacloprid 19.81% w/w (70.123%), Imidacloprid 17.8 SL (64.687%), Neem oil 5% (58.2%), *Metarhizium anisopliae* (55.2%), *Verticillium lecanii* (52.497%), Nisco bio 5% (50.017%) was the least effective among all treatments. While, the highest yield 19.47 q/ha was obtained from the treatment Imidacloprid 17.8 SL + Cypermethrin 25% EC as well as B:C ratio (1:7.59) was obtained high from this treatment. It was followed by Beta cyfluthrin 8.49% w/w + Imidacloprid 19.81% w/w (1:6.89), Imidacloprid 17.8 SL (1:6.59), Neem oil 5% (1:5.60), *Metarhizium anisopliae* (1:4.87), *Verticillium lecanii* (1:4.77), Nisco bio 5% (1:3.98), as compared to Control (1:3.25).

**Keywords:** Beta-cyfluthrin, biopesticides, efficacy, Imidacloprid, *Lipaphis erysimi*, mustard aphid

**Introduction**

Mustard is among the oldest recorded spices as seen in Sanskrit records dating back to about 3000 BC (Mehra, 1968) [18] and was one of the first domesticated crops. Originally it was the condiment that was known as mustard and the word was derived from the Latin *mustum*. Rapeseed-mustard group of crops is the major oilseed crop of India. India holds a premier position in rapeseed-mustard economy of the world with 2nd and 3rd rank in area and production, respectively (Das and Sharma, 2012) [9]. This group of oilseed crops is gaining wide acceptance among the farmers because of adaptability for both irrigated as well as rainfed areas and suitability for sole as well as mixed cropping (Sharma, 2018) [18].

Rapeseed-mustard crops are commercially cultivated in more than 60 countries and major produces include China, Canada, India, Australia, France, Germany, United Kingdom, Poland, Ukraine, Russia, USA and Czech Republic. In the past the area under Rapeseed-mustard globally increased from 6.3 million hectare in 1961 to 34.3 million hectare in 2012 with a mean increment of 0.56 million hectare per annum. Production in the same period increased from 3.68 to 65.1 million tonnes at mean increment of 3.68 m/annum. These crops occupy a prominent position as the second important oilseeds in the world as well as in India. [Biology of *Brassica juncea* L. (Indian mustard) Ministry of Environment, Forest and Climate Change (MoEF&CC)]

The production of rapeseed-mustard is low in India as compared to other countries mainly due to damage caused by insect pest and diseases including other factors (Bakhetia and Sekhon 1989) [9]. More than 43 species of insect pests infest rapeseed-mustard crop in India, out of which about a dozen of species are considered as major pest (Purwar et al., 2004) [25]. Among all the insect pests, the mustard aphid, *Lipaphis erysimi* (Kaltenbach) (Homoptera: Aphididae) has gained the status of key pest of rapeseed-mustard in India. It feeds by sucking sap from its host and damage to the crop ranging from 9 to 96% in different agroclimatic conditions of India (Bakhetia, 1984) [3]; Chorbangi and Bakhetsia, 1987 [8]; Singh and Sachan,
1994 [31], Singh and Sachan, 1995 [33], Parmar et al., 2007 [22]. The loss may go up to 100% in certain mustard growing regions (Singh and Sachan, 1999) [32].

Large colonies of the aphid could cause the plant to become deformed due to curling and shrivelling of leaves (Metcalfe, 1962) [21]. Under severe infestation, both sides of leaves are attacked (Yadav et al., 1988) [39]. On mustard, Lipaphis erysimi prefers to feed on flowers as well as foliage of mustard (Singh et al., 1965) [34].

Adult apterous 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. Both the nymphs and adults suck sap from leaves, inflorescence, stems, flowers and pods; as a result, the plant shows stunted growth, flowers wither and pod formation are hindered. The losses of mustard due to aphids varied from 35 to 90 percent depending upon the seasons (Biswas and Das, 2000 [42], Rohilla et al., 2004 [26]).

Due to aphid infestation mainly leaves become curled and wrinkled. As a result, plants lose their vigour and ultimately become stunted growth and flowers fail to set pods, the affected pods get twisted and shrivelled. In case of severe infestation, the plant fails to develop pods, they do not mature and unable to produce healthy seeds. The Lipaphis erysimi (Kalt.) causes enormous qualitative and quantitative losses in rape seed and mustard crop as result in seed weight loss, viability and oil content get reduced. Cultivation of resistant or tolerant varieties is the very effective and cheapest method of cultural control to save mustard crop from insect pests. Due to screening resistance variety/germplasm against aphids get increase of production in aphid-infested area and save environment from insecticidal residues.

Various varieties of rapeseed-mustard also regulate the population build up on the basis of their suitability. Hence, studying population dynamics provides an opportunity by manipulating the manageable ecological parameters in the form of planting or harvesting time adjustment, varietal selection and correct time of pesticide application. Several chemical and botanical insecticides have been accounted for astonishing gains in production, as the insecticides have reduced the hidden toll exacted by the aggregated attack of insect-pests. The mustard aphid, Lipaphis erysimi (Kalt.) is a major pest of Brassica crops (Rohilla et al., 1987) [27].

Materials and Methods
The experiment was conducted at the experimental research plot of the Department of Entomology, Central Research Farm, Sam Higginbottom University of Agriculture Technology and Sciences, during the rabi season of 2021-2022 in a randomized block design with eight treatments replicated three times using variety Rohini from Chandra Shekhar Azad University of Agricultural & Technology, Kanpur, Uttar Pradesh, in a plot size of 2m x 2m with a recommended package of practices excluding plant protection. The site selected for experiment was uniform, cultivable with typical sandy loam soil having good drainage. The observations on population of sucking pest were recorded visually using a magnifying lens early on top 10cm central apical twig per plant from five randomly selected and tagged plants in each plot. Aphid count was taken 24 hours before spraying at 5 tagged plants per treatment, which was further converted in to per plant population and subsequent observation was recorded at 3, 7 and 14 days after spraying on same plants. The formula used for the calculation of percentage reduction of pest population over control using following formula giving by Henderson and Tilton (1955) referring it to be modification of Abbott (1925).

\[
\text{Percent reduction} = 1 - \frac{\text{Population recorded in control plot} - \text{Population recorded in plot}}{\text{Population recorded in control plot}} \times 100
\]

The average percent reduction of pest population of all two sprays was worked out by using Henderson and Tilton formula as before.

\[
\text{BCR} = \frac{\text{Gross returns}}{\text{Total costs incurred}}
\]

Where, BCR = Benefit Cost Ratio
Gross returns = Marketable yield × Market price
Net return = Gross return - Cost of cultivation. (Zoremppui and Kumar, 2019) [41].

Result and Discussions
In the experiment eight different treatment consisting application of Control (T0), Verticillium lecanii (T1), Beta cyfluthrin 8.40% + Imidacloprid 19.81% 300 OD (T2), Imidacloprid 17.8 SL + Cypermethrin 25% EC (T3), Neem oil 5% (T4), Niisco Bio 5% (T5), Metarhizium anisopliae (T6), Imidiacloprid 17.8 SL (T7) were tested to compare the efficacy against Lipaphis erysimi and their influences on yield of mustard. The result obtained are discussed in the light of available relevant literature in this chapter as before.

Result revealed that, Among the different treatment the highest per cent population reduction over control was recorded in Imidacloprid 17.8 SL + Cypermethrin 25% EC (75.67%) followed by Beta cyfluthrin 8.40% + Imidacloprid 19.81% 300 OD (70.123%), Imidiacloprid 17.8 SL (64.687%), Neem oil 5% (58.2%), Metarhizium anisopliae (55.2%), Verticillium lecanii (52.497%), Niisco Bio 5% (50.017%) was the least effective among all treatments. The data on per cent population reduction over control overall mean of 3rd, 7th and 14th revealed that all the treatments except untreated control are effective and at par.
Biopesticides, chemicals were found to be effective to control rapid multiplication of aphid. Imidacloprid 17.8 SL+ Cypermethrin 25% EC act as a synergistic composition which was found to be effective then Beta cyfluthrin 8.49% w/w + Imidacloprid 19.81%.

The present investigation is also similar with the following authors, Jeyarani et al., (2006) [14], Wale et al. (2013) [18] and Paramasivam et al., (2017) [21]. Use of combi insecticides is on the rise and the products with neonicotinoid and pyrethroid combinations have become very popular in pest management. These products successfully target different groups of insects, resulting in optimum control of insect populations due to their varied mode of action. Superior bio efficacy of neonicotinoid + pyrethroid combi products against crop pests has been reported.

Finding of the Imidacloprid 17.8 SL+ Cypermethrin 25% EC (75.67%) are in agreement with the Xuemei (2011) [39]. The Imidacloprid and cypermethrin synergic compound disclosed by the invention has the advantages of simple production process, safety in use, remarkable synergism on cotton aphids, cabbage aphids, wheat aphids and the like, improvement on the control effect of various pests, acceleration on the insect disinfestation speed of pesticides, lower use cost and strong synergism and controlling function; in addition, the Imidacloprid and cypermethrin synergic compound does not hurt the beneficial insects during controlling pests, is beneficial to comprehensively controlling the pests, also enlarges the insecticidal spectrum and reduces the toxicity on persons and animals.

Beta cyfluthrin 8.40% + Imidacloprid 19.81% 300 OD (solomon) (T3) is found to be the next best treatment which is in line with the finding of Patel et al., (2018) [23], Giraddi et al., (2017) [13], Kumar et al., (2009) [16] and Bhargava et al., (2003) [1].

Imidacloprid 17.8 SL (T7) is found to be the next best treatment which is suppported by Khedkar et al., (2012) [15], Bapari et al., (2008) [16], Devee et al., (2011) [11] and Singh et al., (2014) [34]. In present investigation, Neem oil 5% found to be effective after by chemicals. Result of the neem oil are similar with the Kumar et al., (2016) [16] and Aziz et al., (2014) [1].

Entomopathogenic fungi Metarhizium anisopliae (T6) and Verticillium lecanii (T1) were also effective against mustard aphid as the similar finding was made by Meena et al., (2013) [19], Rawat et al., (2008) [26] Kumar et al., (2016) [16] and Men et al., (2002) [20]. Nisco bio 5% was also effective. It is an organic chemical and useful for Yamuna bank region of Prayagraj and an eco-friendly option for control of mustard aphid.

**Economics of various treatments**

The yield among the treatment were significant. The highest yield was recorded in of The highest grain yield of 19.47 q/ha was registered in Imidacloprid 17.8 SL + Cypermethrin 25% EC (T3) which was followed by Beta cyfluthrin 8.49% w/w + Imidacloprid 19.81% w/w (T2)

34 q/ha, Imidacloprid 17.8 SL (T7) 17.63 q/ha, Neem oil 5% (T4) 14.7 q/ha, Metarhizium anisopliae 106-108 spore load/ml 5gm/lit (T6) 13.79q/ha, Verticillium lecanii (2x108 spores/ml) (T1) 12.63 q/ha, Nisco Bio 5% (T5) 10.33 q/ha. As low as 7.6 q/ha was recorded in untreated plot (Control) (T0). Dhaked et al., (2016) [10].

When cost benefit ratio was worked out, interesting result were achieved. Among the treatment studied, the best and most economical treatment was Imidacloprid 17.8 SL + Cypermethrin 25% EC (T3) (1:7.59) followed by Beta cyfluthrin 8.49% w/w + Imidacloprid 19.81% (T2) (1:6.89). Imidacloprid 17.8 SL (T7) (1:6.59), Neem oil 5% (T4) (1:5.60), Metarhizium anisopliae 106-108 spore load/ml 5gm/lit (T6) (1:4.87), Verticillium lecanii (2x108 spores/ml) (T1) (1:4.77) and Nisco Bio 5% (T4) (1:3.98). Least monetary return was obtained with control (T0) (1:3.25). Vishal et al., (2019) [17], Ahlawat et al., (2018) [3], Meena et al., (2013) [19] and Seeja et al., (2022) [20].

Table 1: Per cent population reduction over control due to application of certain biopesticides and chemicals against mustard aphid, L. erysimi on Indian mustard

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Population of L. erysimi / Plant</th>
<th>Aphid population reduction in percent over control of L. erysimi / plant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 DBS</td>
<td>3 DAS</td>
</tr>
<tr>
<td>T0</td>
<td>Control</td>
<td>250.53</td>
</tr>
<tr>
<td>T1</td>
<td>T1- Verticillium lecanii</td>
<td>245</td>
</tr>
<tr>
<td>T2</td>
<td>T2- Beta cyfluthrin 8.49% w/w + Imidacloprid 19.81% w/w</td>
<td>229</td>
</tr>
<tr>
<td>T3</td>
<td>T3- Imidacloprid 17.8 SL + Cypermethrin 25% EC</td>
<td>224.53</td>
</tr>
<tr>
<td>T4</td>
<td>T4- Neem oil 5% EC</td>
<td>245.86</td>
</tr>
<tr>
<td>T5</td>
<td>T5- Nisco Bio 5%</td>
<td>236.46</td>
</tr>
<tr>
<td>T6</td>
<td>T6-Metarhizium anisopliae</td>
<td>513</td>
</tr>
<tr>
<td>T7</td>
<td>T7-Imidacloprid 17.8 SL</td>
<td>524</td>
</tr>
<tr>
<td>F- test</td>
<td>NS</td>
<td>S</td>
</tr>
<tr>
<td>S. E (±)</td>
<td>0.422</td>
<td>0.333</td>
</tr>
<tr>
<td>C. D. (P = 0.05)</td>
<td>1.659</td>
<td>1.473</td>
</tr>
</tbody>
</table>
**Fig 1:** Graphical representation of per cent population reduction over control (3rd, 7th, 14th DAS and Mean) due to application of biopesticides and chemicals against *Lipaphis erysimi* on Indian mustard

**Table 2:** Economics of Cultivation

<table>
<thead>
<tr>
<th>S. N.</th>
<th>Treatments</th>
<th>Yield q/ha</th>
<th>Cost of Yield (₹/q)</th>
<th>Total cost of yield (₹)</th>
<th>Common cost (₹)</th>
<th>Treatment cost (₹)</th>
<th>Net return (₹)</th>
<th>Total cost (₹)</th>
<th>B:C Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>T0</td>
<td>Control</td>
<td>7.6</td>
<td>6500</td>
<td>49400</td>
<td>15184</td>
<td>-</td>
<td>34216</td>
<td>15184</td>
<td>1:3.25</td>
</tr>
<tr>
<td>T1</td>
<td><em>Verticillium lecanii</em> (2x10^8 spores/ml)</td>
<td>12.63</td>
<td>6500</td>
<td>82095</td>
<td>15184</td>
<td>2000</td>
<td>64911</td>
<td>17184</td>
<td>1:4.77</td>
</tr>
<tr>
<td>T2</td>
<td>Beta cyfluthrin 8.49% w/w + Imidacloprid 19.81% w/w</td>
<td>18.43</td>
<td>6500</td>
<td>119795</td>
<td>15184</td>
<td>2200</td>
<td>102411</td>
<td>17384</td>
<td>1:6.89</td>
</tr>
<tr>
<td>T3</td>
<td>Imidacloprid 17.8 SL + Cypermethrin 25% EC</td>
<td>19.47</td>
<td>6500</td>
<td>126555</td>
<td>15184</td>
<td>1475</td>
<td>109896</td>
<td>16659</td>
<td>1:7.59</td>
</tr>
<tr>
<td>T4</td>
<td>Neem oil 5% EC</td>
<td>14.7</td>
<td>6500</td>
<td>95550</td>
<td>15184</td>
<td>1875</td>
<td>78706</td>
<td>17059</td>
<td>1:5.60</td>
</tr>
<tr>
<td>T5</td>
<td>Nisco Bio 5%</td>
<td>10.33</td>
<td>6500</td>
<td>67145</td>
<td>15184</td>
<td>1660</td>
<td>50301</td>
<td>16844</td>
<td>1:3.98</td>
</tr>
<tr>
<td>T6</td>
<td><em>Metarhizium anisopliae</em> 106-108 spore load/ml 5gm/lit</td>
<td>13.79</td>
<td>6500</td>
<td>89635</td>
<td>15184</td>
<td>3200</td>
<td>71251</td>
<td>18384</td>
<td>1:4.87</td>
</tr>
<tr>
<td>T7</td>
<td>Imidacloprid 17.8 SL</td>
<td>17.63</td>
<td>6500</td>
<td>114595</td>
<td>15184</td>
<td>2200</td>
<td>97211</td>
<td>17384</td>
<td>1:6.59</td>
</tr>
</tbody>
</table>
Conclusion
From the critical analysis of the present findings, it can be concluded that Imidacloprid 17.8 SL+ Cypermethrin 25% EC(T3) recorded highest percent reduction of Lipaphis erysimi population. i.e., (75.67%) with highest cost benefit ratio (1:7.59) which was significantly superior over control. Insecticides like Neem oil 5%, Metarhizium anisopliae, Verticillium lecanii and Nisco bio 5% is showing good result against mustard aphid and can be a part of integrated pest management an effective tool for environment under biological control. It is also concluded that spraying of synergic compound like Imidacloprid 17.8 SL+ Cypermethrin 25% EC and Beta cyfluthrin 8.49% w/w + Imidacloprid 19.81% was benefited seed yield and plant biomass, which was presumably due to reduction of aphid number; protection of crops from pest pressure has frequently been found to result in yield increase, which is very important in the context of the socio-economic conditions of Prayagraj.

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