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Soumya Ashna Singh
M.Sc. Scholar, Department of Entomology, SHUATS, Prayagraj, Uttar Pradesh, India

Ashwani Kumar
Associate Professor and Head, Department of Entomology, SHUATS, Prayagraj, Uttar Pradesh, India

Corresponding Author:
Soumya Ashna Singh
M.Sc. Scholar, Department of Entomology, SHUATS, Prayagraj, Uttar Pradesh, India

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.)

Soumya Ashna Singh and Ashwani Kumar

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* (2x108 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 2st 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) [30].

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 mt/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) [5]. 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]; Chorbandi and Bakhetia, 1987 [8]; Singh and Sachan, 1994 [31]; Singh and Sachan, 1995 [33]; Parmar *et al*., 2007 [22]). The loss may go upto 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 (Metcalf, 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 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. 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 [4]; Rohilla *et al.,* 2004 [26]).

Due to aphid infestation mainly leaves become curled and wrinkled. As a result, plants loss their vigour and ultimately became 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 grains 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 (Rohila *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×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).

$$\text{Percent reduction over control} = \frac{\text{(Population recorded in control plot - Population recorded after spray)}}{\text{Population recorded in control plot}}$$

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

$$\text{Percent reduction} = 1 - \frac{T_a}{T_b} \text{ x } \frac{C_b}{C_a} \text{ x } 100$$

Where, Ta = number of insects in treated plot after insecticides application Tb=number of insects in treated plot before insecticides application

Ca= number of insects in Untreated check after insecticide application Cb= number of insects in untreated check before insecticide application (Dotasara *et al.*, 2017) [12].

The healthy marketable yield obtained from different treatments was collected separately and weighed. The cost of insecticides used in this experiment was recorded during Rabi season of 2021-22. The cost of botanicals used was obtained from nearby market. The total cost of plant protection consisted of cost of treatments, sprayer rent and labour charges for the spray. There were two sprays throughout the research period and the overall plant protection expenses were calculated. The B:C ratio can be calculated by formula…

BCR = Gross returns / Total costs incurred

Where, BCR = Benefit Cost Ratio

Gross returns = Marketable yield × Market price

Net return = Gross return − Cost of cultivation. (Zorempuii 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), Nisco Bio 5% (T5), *Metarhizium anisopliae* (T6), Imidacloprid 17.8 SL (T7) were tested to compare the efficacy againt *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%), 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.

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) [38] and Paramasivam *et al.*, (2017) [23]. 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 (soloman) (T3) is found to be the next best treatment which is in line with the finding of Patel *et al*, (2018) [24], Giraddi *et al.*, (2017) [13], Kumar *et al.*, (2009) [16] and Bhargava *et al.*, (2003) [7].

Imidacloprid 17.8 SL (T7) is found to be the next best treatment which is suppperted by Khedkar *et al.*, (2012) [15], Bapari *et al.*, (2008) [6], 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 *Metazhizium 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) [28] 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* (2x108spores/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) [37], Ahlawat *et al.*, (2018) [2], Meena *et at.*, (2013) [19] and Seeja *et al.*, (2022) [29].

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

Treatments		Population of *L. erysimi* / Plant	Aphid population reduction in percent over control of *L. erysimi / plant*			
		1 DBS	3 DAS	7 DAS	14 DAS	Overall Mean
T0	Control	250.53	0.00	0.00	0.00	0.00
T1	T1- *Verticillium lecanii*	245	27.59	60.03	70.15	52.43
T2	T2- Beta cyfluthrin 8.49% w/w + Imidacloprid 19.81% w/w	229	48.30	73.57	89.88	70.12
T3	T3- Imidacloprid 17.8 SL + Cypermethrin 25% EC	224.53	54.34	78.38	94.86	75.67
T4	T4- Neem oil 5% EC	245.86	28.9	65.28	80.23	58.20
T5	T5- Nisco Bio 5%	236.46	19.88	56.05	78.8	50.01
T6	T6-*Metarhizium anisopliae*	251.33	28.006	63.64	73.22	55.20
T7	T7-Imidocloprid 17.8 SL	249	37.34	70.82	86.84	64.68
F- test		NS	S	S	S	S
S. E (±)			0.422	0.333	0.505	0.073
C. D. (P = 0.05)			1.659	1.473	1.813	0.692

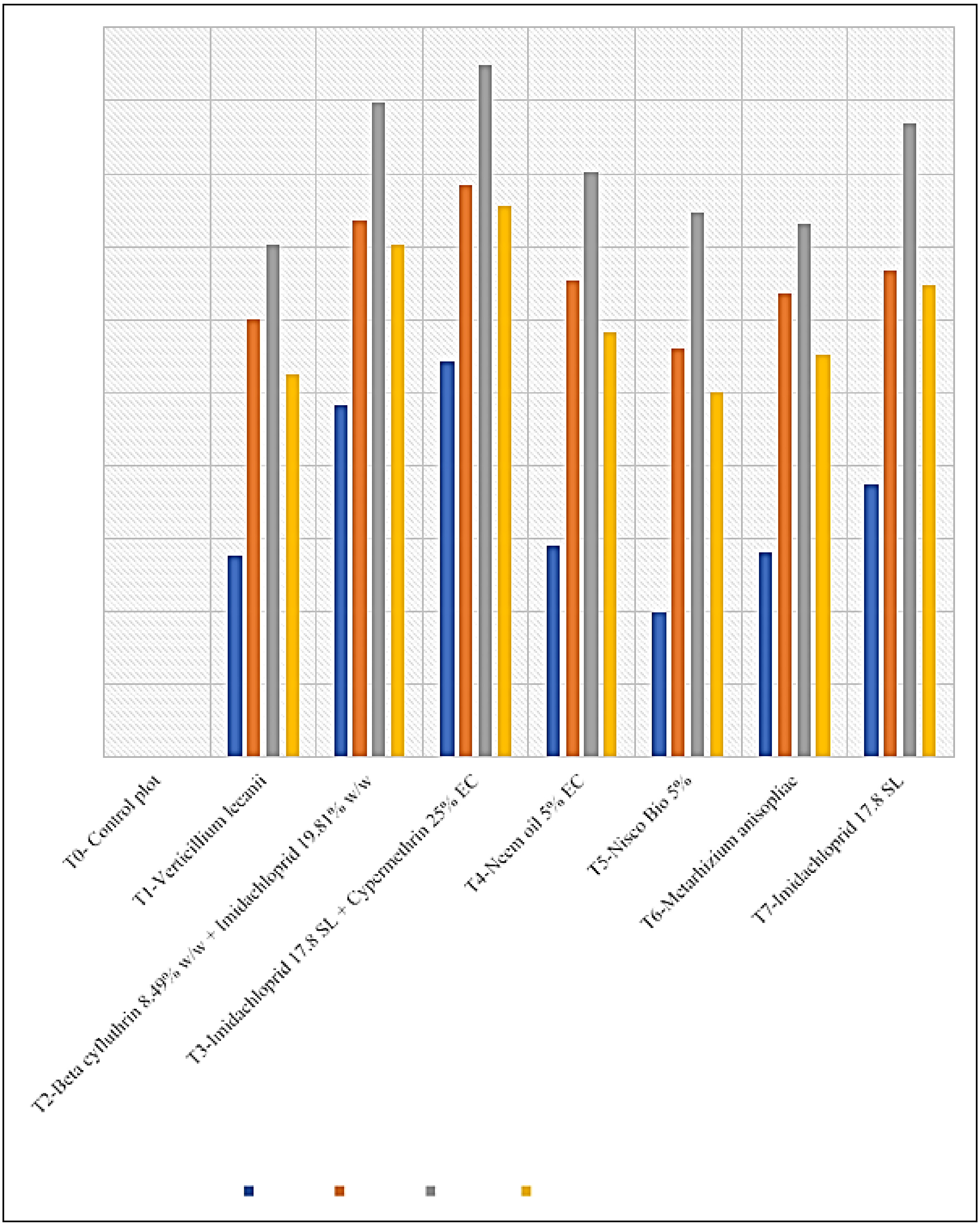

Fig 1: Graphical representation of per cent population reduction over control (3rd, 7th, 14th DAS and Mean) due to application of biopesticides and chemicals against *Lipaphis erysimi* on Indian mustard

Table 2: Economics of Cultivation

S. N.	Treatments	Yield q/ha	Cost of Yield (₹/q)	Total cost of yield (₹)	Common cost (₹)	Treatment cost (₹)	Net return (₹)	Total cost (₹)	B:C Ratio
T0	Control	7.6	6500	49400	15184	-	34216	15184	1:3.25
T1	*Verticillium lecanii* (2x108 spores/ml)	12.63	6500	82095	15184	2000	64911	17184	1:4.77
T2	Beta cyfluthrin 8.49% w/w + Imidacloprid 19.81% w/w	18.43	6500	119795	15184	2200	102411	17384	1:6.89
T3	Imidacloprid 17.8 SL + Cypermethrin 25% EC	19.47	6500	126555	15184	1475	109896	16659	1:7.59
T4	Neem oil 5% EC	14.7	6500	95550	15184	1875	78706	17059	1:5.60
T5	Nisco Bio 5%	10.33	6500	67145	15184	1660	50301	16844	1:3.98
T6	*Metarhizium anisopliae* 106-108 spore load/ml 5gm/lit	13.79	6500	89635	15184	3200	71251	18384	1:4.87
T7	Imidacloprid 17.8 SL	17.63	6500	114595	15184	2200	97211	17384	1:6.59

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 *Lipashis 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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