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Comparative efficacy and cost benefit ratio of selected biopesticides and chemicals against mustard aphid, *Lipaphis erysimi* (Kaltenbach)

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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), Cypermethrin 25% EC (T1), *Verticillium lecanii* (2 x 108 spores/ml) (T2), Nisco sixer plus (T3), Neem oil 0.03% EC (T4), *Beauveria bassiana* 1.5% L (1 x 108 CFU/ml) (T5), Cypermethrin 25% EC + Nisco sixer plus (T6), Profenofos 40%+ Cypermethrin 25% EC (T7) were evaluated against mustard aphid (*Lipaphis erysimi*). Results revealed that, among the different treatments, the highest per cent population reduction of mustard aphid was recorded in Profenofos 40%+ Cypermethrin 25% EC (71.37%) followed by Cypermethrin 25% EC + Nisco sixer plus (65.08%), Cypermethrin 25% EC (59.79%), Nisco sixer plus (56.82%), *Beauveria bassiana* (44.10%), *Verticillium lecanii* (43.58%), Neem oil 0.03% EC (41.17%) was the least effective among all treatments. While, the highest yield 19.69 q/ha was obtained from the treatment Profenofos 40%+ Cypermethrin 25% EC as well as B:C ratio 1: 7.98 was obtained high from this treatment. It was followed by Cypermethrin 25% EC (1: 7.26), Cypermethrin 25% EC + Nisco sixer plus (1: 6.88), Neem oil 0.03% EC (1:5.64), Nisco sixer plus (1: 5.22) *Beauveria bassiana* (1:4.85), *Verticillium lecanii* (1: 4.62)., as compared to Control (1: 2.93).

Keywords: Biopesticides, chemicals, cost benefit ratio, efficacy, *Lipaphis erysimi*, mustard aphid

Introduction

Indian mustard account for about 75-80% of the 6.23 mha of rapeseed and mustard area with the production 8.32 mt and productivity of 1397 kg/ha in the country. (Anonymous, 2019) [4]

India is the fourth-largest contributor of oilseeds in the world and Rapeseed and mustard contributes about 28.6% of total oilseeds production. Central Organization for Oil Industry and Trade (COOIT), an apex body of the edible oil industry, estimates that the country's mustard seed production will increase to 100-110 lakh tonnes in the current *rabi* season (2021-22 crop year) because of higher sowing by farmers. The production of mustard, which is one of the major rabi crops, stood at 85 lakh tonnes in the 2020-21 crop years (July-June).

Oilseeds and edible oils hold a key position in the Indian economy. In terms of vegetable oils, India is the fourth largest oil economy in the world after USA, China and Brazil. (Sen *et al*., 2017) [32]. Mustard is among the oldest recorded spices as seen in Sanskrit records dating back to about 3000 BC (Mehra, 1968) [21] and was one of the first domesticated crops.

The major pungent chemical constituent of such commercialized oils is Allyl isothiocyanate which is formed from its precursor during the processing of the seeds (Yu *et al*., 2003) [42]. This isothiocyanate is now considered to be the most important cancer chemo-preventive phytochemical with other potential health benefits (Okulicz, 2010) [24] and antimicrobial agent against a variety of organisms. Structurally diverse glucosinolates and other precursors of isothiocyanates are encountered not only in *Brassica juncea* leaves, but also in diverse other edible cruciferous vegetables well recognized for their health benefits.

Amongst many such vegetables, the glucosinolates contents of *Brassica juncea* leaves are reported to be the highest. In general, contents of these phyto-chemicals in seeds of Brassicacea family grown in tropical environment are higher than of those grown in temperate regions (Tripathi *et al*., 2007) [39].

It is reported that mustard aphid reduces the yield from 9 to 95% different places in India (Bakhetia and Singh, 1992) [6]. The aphid (*Lipaphis erysimi*) is an important insect pest of mustard and causes heavy yield losses worldwide (Shylesha *et al*., 2006; Thakur *et al*., 2009) [34, 38]. They suck the sap from the plant and hamper the plant nutrition to a great extent.

As a result, plant loses their vigour and their growth is hampered which ultimately affects the yield of the crop. The yield losses may be 10-90% depending upon the severity of damage and the stage of the crop (Parmar *et al*., 2007) [25]. The economic thresh hold (ETL) of this insect pest is infestation of 40 aphids per 10 cm length of the twig on the top portion of the central shoot or infestation of 30% plants (Rai, 1997) [26]. Nymphs and adults of aphid, *Lipaphis erysimi*, suck the cell sap from inflorescence, terminal twig, siliqua (pod), leaves and branches which causes yield loss. Severe infestation leads to poor pod formation, curling, shriveling of leaves and drying of plants. On the other hand, aphids secrete honeydew, which facilitates the growth of black sooty mold that makes the leaves appear dirty black.

Mustard aphids have the capability to increase their population and spread rapidly within a very short span of time in favourable environmental condition. For this, all control measures except, chemical control are time consuming. But chemical insecticides are not only toxic to natural enemies of aphid such as *Diaeretiella rapae*, *Chrysoperla zastrowi arabica*, coccinellids and syrphid flies but these are also responsible for environmental pollution, health hazards to human beings, toxic to pollinators, pest resurgence, development of resistance in insect-pests and residues in oil and cake.

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 RH-0749 from National Seed Corporation, 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) [14] referring it to be modification of Abbott (1925) [1].

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

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

$$\text{Percent reduction} = 1 - \frac{Ta}{Tb} \times \frac{Cb}{Ca} \times 100$$

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) [10].

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) [43].

Results and Discussions

In the experiment, eight different treatments, consisting application of Control (T0), Cypermethrin 25% EC (T1), *Verticillium lecanii* (2 x 108 spores/ml) (T2), Nisco sixer plus (T3), Neem oil 0.03% EC (T4), *Beauveria bassiana* 1.5% L (1 x 108 CFU/ml) (T5), Cypermethrin 25% EC + Nisco sixer plus (T6), Profenofos 40%+ Cypermethrin 25% EC (T7) were tested to compare the efficacy against *Lipaphis erysimi* and their influences on yield of mustard. The results obtained are discussed in the light of available relevant literature in this chapter as before.

Results revealed that, Among the different treatments, the highest per cent population reduction over control was recorded in Profenofos 40%+ Cypermethrin 25% EC (71.37%) followed by Cypermethrin 25% EC + Nisco sixer plus (65.08%), Cypermethrin 25% EC (59.79%), Nisco sixer plus (56.82%), *Beauveria bassiana* (44.10%), *Verticillium lecanii* (43.58%), Neem oil 0.03% EC (41.17%) 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.

Among the evaluation of biopesticides and Cypermethrin against mustard aphid (*L. erysimi*) the combination of chemicals was found to be effective. Profenofos 40%+ Cypermethrin 25% EC (71.378%) was highest effective among all the treatments. as the similar findings was reported by Rashid *et al*. (2021) [28], Kumar *et al.* (2018) [18], Gupta *et al.* (2013) [13].

Cypermethrin 25% EC + Nisco sixer plus(T6) is found to be the next best treatment which is in line with the findings of Reddy *et al*., (2020) [30], Tejaswari and Kumar (2021) [37] and Gayathri and Kumar (2021) [11]. Nisco sixer plus (T3) was also effective. It is an organic chemical and useful for Yamuna bank region of Prayagraj. as the similar findings was reported by Sreeja and Kumar (2022) [36], Barwa and Kumar (2022) [7], Nagaraju and Kumar (2022) [22], Jamir and Kumar (2022) [15], Neelofor and Kumar (2022) [23].

Cypermethrin 25% EC(T1) is found to be the next best treatment which is supported by Saha *et al.* (2021) [31], Devi *et al.* (2001) [9], Raj *et al.* (1993) [27] and Bhatta *et al.* (2019) [8]. Entomopathogenic fungi *Verticillium lecanii* (T2), *Beauveria bassiana 1.5% L* (T5) were also effective against mustard aphid as the similar findings was made by Janu *et al.* (2018) [16], Shinde *et al.* (2021) [33], Rawat *et al.* (2008) [29], Singh and Lal (2011) [35] and Gebreyohans *et al.* (2021) [12]. Neem oil 0.03% EC (T4) is an eco-friendly option for control of mustard aphid supported by Meena *et al.* (2013) [20].

Economics of various treatments

The yields among the treatments were significant. The highest yield was recorded in of 19.69 q/ha was registered in Profenofos 40%+ Cypermethrin 25% EC which was followed by Cypermethrin 25% EC 17.8 q/ha, Cypermethrin 25% EC + Nisco sixer plus 16.97 q/ha, Neem oil 0.03% EC 14.85 q/ha, Nisco sixer plus 13.53 q/ha, *Beauveria bassiana* 12.84 q/ha, *Verticillium lecanii* 12.23 q/ha. As low as 6.86 q/ha was recorded in untreated plot (Control). These findings are supported by Vishal *et al.* (2019) [40], Bhatta *et al.* (2019) [8], Akter *et al.* (2021) [3], Yadav *et al.* (2021) [41], Aziz *et al.* (2014) [5], Meena *et al.* (2013) [20], Kumar and Kumar (2016) [17].

When cost benefit ratio was worked out, interesting result were achieved. Among the treatment studied, the best and most economical treatment was Profenofos 40% + Cypermethrin 25% EC (1: 7.98) followed by Cypermethrin 25% EC (1: 7.26), Cypermethrin 25% EC + Nisco sixer plus (1: 6.88), Neem oil 0.03% EC (1:5.64), Nisco sixer plus (1: 5.22) *Beauveria bassiana* (1:4.85), *Verticillium lecanii* (1: 4.62). Least monetary return was obtained with control (1: 2.93). These findings are supported by Sreeja and Kumar (2022) [36], Mandal *et al.* (2012) [19], Ahlawat *et al.* (2018) [2] and Akter *et al.* (2021) [3].

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	175.33	0.00	0.00	0.00	0.00
T1	Cypermethrin 25% EC	183.8	18.67	72.19	88.53566	59.799
T2	*Verticillium lecanii* (2 x 108 spores/ml)	175	7.3366	45.26	78.1633	43.587
T3	Nisco sixer plus	162.8	11.67	71.2833	87.52	56.824
T4	Neem oil 0.03% EC	165.6	5.8866	41.7633	75.88	41.177
T5	*Beauveria bassiana* 1.5% L (1 x 108 CFU/ml)	179.2	6.983	46.57073	78.77	44.108
T6	Cypermethrin 25% EC + Nisco sixer plus	175	30.14	73.433	91.8	65.083
T7	Profenofos 40%+ Cypermethrin 25% EC	177.13	41.2633	78.74	94.133	71.378
F- test		NS	S	S	S	S
S. E (±)		6.94	0.45	0.58	0.34	0.27
C. D. (P = 0.05)			0.979	1.250	0.741	0.591

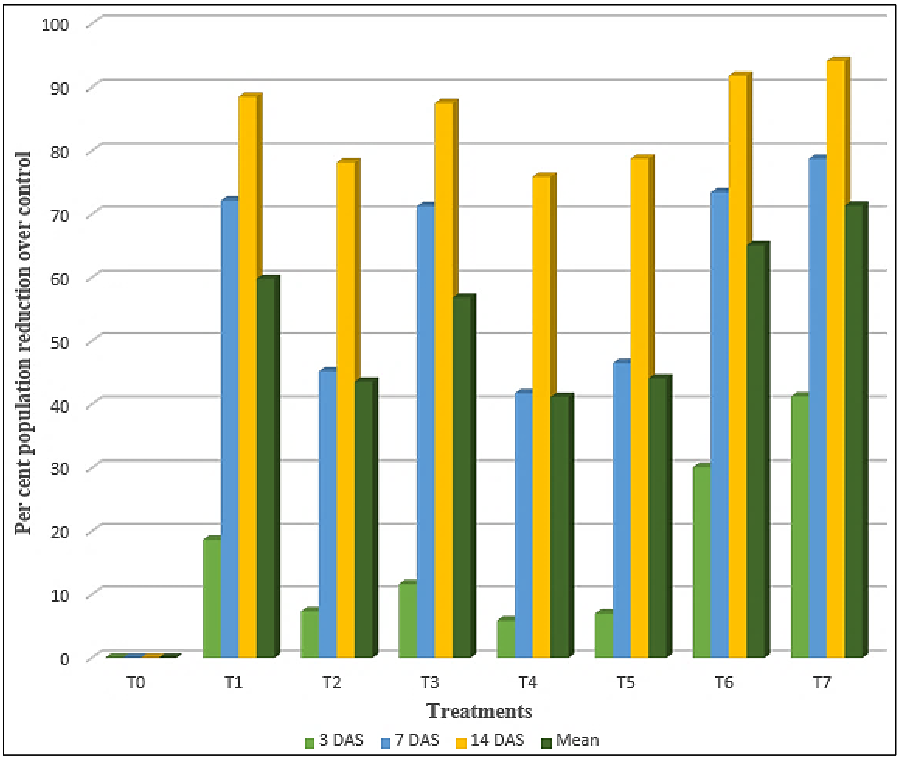

Fig 1: Graphical representation of per cent population reduction over control (3rd, 7th 14th DAS and Mean) due to application of biopesticides and chemicals against *L. erysimi* on Indian mustard

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	6.86	6500	44590	15184	-	29406	15184	1:2.93
T1	Cypermethrin 25% EC	17.8	6500	115700	15184	750	99766	15934	1:7.26
T2	*Verticillium lecanii* (2 x 108 spores/ml)	12.23	6500	79459	15184	2000	62275	17184	1:4.62
T3	Nisco sixer plus	13.53	6500	87945	15184	1660	71101	16844	1:5.22
T4	Neem oil 0.03% EC	14.85	6500	96525	15184	1875	66401	17059	1:5.64
T5	*Beauveria bassiana* 1.5% L (1 x 108 CFU/ml)	12.84	6500	83460	15184	2000	66276	17184	1:4.85
T6	Cypermethrin 25% EC + Niscosixer plus	16.97	6500	110305	15184	840	94281	16024	1:6.88
T7	Profenofos 40% + Cypermethrin 25% EC	19.69	6500	127985	15184	850	111951	16034	1:7.98

Conclusion

From the critical analysis it was concluded that among all the treatments Profenofos 40% + Cypermethrin 25% EC (T7) recorded highest percent reduction of *Lipaphis erysimi* population i.e., (71.378%) with the highest cost benefit ratio (1: 7.98) which was significantly superior over control. While the lowest percent reduction is recorded with Neem oil 0.03% EC (T4) (41.17%) as such more trails are required in future to validate the findings which can be useful for the farmers in a feasible manner for sustainable production and to prevent the losses occurring from the pest infesting the mustard crop.

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