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Bio-efficacy of insecticides against mustard aphid (*Lipaphis erysimi*) in Indian mustard (*Brassica juncea* L.)

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Abstract

The study was aimed to evaluate the efficacy of different insecticides in minimizing aphid (*Lipaphis erysimi*) damage in the Indian mustard (*Brassica juncea*) under natural infestation of the pest. The field experiment was conducted at the farmer's field in Rewari, Haryana during 2021-22. The experiment was laid out in randomized block design with seven treatments viz., imidacloprid 17.8 SL @ 125 ml ha^{-1}, thiamethoxam 25 WG @ 100 g ha^{-1}, thiamethoxam 25 WG @ 50 g ha^{-1}, acetamiprid 20 SP @ 50 g ha^{-1}, imidacloprid 17.8 SL @ 100 ml ha^{-1}, fipronil 5 SC @ 1000 ml ha^{-1} and control and replicated thrice. Insecticides were sprayed as per the treatment at the pod developmental stage of the crop. Results showed that the imidacloprid 17.8 SL @ 125 ml ha^{-1} was found highly effective (97.7 %) in reducing aphid infestation and increasing seed yield of mustard (1773 kg ha^{-1}) against the control (1346 kg ha^{-1}). The thiamethoxam 25 WG @ 100 g ha^{-1} was next best treatment with 94.9 % reduction in aphid population and 1731 kg ha^{-1} of seed yield. The maximum gross returns (Rs. 89537 ha^{-1}), net returns over control (Rs. 20614 ha^{-1}) and incremental benefit: cost ratio (21.7) also obtained under imidacloprid 17.8 SL @ 125 ml ha^{-1}, followed by thiamethoxam 25 WG @ 100 g ha^{-1}. Thus, use of imidacloprid 17.8 SL @ 125 ml ha^{-1} could be effective and economically viable option for the management of aphid in Indian mustard.

Keywords: *Aphid, bio-efficacy, economics, insecticides, Indian mustard, seed yield*

Introduction

Oilseeds occupied a significant position in Indian agriculture after cereals. India is the fourth largest oilseed producing economy globally after China, the USA, and Brazil, accounting for 10 per cent of worldwide oilseed production and 6 to 7 per cent of vegetable oil production (Reddy and Immanuelraj, 2017). In India, different kinds of oilseed crops are grown which include rapeseed-mustard, sesame, groundnut, sunflower, linseed, soybean, and coconut. In the midst of these, rapeseed-mustard is 3rd most widely produced oilseed crop, contributing 32 % of total oil production in India. In India, rapeseed-mustard is cultivated on 6.69 million hectares area with production of 10.11 million tonnes and productivity of 1511 kg ha^{-1}. The area under this crop in Haryana is about 0.63 million hectares with production of 1.28 million tonnes and productivity of 2027 kg ha^{-1} (Anonymous, 2021). Amongst six economically significant species of the rapeseed-mustard; Indian mustard (*Brassica juncea* L.) is the most extensively cultivated oilseed crop, because of its high sustainability to grow under the different agro-ecological conditions in India (Singh *et al*., 2020). Across the globe, aphids are detrimental insect pests of Brassicaceous crops and impose heavy losses in yield attributable to their capacity to reproduce parthenogenetically and multiply at a very fast rate (Goggin, 2007; Mezgebe *et al*., 2018). A specialist aphid species, mustard aphid, *Lipaphis erysimi* (Homoptera: Aphididae) inflicts seed yield loss of 76 to 100 % in *B. juncea* (Patel *et al*., 2004) and it also influences the oil content (4.92-8.14 %) (Sharma *et al*., 2019). Rana (2005) reported the losses ranging from 10 to 90 % in yield due to aphid in *B. juncea*. Hence, controlling aphid infestation by chemical method offers a good scope to harvest a high crop yield of good quality. In many previous scrutinizes, various researchers found that a wide range of insecticides (dimethoate 30 EC, imidacloprid 17.8 SL, thiamethoxam 25 WG, clothianidin 50 WDG, quinalphos 25 EC, chlorpyriphos 20 EC, and acetamiprid 20 SP) effectively protected the *Brassica* crops against the infestation of aphid (Vishal *et al*., 2019; Kumar and Sharma, 2020; Kumar, 2021). Usually, insecticides act on the nervous system of insect; when their molecules bind at neurotransmitter sites consequently function of particular cellular channels become deregulated (Bloomquist, 1999). The Neonicotinoid insecticides viz., imidacloprid, acetamiprid and thiamethoxam are acting as neurotoxins for insect pests that affect the nicotinic acetylcholine receptor (nAChR) in insects. It causes the accumulation of acetylcholine at nerve synapses, which ultimately leads to paralysis and death of the target organism (Tomizawa and Casida, 2009; Goulson, 2013). Fipronil is a phenylpyrazole compound that affecting chloride channels as a result Gamma-aminobutyric acid (GABA) blocked in insects (Oberemok *et al*., 2015). The aphid is still sustained to be a danger for the farming of *Brassica* crops. Farmers are keenly waiting for effective and economically feasible management strategies against this insect pest. Therefore, the current research was undertaken to test the effectiveness of different insecticides against aphid in Indian mustard in the semi-arid region of Haryana.

Materials and Methods

A field experiment was carried out at the farmer's field, Kolana village, Aravalli Hills Region, Rewari, Haryana, India (28°12'24.7"N latitude, 76° 21'11.0"E longitude, and 296 m altitude) during *rabi* season of 2021-22. The soil of experimental field was sandy loam in texture. The *B. juncea* cultivar RH 725 was cultivated in the randomized block design (RBD) with seven treatments, including control, and each treatment was replicated thrice. The seeds of genotype RH 725 were sown on 13th November, 2021. The individual plot size was 4.2 × 3 m, keeping row to row and plant to plant spacing of 30 and 10 cm, respectively. All the recommended agronomic practices were followed to raise the healthy crop except spray of insecticides. The trial comprised seven treatments namely, imidacloprid 17.8 SL @ 125 ml ha^{-1}, thiamethoxam 25 WG @ 100 g ha^{-1}, thiamethoxam 25 WG @ 50 g ha^{-1}, acetamiprid 20 SP @ 50 g ha^{-1}, imidacloprid 17.8 SL @ 100 ml ha^{-1}, fipronil 5 SC @ 1000 ml ha^{-1} and control (unsprayed).

The suggested concentration of the tested insecticides was applied with the help of a knapsack sprayer at the pod development stage of the crop when the target pest reached the economic threshold level. The experimental crop was regularly monitored from aphid appearance to harvesting of the crop. The data concerning aphid population was recorded from 10 cm main apical shoot of ten randomly selected and tagged plants in each plot, before applying the insecticides and afterwards first, third, seventh, tenth and fifteenth day after spray (Sharma *et al*., 2017). The % reduction in aphid population over control was computed by using following formula: % reduction over control = [(Population recorded in control plot – population recorded after spray of the insecticide in the treated plot)/ Population recorded in control plot] × 100. Seed yield of mustard was recorded from each plot and converted into kilogram hactare^{-1} (kg ha^{-1}). The minimum support price of mustard during 2021-22 *i.e.* Rs. 5050 quintal^{-1} was used to calculate the gross returns. Increased seed yield over control calculated by deducting the seed yield registered in control from the seed yield recorded in treatment. Net return over control for each treatment was computed by deducting total cost of treatment from income of increased seed yield. The incremental benefit cost ratio (IBCR) was worked out for assessing the cost effectiveness of each treatment by using the following formula:

$$\text{IBCR} = \frac{\text{Net return over control (Rs. ha}^{-1}\text{)}}{\text{Total cost of treatment (Rs. ha}^{-1}\text{)*}}$$

*Total cost of treatment included cost of insecticide + labour charge.

The critical difference (CD) at 5% level of probability was calculated for making a comparison among the treatment means by using the software OPSTAT (Sheoran *et al*., 1998).

Results and Discussion

Field assessment of tested insecticides

Data presented in Table 1 reveals that before imposing spray of insecticides, the aphid population distributed non- significantly ($p > 0.05$) and it ranged from 23.0 to 27.1 aphids plant^{-1}. At first day after spray, it was observed that all the tested insecticides significantly ($p< 0.05$) superior over control. However, a substantial difference was observed in between the different insecticidal treatments. The imidacloprid 17.8 SL @ 125 ml ha^{-1} was most effective (14.9 aphids plant^{-1}) in target pest population reduction as compared to control (27.6 aphids plant^{-1}) and it was statistically at par with thiamethoxam 25 WG @ 100 g ha^{-1} (17.4 aphids plant^{-1}) and imidacloprid 17.8 SL @ 100 ml ha^{-1} (18.0 aphids plant^{-1}). The next effective treatment was thiamethoxam 25 WG @ 50 g ha^{-1} (20.2 aphids plant^{-1}), followed by fipronil 5 SC @ 1000 ml ha^{-1} (20.8 aphids plant^{-1}) and acetamiprid 20 SP @ 50 g ha^{-1} (22.3 aphids plant^{-1}), which were statistically at par. Almost similar trend of efficacy of different insecticides against the target pest was observed at third, seventh and tenth day after spray, where imidacloprid 17.8 SL @ 125 ml ha^{-1} and thiamethoxam 25 WG @ 100 g ha^{-1} provided maximum reduction in the pest population. The minimum reduction in pest population was also recoded in acetamiprid 20 SP @ 50 g ha^{-1}. The target pest population varied from 9.2 to 19.4, 5.7 to 18.9 and 3.4 to 18.2 aphids plant^{-1} at the third, seventh, and tenth day after spray of insecticides, respectively (Table 1). At fifteenth day after spray, overall, the imidacloprid 17.8 SL @ 125 ml ha^{-1} treated plots exhibited maximum efficacy against the target pest (1.1 aphids plant^{-1}), followed by thiamethoxam 25

WG @ 100 g ha^{-1} (2.4 aphids plant^{-1}), imidacloprid 17.8 SL @ 100 ml ha^{-1} (8.0 aphids plant^{-1}) and thiamethoxam 25 WG @ 50 g ha^{-1} (13.5 aphids plant^{-1}). The next effective insecticides, fipronil 5 SC @ 1000 ml ha^{-1} (16.0 aphids plant^{-1}) was found statistically at par with acetamiprid 20 SP @ 50 g ha^{-1} (17.5 aphids plant^{-1}). The highest pest population was registered in control (47.1 aphids plant^{-1}).

The data given in Table 1 indicated that the % reduction in target pest population over control at fifteenth day after spray was found to be highest in the imidacloprid 17.8 SL @ 125 ml ha^{-1} (97.7 %), followed by thiamethoxam 25 WG @ 100 g ha^{-1} (94.9 %), imidacloprid 17.8 SL @ 100 ml ha^{-1} (83.0 %) and thiamethoxam 25 WG @ 50 g ha^{-1} (71.3 %). Insecticides viz., fipronil 5 SC @ 1000 ml ha^{-1} (66.0 %) and acetamiprid 20 SP @ 50 g ha^{-1} (62.8 %) were reported least effective. The current outcomes get support from the findings of Kumar (2021), who reported that thiamethoxam 25 WG @ 0.2 g litre^{-1} water (4.8 aphids plant^{-1}) and imidacloprid 17.8 SL @ 0.25 ml litre^{-1} water (5.5 aphids plant^{-1}) were effective in controlling aphid infestation on the *Brassica juncea* var. PBR 357. The present results are also in agreement with that of Vishal *et al.* (2019) wherein they had reported imidacloprid 17.8 SL @ 20 g *a.i.* ha^{-1} (0.67 aphids plant^{-1}) and thiamethoxam 25 WG @ 25 g *a.i.* ha^{-1} (8.33 aphids plant^{-1}) were effective against aphid on Indian mustard. Kumar and Sharma (2020) have also showed superiority of thiamethoxam 25 WG in reducing aphid infestation and enhancement of crop yield of *Brassica juncea*. Spray of insecticides such as imidacloprid 17.8 SL, thiamethoxam 25 WG and fipronil 5 SC were effectively control infestation of aphid in mustard variety of Pusa bold (Maurya *et al*., 2018).

Fig.1. Mustard aphid, *Lipaphis erysimi* infestation on Indian mustard (var. RH 725)

Table 1: Bio-efficacy of different insecticides against mustard aphid in Indian mustard

Treatments	Population of mustard aphid plant^{-1} (DAS*)						% reduction in aphid population over control @ 15 DAS
	Before spray	1	3	7	10	15	
Imidacloprid 17.8 SL @ 125 ml ha^{-1}	24.6 (5.1)	14.9 (4.0)	9.2 (3.2)	5.7 (2.6)	3.4 (2.1)	1.1 (1.4)	97.7
Thiamethoxam 25 WG @ 100 g ha^{-1}	26.8 (5.3)	17.4 (4.3)	11.0 (3.5)	5.9 (2.6)	4.0 (2.2)	2.4 (1.8)	94.9
Thiamethoxam 25 WG @ 50 g ha^{-1}	27.1 (5.3)	20.2 (4.6)	16.6 (4.2)	14.8 (4.0)	14.1 (3.9)	13.5 (3.8)	71.3
Acetamiprid 20 SP @ 50 g ha^{-1}	26.3 (5.2)	22.3 (4.8)	19.4 (4.5)	18.9 (4.5)	18.2 (4.4)	17.5 (4.3)	62.8
Imidacloprid 17.8 SL @ 100 ml ha^{-1}	24.2 (5.0)	18.0 (4.4)	12.5 (3.7)	9.6 (3.3)	8.2 (3.0)	8.0 (3.0)	83.0
Fipronil 5 SC @ 1000 ml ha^{-1}	23.0 (4.9)	20.8 (4.7)	18.5 (4.4)	16.7 (4.2)	16.3 (4.2)	16.0 (4.1)	66.0
Control	25.2 (5.1)	27.6 (5.3)	31.2 (5.7)	36.6 (6.1)	43.9 (6.7)	47.1 (6.9)	
CD at 5%		0.5	0.4	0.4	0.4	0.3	
SE (m)	0.1	0.1	0.1	0.1	0.1	0.1	

*DAS: Day after spray; figures in parentheses are square root transformations

Seed yield and economics

Regarding the effect of different insecticides on seed yield, the data in Table 2 showed that the spray of imidacloprid 17.8 SL @ 125 ml ha^{-1} gave maximum seed yield (1773 kg ha^{-1}), followed by thiamethoxam 25 WG @ 100 g ha^{-1}(1731 kg ha^{-1}), imidacloprid 17.8 SL @ 100 ml ha^{-1} (1658 kg ha^{-1}), thiamethoxam 25 WG @ 50 g ha^{-1}(1602 kg ha^{-1}), fipronil 5 SC @ 1000 ml ha^{-1} (1575 kg ha^{-1}), acetamiprid 20 SP @ 50 g ha^{-1} (1524 kg ha^{-1}) and least

Table 2: Effect of different insecticides on economics of mustard

Treatments	Insecticide cost (Rs. ha^{-1})	Labour cost (Rs. ha^{-1})	Total cost (Rs. ha^{-1})	Seed yield (kg ha^{-1})	Seed yield increased over control (kg ha^{-1})	Gross returns (Rs. ha^{-1})	Income from increased seed yield (Rs. ha^{-1})	Net returns over control (Rs. ha^{-1})	Incremental benefit cost ratio
Imidacloprid 17.8 SL @ 125 ml ha^{-1}	500	450	950	1773	427	89537	21564	20614	21.7
Thiamethoxam 25 WG @ 100 g ha^{-1}	520	450	970	1731	385	87416	19443	18473	19.0
Thiamethoxam 25 WG @ 50 g ha^{-1}	260	450	710	1602	256	80901	12928	12218	17.2
Acetamiprid 20 SP @ 50 g ha^{-1}	120	450	570	1524	178	76962	8989	8419	14.8
Imidacloprid 17.8 SL @ 100 ml ha^{-1}	400	450	850	1658	312	83729	15756	14906	17.5
Fipronil 5 SC @ 1000 ml ha^{-1}	1400	450	1850	1575	229	79538	11565	9715	5.3
Control	-	-	-	1346	-	67973	-	-	-

under the control (1346 kg ha^{-1}). All the treatments found superior over control pertaining to seed yield. Kumar (2021) reported highest seed yield of mustard with the thiamethoxam 25 WG @ 0.2 g litre^{-1} water (1925 kg ha^{-1}). As reported by Vishal *et al*. (2019), utmost seed yield was listed in imidacloprid 17.8 SL @ 20g a.i. ha^{-1} treated plots (1415 kg ha^{-1}).

The economics computed on different treatments evinced in Table 2 revealed that the maximum gross returns (Rs. 89537 ha^{-1}) and net returns over control (Rs. 20614 ha^{-1}) was obtained in imidacloprid 17.8 SL @ 125 ml ha^{-1}, followed by thiamethoxam 25 WG @ 100 g ha^{-1} (Rs. 87416 ha^{-1}; Rs. 18473 ha^{-1}), respectively. The highest incremental benefit cost ratio (IBCR) was also calculated in imidacloprid 17.8 SL @ 125 ml ha^{-1} (21.7), subsequently thiamethoxam 25 WG @ 100 g ha^{-1} (19.0) and imidacloprid 17.8 SL @ 100 ml ha^{-1} (17.5). Vishal *et al*. (2019) reported the maximum cost benefit ratio in imidacloprid 20 g @ a.i. ha^{-1} (10.36), followed by thiamethoxam 25 WG @ 25g *a.i.* ha^{-1} (8.33). Maurya *et al.* (2018) also computed highest cost benefit ratio with imidacloprid 17.8 SL @ 150 ml ha^{-1} (9.54).

Conclusion

It can be concluded that for managing aphid in the mustard ecosystem, imidacloprid 17.8 SL @ 125 ml ha^{-1} was most effective with maximum seed yield, net return over control, and highest incremental benefit cost ratio.

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