Evaluation of the new molecular insecticides and biopesticides against mustard aphid *Lipaphis erysimi* (Kalt.) on yield parameter in mustard

Dwivedi, S. A. [1*] **and Singh, R. S.** [2]

ABSTRACT

A field experiment on mustard *var.* Varuna was conducted during Rabi season of year 2013-14 and 2014-15 at CSAUA&T, Kanpur. Among the various insecticides evaluated against the mustard aphid, *Lipaphis erysimi* Kalt, imidacloprid 17.8 SL @ 0.2 g/litre showed highest reduction Significantly lower mean aphid intensity 14 days after second spray 6.89 and19.66 aphids/ 10 cm apical shoot were recorded on the crop treated with imidacloprid 17.8 SL with 94.09 and 90.34 percent reduction over control which provided significantly highest seed yield 2287 and 2235 kg/ha with 40.73 and 37.79 percent increase in yield, respectively. Application of Thiamethoxam 25% WP was found second best treatment with 8.49 and 23.46aphids/ 10 cm apical shoot 14 days after second spraying with 89.91 and 87.54 percent reduction over control during both year with provided 2229 and 2216 kg/ha with 37.71 and 36.62 percent increase in yield. The ranking of insecticides on the basis percent reduction over control after second spraying after 14 days for the management of aphids most effective were imidacloprid 17.8SL and thiametoxam25 WP and least effective spinosad 45 SC. Among biopesticides *M.anisopoliae* 1.15 WP was more effective than *B.bassiana* 1.15WP.Among the chemical insecticides imidacloprid 17.8 SL found safe followed by thiamethoxam 25WP with less number of percent reducing over control.

Keywords: Imidacloprid, Thiamethoxam, Microbial, Mustard aphid, Management

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INTRODUCTION

Oilseeds have been the backbone of agricultural economy of India since long. Indian vegetable oil economy is the fourth largest in the world next to U.S.A., China and Brazil. Oilseed *Brassica* because of resilience to grow under diverse agro-climatic conditions have gained good momentum in India. (*Anonymous,* 2013). Among the different edible oilseed cultivated in India, rapeseed-mustard (*Brassica* spp.) contributes 28.6% in the total production of oilseeds. In India, it is the second most important edible oilseed after groundnut sharing 27.8% in the India's oilseed economy. India contributes 28.3% in world acreage and 19.8% in world production. India produces around 6.7 m.t .of rapeseed-mustard next to China (11-12 mt) and EU (10–13 mt) with significant contribution in world rapeseed-mustard industry (Shekhawat *et al.,* 2012) 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 (Singh, 2009.) Among them aphid species i.e. *Lipaphis erysimi* Kalt., *Brevicornae Brassicae* L. and *Myzus persicae* Sulzer are the key pest (Desh Raj, 1996; Sarangdevot *et al.,* 2006). Among them mustard aphid, *Lipaphis erysimi* (Kalt.) is the key pest in all the mustard growing regions of the country That resulting qualitative and quantitative loss causing up to 96 per cent yield losses and 5-6 % reduction in oil content (Shylesha *et al*., 2006) Such losses may go up to 100% in certain mustard growing regions (Aamir and Khalid, 1961; Singh and Sachan, 1999). Both nymphs and adults of the mustard aphid suck cell sap from the leaves, inflorescences and immature pods resulting into poor yield. It is also found that they prefer flowers to leaves for feeding (Singh *et al.,* 1965; Srivastava, 2002). Large colonies can

cause the plants to become deformed and the Large colonies can cause the plants to become deformed and the leaves curled, shriveled and yellowed (Metcalf, 1962). They also produce a large amount of honey dew through anus which facilitates the growth of the fungus that makes the leaves and pods black sooty mould appearance which ultimate create problem in photosynthesis (Awasthi, 2002; Bakhetia and Arora, 1986; Bakhetia and Sekhon, 1989; Sahoo, 2012; Mandal *et al.*, 2012**)** Mustard aphids have the capability to increase their population and spread rapidly within very short span of time in favourable environmental condition. For this, other control measures except chemical control is time consuming (Sahoo, 2012) But chemical insecticides are not only toxic to natural enemies of aphid such as *Diaeretiella rapae*, *Chrysoperla zastrowi arabica*, coccinellids and syrphid flies (Nagar *et al*., 2012) 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 (Singh, 2001) So, chemical control is the last resort to check the aphid population within short period of time. Keeping in view, the present study was aimed to evaluate the efficacy of certain new molecular insecticides and biopesticides against this pest in order to monitoring insecticide resistance and to identify the potential molecules for developing proper management strategy against this pest.

MATERIAL AND METHODS

The field experiment was conducted at Student Instructional Farm, Chandra Shekhar Aazd University of Agriculture and Technology, College of Agriculture, Kanpur (U.P.), India, during the *Rabi* season of 2013-2014 and 2014-15. Of mustard cultivar "Varuna" was sown in a plot size of 5 x 3.5 m^2 on 30 th October with row to row and plant to plant distance as 45 cm and 10 cm respectively. Experimental area was conducted in a Randomized Block Design with 3 replicates. All the agronomical practices were followed to raise a healthy crop. Two fortnightly sprays of imidacloprid17.8% SL @ 0.0045% (0.25 ml/l), Deltamethrin 2.8%EC @ 0.004% (0.2 g/l), thiamethoxam25 WG @ 0.005% (0.2 g/l), fipronil 5% SL @ 0.01% (2 ml/l), spinosad45% SC @ 0.2 ml/l, *M. anisopliae* 1.15%WP and *B. bassiana* 1.15%WP including untreated were applied for their evaluation against aphid. First application of insecticides was done at the economic threshold level of 15.6 aphids /plant, which is reported for in central Uttar Pradesh (Kanpur) by (Singh *et al*., 2000). The economic analysis for the application of insecticides was also done for recommending the effective and economic treatment. Necessary information on insecticides used in the experiment was given in Table below 2. Required concentration of insecticides for the spray as prepared with the help of following formula:

$$\text{Quantity of insecticide (l/ha)} = \frac{\text{Quantity of active ingredient (litre/kg) to be required (g)}}{\text{Concentration (%) of active ingredient in insecticidal formulation}}$$

Observations on aphid

The observations on aphid intensity were recorded at weekly intervals in all the experiments except in the trial on aphid management through newer insecticide during both the years. The intensity of the aphid population of mustard aphid was observed on 10 randomly selected plants on 10 cm top shoot/inflorescence of the main shoot. In management of aphid through newer insecticides, the intensity was recorded before spray, 3, 5, 7 and 14-days after each spray. The weekly aphid population was recorded on central terminal twigs (10 cm) randomly selected 10 plants/plot. The aphids were removed from the plants with the help of a soft brush and placed on a piece of white paper. Their number was counted by visual observation. Yield was also recorded from net plot area and converted in to kilogram per ha and data were statistically analyzed as per statistical guidelines given by (Gomez and Gomez, 1984) The percentage reduction of pest populations over control was also calculated by using the following formula giving by (Henderson and Tilton, 1955) In as per techniques used by (Bakhetia and Sekhon, 1989).General equilibrium position (GEP) of aphid was calculated in all the experiments.

Table 1. Information on different treatment use as insecticides

Common name	Trade name	Formulation Dose a.i./ha	Rate	Source of supply
Imidacloprid	Ultimo	17.8 SL	Rs160/ 100ml	Sudarsan Chemicals Industries Ltd.,Pune,
Deltamethrin	Decis	2.8 EC	Rs1800 /kg	Wockhardt, Biostadt Biostadt Agriscience, Mumbai
Spinosad	Tracer	45 SC	Rs 900/ 100gm	Dow Agro Science India Pvt. Ltd. Mumbai
Fipronil	Regent	5 SL	Rs125/ 100 ml	Saraswati Agro Chemicals (India) Pvt. Ltd. Lane 2 phase 1,Industrial complex, bori, Brahmana(J&K)
Thiamethoxam	Actara	25 WP	Rs25/ 5gm	Syngenta India limited 14,J.Tata Road Mumbai
M.anisopliae	Biomet	1.15 WP	Rs90/ 100gm	Biotech International Ltd.B-21,Site-C,Surajpur Greater Noida-201306
B. bassiana	Biorin	1.15 WP	Rs90/ 50gm	Biotech International Ltd.B-21,Site-C,Surajpur Greater Noida-201306
Uncontrol	--	---	---	----

Statistical analysis

All the experiment was conducted in RBD and data on aphid intensity at different time intervals were recorded. Average aphid intensity was also calculated. The seed yield was recorded after harvesting of the experiments. Data on aphid intensity and seed yield were analyzed for their critical differences in all the trials. Pest intensity observed in population dynamics was correlated with weather parameters. Simple correlation coefficient (r) was calculated between the aphid intensity and weather factors Economic injury level was estimated by computing the relationship between average aphid intensity (x) and seed yield (y) in corresponding treatments as described earlier (Stone and Pedigo, 1972; Atwal and Singh, 1990; Pedigo, 1991), which were later on adopted by several workers on various crops for different insect- pests. Co-efficient of correlation, (b) was calculated by computing the simple correlation equation between average aphid intensity and seed yield. All the experiment was conducted in RBD and data on aphid intensity at different time intervals were recorded. Average aphid intensity was also calculated. The seed yield was recorded after harvesting of the experiments. Data on aphid intensity and seed yield were analyzed for their critical differences in all the trials. Pest intensity observed in population dynamics was correlated with weather parameters. Simple correlation coefficient (r) was calculated between the aphid intensity and weather factors Economic injury level was estimated by computing the relationship between average aphid intensity (x) and seed yield (y) in corresponding treatments as per technique of Stone and Pedigo (1972), Atwal and Singh (1990) and Pedigo (1991), which were later on adopted by several workers on various crops for different insect - pests. Co-efficient of correlation, (b) was calculated by computing the simple correlation equation between average aphid intensity and seed yield.

RESULT

To control the mustard aphid (*L. erysimi* Kalt) on mustard variety Varuna efficiently, two spray of various insecticide such as Imidacloprid Deltamethrin, Spinosad, Fipronil, Thiamethoxam and two microbial insecticides such as *M. anisopliae* and *Beauveria bassiana* were made and aphid population were recorded after 3, 5, 7 and 14 days of spraying (in each spray) to judge their efficacy.

First spraying of different insecticides against mustard aphid during 2013-14

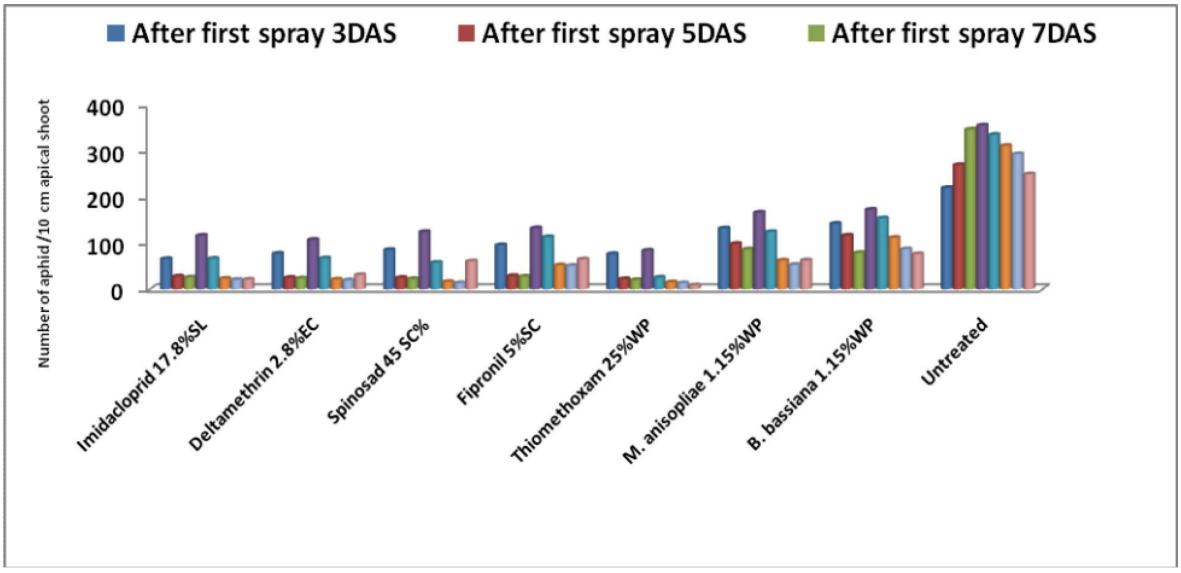
The aphid population in each treatment before one day spraying was varied from 160 to 190 aphids /10 cm apical shoot (Table 2 and Fig 1).

Table 2. Bioefficacy of different insecticides against mustard aphid after first spray (2013-14)

T.N.	T. Name	Dose a.i./ha	Before spray	Mean of aphid population /10 cm apical shoot							
				3DAS	PROC	5DAS	PROC	7DAS	PROC	14DAS	PROC
1	Imidacloprid 17.8%SL	40gm	175	66.04	62.26	27.96	84.02	25.85	85.22	116.70	33.31
2	Deltamethrin 2.8%EC	100gm	190	77.58	59.16	25.11	86.78	23.70	87.52	107.84	43.68
3	Spinosad 45 SC%	75gm	160	85.74	46.41	24.91	84.43	22.29	86.06	124.99	21.88
4	Fipronil 5%SC	75gm	185	95.98	48.11	29.07	84.28	27.53	85.11	132.99	28.11
5	Thiamethoxam 25%WP	25gm	168	76.86	54.25	22.18	86.79	20.08	88.04	84.16	49.90
6	*M. anisopliae 1.15%WP*	2000 gm	195	132.5	32.00	98.94	49.26	86.75	58.51	167.05	14.33
7	*B. bassiana1. 15%WP*	2500 gm	185	142.87	22.77	116.98	36.82	79.31	57.12	173.29	6.32
8	Untreated		172	220.70	0.00	270.50	0.00	347.97	0.00	356.79	0.00
SE(m±)			0.26	0.51		0.23		0.48		0.25	
CD (P=0.05)			N.S.	2.15		0.71		1.47		0.79	

DAS- Day After Spraying, PROC-Percent Reduction Over Control.

Figure 1. Bioefficacy of different insecticides against mustard aphid



It is evident from the table on reduction of aphid that all insecticidal treatments found significantly superior to control at all the interval of observation. At three day after spraying thiamethoxam, spinosad, and imidacloprid gave excellent control of aphid with minimum population 25.49, 57.77 and 66.48 aphids/10 cm apical shoot. Thiamethoxam was superior all treatment with 69.71 percent reducing pest population. Spinosad, imidacloprid and deltamethrin have 53.78, 43.03 and37.66 percent reduction pest population. Microbial insecticide slightly effect to control aphid population. Fipronil have less aphid control compare to other chemical insecticides *i.e.* 14.55 percent. The treatment, thiamethoxam, spinosad, deltamethrin and imidacloprid were at par after five days of spraying gave lesser aphid population 15.13, 16.06, 21.20 and 22.90

aphids /10 cm apical shoot. Spinosad reducing maximum percent of aphid population followed by thiamethoxam , imidacloprid and deltamethrin with 87.50, 82.02, 80.37 and 80.34percent respectively. Fipronil have maximum aphid population 52.16 aphid/shoot with reducing 60.77 percent found less compare to *M. anisopliae* Microbial insecticide also helpful to reduce aphid population. *M.anisopoliae* was more effective than *B.bassiana.* After seven days of spraying spinosad, imidacloprid, thiamethoxam, and deltamethrin were observed effective against pest recorded to reduce aphid population 13.47, 12.67, 13.16 and19.52 aphids/10 cm apical shoot with 89.22, 89.12, 84.43 and 81.89 percent reduction pest population. Efficacies of other treatments were also significantly superior over control recorded 50.96, 53.18 and 87.10 aphids/10 cm apical shoot. *M.anisopliae* and *B. bassiana* found most effective for reducing pest population up to 68.16 and 49.73 percent. After fourteen days of spraying imidacloprid and thiamethoxam were found most effective against pest these both insecticides were significantly superior to all treatment and grouped in excellent category of insecticides .Reducing population recorded against both insecticides were 6.89 and 8.89 aphids/10 cm apical shoot with reducing maximum percent pest population among treatment *i.e.* 94.09 and 89.91 (PROC) followed by deltamethrin was reducing population 31.09 aphids/10 cm apical shoot spinosad and fipronil at par with each other *M.anisopoliae* and *B. bassiana* reduced the aphid population up to 62.27 and 55.86 percent respectively. Among all chemical spinosad reducing less population 63.26 percent. Therefore, imidacloprid, thiamethoxam, deltamethrin, fipronil and spinosad were included in the most effective group of insecticides against mustard aphid, at all the testing intervals i.e. three, five, seven and fourteen days, whereas imidacloprid and thiamethoxam were remained effective up to fourteen days after second spraying. Spinosad, deltamethrin and fipronil were effective up to seven days after the spraying

First spraying of different insecticides against mustard aphid during 2014-15

Initial count of the aphid population and predator present on apical twigs before treatment reveal that the population of aphid and predator (*Coccinella spp.*) was present uniformly throughout the experimental plots. It is evident from the observation that all the insecticides proved better against aphids than control at the interval of observation. The aphid populations on various treatments before spraying was varied from187 to 243 aphids/10 cm apical shoot significantly differ among themselves. (Table 3 and Fig. 2)**.**

Maximum reduction of aphid was noticed three days after spraying in the imidacloprid treated plots, followed by thiamethoxam, fipronil and deltamethrin. All the chemicals were also proved quite toxic to aphid at three day after treatment. All chemical except imidacloprid before second spraying was homogenously distributed in all the experimental plots. It is evident from the observations that reduction of aphid in all insecticidal treatments proved significantly superior to control at all the interval of observation. The significant efficacy all insecticide was increased after three days of application over control except *B.bassiana* and *M. anisopliae.*

The reduction of aphid population was 91.06, 154.35, 170.43 and 178.48 aphids/10 cm apical shoot against treated insecticides deltamethrin, imidacloprid, spinosad and thiamethoxam respectively. Maximum percent of pest reduction by deltamethrin followed by imidacloprid thiamethoxam, spinosad and fipronil with 51.30, 34.59, 26.55, 18.84 and 15.28 percent

After five days of spraying deltamethrin and thiamethoxam reduced minimum population of aphid i.e.65.01 and 93.76 aphids/10 cm apical shoot with reducing 65.23 and 61.14 percent aphid population over control deltamethrin was proving at par with most reduced the aphid population. Imidacloprid, Fipronil and Spinosad were at par with each other have population 102.79, 105.41 and 107.99 aphids/10 cm apical shoot with

56.44,53.94 and 48.57 percent reducing population over control.

After seven days of insecticide spraying thiamethoxam and deltamethrin were found most effective to minimize the aphid population up to 47.08 and 42.21 aphids/10 cm apical shoot with reducing 80.62 and 77.42 percent pest population respectively *B.bassiana* and *M.anisopoliae* found very effective for reducing the pest population up to 57.43 and 64.60 percent.

After 14 days of spraying deltamethrin, spinosad and thiamethoxam grouped in excellent category of the insecticides having population 125.88, 167.83 and 188.34 aphids/10 cm apical shoot. Hence increase aphid population after seven days spraying. No one insecticide show controlling pest population up to fourteen days of spraying that why second spraying was necessary for controlling aphid population. *M.anisopoliae* and *B. bassiana* show the effective control of aphid population up to 23.91 and 19.20 percent.

Table 3. Bioefficacy of different insecticides against mustard aphid after first spray (2014-15)

T.N	T. Name	Dose a.i./ha	Before spray	Mean of aphid population /10 cm apical shoot							
				3DAS	PROC	5DAS	PROC	7DAS	PROC	14DAS	PROC
1	Imidacloprid 17.8%SL	40gm	236	154.35	34.59	102.79	56.44	99.64	57.77	198.44	15.91
2	Deltamethrin 2.8%EC	100gm	187	91.06	51.30	65.01	65.23	42.21	77.42	125.88	32.68
3	Spinosad 45 SC%	75gm	210	170.43	18.84	107.99	48.57	87.25	58.45	167.83	20.47
4	Fipronil 5%SC	75gm	228	193.15	15.28	105.41	53.94	65.52	71.26	184.76	18.96
5	Thiamethoxam 5%WP	25gm	243	178.48	26.55	93.76	61.14	47.08	80.62	188.34	22.49
6	*M.anisopliae .15%WP*	2000 gm	215	180.41	16.08	133.44	25.86	76.10	64.60	163.58	23.91
7	*B.bassiana 1.15%WP*	2500 gm	227	198.78	12.43	145.22	36.02	95.94	57.43	183.41	19.20
8	Untreated		212	254.94	0.00	284.52	0.00	317.16	0.00	378.53	0.00
SE(m±)			0.29	0.20		0.25		0.19		0.17	
CD (P=0.05)			N.S	0.62		0.78		0.55		0.54	

DAS- Day After Spraying, PROC-Percent Reduction Over Control.

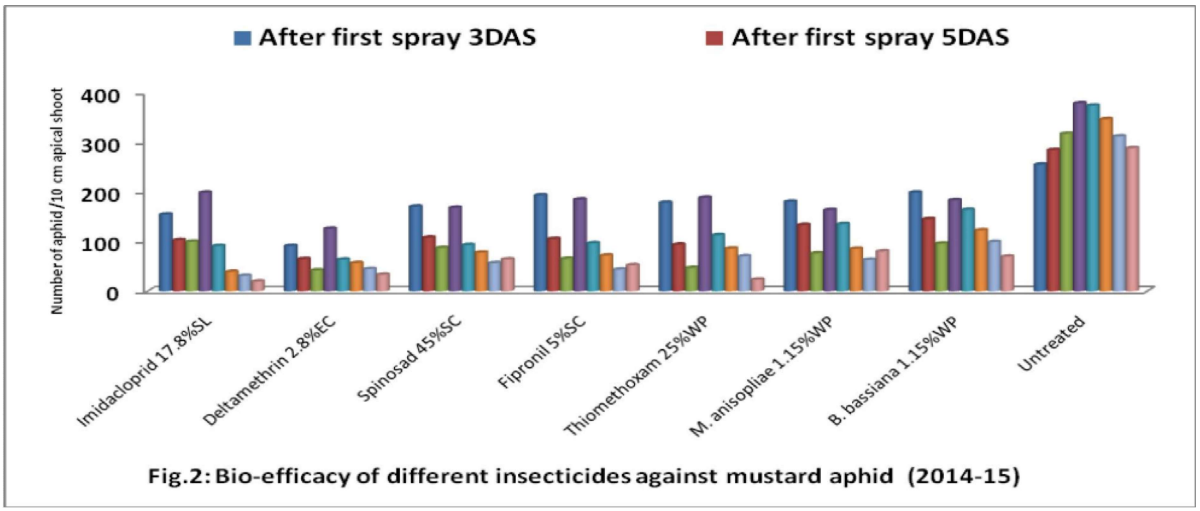


Fig.2: Bio-efficacy of different insecticides against mustard aphid (2014-15)

Second spraying of different insecticides against mustard aphid during 2014-15

The perusal of Table 3, and Fig 2 indicates that all treatments were again proved significantly effective to reduce the aphid population after first and second spraying.

After three days of spraying the efficacy of all insecticides were significantly increased over control, imidacloprid and thiamethoxam were found most effective to reduce aphid population and most significant all treated insecticides. The minimum number of aphids found in deltamethrin, imidacloprid, spinosad and fipronil 63.69, 91.03, 93.12 and 96.70 aphids/ 10 cm apical shoot respectively.

The maximum percent of reduction found 54.12, 49.40, 47.66, 44.51 and 40.14 of imidacloprid, deltamethrin, fipronil, spinosad, thiamethoxam respectively. *M. anisopliae* and *B.bassiana* found most effective for reducing pest population up to 23.91 and 19.20 percent.

After five days of spraying imidacloprid was found most significant to all treated insecticide having less number of aphid population found 39.10 aphids/ 10 cm apical shoot followed by deltamethrin, fipronil and spinosad having population 56.82, 71.82 and 77.82 aphids/ 10 cm apical shoot and maximum percent reduction found against imidacloprid, fipronil, deltamethrin, thiamethoxam and spinosad having 80.29, 61.12, 54.86, 54.35 and 53.63 percent respectively. *M. anisopliae* and *B.bassiana* found effective for control aphid population. Both insecticides were helpful to reducing population of aphid in the treated plot.

The application of imidacloprid was again proved most effective with less number of aphid populations 31 .06 aphids/ 10 cm apical shoot after seven days spraying followed by spinosad and deltamethrin were at par with each other having population 43.54 and 44.47 aphids/ 10 cm apical shoots. *M. anisopliae* and *B. bassiana* were found effective to control pest population up to 61.42 and 46.01 percent respectively.

Imidacloprid was most effective treatment after 14 days of application which reduced aphid population up to 19.66 aphids/ 10 cm apical shoot but at par with thiamethoxam having with population 23.46 aphids/ 10 cm apical shoot followed by deltamethrin and fipronil. The chemical insecticides imidacloprid and thiamethoxam were found effective up to fourteen days after spraying continuous reduce aphid population. *B.bassiana* effective to reduce aphid population up to fourteen days after spraying, *M.anisopoliae* effective to control aphid population up seven day after that it was slightly increase population up to fourteen days. *B. bassiana* found most effective to reducing pest population up to 61.95 percent which is more than *M.anisopliae*. Maximum percent reduction found in imidacloprid, thiamethoxam, deltamethrin, fipronil and spinosad with 90.34, 87.54, 73.53, 71.58 and 61.77 percent respectively.

The efficacy of all the tested insecticides viz. systemic, contact and microbial exhibited similar result during two consecutive 2013-14 and 2014-15 years and were significantly superior over control. The best effective insecticides were imidacloprid followed by thiamethoxam to reduce aphid population. Spraying with deltamethrin, spinosad and fipronil provide moderate control of aphid but significantly better than microbial product. *B.bassiana* found most effective compare with *M.anisopoliae*.

Microbial insecticides were also found effective for reducing the pest population but comparatively less than the chemical insecticide.

Grain yield of mustard obtained after insecticidal treatments during 2013-14

The grain yield of mustard obtained after the three insecticidal applications, one at early vegetative stage to control sawfly and two at reproductive stage to control mustard aphid, was recorded and the percent increase over control was estimated in each treatments to evaluate their efficacy.

It is clearly depicted from the Table 4 and Fig 3 that all the treatments recorded significantly higher grain yield than that of control. The treatment imidacloprid 2287 kg/ha with 40.73 percent increase in yield over control followed by thiamethoxam 2229 kg/ha with 37.71

percent increase in yield over control. The next treatment was deltamethrin with 2144 kg/ha grain yield with 31.93 percent followed by spinosad with 2057 kg/ha grain yield 26.58 percent increase in yield. *M.anisopoliae* and *B. bassiana* at par with each other with 1814 and 1805 kg/ha grain yield with 11.63 and 11.07 percent increase in yield both microbial insecticides were give least production of grain compare to chemical insecticides.

Grain yield of mustard obtained after insecticidal treatments during2014-15.

A perusal of Table 4 revealed that all the treatments performed similarly as a previous year. All the treatments were found effective to increase the grain yield of mustard as compared to control. Imidacloprid was again found to be best treatment recorded 2235 kg /ha grain yield with 37.79 percent increase in yield was at par with thiamethoxam with 2216 kg/ha grain yield with 36.62 percent increase in yield. Deltamethrin was 2116 kg/ha grain yield came to third position with 30.45 percent

Table 3. Bioefficacy of different insecticides against mustard aphid after second spray (2014-15)

T.N.	T. Name	Dose a.i./ha	Mean of aphid population /10 cm apical shoot							
			3DAS	PROC	5DAS	PROC	7DAS	PROC	14DAS	PROC
1	Imidacloprid 17.8%SL	40gm	91.03	54.12	39.10	80.29	31.06	84.34	19.66	90.34
2	Deltamethrin 2.8%EC	100gm	63.69	49.40	56.82	54.86	44.47	64.67	33.32	73.53
3	Spinosad 45 SC%	75gm	93.12	44.51	77.82	53.63	56.67	66.23	64.16	61.77
4	Fipronil 5%SC	75gm	96.70	47.66	71.82	61.12	43.54	66.43	52.50	71.58
5	Thiamethoxam 25%WP	25gm	112.74	40.14	85.96	54.35	70.35	62.64	23.46	87.54
6	*M. anisopliae 1.15%WP*	2000	135.25	17.31	85.43	47.77	63.10	61.42	80.06	51.05
7	*B. bassiana 1.15%WP*	2500	164.07	10.54	122.69	22.56	99.02	46.01	95.77	47.78
8	Untreated		373.64	0.00	346.25	0.00	311.80	0.00	288.08	0.00
SE(m±)			0.17		0.15		0.46		0.19	
CD (P=0.05)			0.50		0.48		0.49		0.59	

DAS- Day After Spraying, PROC-Percent Reduction Over Control.

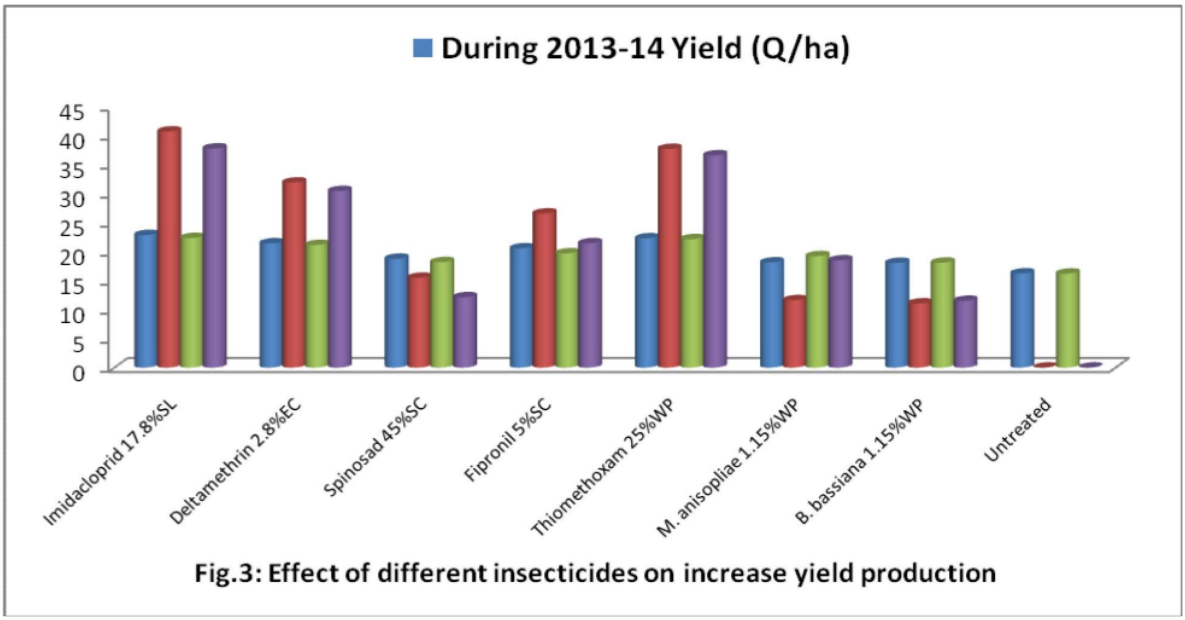


Fig.3: Effect of different insecticides on increase yield production

increase in yield. Application of spinosad was found to be next treatment to increase the grain yield over control up to 21.45 percent with 1970 kg/ha grain yield followed by *M.anisopoliae* with 1922kg/ha grain yield with 18.49 percent increase in yield. Spinosad and *B. bassiana* were at par with each other with 1819 and 1809 kg/ha grain yield with 12.14 and 11.52 percent increase in yield over control. During both year study all the insecticides were significantly effective to increase the grain yield of mustard as compared untreated check. Spraying of imidacloprid, thiamethoxam and deltamethrin provided maximum grain yield, where as spinosad and fipronil were found moderate grain yield compare to these treatments. *M .anisopoliae* was found more effective than spinosad in next year but in the first year *M. anisopoliae* and *B. bassiana* was least effective to increase the grain yield compared to other insecticides.

Table 4. Effect of different insecticides on yield production during both years.

T.N.	T. Name	Dose a.i./ha	During 2013-14		During 2014-15	
			Yield (Kg/ha)	Percent increase in yield	Yield (Kg/ha)	Percent increase in yield
1	Imidacloprid17.8%SL	40gm	2287	40.73	2235	37.79
2	Deltamethrin 2.8%EC	100gm	2144	31.93	2116	30.45
3	Spinosad 45%SC	75gm	2057	26.58	1970	21.45
4	Fipronil 5%SC	75gm	1857	15.50	1819	12.14
5	Thiomethoxam25%WP	25gm	2229	37.71	2216	36.62
6	M. anisopliae1.15%WP	2000gm	1814	11.63	1922	18.49
7	B. bassiana1.15%WP	2500gm	1805	11.07	1809	11.52
8	Untreated	-	1625	00.00	1622	00.00
	SE(m±)		58.46		83.28	
	CD at 5%		179.04		255.06	

DISCUSSION

The present findings are in accordance to work done by (Awaneesh Chandra *et al.,* 2014) reported that the efficacy of newer insecticide for the management of mustard aphid most effective was imidacloprid 17.8 SL followed by acetamiprid 20 SP. (Kantipudi Rajesh Kumar *et al.,* 2013) to evaluate the efficacy of some new insecticides with conventional insecticides for the control of mustard aphid and their effect on Coccinellids population in rapeseed mustard and found that maximum control of aphid was obtained with the application of thiamethoxam. Mandal and Mandal (2010) reported that the application of difenthiuron 50 WP @50 g a.i./ha as the most effective in managing aphid incidence and realizing higher yield of mustard (10.70 q/ha) followed by thiamethoxam 25WG @25g a.i./ha (10.53q/ha.). (Akhauri and Singh, 2009) reported that imidacloprid 17.8 SL is highly efficacious against mustard aphid, *Lipaphis erysimi* (Kalt.) registering 95.26 and 83.33 percent aphid mortality on 3 and 7 DAS, respectively. The maximum seed yield was obtained from Imidacloprid followed by dimethoate. Singh and Singh (2009) reported that the insecticidal treatment significantly less aphid population was observed during the both year under fipronil5SC@75 g a.i./ha followed by Imidacloprid 17.8SL @40 g a.i./ha. (Prasad and Dey, 2006) reported that oxy-demeton methyl was found most effective with the reduction of 69, 97, 100 and 100% at 1, 2, 3 and 7 DAS respectively. Rohilla *et al.* (2004) evaluated the bio efficacy of Imidacloprid 17.8 SL and Thiamethoxam 25 WG at 50 g a.i. /ha prove most effective against mustard aphid. Meena and Lal (2004) also reported that Imidacloprid (0.01%) was superior to

endosulfan (0.07%) to control mustard aphid. (Gour and Pareek, 2003) who reported that Dimethoate (0.03%) followed by Imidacloprid (0.05%) were most effective and endosulfan (0.035) was moderate effective to control *L.erysimi.* (Rajendra *et al.,* 2001) applied Imidacloprid as seed treatment (Gaucho 70 WS @5 and 10 g a.i for 1 kg seed.) and foliar spray (Confidor 200 SL @ 20 and 40 g a.i./ha) at 50 % pod formation stage at mustard. Imidacloprid prove best controlled the aphid population when used as seed and foliar spray treatment. 25% WDG @100 g/ha followed by Imidacloprid 17.8% S.L.@150 ml/ha.(Barar and Sandhu 1999) got the similar result that dimethoate was most effective and endosulfan was moderate effective to control aphid. The finding of (Chinnabbai *et al.,* 1999) after 24 hr acetamiprid (0.02%) caused 87.95 percent mortality of *L. erysimi* followed by Imidacloprid caused 66.25 percent.

It is concluded from the study that all the insecticidal treatments were found significantly effective in reducing the population of aphid as compared to untreated plots. The minimum aphid population was recorded in the plot treated with Imidacloprid 17.8% SL highest seed yield of 2287 and 2235 kg/ha was obtained from the Imidacloprid 17.8% SL treated plot and it was significantly superior over the rest of the treatments Followed by Thiamethoxam 25% WG was second most effective treatment with a yield of 2144 and 2116 kg/ha respectively during both year. *M.anisopoliae* and *B.bassiana* was least effective to increase the grain yield compared to other insecticides but safer to natural enemies.

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S. A. Dwivedi[1] and R.S.Singh[2]

[1]Domain of Entomology, School of Agriculture Lovely Professional University Punjab-144411, India

[2]Department of Entomology, College of Agriculture, Chandra Shekhar Azad University of Agriculture and Technology Kanpur Uttar Pradesh-208002, India

***Corresponding author**

E-mail:sunil.21186@lpu.co.in

Mobile Number: 7309097889