Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; SP1: 1814-1820

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Efficacy of bio pesticides and novel insecticides for control of *Lipaphis erysimi* (Kalt) on mustard crop in western U.P.

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Abstract
The field experiment was conducted in randomized block design with three replications of eight treatments for a crop season of the year i.e. " *Rabi* 2015-16 " at entomological research block of crop research centre, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut - 250110 (U.P.), India. Different insecticides against *L. erysimi* revealed that all the insecticides were significantly effective in reducing the population of aphids and thus increasing the yield than control. Higher yield ranging between 15.55 to 18.15 q/ha and were proved significantly superior over control (14.17 q/ha). The highest seed yield of 18.15 q/ha was obtained from the imidacloprid 17.8 %SL @ 20 ml a.i/ha treated plot and it was significantly superior over rest of the treatments. Cost benefit ratio from the table that imidacloprid 17.8 %SL @ 20 ml a.i/ha ranked first indicating the maximum return Rs 1: 9.55 per rupee invested followed by dimethoate 30 %EC @ 300 ml a.i/ha, Thiamethoxam 25 % WDG @ 25 g a. i ha.

Keywords: Efficacy, bio-pesticides, novel insecticides, mustard aphid *Lipaphis erysimi.*

Introduction
Mustard, *Brassica juncea* (Linnaeus), belongs to family cruciferae So that oilseed crops play an important role in agricultural economy of India. It constitutes the second largest agricultural product in the country next to food grains. India holds first position as a grower, producer, importer and exporter of vegetable oils in the world scenario, source of edible oil and vegetable for human as well as cakes for animals. Aurvedic Samhitas describes the use of 'Sarson' in India. In Sanskrit literature, 'Sorson' seeds have been described as antiseptic (Das, 1997). Rapeseed-mustard (*Brassica* spp.) are the major *Rabi* oilseed crops, grown over an area of 6.34 million hectare with a production of 7.82 million tones and productivity of 1234 kg/ha in 2012-13 in India (Thomas *et al*., 2014). Rajasthan is the largest mustard seed producing state in India accounting for over 45 per cent share in Indian mustard seed production followed by UP (15 per cent), M.P. (11 per cent). It also account for over 40 per cent of acreage. According to latest, data released from Department of Agriculture, Govt of Rajasthan, as on 2nd Nov, 2015, area under Rape & Mustard is pegged at 11.77 lakh hectares (lh) which is lower by 2.93 lh or 20 per cent lower compared to last years' sowing data. In 2015-16 *Rabi* season, Rajasthan has target to plant about 27 lakh hectares (lh) of Rape & Mustard. (Anonymous 2015-16) Among these, *L. erysimi* is one of the most destructive insect (Rai, 1976) It causes damage directly by sucking phloem from different parts of plant and indirectly as a vector of plant viruses. The attack is severe in those regions where the numbers of cloudy days are more during the pest activity period. On heavy infestation, aphids are largely congregated underside of leaves, they curling and yellowing them and plants fail to develop pods, if young pods develop do not produce healthy seeds and also resulting plant to loss their growth (Mamun *et al*., 2010). The yield loss in rapeseed-mustard also varies with their germplasms and agro-ecological practices (Ansari *et al*., 2007).

Materials and Methods
The present investigation on Efficacy of bio-pesticides and novel insecticides against mustard aphid, *Lipaphis erysimi* (Kalt.) in western U.P." was carried out from *Rabi* 2015-16 in order to explore better developing management against this pest on aphid. The details field experiment was carried out during *Rabi* 2015-16 at Crop Research Centre (C.R.C), Chirauri farm, Sardar Vallabhbhai Patel University of Agriculture & Technology., Meerut (U.P.) India. Treatments T_1 Spray of imidacloprid 17.8% SL @ 20 ml a.i/ha^{-1}, T_2 Spray of acephate 75% SP @ 350

g a.i/ha^{-1}, T_3 Spray of dimethoate 30% EC @ 300 ml a.i/ha^{-1},T_4 Spray of fipronil 5% SC @ 50 ml a.i/ha^{-1}, T_5 Spray of thiamethoxam 25% WDG @ 25 g a.i/ha^{-1}, T_6 Spray of neem seed extracts (NSE) 5%, T_7 Spray of neem oil, 1500 ppm and T_8 Control

Harvesting and Threshing

Harvesting of the crop was done on 4th week of March when the crop was matured (75-85 per cent siliquae have turned golden colour). The borders (one row of either side of each plot) were harvested separately to eliminate row effect. The bundles were sun dried to bring uniform moisture. Threshing was done after 7-8 days.

Standard evaluation system for aphids

0	=	Plant free from aphid infestation
1	=	Aphids present but colonies not built up. No injury due to pest appearance on plant
2	=	Small colonies of aphids present on leaves of plant. Such leaves exhibit slight curling due to aphid feeding
3	=	Large colonies of aphids present on leaves and others parts, damage symptoms visible due to aphid feeding
4	=	Most of the leaves covered with aphid colonies and the plant shows more damage symptoms due to aphid feeding.
5	=	The plant completely covered with aphid colonies, plant growth hindered due to feeding (Stunting)

The average aphid index will worked out by using following equation:

$$\text{Average aphid index} = \frac{0N+ 1N +2N+ 3N + 4N+ 5N}{\text{Total number of plants observed}}$$

Where,

0, 1, 2, 3, 4, 5 are the aphid index.

N = Number of plants showing respective aphid index.

Estimation of mustard aphid population

To record the aphid population, ten plants were randomly selected and tagged. The aphid population was recorded on these selected plants, starting with the appearance of the aphids till the harvesting of the crop. The observation for recorded on 4th January, 2015 and other observation were recorded at weekly intervals. The observation for recording the aphid population was confined to only top 10 cm of the central shoot on each plant. Further, 5 Plants from each row were selected to record the average height of the plant, average number of branches per plant and pod size of each tested variety.

Efficacy of Bio pesticide and novel insecticides against mustard aphid, *L. erysimi* (Kalt)

The experiment was laid out by growing a popular variety 'Pusa bold' following recommended agronomic practices as mentioned under Experiment-1st on Screen of mustard varieties against aphid. For management of insect-pests, 8 treatments were taken according to details as follows.

Determination of insecticides application

The required amounts of bio pesticide and novel insecticides were calculated by using the formula as given below:

$$\text{Required amount of insecticides} = \frac{\text{Volume of water (lit ha}^{-1}) * \text{x Disired concentraton (\%)}}{\text{(\%) Strength of insecticide formulation}}$$

* Spraying solution of insecticides was prepared based on plot size.

Insecticides were sprayed with the help of Knapsack Sprayer. The care was taken to avoid drift of spray from one plot to another plot by surrounding the plots with polythene sheets as border at the time of spraying.

Pre-treatment and post-treatment observation

The pre-treatment and post treatment observations on mustard aphid were taken on 10 randomly selected plants plot^{-1}. The population of mustard aphid was recorded one day before of spray as pre-treatment observation and post-treatment observations were taken at 1, 3, 7 and 14 days after spray.

Efficacy of bio pesticides and novel insecticides against *Lipaphis erysimi*

Each treatment in the form of insecticidal spray was applied twice during the crop season. First spray was conducted when the crop was 105 days old and second spray was done after 15 days of first spray. Five plants from three central rows in each plot were tagged randomly much before the appearance of the mustard aphid on the crop. The population of *L. erysimi* was recorded on the selected plants with the help of soft camel hair brush from 10 cm main apical shoot one day before and 1, 3, 7 and 14 days after each treatment application (annexure-plate no 1-6). The grain yield of all the plots were recorded at the time of harvest and it was converted into quintal per hectare for analysis and comparison.

Harvesting and threshing

Harvesting of the crop was carried out early in the morning when 75-85 percent siliquae have turned golden colour. After that bundles were kept in sun for 7-8 days. Threshing was done and seeds are separated by winnowing.

Yield of mustard seeds

Seed yield of mustard was taken on the basis of individual plot and expressed in kg/plot^{-1} and converted into q/ha^{-1}.

Determination of cost: benefit ratio

A comparison of cost involved in different treatment was also calculated on the basis of the maximum retail price printed on the pack taking account of the smallest pack size as reference. Net return for each treatment was calculated by deducting the cost of treatment from the monetary value of increased yield. Benefit cost ratio, net return per rupees invested was calculated using the following formula:

$$\text{Cost : benefit ratio} = \frac{\text{Net profit (Rs./ha)}}{\text{Total cost of protection (Rs./ha)} *}$$

*Total cost of protection included cost of test materials + labour charges + sprayer charges.

Statistical analysis of the different insecticides treatments

The data recorded during the course of investigation were subjected to statistical analysis by using analysis of variance technique (ANOVA) for randomized block design as suggested by Panse and Sukhatme (1978). The data were transformed necessarily as and when required. Standard error of mean in each case and the critical difference only for significant cases were computed at 5% level of probability.

Result

Bio efficacy of different bio pesticides and novel insecticides against *L. erysimi.*

First application

Bio efficacy of different insecticides on the incidence of *L. erysimi* recorded by counting the number of aphids present on the 10 cm of main apical shoot (Table 1).The results revealed that all the treatments were significantly effective in reducing the infestation of *L. erysimi* and thus increasing the yield significantly as compared to control. The initial mustard aphid population ranged from 178.33 to 208.0 aphids before the spray and did not differ significantly. The data recorded on first day after spraying, the minimum aphids 110.00 was recorded in the plot treated with imidacloprid 17.8 %SL @ 20 ml a.i/ha and it was significantly superior to rest of treatments. It was followed by dimethoate 30 % EC @ 300 ml a.i/ha, thiamethoxam 25 % WDG @ 25 g a. i ha (111.67, 117.33) and the treatment acephate 75 %SP @ 350g a.i/ha (142.33), respectively. The treatment Fipronil 5 % SC @ 50 ml a.i/ha had 145.67 aphids followed by Neem oil 1500 ppm @ 3.0 lit/ha (155.67) and Neem seed extract (NSE) @ 5% both having 160.67 aphids. Maximum number of aphids (223.33 aphids) was recorded in control plot. Observation recorded on third day after first application, aphid population was decreased in every treatment and increased in control plot. imidacloprid 17.8 %SL @ 20 ml a.i/ha proved most effective treatment with minimum number of aphids (56.67), followed by Dimethoate 30 %EC @ 300 ml a.i/ha, thiamethoxam 25 % WDG @ 25 g a. i ha and acephate 75 %SP @ 350g a.i/ha forming the next effective group where aphids population (70.00, 74.67 and 83.33) aphids. The next in order of effectiveness of treatments was fipronil 5 % SC @ 50 ml a.i/ha (88.67 aphids), Neem oil 1500 ppm @ 3.0 lit/ha (92.67 aphids) and Neem seed extract (NSE) @ 5% (95.33 aphids). A maximum aphid (234.67 aphids) was recorded in untreated control plot. Data recorded on seventh day after spraying, showed decrease of aphids in all treatments and increased in control plot. The minimum number of aphids (38.67 aphids) was secorded in the plot treated with imidacloprid 17.8 %SL @ 20 ml a.i/ha and it was significantly superior to rest of treatments. It was closely followed by dimethoate 30 %EC @ 300 ml a.i/ha and thiamethoxam 25 % WDG @ 25 g a. i ha having 41.33 and 58.67 aphids, respectively. The treatment acephate 75 %SP @ 350g a.i/ha had 72.67 aphids followed by fipronil 5 % SC @ 50 ml a.i/ha (82.33 aphids), Neem oil 1500 ppm @ 3.0 lit/ha (97.67 aphids) and Neem seed extract (NSE) @ 5% /ha (107.65 aphids). Maximum aphids 224.00 was recorded in control plot. On fourteenth day after first application, showed increase pattern of aphids in all the treatments but still all treatments maintained their efficacy and significance over control. Most effective treatment found was imidacloprid 17.8 %SL @ 20 ml a.i/ha with 100 aphids followed by dimethoate 30 %EC @ 300 ml a.i/ha with 133.33,aphids. The next effective treatment was Thiamethoxam 25 % WDG @ 25 g a. i ha (142.33 aphids) followed by acephate 75 %SP @ 350g a.i/ha (145.0 aphids), fipronil 5 % SC @ 50 ml a.i/ha (167.67 aphids), and Neem oil 1500 ppm @ 3.0 lit/ha (175.00 aphids). Neem seed extract (NSE) @ 5% was the least effective with 190.33 aphids. However, maximum aphid population (336.67) was recorded in control.

Table 1: Bio efficacy of different insecticides against mustard aphid (*L. erysimi*) on first application

Treatment no.	Treatment name	Dose (a.i./ha)	Before spray	Number of aphids/ 10 cm apical shoot			
				After first spray			
				1DAS	3DAS	7DAS	14DAS
T_1	Imidacloprid 17.8 %SL	20 ml a.i/ha	208.00 (14.42)	110.00 (10.48)	56.67 (7.52)	38.67 (6.29)	100.00 (9.99)
T_2	Acephate 75 %SP	350g a.i/ha	198.67 (14.09)	142.33 (11.97)	83.33 (9.11)	72.67 (8.52)	145.00 (12.92)
T_3	Dimethoate 30 %EC	300 ml a.i/ha	187.33 (13.68)	111.67 (10.57)	70.00 (8.36)	41.33 (6.43)	133.33 (11.67)
T_4	Fipronil 5 % SC	50 ml a.i/ha	178.33 (13.35)	145.67 (12.10)	88.67 (9.41)	82.33 (9.02)	167.67 (12.86)
T_5	Thiamethoxam 25 % WDG	25 g a. i ha	208.00 (14.42)	117.33 (10.81)	74.67 (8.63)	58.67 (7.65)	142.33 (9.99)
T_6	Neem seed extract (NSE)	5%	179.33 (13.05)	160.67 (12.69)	95.33 (9.80)	107.33 (10.34)	190.33 (11.97)
T_7	Neemoil 1500 ppm	3.0 lit/ha	197.00 (14.03)	155.67 (11.56)	92.67 (9.67)	97.67 (6.94)	175.00 (13.22)
T_8	Control		191.33 (13.83)	223.33 (14.94)	234.67 (15.32)	234.00 (15.29)	336.67 (18.32)
SE(m)±			**0.32**	**0.44**	**0.38**	**0.44**	**0.57**
CD at 5%			**N.S.**	**1.34**	**1.16**	**1.34**	**1.74**

*Figures in parentheses are square root transformed values
DAS = Days after spray

Second application

The second insecticides sprays was applied 15 days after first application i.e. at 105 days crop age and data recorded on the incidence of *L. erysimi* (Table 2). A similar trend of efficacy of treatments as in first application on reduction of aphids was recorded after the second spray and all the treatments proved better than the control. Observations recorded on fist day after second application revealed that imidacloprid 17.8 %SL @ 20 ml a.i/ha again proved most effective treatment with (68.00) aphids. The next effective treatment was dimethoate 30 %EC @ 300 ml a.i/ha (83.0 aphids) followed by thiamethoxam 25 % WDG @ 25 g a. i ha (92.00 aphids), acephate 75 %SP @ 350g a.i/ha (104.00 aphids), fipronil 5 % SC @ 50 ml a.i/ha (109.33 aphids), and Neem oil 1500 ppm @ 3.0 lit/ha (145.67 aphids). Neem seed extract (NSE) @ 5% was the least effective with 151.67 aphids. However, a maximum aphid (360.33 aphids) was recorded in the control plot. Data recorded on Third day after second application showed that all the treatments were found effective over control in table 1 imidacloprid 17.8 %SL @ 20 mla.i/ha maintained its efficacy

and recorded lower aphid population (45.00 aphids). The next effective treatment was dimethoate 30 % EC @ 300 ml a.i/ha (48.33 aphids) followed by thiamethoxam 25 % WDG @ 25 g a. i ha, acephate 75 % SP @ 350g a.i/ha, fipronil 5 % SC @ 50 ml a.i/ha, Neem oil 1500 ppm @ 3.0 lit/ha and Neem seed extract (NSE) @ 5% where aphid population ranged from 49.67, 66.0, 66.0 81.00, to 99.33 aphids. A maximum aphid (347.33 aphids) was recorded in control plot.

After the seventh day of insecticidal application, all the treatments were found significantly superior than the control. The minimum aphids (31.33) was recorded with imidacloprid 17.8 %SL @ 20 ml a.i/ha. The treatment dimethoate 30 % EC @ 300 ml a.i/ha had 34.00 aphids followed by thiamethoxam 25 % WDG @ 25 g a. i ha (35.67 aphids), acephate 75 %SP @ 350g a.i/ha (41.33 aphids).Treatment fipronil 5 % SC @ 50 ml a.i/ha was found least effective where 42.67 aphids was recorded but it was better than untreated control plot (372.33) in controlling mustard aphid. The data recorded on fourteenth day after second application, showed that decreased pattern of mustard aphids. Maximum aphid population (274.0 aphids) was recorded in control plot. All the treatments were least effective at this stage as compare to previous one. The lower aphid (23.67 aphids) population was recorded with the treatment of imidacloprid 17.8 %SL @ 20 ml a.i/ha. The order of efficacy of all the treatments were dimethoate 30 %EC @ 300 ml a.i/ha > thiamethoxam 25 % WDG @ 25 g a. i ha,> acephate 75 %SP @ 350g a.i/ha, >fipronil 5 % SC @ 50 ml a.i/ha, >Neem oil 1500 ppm @ 3.0 lit/ha and Neem seed extract (NSE) @ 5% where aphid population ranged aphids, respectively. It is evident from the data that all the treatment were effective in controlling mustard aphid in different intervals after each spray in comparison to untreated control. The most effective treatment was imidacloprid 17.8 %SL @ 20 ml a.i/ha. which was closely followed by dimethoate 30 %EC @ 300 ml a.i/ha. Earlier Kantipudi Rajesh *et al.,* (2013) and Sachan *et al*. (2006) also reported that application of imidacloprid 17.8 %SL @ 20 ml a.i/ha. was proved most effective in reducing the population of mustard aphid and increasing the grain yield. Rohilla *et al*. (2004) also found that application of imidacloprid 17.8 %SL @ 20 ml a.i/ha and dimethoate 30 %EC @ 300 ml a.i/ha provides best control for mustard aphid. The efficacy of imidacloprid is reported by several workers viz., Kantipudi Rajesh *et al.,* (2013) and Sachan *et al*. (2006) was recorded effective in reducing aphid population in the present studies which is conformity with the findings of earlier studies conducted by Kantipudi Rajesh *et al.,* (2013) and Sachan *et al*. (2006) was also found effective in the present studies which is in agreement with the results.

Table 2: Bio efficacy of different insecticides against mustard aphid (*L. erysimi*) on second application

Treatment no.	Treatment name	Dose (a.i./ha)	Number of aphids/ 10 cm apical shoot			
			After second spray			
			1DAS	3DAS	7DAS	14DAS
T_1	Imidacloprid 17.8 %SL	20 ml a.i/ha	68.00 (8.24)	45.00 (6.68)	31.33 (5.56)	23.67 (4.83)
T_2	Acephate 75 %SP	350g a.i/ha	109.33 (10.45)	66.00 (8.12)	42.67 (6.46)	41.00 (6.40)
T_3	Dimethoate 30 %EC	300 ml a.i/ha	104.00 (10.19)	66.33 (8.13)	41.33 (6.43)	39.67 (6.29)
T_4	Fipronil 5 % SC	50 ml a.i/ha	92.00 (9.56)	49.67 (7.03)	34.00 (5.82)	31.00 (5.56)
T_5	Thiamethoxam 25 % WDG	25 g a. i ha	83.00 (9.10)	48.33 (6.94)	35.67 (5.97)	27.00 (5.19)
T_6	Neem seed extract (NSE)	5%	159.33 (12.92)	99.33 (10.40)	69.67 (7.63)	49.33 (6.75)
T_7	Neem oil 1500 ppm	3.0 lit/ha	145.67 (12.07)	81.00 (8.99)	54.67 (7.38)	45.33 (6.70)
T_8	Control		360.33 (18.97)	347.33 (18.62)	372.33 (19.29)	274.00 (16.55)
SE(m)±			0.43	0.38	0.69	0.50
CD at 5%			1.31	1.17	2.10	1.54

*Figures in parentheses are square root transformed values
DAS = Days after spray

Yield and economics of bio pesticides and novel insecticides treatments

Data on mustard yield recorded under different treatments are presented in Table 3. All the treated plots resulted higher yield ranging between 15.55 to 18.15 q/ha and were proved significantly superior over control (14.17 q/ha). The highest seed yield of 18.15 q/ha was obtained from the imidacloprid 17.8 %SL @ 20 ml a.i/ha treated plot and it was significantly superior over rest of the treatments. The dimethoate 30 %EC @ 300 ml a.i/ha was second most effective treatment with yield of 17.50 q/ha followed by thiamethoxam 25 % WDG @ 25 g a. i ha, acephate 75 %SP @ 350g a.i/ha, fipronil 5 % SC @ 50 ml a.i/ha and Neem oil 1500 ppm @ 3.0 lit/ha with the yield of 17.35, 16.95, 16.78, 15.85, 15.55, q/ha, respectively. Among the different treatments lowest yield (14.17q/ha) was found in Neemarin 1500 PPM @ 3000 ml/ha treated plot. Increase in yield over the control varied from 1.38 to 3.98 q/ha in different treatments. Maximum increase in yield (3.98 q/ha) over control was recorded in imidacloprid 17.8 %SL @ 20 ml a.i/ha treated plot followed by dimethoate 30 %EC @ 300 ml a.i/ha in which increase in yield was 3.68 q/ha. However, lowest increase in yield 1.38 q/ha was recorded in plot treated with Neem seed extract (NSE) @ 5%. On the basis of increase in yield over control, imidacloprid 17.8 %SL @ 20 ml a.i/ha was found to be the most effective insecticide followed by dimethoate 30 %EC @ 300 ml a.i/ha in reducing the population of mustard aphid. Economic analyses of treatments were made on the basis of seed yield, treatment cost and marketable value of produce (Table 4). It is clear from the table that the application cost of treatment imidacloprid 17.8 %SL @ 20 ml a.i/ha is lowest (Rs 1410.00 /ha) followed by dimethoate 30 %EC @ 300 ml a.i/ha (Rs

1495.00 /ha), thiamethoxam 25 % WDG @ 25 g a. i ha (Rs 1650.00 /ha), acephate 75 %SP @ 350g a.i/ha (Rs 1785.00) and Neem oil 1500 ppm @ 3.0 lit/ha (Rs 1915.00). The higher cost of treatment was recorded in Neem seed extract (NSE) @ 5% (Rs 1995.00/ ha) due to higher cost of insecticide. 13,471.50/ha) was obtained from the plots sprayed with imidacloprid 17.8 %SL @ 20 ml. a.i/ha followed by dimethoate 30 %EC @ 300 ml a.i/ha, thiamethoxam 25 % WDG @ 25 g a. i ha, acephate 75 %SP @ 350g a.i/ha, fipronil 5 % SC @ 50 ml a.i/ha and Neem oil 1500 ppm @ 3.0 lit/ha with net profit of Rs 11,892.5, 11,362.5.00, 10,927.00, 10,695.00, and 9,9720.00 /ha, respectively. The lowest net profit (Rs 9667.00 /ha) was found in Neem seed extract (NSE) @ 5% treated plot. By working cost benefit ratio from the Table 4 it is evident that imidacloprid 17.8 %SL @ 20 ml a.i/ha ranked first indicating the maximum return Rs 1: 9.55 per rupee invested followed by dimethoate 30 %EC @ 300 ml a.i/ha, thiamethoxam 25 % WDG @ 25 g a. i ha, acephate 75 %SP @ 350g a.i/ha, fipronil 5 % SC @ 50 ml a.i/ha, Neem oil 1500 ppm @ 3.0 lit/ha with 1:7.95, 1:6.88, 1:6.12, 1:5.65, 1:5.20 C : B ratio, respectively. Neem seed extract (NSE) @ 5% was also found effective in reducing the number of aphids in mustard. However, this treatment had low cost benefit ratio (1:4.84) because of high cost. Conformity according to Rana *et al.* (2007) also reported that the application of acetamiprid and imidacloprid were the most effective against mustard aphid., Yadav Sunita and Singh S. P. (2016) reported that imidacloprid 17.8 SL @ 20 g a.i. per ha (0.70 aphids /10 cm main apical shoot & 97.88 per cent reduction over control) was most effective among all the tested treatments followed by thiamethoxam 25 WG @ 25 g a.i. per ha (0.90 aphids /10 cm main apical shoot & 97.27 per cent reduction over control) and dimethoate 30 EC @ 300 g a.i. per ha (1.10 aphids /10 cm main apical shoot & 96.67 per cent reduction over control) followed by thiamethoxam, dimethoate and fipronil with 97.27, 96.67 and 95.45 per cent reduction in aphid population over control respectively. The maximum seed yield of 1630 kg/ha was recorded in imidacloprid, which remained on par with thiamethoxam (1620 kg/ha) and dimethoate (1615 kg/ha). The lowest seed yield was obtained from untreated plots (1370 kg/ha). Yadav Sunita and Singh S. P. (2015) carried out field experiment found on par with spray of dimethoate @ 1 ml/l followed by *Coccinella septempunctata* @ 5,000 beetles/ha with pooled mean aphid population of 5.0, 4.0 and 2.0 aphids/plant after 3, 7 and 10 days of treatment, respectively and pooled mean seed yield of (1470.0 kg/ha). But the cost benefit ratio was maximum (7.25) in treatment dimethoate followed by *C. septempunctata* and NSKE @ 5% followed by *C. septempunctata* @ 5,000 beetles/ha (6.68). Thus, entomopathogenic fungi like *V. lecanii* or NSKE along with release of *C. septempunctata* can be used as alternative measure to manage mustard aphid instead of solely relying on insecticides. Bhati and Sharma (2014) effective pest control by Acephate 75 SP @ 350 g a.i./ha was most effective to pest control as this resulted in more reduction in population of mustard aphid. Higher seed yield was obtained from Fipronil 5 SC @ 50 g a.i./ha (15.56 q/ha) and higher return based on C:B ratio (1:6.8) with Thiamethoxam 25 WG @ 25 g a.i./ha. However, imidacloprid 17.8 SL @ 20 g a.i./ha and clothianidine 50 WDP @ 15 g a.i./ha were moderately effective. Kantipudi Rajesh Kumar, S. K. Sachan and D. V. Singh (2013) the application of thiamethoxam 25% WDG @100 g/ha followed by imidacloprid 17.8% SL @ 150 ml/ha. Conventional insecticides were found less effective than newer insecticides for controlling mustard aphid. The newer insecticides which were found effective in controlling mustard aphid are also found safe to coccinellid population than conventional insecticides at all observational interval. acephate, thiamethoxam, dimethoate were found effective in controlling mustard aphid.

Table 3: Bio efficacy of different insecticides on yield against mustard aphid (*L. erysimi*) during *Rabi* 2015-16

Treatment no.	Treatment name	Dose (a.i./ha)	Yield (kg/plot) 4x3 m2	Yield (q/ha)	Increased in the yield over control
T_1	Imidacloprid 17.8 %SL	20 ml a.i/ha	2.10	**18.15** (25.20)	**3.98**
T_2	Acephate 75 %SP	350g a.i/ha	1.55	**16.95** (24.30)	**2.78**
T_3	Dimethoate 30 %EC	300 ml a.i/ha	1.90	**17.85** (24.99)	**3.68**
T_4	Fipronil 5 % SC	50 ml a.i/ha	1.50	**16.78** (24.18)	**2.61**
T_5	Thiamethoxam 25 % WDG	25 g a. i ha	1.60	**17.35** (24.61)	**3.18**
T_6	Neem seed extract (NSE)	5%	1.35	**15.55** (23.21)	**1.38**
T_7	Neem oil 1500 ppm	3.0 lit/ha	1.40	**15.85** (23.45)	**1.68**
T_8	Control	-------	1.10	**14.17** (22.81)	------
SE(m)±				**0.120**	
CD at 5%				**0.368**	

*Figures in parentheses are square root transformed values
DAS = Days after spray

Table 4: Cost benefit (C:B) ratio of different treatments

Treatment	Name of treatment	Yield (q/ha)	Increase in yield over control (q/ha)	Value of increase yield (Rs/ha)	Cost of treatment (Rs/ ha)	Net profit (Rs/ ha)	Cost benefit ratio
T_1	Imidacloprid 17.8 %SL	**18.15**	**3.98**	13612.5	1410.0	1371.5	1:9.55
T_2	Acephate 75 %SP	**16.95**	**2.78**	12712.5	1785.0	10927.5	1:6.12
T_3	Dimethoate 30 %EC	**17.85**	**3.68**	13387.5	1495.0	11892.5	1:7.95
T_4	Fipronil 5 % SC	**16.78**	**2461**	12585.0	1890.0	10695.0	1:5.65
T_5	Thiamethoxam 25 % WDG	**17.35**	**3.18**	13012.5	1650.0	11362.5	1:6.88
T_6	Neem seed extract (NSE) 5%	**15.55**	**1.38**	11662.5	1995.0	9667.5	1:4.85
T_7	Neem oil 1500 ppm	**15.85**	**1.68**	11887.5	1915.0	9972.5	1:5.20
T_8	Control	**14.17**	-	-	-	-	-

Average price of mustard Rs 7,500/quintal
Cost of labour @ Rs 150/labour/day
Charge of sprayer @ Rs 40/day

Summery and conclusion

The first day after spraying, the minimum aphids 110.00 was recorded in the plot treated with imidacloprid 17.8 %SL @ 20 ml a.i/ha and it was significantly superior to rest of treatments. It was followed by dimethoate 30 % EC @ 300 ml a.i/ha, thiamethoxam 25 % WDG @ 25 g a. i ha (111.67, 117.33) and the treatment acephate 75 %SP @ 350g a.i/ha (142.33), respectively. Observation recorded on third day after first application, aphid population was decreased in every treatment and increased in control plot. imidacloprid 17.8 %SL @ 20 ml, decreased in every treatment and increased in control plot. imidacloprid 17.8 %SL @ 20 ml a.i/ha proved most effective treatment with minimum number of aphids (56.67). On seventh day after spraying, showed decrease of aphids in all treatments and increased in control plot. The minimum number of aphids (38.67 aphids) was recorded in the plot treated with imidacloprid 17.8 %SL @ 20 ml a.i/ha. Observations recorded on fourteenth day after first application, Most effective treatment found was imidacloprid 17.8 %SL @ 20 ml a.i/ha with 100 aphids followed by dimethoate 30 %EC @ 300 ml a.i/ha with 133.33, aphids. The second insecticide a spray was applied on reduction of aphids was recorded after the second spray and all the treatments proved better than the control. Observations recorded on fist day after second application revealed that imidacloprid 17.8 %SL @ 20 ml a.i/ha again proved most effective treatment with (68.00) aphids. The next effective treatment was dimethoate 30 %EC @ 300 ml a.i/ha (83.0 aphids) followed by thiamethoxam 25 % WDG @ 25 g a. i ha (92.00 aphids), acephate 75 %SP @ 350g a.i/ha (104.00 aphids), fipronil 5 % SC @ 50 ml a.i/ha (109.33 aphids), and Neem oil 1500 ppm @ 3.0 lit/ha (145.67 aphids). Neem seed extract (NSE) @ 5% was the least effective with 151.67 aphids. The yield under different treatments are higher yield ranging between 15.55 to 18.15 q/ha and were proved significantly superior over control (14.17 q/ha). The highest seed yield of 18.15 q/ha was obtained from the imidacloprid 17.8 %SL @ 20 ml a.i/ha treated plot and it was significantly superior over rest of the treatments. The dimethoate 30 %EC @ 300 ml a.i/ha was second most effective treatment with yield of 17.50 q/ha. Economic analyses, cost of treatment imidacloprid 17.8 %SL @ 20 ml a.i/ha is lowest (Rs 1410.00 /ha) followed by dimethoate 30 %EC @ 300 ml a.i/ha (Rs 1495.00 /ha). The cost benefit ratio with imidacloprid 17.8 %SL @ 20 ml a.i/ha ranked first indicating the maximum return Rs 1: 9.55 per rupee invested followed by dimethoate 30 %EC @ 300 ml a.i/ha, thiamethoxam 25 % WDG @ 25 g a. i ha, acephate 75 %SP @ 350g a.i/ha, fipronil 5 % SC @ 50 ml a.i/ha, Neem oil 1500 ppm @ 3.0 lit/ha with 1:7.95, 1:6.88, 1:6.12, 1:5.65, 1:5.20 C : B ratio, respectively. Neem seed extract (NSE) @ 5% was also found effective in reducing the number of aphids in mustard. However, this treatment had low cost benefit ratio (1:4.84) because of high cost. Conformity according to Rana *et al.* (2007) also reported that the application of acetamiprid and imidacloprid were the most effective against mustard aphid., Yadav Sunita and Singh S. P. (2016) reported that imidacloprid 17.8 SL @ 20 g a.i. per ha (0.70 aphids /10 cm main apical shoot & 97.88 per cent reduction over control)

References

1. Anonymous. Annual Progress Report of All India Coordinated Research Project on Rapeseed and Mustard. National Research Centre on Rapeseed Mustard, Sewar, 3213003, Bharatpur, Rajasthan, 2014, 4-5.
2. Anonymous. Annual Progress Report of All India Coordinated Research Project on Rapeseed and Mustard. National Research Centre on Rapeseed Mustard, Sewar, 3213003, Bharatpur, Rajasthan, 2015-16, 155.
3. Ansari MS, Barkat H, Quzi NS. Influence of abiotic environment on the population dynamics of mustard aphid, *Lipaphis erysimi* (Kalt.). J Bio. Sci. 2007; 7(6):993-996.
4. Das PC. Oilseed Crops of India. Kalyani Publishers, New Delhi, 1997, 273.
5. Kumar KR, Sachan SK, Singh DV. Bio-efficacy of some new insecticides against mustard aphid, *Lipaphis erysimi* (Kalt.) and their effect on coccinellid population in rapeseed mustard. Journal article. 2013; 26(2):159-163.
6. Mamun MSA, Ali MH, Ferdous MM, Rahman MA, Hossain MA. Assessment of several mustard varieties resistance to mustard aphid, *Lipaphis erysimi* (Kalt.). J Soil Nat. 2010; 4:34-38.
7. Panse VG, Sukhatme PV. Statistical methods for agricultural workers. Indian Council of Agricultural Research, New Delhi 4th edition, 1961, 235-257.
8. Rai BK. Pests of oilseed crops in India and their control.

I.C.A.R., New Delhi, 1976, 131.
9. Rohilla HR, Bhatnagar P, Yadav PR. Chemical control of mustard aphid with newer and conventional insecticides. Indian Journal of Entomology. 2004; 66(1):30-32.
10. Sunita Yadav, SP Singh. Bio-efficacy of some new insecticides against mustard aphid, lipaphis erysimi kalt. (hemiptera: aphididae) on indian mustard bio scane 2016; 11(1):23-26.
11. Sunita Yadav, SP Singh. Bio-intensive integrated management strategy for mustard aphid *Lipaphis erysimi* Kalt. (Homoptera: Aphididae) Journal of Applied and Natural Science. 2015; 7(1):192-196.