Efficacy of novel insecticides against mustard aphid *Lipaphis erysimi* (Kaltenbach)

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**ABSTRACT**

An examination was carried out to study in randomized block design with three replications at Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut during rabi 2014-15, the evaluation of novel insecticides viz., imidacloprid, acephate, chlorpyriphos, fipronil, thiamethoxam, dimethoate, and pymetrozine, against *L. erysimi* revealed that all the treatments schedule proved better than control at all the time intervals after each spray. The thiamethoxam 25% WG @100 g/ha was found most effective treatment in reducing the aphids population followed by acephate 75 SP @ 500g/ha. The pymetrozine 50 WG @ 250 g/ha was recorded less effective. Among conventional insecticides imidacloprid 17.8 SL @ 150 ml/ha was found more effective than dimethoate 30% EC @ 1000 ml/ha and fipronil 5 SC @ 1000 ml/ha. The higher yield was obtained from thiamethoxam 25% WG @100 g/ha with (17.15 q/ha) whereas, highest cost benefit ratio is obtained from imidacloprid 17.8 SL @ 150 ml/ha with (1:9.54).

**KEYWORDS**

Insecticides, Mustard, Aphid, RBD, Pusa Bold, Agriculture

**HOW TO CITE THIS ARTICLE**


*Brassica* oilseed crops are the major *Rabi* oilseed crops grown in India, which is collectively referred to as rapeseed-mustard. Ayurvedic Samhitas describes the use of ‘Sarson’ in India. In Sanskrit literature, ‘sarson’ seeds have been described as antiseptic (Das, 1997). 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.

The vegetable oil scenario is very complex and is greatly influenced by market forces, conflicting interests, vagaries of weather, technology and various biotic and a biotic problem. Rapeseed-mustard is self-pollinated, cruciferous plant belonging to genus *Brassica*, originated from eastern Afghanistan and adjoining parts of India and Pakistan. Rapeseed-mustard is the second most important oilseed crop in India and constitutes the major source of edible oil for human consumption and cake for animals.
India is the largest rapeseed-mustard growing country in the world, occupying first position in area and second position in production after China. *Brassica* crops account for 30 per cent of the total oilseeds production and 13 per cent of the country’s gross cropped area. Mustard seed is the second largest produced oilseed in the world with an area of 37.0 m ha\(^{-1}\), with the production of 63.09 m tonnes and the productivity of 18.50 q/ha. In India it had the area of 6.3 m ha\(^{-1}\) with production of 7.37 m tonnes and productivity of 11.90 q/ha. India contributes 28.3% and 19.8% in world acreage and production. India produced around 7.4 mt of rapeseed-mustard next to China (11-12 mt). Among the entire oilseed crops producing states in India and in U.P. the area of rapeseed-mustard during the year 2013-14 was recorded 4.70 m ha\(^{-1}\) with production 2.5 mt and productivity of 890 kg/ha (Anonymous, 2014) indicate the severity of this pest. The incidence and multiplication of insect pests of mustard crop greatly depend upon ecological factors. Thus the pests require need based application of insecticides at appropriate stage so as to minimize their residues in mustard oil and environment and hazards to natural enemies and biodiversity the mustard aphid, *Lipaphis erysimi* (Kaltenbach), is the key pest of rapeseed- mustard. Nymphs and adults suck cell sap from leaves, shoots, flower buds, flowers and pods.

This pest is more abundant from December to March when it infests various cruciferous oilseeds and vegetables. The cloudy and cold weather (20 °C or below), with high relative humidity (70-75%) are very favourable conditions for the multiplication of this pest. The yield losses due to this pest vary with the variety, agro technological practices and environmental factors. However, it causes the yield losses up to 54.2% (Bakhetia and Sekhon, 1989). The indigenous species of rapeseed-mustard grown in India *i.e.* Brown sarson (*Brassica campestris* var. brown sarson), Indian mustard (*Brassica juncea*), gobi sarson (*Brassica napus*), Kiran rai (*Brassica carinata*), Toria (*Brassica rapa* var. toria), Taramira (*Eruca sativa*) and Yellow sarson (*Brassica rapa* var. yellow sarson). These crops are being cultivated in about 53 countries spreading over the six continents (Europe, Africa, North America, South America, Oceania and Asia) across the globe. In Asia, it is primarily cultivated in China (Amer et al., 2010). Asian continent alone contributes 59.1% of the acreage and 48.6% of the world production.

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). The pest survives on other *Brassica* host plants for some time after the rapeseed-mustard crop is harvested. The winged form of mustard aphids migrate to the hilly parts of the country and pass the unfavourable season there on *Brassica* crops as wingless form. As soon as the favourable conditions prevail in plains, wings appear and aphids migrate to the plain part of the country through gliding.

**Materials and Methods**

**Efficacy of Novel Insecticides against Mustard Aphid, *Lipaphis erysimi* (Kalt)**

The experiment was laid out by growing a popular variety ‘Pusa Bold’ following recommended agronomic practices as mentioned under first experiment on screen of mustard varieties against aphid. For management of insect-pests, 8 treatments were taken according to details as follows.

**Application of Treatments**

The incidence of mustard aphid was recorded on regular basis to apply different treatments at appropriate time. Chemical Control was done by applying imidacloprid 17.8 SL @ 150 ml/ha\(^{-1}\), acephate 75 SP @ 500 g/ha\(^{-1}\), chlorpyriphos 20 EC @ 500 ml/ha\(^{-1}\), fipronil 5 SC @ 1000 ml/ha\(^{-1}\), thiamethoxam 25 WG @ 100 g/ha\(^{-1}\), dimethoate 30 EC @ 1000 ml/ha\(^{-1}\) and pymetrozine 50 WG @ 250 g/ha based on ETL (25 aphids 10 cm\(^3\) central twig) of mustard aphid.

**Experimental Layout**

Design; RBD, Variety; Pusa Bold, Treatment; 8, Replication; 3, Plot size; 3 x2 m\(^2\), Spacing; 30 x 10 cm, Date of sowing; 09.11.2014.
Determination of Amount of Insecticides

The required amounts of insecticides were calculated by using the formula as given below:

\[ \text{Required amount of insecticides } = \frac{\text{Volume of water (lit ha}^{-1}) \times \text{Disired concentration (%)}}{\text{Strength of insecticide formulation}} \]

*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 3, 7 and 10 days after spray.

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.

Seed Yield

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

The weight of seeds was recorded separately for all plots after winnowing. Cumulative yield of seeds was converted into quintal per hectare for analyzing and comparison. Increase in yield over control was worked out by deducting the yield recorded in control plot from the yield of the respective treated plot. The monetary value of increased yield was computed in rupees using local market price of mustard. 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

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 as under:

\[ \text{SE(m)} = \frac{\sqrt{\text{EMSS}}}{r} \]

Where,

\( \text{SE(m)} = \text{Standard error of mean} \)
\( \text{EMSS} = \text{Error mean sum of square} \)
\( r = \text{Number of replication} \)

The critical differences at 5 per cent level of probability was worked out to compare treatment means wherever, ‘F’ was significant. Critical difference =SE (m) ± x V2 x t (at error degree of freedom). The data, recorded during the course of investigation, were also analyzed with the help of computer software “OPSTAT” developed by O. P. Sheoran.

Result and Discussion

Efficacy of Novel Insecticides against Rapeseed-Mustard Aphid, \textit{Lipaphis erysimi}\n
Each treatment was applied two times during the crop season. First spraying was done when the crop was 70 days old and second spraying was given at 13 days interval. The data on the number of aphids/10 cm main apical shoots is introduced in the following text.

First Application

Efficacy of different novel insecticides on the incidence of \textit{Lipaphis erysimi} recorded by counting the number of aphids present on the 10 cm of main apical shoot (table 1).
Table 1. Efficacy of novel insecticides against aphid on rapeseed-mustard during rabi 2014-15.

<table>
<thead>
<tr>
<th>T. No.</th>
<th>Chemical Name</th>
<th>Doses /ha</th>
<th>Pre Treatment Pre Treatment</th>
<th>Population of Aphids /10 cm Apical Shoot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1DBS</td>
<td>3 DAS</td>
</tr>
<tr>
<td>T1</td>
<td>Imidacloprid 17.8 SL</td>
<td>150 ml</td>
<td>151.33 (12.33)</td>
<td>47.06</td>
</tr>
<tr>
<td>T2</td>
<td>Acephate 75 SP</td>
<td>500 g</td>
<td>149.06 (12.23)</td>
<td>45.03</td>
</tr>
<tr>
<td>T3</td>
<td>Chlorpyriphos 20 EC</td>
<td>500 ml</td>
<td>142.43 (11.97)</td>
<td>60.20</td>
</tr>
<tr>
<td>T4</td>
<td>Fipronil 5 SC</td>
<td>1000 ml</td>
<td>140.03 (11.87)</td>
<td>55.96</td>
</tr>
<tr>
<td>T5</td>
<td>Thiamethoxam 25 WG</td>
<td>100 g</td>
<td>150.46 (12.30)</td>
<td>44.63</td>
</tr>
<tr>
<td>T6</td>
<td>Dimethoate 30 EC</td>
<td>1000 ml</td>
<td>154.13 (12.45)</td>
<td>50.93</td>
</tr>
<tr>
<td>T7</td>
<td>Pymetrozine 50 WG</td>
<td>250 g</td>
<td>144.43 (12.05)</td>
<td>69.83</td>
</tr>
<tr>
<td>T8</td>
<td>Control (untreated)</td>
<td></td>
<td>155.4 (12.50)</td>
<td>207.96</td>
</tr>
</tbody>
</table>

SE(m) ± CD (0.05)

*Figure in parenthesis is square root transformed values, DBS - Day before spray, DAS - Day after spray.

Table 2. Efficacy of novel insecticides against aphid on rapeseed-mustard (second application) during rabi 2014-15.

<table>
<thead>
<tr>
<th>T. No.</th>
<th>Chemical Name</th>
<th>Doses /ha</th>
<th>Population of Aphids /10 cm Apical Shoot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>3 DAS</td>
</tr>
<tr>
<td>T1</td>
<td>Imidacloprid 17.8 SL</td>
<td>150 ml</td>
<td>24.36</td>
</tr>
<tr>
<td>T2</td>
<td>Acephate 75 SP</td>
<td>500 g</td>
<td>26.16</td>
</tr>
<tr>
<td>T3</td>
<td>Chlorpyriphos 20 EC</td>
<td>500 ml</td>
<td>34.86</td>
</tr>
<tr>
<td>T4</td>
<td>Fipronil 5 SC</td>
<td>1000 ml</td>
<td>30.46</td>
</tr>
<tr>
<td>T5</td>
<td>Thiamethoxam 25 WG</td>
<td>100 g</td>
<td>22.43</td>
</tr>
<tr>
<td>T6</td>
<td>Dimethoate 30 EC</td>
<td>1000 ml</td>
<td>32.23</td>
</tr>
<tr>
<td>T7</td>
<td>Pymetrozine 50 WG</td>
<td>250 g</td>
<td>36.43</td>
</tr>
<tr>
<td>T8</td>
<td>Control (untreated)</td>
<td></td>
<td>292.16</td>
</tr>
</tbody>
</table>

SE(m) ± CD (0.05)

*Figure in parenthesis is square root transformed values, DAS - Day after spray.

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 untreated. The initial mustard aphid population ranged from 149.06 to 155.4 aphids before the spray and did not differ significantly. Data recorded on 3rd day after first application, aphid population was decreased in every treatment except control plot. Thiamethoxam 25% WG @100 g/ha proved most effective treatment with minimum number of aphids (44.63 aphids) and it was significantly superior over rest of the treatments. Thiamethoxam is at par with acephate 75% SP @ 500 g/ha (45.03 aphids) and imidacloprid 17.8 % SL @ 150 ml /ha (47.06 aphids).
The next in order of effectiveness of treatments was dimethoate 30% EC @ 1000 ml/ha (50.93 aphids), fipronil 5 % SC @ 1000 ml/ha (55.96 aphids), chlorpyriphos 20 % EC @ 500 ml/ha (60.2 aphids), pymetrozine 50 % WG @ 250 g/ha (69.83 aphids). A maximum aphid (207.96 aphids) was recorded in control plot. Data recorded on 7th day after spraying, showed decrease of aphids in all treatments except in control plot.


<table>
<thead>
<tr>
<th>T. No.</th>
<th>Treatments</th>
<th>Doses/ha</th>
<th>Yield (kg)/treatment</th>
<th>*Increase in yield over control (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>Imidacloprid 17.8 SL</td>
<td>150 ml</td>
<td>1.008</td>
<td>50.59</td>
</tr>
<tr>
<td>T2</td>
<td>Acephate 75 SP</td>
<td>500 g</td>
<td>0.990</td>
<td>49.69</td>
</tr>
<tr>
<td>T3</td>
<td>Chlorpyriphos 20 EC</td>
<td>500 ml</td>
<td>0.795</td>
<td>37.35</td>
</tr>
<tr>
<td>T4</td>
<td>Fipronil 5 SC</td>
<td>1000 ml</td>
<td>0.960</td>
<td>48.12</td>
</tr>
<tr>
<td>T5</td>
<td>Thiamethoxam 25 WG</td>
<td>100 g</td>
<td>1.029</td>
<td>51.60</td>
</tr>
<tr>
<td>T6</td>
<td>Dimethoate 30 EC</td>
<td>1000 ml</td>
<td>0.858</td>
<td>41.99</td>
</tr>
<tr>
<td>T7</td>
<td>Pymetrozine 50 WG</td>
<td>250 g</td>
<td>0.780</td>
<td>36.20</td>
</tr>
<tr>
<td>T8</td>
<td>Control (water spray only)</td>
<td></td>
<td>0.498</td>
<td></td>
</tr>
</tbody>
</table>

SE(m) ± 0.041 CD at (0.05) 0.125

Table 4. Economics of various novel insecticides used for the management of rapeseed-mustard aphid during rabi, 2014-15.

<table>
<thead>
<tr>
<th>T. No.</th>
<th>Treatments</th>
<th>Number of spray</th>
<th>Yield (q/ha)</th>
<th>Increase yield over control (q/ha)</th>
<th>Value of increase yield (Rs/ha)</th>
<th>Total cost of protection (Rs/ha)</th>
<th>Net Profit Rs/ha</th>
<th>C:B ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>Imidacloprid 17.8 SL</td>
<td>2</td>
<td>16.80</td>
<td>8.50</td>
<td>26350</td>
<td>2500</td>
<td>23850</td>
<td>1:9.54</td>
</tr>
<tr>
<td>T2</td>
<td>Acephate 75 SP</td>
<td>2</td>
<td>16.50</td>
<td>8.20</td>
<td>25420</td>
<td>2780</td>
<td>22640</td>
<td>1:8.1</td>
</tr>
<tr>
<td>T3</td>
<td>Chlorpyriphos 20 EC</td>
<td>2</td>
<td>13.25</td>
<td>4.95</td>
<td>15345</td>
<td>3200</td>
<td>12145</td>
<td>1:3.8</td>
</tr>
<tr>
<td>T4</td>
<td>Fipronil 5 SC</td>
<td>2</td>
<td>16.00</td>
<td>8.00</td>
<td>24800</td>
<td>3460</td>
<td>21340</td>
<td>1:6.1</td>
</tr>
<tr>
<td>T5</td>
<td>Thiamethoxam 25 WG</td>
<td>2</td>
<td>17.15</td>
<td>8.85</td>
<td>27435</td>
<td>2760</td>
<td>24675</td>
<td>1:8.9</td>
</tr>
<tr>
<td>T6</td>
<td>Dimethoate 30 EC</td>
<td>2</td>
<td>14.31</td>
<td>6.01</td>
<td>18631</td>
<td>2900</td>
<td>15731</td>
<td>1:5.4</td>
</tr>
<tr>
<td>T7</td>
<td>Pymetrozine 50 WG</td>
<td>2</td>
<td>13.01</td>
<td>4.71</td>
<td>14601</td>
<td>4020</td>
<td>10581</td>
<td>1:2.7</td>
</tr>
<tr>
<td>T8</td>
<td>Control (water spray only)</td>
<td></td>
<td>8.30</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

The minimum number of aphids (18.93 aphids) was recorded in the plot treated with thiamethoxam 25% WDG @100 g/ha and it was significantly superior to rest of treatments. Thiamethoxam is at par with acephate 75% SP @ 500 g/ha (19.36 aphid) and imidacloprid 17.8% SL @ 150 ml/ha (20.23 aphids), respectively. The treatment dimethoate 30% EC @ 1000 ml/ha had (21.96 aphids). Dimethoate is at par with fipronil 5 % SC @ 1000 ml/ha (23.26 aphids), by chlorpyriphos 20 % EC @ 500 ml/ha (25.03 aphids), pymetrozine 50 % WG @ 250 g/ha (28.33 aphids). Maximum aphids 251.43 were recorded in control plot. On the 10th day after spray also showed decreased pattern of aphids in all treatments except control plot.
Second Application

The second insecticidal sprays were applied 13 days after first application 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 3rd day after second application showed that all the treatments were found effective over control (table 2). Effective treatment was thiamethoxam 25% WDG @100 g/ha maintained its efficacy (22.43 aphids) and next imidacloprid 17.8% SL @ 150 ml/ha (24.36 aphids). Imidacloprid is at par with acephate 75 % SP @ 500g /ha (26.16 aphids) and next effective treatment fipronil 5 % SC @ 1000 ml/ha (30.46 aphids). Fipronil is at par with dimethoate 30% EC @ 1000 ml/ha had (32.23 aphids), by chlorpyriphos 20 % EC @ 500 ml/ha (34.86 aphids) followed by pymetrozine 50 % WG @ 250 g/ha (36.43 aphids).

A maximum aphid (292.16 aphids) was recorded in control plot. After the 7th day of insecticidal application, all the treatments were found significantly superior than the control. The minimum aphids (1.86) was recorded with thiamethoxam 25% WDG @100 g/ha. Thiamethoxam is at par with acephate 75% SP @ 500 g/ha (1.93 aphids) and imidacloprid 17.8% SL @ 150 ml/ha (2.23 aphids), by dimethoate 30% EC @ 1000 ml/ha (2.93 aphids). Dimethoate is at par with fipronil 5 % SC @ 1000 ml/ha (3.36 aphids), by chlorpyriphos 20 % EC @ 500 ml/ha (4.13 aphids), pymetrozine 50 % WG @ 250 g/ha was found least effective where 6.26 aphids was recorded but it was better than control with (276.53 aphid) found.

On the 10th day after spray also showed decreased pattern of aphids in all treatments. The minimum aphid population (0.00 aphids) observed in thiamethoxam 25% WG @100 g/ha, acephate 75% SP @ 500 g/ha and imidacloprid 17.8% SL @ 150 ml/ha. The order of efficacy of all the treatments were fipronil 5 % SC @ 1000 ml/ha (0.9 aphid). Fipronil is at par with dimethoate 30% EC @ 1000 ml/ha (1.23 aphid), followed by chlorpyriphos 20 % EC @ 500 ml/ha. Chlorpyriphos is at par with pymetrozine 50 % WG @ 250 g/ha with aphid population of 2.13 aphids, respectively.

The maximum number of aphids (255.43 aphids) was recorded in control plot. It is evident from the data that all the treatment was effective in controlling mustard aphid in different intervals after each spray in comparison to untreated control. Effectiveness of management treatments against mustard aphid revealed that the Chemical Control with thiamethoxam 25% WDG @100 g/ha was the most effective treatment by acephate 75 SP @ 350 g a.i./ ha and imidacloprid 17.8 % SL @ 150 ml/ha was the most effective, dimethoate 30 EC @ 1000 ml/ha and fipronil 5 % SC @1000 ml/ha was moderate effective in comparison of thiamethoxam, acephate and imidacloprid. Chlorpyriphos 20 EC and pymetrozine 50 WG found least effective in comparison of all other insecticides for management of mustard aphid. The most effective treatment was thiamethoxam 25% WDG @100 g/ha which was closely by acephate 75 SP @ 350 g a.i./ ha.

Earlier (Choudhury and Pal, 2005, Rohilla et al., 2004) also found that application of thiamethoxam and acephate provides best control for mustard aphid. Acephate 75% SP @ 500 g/ ha was also found effective in the present studies which is in agreement with the results obtained by (Gour and Pareek, 2003, Choudhury and Pal, 2005). The efficacy of imidacloprid is reported is reported by several workers viz. (Kumar et al., 2007, Rana et al., 2007, Singh and Verma, 2008, Bapari et al., 2008). Dimethoate 30 EC @ 1000 ml/ha was recorded effective in reducing aphid population in the present studies which is conformity with the findings of earlier studies conducted by (Islam et al., 1990, Sinha et al., 1997, Gazi et al., 2001), Choudhury and Pal, 2005, Bapari et al., 2008, Khedkar et al., 2012, Bhati and Sharma, 2014).

Fipronil 5 % SC @1000 ml/ha was also found effective in the present studies which is in agreement with the results obtained by (Sahoo, 2012, Bhati and Sharma, 2014, Singh et al., 2014). Next to chlorpyriphos 20 EC @ 500 ml/ha, was found effective in controlling mustard aphid, had also been reported effective by earlier workers i.e. (Mandal, et al., 2012). The results pertaining to the effect of pymetrozine 50 WG@ 250 g/ha in present studies they are use in sucking type of insect.
Effect of Novel Insecticides on Seed Yield

The effectiveness of novel insecticides against mustard aphid was also determined on the basis of seed yield (table 3). Significantly higher seed yield 17.15 q/ha\(^{-1}\) was obtained with thiamethoxam 25\% WDG @100 g/ha (T\(_3\)), followed by imidacloprid 17.8\% SL @ 150 ml/ha (T\(_1\)), acephate 75 SP@ 500 g/ha (T\(_2\)), fipronil 5 SC@ 1000 ml/ha (T\(_4\)), dimethoate 30 EC @ 1000 ml/ha (T\(_5\)) and chlorpyriphos 20 EC @ 500 ml/ha (T\(_3\)) with 16.80, 16.50, 16.00, 14.31, and 13.25 q/ha\(^{-1}\). All the treatments were found superior on control on the basis of seed yield. The lowest seed yield (13.01 q/ha\(^{-1}\)) obtained from pymetrozine 50 \% WG @ 250 g/ha (T\(_7\)). Earlier (Mandal et al., 2012) also reported that application of thiamethoxam 25 WG @100 g/ha and imidacloprid 17.8\% SL @ 150 ml/ha most effective in increasing the grain yield. Mishra and Yadav (2013) reported that increased seed yield as 6.14 and 3.14 q/ha over control due to application of imidacloprid and methamexason, respectively. Singh et al. (2014) reported that plot treated with imidacloprid provided highest yield. Bhati and Sharma (2014) who reported that seed yield increased due to application of fipronil and thiamethoxam as 4.28 and 3.58 q/ha\(^{-1}\).

Effectiveness of Treatments Based on C: B Ratio

Data on mustard yield recorded under different treatments are presented in (table 4). All the treated plots resulted higher yield ranging between 13.01 to 17.15 quintal/ha and were proved significantly superior over control (8.30 q/ha). The highest seed yield of 17.15 q/ha was obtained from the thiamethoxam 25\% WG @100 g/ha treated plot and it was significantly superior over rest of the treatments. The acephate 75\% SP @ 500 g/ha, was second most effective treatment with yield of 16.50 q/ha by imidacloprid 17.8\% SL @ 150 ml/ha, dimethoate 30\% EC @ 1000 ml/ha, fipronil 5 \% SC @ 1000 ml/ha, chlorpyriphos 20 \% EC @ 500 ml/ha and pymetrozine 50 \% WG @ 250 g/ha with the yield of 16.80, 14.31, 16.00, 13.25, 13.01 q/ha, respectively. It is clear from the table that the application cost of treatment imidacloprid 17.8\% SL @ 150 ml/ha, is lowest (Rs 2500.00/ha) by thiamethoxam 25\% WG @100 g/ha (Rs 2760.00/ha), acephate 75\% SP @ 500 g/ha (Rs 2780.00/ha), dimethoate 30\% EC @ 1000 ml/ha (Rs 2900.00/ha), chlorpyriphos 20 \% EC @ 500 ml/ha (Rs 3200.00/ha), fipronil 5 \% SC @ 1000 ml/ha (Rs 3460.00/ha) and neemarin 1500 PPM @ 3000 ml/ha (Rs 2180.00). The higher cost of treatment was recorded in pymetrozine 50 \% WG @ 250 g/ha (Rs 2280.00/ha) due to higher cost of insecticide. The data pertaining to net income revealed that highest net income (Rs 24675.00/ha) was obtained from the plots sprayed with thiamethoxam 25\% WG @100 g/ha by imidacloprid 17.8\% SL @ 150 ml/ha, acephate 75\% SP @ 500 g/ha, fipronil 5 \% SC @ 1000 ml/ha, dimethoate 30\% EC @ 1000 ml/ha and chlorpyriphos 20 \% EC @ 500 ml/ha (Rs 3200.00/ha), with net profit of Rs 23850, 22640, 21340,15731, 12145 and10581.00/ha, respectively.

Related to work of cost benefit ratio from the (table 4) it is understood that imidacloprid 17.8\% SL @ 150 ml/ha ranked first to show the maximum return 9.54 per rupee invested thiamethoxam 25\% WG @100 g/ha, acephate 75\% SP @ 500 g/ha, fipronil 5 \% SC @ 1000 ml/ha, dimethoate 30\% EC @ 1000 ml/ha, chlorpyriphos 20 \% EC @ 500 ml/ha with 1:8.9, 1:8.1, 1:6.1, 1:5.4, 1:3.8, cost benefit ratio, respectively, pymetrozine 50 \% WG @ 250 g/ha was also found successful in reducing the number of aphids in mustard. However, this treatment had low cost benefit ratio (1:2.7) because of high cost of treatment. Earlier (Mandal et al., 2012, Khedkar et al., 2012, Sahoo, 2012, Singh, et al., 2014) also reported that the application of imidacloprid were the most effective against mustard aphid. According to (Misra, 1993, Bapari et al., 2008, Sahoo, 2012, and thiamethoxam, dimethoate, chlorpyrifos, fipronil and were found effective in controlling mustard aphid.

Summary and Conclusion

Efficacy of different insecticides viz. imidacloprid, acephate, chlorpyriphos, fipronil, thiamethoxam, dimethoate, and pymetrozine on the incidence of *L. erysimi* in mustard crop revealed that all the treatments were found significantly effective in reducing the population of aphids and thus increasing the yield significantly as compared to control. The most effective treatment in reducing the incidence of *L. erysimi* was thiamethoxam 25\% WG @100 g/ha followed by acephate 75\% SP @ 500 g/ha, imidacloprid 17.8\% SL @150 ml/ha,
dimethoate 30% EC @ 1000 ml, fipronil 5% SC @ 1000 ml/ha, chlorpyriphos 20% EC @ 500 ml/ha, at all observational periods after first and second sprays. The pymetrozine 50% WG @ 250 g/ha was found least effective but it was significantly superior over control. The highest yield (17.15 q/ha) is obtained from treatment thiamethoxam 25% WDG @100 g/ha, whereas higher cost benefit ratio (1:9.54) was obtained from treatment imidacloprid 17.8% SL @ 150 ml/ha, it is due to higher cost of treatment pymetrozine 50% WG @ 250 g/ha. The second highest yield and cost benefit ratio was obtained from treatment thiamethoxam 25% WG @ 100 g/ha. The lowest yield and cost benefit ratio obtained from the treatment pymetrozine 50% WG @ 250 g/ha. The fipronil 5% SC @ 1000 ml/ha has good cost benefit ratio (1:6.1) as compared to dimethoate (1:5.4), chlorpyriphos (1:3.8) and pymetrozine (1:2.7). Therefore, it is concluded from the present experiment that the variety Pusa Jagnath found highly tolerant to aphid attack and recommended for the grower to gain high benefits. For the control of newer insecticides were found more effective. Novel insecticides were found most effective in reducing the population of mustard aphids, *L. erysimi*.

**References**


