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Persistence and residual toxicity of some insecticides against mustard aphid, *Lipaphis erysimi* (Kalt.)

Narava Ramana, RS Bandral, RK Gupta and Sachin Gupta

Abstract
The experiment was conducted to evaluate the persistent toxicity of insecticides viz., methyl-o-demeton, spinosad, acetamiprid, chlorfenapyr, and fipronil against neonate mustard aphid, *Lipaphis erysimi*. Mean aphid mortality of mustard aphid revealed that methyl-o-demeton (0.03%) exerted superior mortality (93.75%) after 1 hour of spraying but acetamiprid was the most effective insecticide after one, three, seven and ten days of spraying. Fipronil and chlorfenapyr were at par with methyl-o-demeton (0.03%). Whereas, spinosad was the least effective insecticide. Mean aphid mortality on twigs has also revealed that acetamiprid was the most promising insecticide. Based on persistence toxicity values the order of persistent toxicity (PT) was acetamiprid (612.9) > methyl-o-demeton (593.8) > fipronil (530.4) > chlorfenapyr (482.8) > spinosad (459.2).

Keywords: Persistent toxicity, insecticides, Gobhi sarson, mustard aphid, *L. erysimi*

Introduction
Rapeseed-mustard is the major oilseed crop grown in various states of the country. It is grown both in subtropical and temperate countries and is the third most important oilseed crop in the world after soybean (*Glycine max*) and palm oil, *Elaeis guineensis* (Jacq.). Several biotic and abiotic factors are responsible for reducing the yield of rapeseed-mustard. Among various biotic factors, insect pests are one of the major constraints. Mustard aphid, *L. erysimi* is the main constraint for qualitative as well as quantitative production of rapeseed-mustard. It has attained the key pest status because of its prolific multiplication, resulting in the curling of the leaf, stunting and drying up of the plants (Rana *et al*., 2007) [23]. In North India, *L. erysimi* is present in the fields throughout the year, however, showing its intense activity in January-March. Its population on brown/yellow sarson (*Brassica rapa*) and raya or rai (*B. juncea*) reaches at its peak during January-February. The population declines steadily by March onwards and is found negligible on the crop in April (Kulkami and Patel, 2001) [13] (Naqvi *et al*., 2003) [17].

The mode of reproduction is parthenogenetic and viviparous. A single female can produce as many as 135 off-springs in 15 to 30 days, which completes its life span in 23 to 60 days in different weather conditions. The favorable conditions for rapid multiplication of mustard aphid are mean maximum and minimum temperatures of 16-30 °C and 4-12 °C, respectively coupled with 60-80 % relative humidity. Rainfall below 1.0 cm is useful as it increases the relative humidity, but higher rainfall is detrimental as it washes and kills the aphid colonies (Bakhetia and Sachan, 1997) [4].

The regular and frequent application of chemical insecticides is quite effective but creates a lot of problems *viz*., pest resurgence, secondary pest outbreak, development of resistance, increase the cost of cultivation and residual toxicity in soil. In recent years, selective insecticides were introduced into the market instead of traditional insecticides because insect pests became resistant to conventional insecticides and are increasingly replacing the organophosphates and methyl carbonates (Tomizawa *et al*., 2007) [35]. Because of the resistance development to conventional insecticides and the introduction of selective insecticides into the market, the present study is aimed to assess the effect of some insecticides against *L. erysimi* under field and laboratory conditions.

Materials and Methods

For determination of field weathered toxicity, the experiment was laid out in a Randomized Block Design (RBD) with six treatments including control and four replications having each plot size of 3m × 3m during Rabi season of 2017-18 at Experimental farm, Division of Entomology, SKUAST-Jammu. The crop Gobhi sarson, *Brassica napus* L. variety (DSH-1) was sown on October 15, 2017, at a spacing of 30cm × 10cm and raised as per the packages and practices of SKUAST-Jammu. When the aphid population started build-up, crop was sprayed with insecticides *viz*., fipronil 5 SC @ 0.005%, acetamiprid 20 SP @ 0.05%, spinosad 45 SC @ 0.03%, chlorfenapyr 10 SC @ 0.015% and oxydemeton methyl 25 EC @ 0.03% with a spray volume of 500 litres per ha using Knapsack sprayer. For control plots, only water was used for spraying. After spraying in each plot three plants were selected randomly and tagged. Aphids were removed from leaves and twig samples. A buffer area of one-meter width was left around each experimental plot to safeguard against the possible drift during spraying operations.

Samples of *Gobhi sarson* leaves and twigs were taken separately in poly bags from the tagged plants in each treated plot at 0 days (1 hr), 1, 3, 7 and 10 days after spraying. Border rows were skipped for sampling. All the samples were brought to the laboratory for further studies. Leaf discs of 9 cm size were made and placed upside down over the moist filter paper in Petriplates in the laboratory. Twenty apterous neonate aphids of the same size from stock culture were released on each leaf discs by using a soft camel hairbrush. These Petriplates were kept in a B.O.D. incubator at 26 ± 1oC. Observations on mortalities were recorded after 24 hr exposure periods. The moribund aphids were also counted as dead. The mortality data averaged and then subjected to angular transformation and analyzed statistically at five percent level of significance by using OP STAT software. To compare the field weathered toxicity of different insecticides, the percent reduction of aphids over untreated control was calculated by using (Abbott's 1925) [1] formula. Persistence toxicity (PT) values were calculated from corrected mortalities data as per the method given by (Sarup *et al*., 1970) [28]. By using these PT values as a base, relative persistence of toxicity (RPT) values were calculated.

$$\text{Corrected \% mortality} = \frac{\text{\% Mortality in treatment - \% Mortality in control}}{\text{100- \% Mortality in control}} \times 100$$

$$\text{Mean percent mortality (T)} = \frac{\text{Sum of corrected mortalities at different intervals}}{\text{Number of observations}}$$

Persistent toxicity (PT) = Average residual toxicity × Period for which toxicity was observed.

Results and Discussion

Persistent toxicity of insecticides on *G. sarson* leaves against *L. erysimi*.

0 day (1 hour) after spraying:

Data on mean aphid mortality revealed that methyl-o-demeton @ (0.03%) was the most effective (93.75%). however acetamiprid (0.05%), fipronil (0.005%) and chlorfenapyr (0.015%) were at par with methyl-o-demeton (0.03%) with 90%, 87.50% and 86.5% mortalities, respectively. Spinosad (0.03%) was the least effective insecticide with 78.75% mortality.

One day after spraying

Mean aphid mortality data has shown that acetamiprid (0.05%) was the most promising treatment (87.50%). The treatments methyl-o- demeton (0.03%) fipronil (0.05%) spinosad (0.03%) recorded 86.25% 80.00% and 72.50% mortalities. Whereas, chlorfenapyr (0.015%) was least effective.

Three days after spraying

Acetamiprid (0.05%) was significantly superior over all other insecticidal treatments with 68.75% mortality. Methyl-o-demeton (0.03%) and Fipronil (0.05%) were the next best treatments with 60.00% and 56.25% mortalities. Succeeding treatments, Chlorfenapyr (0.015%) and Spinosad (0.03%) were on par with fipronil (0.005%) indicated 51.25% and 47.5% mortalities.

Seven days after spraying

Mean aphid mortality recorded shown decreased trend after seven days of spraying. the treatments acetamiprid (0.05%)and methyl-o-demeton has shown more or less effect with 46.25% and 42.50% mortalities, however, Fipronil (0.005%) and chlorfenapyr (0.015%) both exerted equal mortality of 37.20%. Whereas, spinosad was the least effective.

Ten days after spraying

It is evident from Table 1 that acetamiprid (0.05%) was the most effective insecticide with 26.25% mortality. Methyl-o-demeton (0.03%) was the second best treatment with 22.50%. Fipronil (0.005%) was the succeeding best treatment with 18.75% mortality. While, chlorfenapyr (0.015%) and spinosad (0.03%) has shown 15.00% and 13.75% mortalities, respectively.

The relative persistence toxicity was calculated by taking the persistence toxicity values of spinosad as unity. Acetamiprid, methyl-o-demeton, fipronil and chlorfenapyr 1.33, 1.29, 1.15 and 1.05 times persistent than spinosad respectively. Acetamiprid was found as the most persistent insecticide and spinosad was the least persistent insecticide. The order of persistent toxicity (PT) of different insecticides on Gobhi sarson leaves against mustard aphid was acetamiprid (612.9) > methyl-o-demeton (593.8) > fipronil (530.4) > chlorfenapyr (482.8) > spinosad (459.2).

Table 1: Field weathered toxicity of insecticides on *Gobhi sarson* leaves against *L. erysimi.*

Insecticide	Mean aphid mortality (%).				
	1 hour	1 DAS	3 DAS	7 DAS	10 DAS
Fipronil (0.005%)	87.50 (69.36)	80.00 (63.86)	56.25 (48.58)	37.50 (37.73)	18.75 (25.52)
Acetamiprid (0.05%)	90.00 (72.26)	87.50 (70.02)	68.75 (56.00)	46.25 (42.82)	26.25 (30.79)
Spinosad (0.03%)	78.75 (62.69)	72.50 (58.42)	47.50 (43.54)	33.75 (35.46)	13.75 (21.69)
Chlorfenapyr (0.015%)	86.25 (71.08)	67.50 (55.29)	51.25 (45.70)	37.50 (37.73)	15.00 (22.63)
Methyl-o- demeton (0.03%)	93.75 (75.67)	86.25 (68.27)	65.00 (53.79)	42.50 (40.66)	22.50 (28.27)
Control	2.50 (8.80)	5.00 (12.39)	6.25 (13.61)	7.50 (15.99)	6.25 (14.77)
S. E(m)	3.34	2.50	2.11	1.16	1.25
C. D. (p=0.05)	(10.17)	(7.61)	(6.41)	(3.54)	(3.80)

DAS: Days after spraying; data are means of three replications: Figures in parentheses are Angular transformed values

Table 2: Persistent toxicity of insecticides on *Gobhi sarson* leaves against *Lipaphis erysimi.*

Days	Corrected mortality (%)				
	Fipronil (0.005%)	Acetamiprid (0.05%)	Spinosad (0.03%)	Chlorfenapyr (0.015%)	Methyl-o-demeton (0.03%)
0(1 hr.)	87.17	89.74	78.20	85.89	93.59
1	78.94	86.84	71.05	65.78	85.52
3	53.33	66.66	44.00	48.00	62.66
7	32.43	41.89	28.37	32.43	37.83
10	13.33	21.33	8.00	9.33	17.33
ART	265.2	306.46	229.62	241.43	296.93
P	10	10	10	10	10
T	53.04	61.29	45.92	48.28	59.38
PT	530.4	612.9	459.2	482.8	593.8
RPT	1.15	1.33	1	1.05	1.29
ORE	3	1	5	4	2

ART = Average residual toxicity; P = Period of toxicity; T = Mean per cent mortality; PT = Persistent toxicity; RPT = Relative Persistent toxicity; O.R.E. = order of relative efficacy.

Persistent toxicity of insecticides on *Gobhi sarson* twigs against *L. erysimi.* 0 day (1 hour) after spraying

Data on mean aphid mortality indicated chlorfenapyr (0.015%) was the most effective treatment with the highest mortality (87.50%). The treatments, acetamiprid (0.05%), methyl-o-demeton (0.0%) and fipronil (0.005%) were on par with chlorfenapyr (0.015%) with 83.75%, 78.9% and 77.50% mortalities, respectively. Spinosad (0.03%) was the least effective that recorded 68.75% mortality.

One day after spraying

After one day of spraying fipronil(0.005%) was the most promising treatment with 83.75% mortality. The treatments methyl-o- demeton (0.03%) and acetamiprid (0.05%) recorded 82.50%, 78.75% mortalities, respectively and were on par with the treatment fipronil (0.005%). Chlorfenapyr (0.015%) was the next best treatment with 70% mortality. Whereas, spinosad (0.03%) was the least effective (60%) insecticide.

Three days after spraying

The treatment acetamiprid (0.05%) was significantly superior over all other insecticidal treatments with 65.00% mortality. Methyl-o- demeton (0.03%), fipronil (0.005%) recorded 63.75% and 52.50% mortalities. Succeeding treatments, chlorfenapyr (0.015%) and spinosad (0.03%) were on par with fipronil (0.005%) indicated 52.50% and 43.75% mortalities, respectively.

Seven days after spraying

Mean aphid mortality after seven days spraying revealed that, Methyl-o- demeton (0.03%) was the most effective insecticide with 48.75% mortality. Acetamiprid (0.05%) was the second best treatment with 47.50% mortality. Fipronil (0.005%) and chlorfenapyr (0.015%) both insecticides exerted equal mortality of 43.75%. whereas, spinosad was the least effective insecticide.

Ten days after spraying

Acetamiprid (0.05%) was the most effective insecticide with 26.25% mortality. Methylo- demeton (0.03%) was the second-best treatment with 22.50% mortality. Fipronil (0.005%) was the succeeding best treatment with 18.75% mortality. While, chlorfenapyr (0.015%) and spinosad (0.03%) were on par with fipronil (0.005%) with 17.50% and 13.75% mortalities, respectively. The relative persistence toxicity was calculated by taking the persistence toxicity values of spinosad as unity. Acetamiprid, methyl-o-demeton, fipronil and chlorfenapyr 1.38, 1.36, 1.25 and 1.23 times as persistent than spinosad, respectively. Acetamiprid was found as the most persistent insecticide and spinosad was the least persistent insecticide. The order of persistent toxicity (PT) of different insecticides on *Gobhi sarson* twigs against mustard aphid was acetamiprid (580.6) > methyl-o-demeton (572.8) > fipronil (527.7) > chlorfenapyr (517.6) > spinosad (420.3).

Table 3: Field weathered toxicity of insecticides on *Gobhi sarson* twigs against *L. erysimi.*

Insecticide	Mean aphid mortality (%).				
	1 hour	1 DAS	3 DAS	7 DAS	10 DAS
Fipronil (0.005%)	77.50 (61.83)	83.75 (66.47)	52.50 (46.42)	43.75 (41.38)	18.75 (25.61)
Acetamiprid (0.05%)	83.75 (66.61)	78.75 (63.22)	65.00 (53.73)	47.50 (43.54)	26.25 (30.79)
Spinosad (0.03%)	68.75 (56.15)	60 (51.25)	43.75 (41.38)	38.75 (38.46)	13.75 (21.69)
Chlorfenapyr (0.015%)	87.5 (69.36)	70 (57.10)	52.50 (46.42)	43.75 (41.38)	17.50 (24.52)
Methyl-o- demeton (0.03%)	78.94 (63.49)	82.50 (65.29)	63.75 (53.00)	48.75 (44.25)	22.50 (28.27)
Control	5.00 (11.21)	3.75 (10.02)	5 (13.55)	6.25 (14.77)	5 (13.55)
S. E(m)	2.45	3.18	1.56	1.55	1.20
C. D. (p=0.05)	(7.45)	(9.69)	(4.74)	(4.72)	(3.65)

DAS: Days after spraying; data are means of three replications: Figures in parentheses are Angular transformed values.

Table 4: Persistent toxicity of insecticides on *Gobhi sarson* twigs against *L. erysimi.*

Days	Corrected mortality (%)				
	Fipronil (0.005%)	Acetamiprid (0.05%)	Spinosad (0.03%)	Chlorfenapyr (0.015%)	Methyl-o-demeton (0.03%)
0(1 hr.)	76.31	82.89	67.10	86.84	78.94
1	83.11	77.92	58.44	68.83	81.81
3	50.00	63.15	40.78	50.00	61.84
7	40.00	44.00	34.66	40.00	45.33
10	14.47	22.36	9.21	13.15	18.42
ART	263.89	290.32	210.19	258.82	286.42
P	10	10	10	10	10
T	52.77	58.06	42.03	51.76	57.28
PT	527.7	580.6	420.3	517.6	572.8
RPT	1.25	1.38	1	1.23	1.36
ORE	3	1	5	4	2

ART = Average residual toxicity; P = Period of toxicity; T = Mean per cent mortality; PT = Persistent toxicity; RPT = Relative Persistent toxicity O.R.E. = order of relative efficacy.

Discussion

Perusal of data on mean aphid mortality revealed that all the insecticidal treatments were significantly superior over control. Earlier, (Biswas and Chaterjee, 2006) [6] reported that all the insecticides were significantly superior over control. However, acetamiprid and imidacloprid showed maximum reduction of aphids over other insecticides. In the present study, methyl-o-demeton @ 0.03% was most effective treatment after 0 day (1 hr.) of spraying with highest mortality (93.75%) against aphids. It was also found significantly superior treatment. The treatment, acetamiprid (0.05%) was at par with methyl-o-demeton (0.03%) which recorded 90% mortality. Our results are in conformity with (Ghosal *et al*., 2013) [10], who found that acetamiprid recorded lowest aphid count after 1, 7 and 14 days of first spray with 83.19%, 84.50% and 83.68% reduction of aphid population.

In the present field weathered toxicity assessment studies on *Gobhi sarson* leaves, acetamiprid was the significantly superior insecticide after one, three, seven and ten days of spraying. Earlier, (Chinnabbai *et al*., (1999) [8] also reported that acetamiprid resulted in highest mortality to the tune of 87.95% followed by Polytrin-C (71.25%) and imidacloprid (66.25%) against the mustard aphid, *L. erysimi* (K.) after 24 hours after treatment.

Similarly (Jadhav *et al*., (2016) [11] also found that all the treatments were superior over control but after one day of spray imidacloprid (neonicotinoid like acetamiprid) showed best result with lowest number of aphid population (1.30 aphids/ 3 leaves) followed by fipronil (1.98), while chlorfenapyr was least effective with (6.58 aphids/ 3 leaves). Field efficacy studies of (Vekaria and Patel, (2000) [37] also revealed that 0.025% methyl-o-demeton + 0.05% Nicotine Sulphate resulted in the lowest aphid index and required only two applications to keep the aphid population below the ETL.

In the present studies after three days of spraying methyl-o-demeton (0.03%) was at par with acetamiprid (0.05%). Our experimental results are in line with the (Mustafa, 2000) [16], after 3 days of spraying against *Brassica* aphid, he found that Confidor was most effective insecticide with 92.28% mortality, followed by Metasystox and after seven days of spraying, Confidor, Talstar Polo and Metasystox were statistically similar. (Reddy *et al*., (2014) [24] reported that after 48 hrs of treatment acetamiprid (0.004%) caused 96% mortality. (Sable and Kushwaha, 2014) [26] also found that maximum mortality (53%) was recorded with oxy-methyl demeton 25 EC against mustard aphid. Similarly, (Reza *et al.*, 2004) [25] also revealed that spraying with oxydemeton-methyl @ 0.05% resulted in highest mean aphid mortality against *L. erysimi.* Studies of (Agrawal *et al.*, 2005) [2] found that methyl-o-demeton at 0.025% was the most effective insecticide followed by dimethoate at 0.03% against mustard aphid, *L. erysimi.*

Efficacy studies of (Kumar *et al*., 2007) [14] also reported that oxydemeton-methyl was effective insecticide after one and three days of spray with 88.0% and 96.7% mortality, respectively. Field experiments of (Maula *et al*., 2010) [15] also found that Metasystox-R @ 0.05 was most effective insecticide after one and four days of spraying. In the present

studies acetamiprid was the most effective insecticide against mustard aphid after seven days of spraying. Earlier, (Singh and Verma, 2008) [33] also reported that acetamiprid (91.73%), was the most effective insecticide against aphids after 7 days of application. (Singh and Singh, 2009) [34] also noted that acetamiprid was most effective insecticide followed by methyl -o- demeton, fipronil and spinosad. Studies of (Khedkar *et al.*, 2012) [12] has also reported that acetamiprid was most effective insecticide against aphids.

Field efficacy studies of (Varghese and Mathew, 2012) [36] also found that acetamiprid and imidacloprid were highly toxic to chilli aphids with cent percent mortality followed by dimethoate (85.33%), spirotetramate (80%), indoxacarb (65.33%), spiromesifen (28%), propargite (20%) and flubendiamide (13.33%) after one day of spraying.

Methyl-o-Demeton is systemic and contact insecticide that is a member of the organophosphate group of chemicals. It offers effective control as it absorbed and translocated within the plant in sufficient concentrations to kill insects that feed on the plant by sucking its juices. Methyl -o- demeton inhibits acetyl-cholinesterase, an enzyme critical to the normal function of the nervous system. Studies of (Singh *et al.*, 2013) [31] also found that oxy-demeton methyl was most effective insecticide against mustard aphid with 92.5%, 94.4% and 97.1% after 3, 7 and 10 days of spray, respectively.

In the present studies all insecticides showed their persistence on *Gobhi sarson* against mustard aphids up to 10 days. The order of persistent toxicity (PT) of different insecticides against the mustard aphid was acetamiprid (612.9) > methyl-o-demeton (593.8) > fipronil (530.4) > chlorfenapyr (482.8) > spinosad (459.2). Our results are in conformity with (Preetha *et al*. 2009) [21] found that imidacloprid, a member of neonicotinoids (50g a.i./ha) showed longest persistence up to 27 days for aphids whereas, shorter persistence period of 13 days was found in methyl demeton. (Shaikh *et al.*, (2015) [29] also reported that acetamiprid 20 SP @ 0.004% and spinosad 45SC @ 0.014% gave complete control up to 6 days and there after the effect was decreased with increase in time. However, spinosad showed longer persistence up to 14 days, whereas acetamiprid persisted for 10 days. Studies of (Patil and Lingappa, 2001) [19] noted that persistence effect of oxy-demeton methyl was lost completely in 11-12 days. Persistent toxicity studies of (Prabhavathi *et al*., 2016) [20] against aphids on cotton revealed that acetamiprid persisted for 21 and 19 days at 80 and 40 g a.i. /ha, respectively. Whereas at 20g and 10g a.i./ha it persisted for 15 and 11 days, respectively.

In *Gobhi sarson* twigs also similar trend of mortality was observed. However, fipronil was the most promising insecticide after one day of spraying with 83.75% mortality and it was found significantly superior treatment. Earlier, efficacy studies of (Yadav and Singh, 2016) [38] also revealed that fipronil (88.16%) and acetamiprid (85.51%) were toxic to mustard aphid, *L. erysimi* (K.) after one day of spraying. (Gaikwad *et al.*, 2014) [9] also found that fipronil and spinosad were toxic against okra aphids, *Aphis gossypii* by exerting less survival of aphids.

The treatments methyl-o- demeton and acetamiprid recorded 82.50%, 78.75% mortalities, respectively and were at par with the treatment fipronil. Chlorfenapyr was the next best treatment with 70% mortality. Whereas, spinosad was at par with chlorfenapyr and it was the least effective (60%) insecticide against aphids after one day of spraying. Earlier, (Sahoo, 2012) [27] also reported that based on aphid population/10cm apical twig dimethoate was most effective insecticide with 14.3, 5.33 and 2.5 aphids/10cm apical twig followed by oxydemeton-methyl with 14.97, 5.4 and 2.4 aphids/10cm apical twig after 3, 7 and 10 days of spraying, respectively.

In the present studies methyl-o-demeton was the second best insecticide against mustard aphid. (Nayak, 2012) [18] noted that oxydemeton methyl was most effective insecticide with average aphid population per 10 cm twig 5, 9.4, 13.3 and 35.7 after 1 day, 3, 7 and 15 days of spraying, respectively. (Chandra *et al*., 2014) [7] also gave the ranking of insecticides based on mean mustard aphid intensity was imidacloprid (10.7) < acetamiprid (11.5) < dimethoate (11.9) < thiamethoxam (12.0) < clothianidin (12.3) < fipronil (12.7), however spraying of spinosad significantly shows higher aphid intensity.

Conclusion

The data on mean aphid mortality on *Gobhi sarson* leaves and twigs revealed that Acetamiprid was most effective insecticide and spinosad was the least effective against mustard aphid Based on persistent toxicity values acetamiprid was found as the most persistent insecticide and spinosad was the least persistent insecticide and the order of persistent toxicity (PT) of different insecticides on *Gobhi sarson* leaves and twigs against mustard aphid was acetamiprid (612.9) > methyl-o-demeton (593.8) > fipronil (530.4) > chlorfenapyr (482.8) > spinosad (459.2).

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