Indian Journal of Agricultural Sciences **82** (10): 845–51, October 2012

Bio-efficacy of imidacloprid and bifenthrin against mustard aphid (*Lipaphis erysimi*) on *Brassica rapa* subsp *oleifera*

ANJUMONI DEVEE[1] and A A L H BARUAH[2]

Assam Agricultural University, Jorhat 785 013

Received: 5 April 2011; Revised accepted: 22 June 2012

ABSTRACT

The efficacy, relative toxicity, residual toxicity and dissipation behaviour of imidacloprid and bifenthrin were evaluated against mustard aphid [*Lipaphis erysimi* (Kalt.)] during 2006-07 and 2007-08. Imidacloprid (RiBo 17.8 SL @ 20, 40 and 60 g ai/ha), bifenthrin (Marker 20 per cent EC @ 60, 80 and 100 g ai/ha) and deltamethrin (as standard check) (Decis 2.8 per cent EC @ 15 g ai/ha) were evaluated against mustard aphid, *Lipaphis erysimi* (Kalt.) and was found effective in reducing the aphid population in comparision to control. The highest mortality of aphids and marketable yield was registered by imidacloprid @ 60 g ai/ha, while highest cost benefit ratio was found in imidacloprid @ 20 g ai/ha and proved sufficient to optimize the yield. The LC_{50} values were 0.00017 and 0.00015 for imidacloprid, 0.00152 and 0.00122 for bifenthrin, 0.00199 and 0.00134 for deltamethrin, after 24 and 48 hr of treatment, respectively. Imidacloprid was 8.93 times and bifenthrin 1.10 times more toxic than deltamethrin after 48 hr of treatment. For evaluation of persistence and residual toxicity of imidacloprid the mortality data were taken up to 48 hr, within different exposure periods of 1, 3, 5, 10 and 15 days after application of insecticides. Based on the index of persistence toxicity, the order of effectiveness for the *L. erysimi* were imidacloprid @ 60 g a.i/ha (1014.23)> imidacloprid @ 40 g a.i/ha (931.37) > imidacloprid @ 20 g a.i/ha (820.41)> deltamethrin 15 g a.i/ha (707.93)> bifenthrin @ 100 g a.i/ha (659.76)> bifenthrin @ 80 g a.i/ha (611.12)>bifenthrin @ 60g a.i/ha (545.25). The dissipation behaviour of imidacloprid under field condition on *Brassica rapa* L. subsp. *oleifera* (toria) crop was studied in tender shoots and seeds. The initial deposits of imidacloprid @ 20, 40 and 60 g a.i /ha were 0.830, 1.126 and 1.280, respectively. Imidacloprid residues reached below its detectable level after 5th and 10th day of its application at lower and higher rates. The half life values were 1.44, 1.96, 1.67 days for imidacloprid @ 20, 40 and 60 g a.i/ha, respectively. Based on the observations, a waiting period of at least four days after imidacloprid application @ 20 g a.i/ha is considered safe from point of health hazards due to toxic effect of residues in leaves.

Key words: Bifenthrin, Dissipation, Efficacy, LC_{50}, Imidacloprid, *Lipaphis erysimi*, Persistence

In India, rapeseed-mustard is an important group of edible oilseed crops, second only to groundnut and contributes around 26.1 per cent of the total oilseed production. Out of 61.63 mt of rapeseed-mustard seed produced over 31.02 m ha in the world, India produced 7.20 mt from 6.19 m ha (FAO 2011). Mustard aphid [*Lipaphis erysimi* (Kalt.)] is the most serious insect-pest causing significant yield losses (35.4 to 73.5 per cent) in oilseed Brassicas (Mishra and Agarwal, 1992; Kumar 2004). It is difficult to manage by commonly used insecticides because most of them are associated with undesirable traits and due to high reproductive potential of the aphid (Lal 1996).

Imidacloprid and bifenthrin are insecticides that posses potent insecticidal properties against a number of insect pests (Chinniah and Ali 2000; Singh and Singh 2001). Looking to the economic importance of the pest, for avoiding yield losses and harmful effect of conventional chemicals and to encourage the production, productivity of oilseed Brassicas, the present investigation was carried out with various concentrations of imidacloprid, bifenthrin along with deltamethrin as standard check.

MATERIALS AND METHODS

Field experiments were conducted to evaluate the efficacy of imidacloprid and bifenthrin on mustard aphid, *L. erysimi* at Instructional Cum Research farm (26°44´ N, 94°10´ E) laboratory experiment was conducted in Pesticide Residue Laboratory, Department of Entomology, Assam Agricultural University, Jorhat, Assam during 2006–07 (sown on 22nd November, 2006) and 2007-08 (sown on 27th November, 2007) using variety M 27 of *Brassica rapa* L. subsp *oleifera* (toria). The experiment was laid out with eight treatments in

[1]Assistant Professor (e mail: amdevee@gmail.com), [2]Principal Scientist (e mail: adil_baruah@yahoo.com), Department of Entomology

three replications in Randomized Block Design. Each plot measured 5 m × 7 m with plants spaced at 10 cm intervals in rows 30 cm apart. Recommended doses of N and P fertilizers (Anonymous 2009) were applied. At the crop stage of 50 per cent flowering or on appearance of the pest (48 days after sowing), the crop was sprayed with imidacloprid @ 20 g, 40 g, 60 g ai/ha, bifenthrin @ 60 g, 80 g, 100 g ai/ha, deltamethrin @15 g ai/ha and water (control). For recording the aphid population, sampling technique as described by Singh *et al.* (1989) was followed. From each plot 10 plants were randomly selected and aphid count was made *in situ* from the top 10 cm shoots. Pre and post count was made at 1 day before spraying and 1 and 7 days after spraying. Crops were harvested 94 (2007) and 98 (2008) days after sowing. Yield was recorded separately at harvest. The benefit-cost ratio was worked out by deducting the value of the yield over control and dividing it by the total cost of expenditure over control. In the year 2006–07, the range of maximum and minimum temperature was 18.6°-22.9° (and 7.5°-13.4°) respectively. The relative humidity was 95-99% (morning) and 70-86% (afternoon) and the sunshine hour was 1.6-8.0.

In next year the range was more or less similar. The maximum and minimum temperature was 18.6^0-23.7° (and 7.5°-12.8°) respectively (2007-08). The relative humidity was 93-99% (morning) and 71-88% (afternoon) and the sunshine hour was 1.6-7.3.

For the laboratory study, insects were reared on potted toria plants. A stock culture of aphid was maintained in the laboratory on toria plants. The plants were grown in pots (50 cm × 38 cm) and standard agronomic practices (Anonymous 2009) were followed. For determination of LC_{50} values the stock solution of known strength of the insecticides was prepared in acetone from the technical grades. Subsequent concentrations of the insecticides were prepared from the stock solution following flow chart. Insecticides were applied in the form of a dry film, deposited on the inner surface of the test tube (20 cm × 2.5 cm dia) (Gupta and Rawlin 1966). Thin, uniform film of insecticide was prepared by taking 1 ml of insecticide solution in a test tube and rotated till dryness. Toxicity was determined against 4th instar nymphs of *L. erysimi* in four replications for each treatment, maintaining appropriate control with 20 nymphs in each replication. The tubes were kept in incubator (28° ± 2°C) and after 24 and 48 hr mortality was noted. If there was mortality in control, the per cent mortalities were corrected using Abbott's (1925) formula. The doses mortality data were subjected to Probit analysis to find out LC_{50} values. Relative toxicity was calculated by taking LC_{50} value of deltamethrin as unity. Because, deltamethrin is recommended in rapeseed against *L. Erysimi* and it is under the same group of test insecticide bifenthrin.

From the field, the top shoot portion (10-15 cm) of three random plants of each plot were cut after 1, 3, 5, 10 and 15 days of spraying and kept in specimen tube (10 × 3.75 cm dia). Each tube contained 10 aphids (4th instar) from stock culture and three tubes made one replication. Observations on mortality were recorded after 24 and 48 hr exposure periods. The data on observed mortality was corrected following Abbott's formula (1925). Zero and cent per cent were subjected to formula ¼ n (Steel and Torrie 1960). Persistence toxicity (PT) values were calculated from corrected mortality data as per the method given by Sarup *et al.* (1970). By using these PT values as base, relative persistence of toxicity (RPT) values were calculated by taking the PT values of deltamethrin as unity.

For determination of dissipation behaviour, samples of toria leaves and siliqua (50 g) were collected from control and treated plots of each treatment at 0, 1, 3, 5, 10 and 15 days after application of insecticide and at harvest for estimating residues in seeds. Leaves and grains were fortified with imidacloprid, bifenthrin and deltamethrin @ 1.0 and 2.0 μg g^{-1} level separately. For imidacloprid analysis (Helal *et al.* 2005), samples were extracted by homogenization with 30 ml of distilled acetone in a mixer grinder and solid residues were extracted two more times with acetone (30 ml). The filtrate was evaporated to 15 ml by vacuum rotary evaporator. Then diluted with 150 ml of saturated aqueous sodium chloride solution and partitioned two times with 20 ml of distilled hexane, again partitioned three times (30 ml each) with dichloromethane. The dichloromethane phases were combined, passed through anhydrous sodium sulphate and evaporated to dryness. The extract was cleaned in glass column packed with 5 g of neutral alumina, mixture of activated charcoal and celite (1: 1) 5 g, between 2 g of sodium sulphate. The column was eluted with 100 ml of hexane-acetone mixture (1:1 v/v). The elute was concentrated by rotary vacuum evaporator and the residues were finally dissolved in HPLC grade acetonitrile (5 ml).

Seeds were extracted by Soxhlet using hexane: acetone mixed solvent (1:1v/v) for 4 hr and solvents were evaporated, volume adjusted by 25 ml of distilled hexane, partitioned three times with acetonitrile saturated with hexane (25 ml each). All the acetonitrile phases were collected in a 500 ml separator funnel and diluted with 300 ml of saturated saline water. It was partitioned three times with dichloromethane (30 ml each). Clean up was done as described above for leaf samples. The residues of imidacloprid were estimated employing HPLC (Nova Pack C-18 Column 4μ, 3.9×150 nm, at λ 170 wave length, acetonitrile solvent system with flow rate 1 ml min^{-1}. The retention time was 1.332 min.

RESULTS AND DISCUSSION

There was no significant difference in infestation of aphids among different treatments one day before spraying (Table 1). At one day after spraying, all the treatments registered significant effect over control. The highest reduction of population over pre-treatment count in the year 2006–07 and 2007–08 was observed in imidacloprid @ 60 g

Table 1 Effect of insecticides on aphid (*Lipaphis erysimi*) population after one and seventh day of spraying

Treatment (g ai/ha)	Average aphid population one day before spraying (no./plant)			Aphid population (no./plant)						Average of 2006–07 and 2007–08	
	2006–07	2007–08	Average of 2006–07 and 2007–08	2006–07		2007-08		Average of 2006–07 and 2007–08		Mean yield (q/ha)	Benefit cost ratio
				1 DAS	7 DAS	1 DAS	7 DAS	1 DAS	7 DAS		
Imidacloprid, 20	46.00	47.13	46.57	19.40 (–58.0)	10.97 (–76.1)	18.77 (–60.2)	11.30 (–75.8)	19.09 (–59.1)	11.14 (–76.0)	6.09	9.42:1
Imidacloprid, 40	52.37	48.73	50.55	16.63 (–68.4)	9.10 (–82.5)	12.60 (–74.5)	8.80 (–81.8)	14.62 (–71.5)	8.95 (–82.2)	6.55	8.49:1
Imidacloprid, 60	53.60	54.90	54.25	10.33 (–81.0)	6.93 (–86.7)	9.63 (–82.4)	7.73 (–85.3)	9.98 (–81.6)	7.33 (–86.0)	6.97	8.12:1
Biofenthrin, 60	49.93	51.53	50.73	26.33 (–47.9)	30.03 (–39.3)	25.30 (–51.0)	29.00 (–43.9)	25.82 (–49.4)	29.52 (–41.6)	4.81	2.20:1
Biofenthrin, 80	50.07	59.67	54.87	19.17 (–61.3)	26.03 (–48.1)	22.93 (–61.4)	29.10 (–51.2)	21.05 (–61.3)	27.57 (–49.7)	5.15	2.42:1
Biofenthrin, 100	51.80	58.63	55.22	18.63 (–64.0)	24.20 (–53.5)	20.83 (–64.6)	26.03 (–55.2)	19.73 (–64.3)	25.12 (–54.3)	5.42	2.46:1
Deltamethrin, 15	49.43	55.53	52.48	10.87 (–76.5)	23.77 (–51.3)	13.70 (–74.7)	24.97 (–55.2)	12.89 (–75.6)	24.37 (–53.3)	5.41	5.07:1
Control	47.40	51.77	49.59	51.40 (+8.3)	55.40 (+14.2)	55.60 (+6.9)	58.47 (+11.8)	53.50 (+7.6)	56.94 (+13.0)	3.53	
SEd				7.43	8.36	4.51	4.58	5.97	6.47	0.44	
CD (P=0.05)	NS	NS	NS	15.95	17.94	9.67	9.82	12.78	13.85	0.94	

Days after spraying; Data are means of 3 replications

Figures in parentheses indicate per cent increase (+) or decrease (-) in population over pre treatment control

ai/ha (80.79 and 82.39 per cent, respectively) treated plot followed by deltamethrin @ 15 g ai/ha (76.50 and 74.69 per cent, respectively). The lowest reduction of population was observed in bifenthrin @ 60 g ai/ha in both the years.

The treatments significantly affected the *L. erysimi* population seven days after spraying. All the imidacloprid concentrations significantly reduced aphid population and were statistically at par. There was no significant difference among the bifenthrin and deltamethrin treatments for aphid mortality. In control plots there were increase of 14.2 and 11.8 per cent over pre treatment counts in 2006–07 and 2007–08, respectively.

Present investigation indicated that imidacloprid treatments effectively controlled the aphid population and they were statistically at par one and seven days after spraying. This finding is in conformity with results of Kumar *et al*. (2001), Kendappa *et al*. (2002), Jain and Ameta (2006). The highest mortality in imidacloprid might be due to its translocation in appreciable amount in plant (Gajbhiye *et al*. 2000) and conversion to olefinic metabolites, which is 10 times more effective than imidacloprid (Kumar *et al*. 2000).

Imidacloprid @ 60 g ai/ha gave the significantly higher toria yield (6.94 q/ha and 7.00 q/ha) in 2006–07 and 2007–08 followed by imidacloprid @ 40 g (6.51 q/ha and 6.58 q/ha) and 20 g ai/ha (6.08 q/ha and 6.10 q/ha). Moreover, imidacloprid 20 g ai/ha registered highest cost benefit ratio (1:9.42). Therefore, imidacloprid @ 20 g ai/ha can be considered enough to optimize the yield of toria the result is supported by the previous findings of Kumar *et al*. (2001).

The order of toxicity with respect to LC_{50} value was as imidacloprid > bifenthrin > deltamethrin (Table 2.). The comparison with toxicity of deltamethrin indicated that imidacloprid and bifenthrin were 11.71, 8.93 and 1.31, 1.10 times more toxic than deltamethrin 24 and 48 hr after treatment. Imidacloprid was the most effective insecticide against nymph and adult stages of red cotton bug at very low concentration; the LC_{50} of imidacloprid against red cotton bug was 0.000031 (Gupta and Lal 1995). The order of toxicity observed in the present study was in conformity with that of Singh and Singh 1997, who reported the order as lambda-cyhalothrin > cypermethrin > bifenthrin > decamethrin > fenvalerate > fluvalinate > malathion > endosulfan, against grey weevil (*Myllocerous undecimpustulatus maculosus*), where bifenthrin was 1.15 times more toxic to deltamethrin. Similar comparison of toxicity between bifenthrin and deltamethrin were also reported against 3rd instar larvae of *Spodoptera litura* (Kodandaram and Dhingra 2003)

Data on per cent nymphal mortality revealed significant difference among treatments after 24 hr exposure when nymphs were fed on treated toria shoot one day after spraying (Table 3). The mortality percentage was highest (75 per cent) in imidacloprid @ 60 g a.i./ha followed by deltamethrin @ 15 g a.i./ha (73.9 per cent) and both were significantly superior over other treatments. The lowest mortality (55.7

Table 2 LC_{50} values and relative toxicity of some insecticides to 4th instar nymph of *Lipaphis erysimi* after 24 and 48 hr

Insecticide	Regression equation		Df	Standard error of regression coefficient		Heterogeneity* (x^2)		LC_{50} (%)		Fiducial toxicity		Relative toxicity		Order of toxicity	
	24 hr	48 hr		24 hr	48 hr	24 hr	48 hr	24 hr	48 hr	24 hr	48 hr	24 hr	48 hr	24 hr	48 hr
Imidacloprid	Y = 3.56 + 0.94 X	Y = 3.82 + 0.99 X	34	0.05138	0.05188	53.417	58.475	0.00017	0.00015	0.00014 0.00019	0.00013 0.00017	11.71	8.93	8.93	8.93
Bifenthrin	Y = 2.72 + 0.97 X	Y = 2.82 + 0.97 X	38	0.05940	0.05966	69.351	71.334	0.00152	0.00122	0.00133 0.00175	0.00106 0.00140	1.31	1.10	1.10	1.10
Deltamethrin	Y = 2.85 + 1.05 X	Y = 2.84 + 0.99 X	38	0.05965	0.05958	58.080	95.944	0.00199	0.00134	0.00177 0.00227	0.00115 0.00157	1.00	1.00	1.00	1.00

*In none of these cases the data were found to be significantly heterogeneous at $P = 0.05$

Y = Probit kill, X = log doseons each with 20 individuals

Mortality based on four replications each with 20 individuals

Table 3 Residual toxicity of some insecticides in rapeseed to 4th instar nymph of *Lipaphis erysimi*

Insecticide	Mean nymphal mortality (%) days after spraying										PT	RPT
	1		3		5		10		15			
	Exposure period		Exposure period		Exposure period		Exposure period		Exposure period			
	24 hr	48 hr	24 hr	48 hr	24 hr	48 hr	24 hr	48 hr	24 hr	48 hr		
Imidacloprid (20 g a.i./ha)	59.12 (50.28)	60.47 (51.07)	63.68 (53.02)	65.02 (53.82)	68.16 (55.78)	71.27 (57.71)	51.08 (45.62)	54.02 (47.33)	20.16 (26.49)	22.69 (28.35)	820.41	1.16
Imidacloprid (40 g a.i./ha)	69.31 (56.38)	70.90 (57.39)	69.31 (56.38)	73.23 (58.86)	74.94 (60.14)	80.46 (63.83)	55.63 (48.25)	58.62 (49.97)	27.01 (31.21)	27.24 (31.24)	931.37	1.32
Imidacloprid (60 g a.i./ha)	74.98 (60.00)	76.68 (61.24)	77.36 (61.86)	79.02 (63.19)	81.84 (65.08)	85.06 (67.39)	57.78 (49.64)	60.92 (51.44)	33.75 (35.50)	36.40 (37.09)	1014.23	1.43
Bifenthrin (60 g a.i./ha)	55.71 (48.28)	57.02 (49.04)	56.86 (48.95)	58.13 (49.71)	45.44 (42.36)	47.13 (43.35)	14.71 (22.38)	16.10 (23.56)	3.34 (8.71)	3.38 (8.77)	545.25	0.77
Bifenthrin (80 g a.i./ha)	61.34 (51.56)	65.11 (53.81)	62.41 (52.25)	66.26 (54.53)	47.78 (43.72)	48.28 (44.01)	18.20 (25.23)	18.39 (25.31)	5.63 (13.57)	5.67 (13.64)	611.12	0.86
Bifenthrin (100 g a.i./ha)	64.75 (53.59)	67.44 (55.25)	66.02 (54.43)	68.64 (56.20)	52.26 (46.32)	54.03 (47.35)	21.50 (27.43)	22.99 (28.48)	6.67 (12.34)	6.82 (14.81)	659.76	0.93
Deltamethrin (15 g a.i./ha)	73.91 (59.35)	76.68 (61.24)	74.87 (60.38)	76.60 (61.48)	51.11 (45.64)	52.88 (46.68)	20.39 (26.65)	21.84 (27.80)	7.85 (15.72)	7.97 (16.32)	707.93	1.00
$SE_d\pm$	1.82	2.59	4.18	4.18	5.42	4.28	3.15	3.06	4.86	3.64		
CD (*P*=0.05)	3.96	5.65	NS	NS	11.80	9.33	6.86	6.67	10.58	7.94		

Figures are average corrected mortalities of three replications

Figures in the parentheses are angular transformed value

PT = Index of persistent toxicity,RPT = Relative persistence of toxicity while taking deltamethrin as standard

per cent) was observed in bifenthrin @ 60 g a.i/ha treated shoots. After 48 h, the highest mortality was observed in imidacloprid @ 60 g a.i/ha (76.7 per cent) and deltamethrin @ 15 g a.i./ha treated (76.7 per cent) and lowest in bifenthrin @ 60 g a.i./ha (57.0 per cent) treated shoot.

After 24 hr and 48 hr exposure periods, there was no significant difference among the treatments when the nymphs were provided with treated shoots three days after spraying. This might be due to the slow action of imidacloprid (Nemade *et al*. 2007) and high initial mortality of pyrethroids (Gupta *et al*. 1995). However, the highest mortality (77.4 and 79.0 per cent) was recorded in imidacloprid 60 g a.i./ha treated shoot at 24 hr and 48 hr exposure periods, respectively, and bifenthrin 60 g a.i./ha registered the lowest mortality (56.9 and 58.1 per cent) at 24 hr and 48 hr, respectively. The highest nymphal mortality at 24 hr and 48 hr exposure periods was observed in imidacloprid 60 g a.i./ha treated shoot (81.8 and 85.1 per cent, respectively), 5 days after spraying. It was on par with mortality achieved with imidacloprid 40 g a.i. (74.9 and 80.5 per cent, respectively) but different from imidacloprid 20 g a.i./ha (68.2 and 71.3) (Table 3). It was noticed that the mortality gradually increased and reached peak at all the concentrations of imidacloprid five days after spraying, which was also reported by Nemade *et al*. (2007). After 5 days of treatment mortality of aphids at 24 hr and 48 hr exposure periods were significantly lower in bifenthrin and deltamethrin treated plots and all the pyrethroid treatments were statistically at par. The lowest mortality was observed in bifenthrin 60 g a.i./ha treated shoots (45.4 and 47.1 per cent) at 24 hr and 48 hr of exposure periods. In all the pyrethroid treatments there was decreasing order of mortality. This might be due to less persistency of pyrethroids (3-7 days) in leaves (Kalita and Rahman 1994; Chaudhury 2005). Ten days after spraying, the nymphal mortality gradually decreased in all the imidacloprid treatments. Mortality of 4th instar nymph of aphid was also significantly reduced in bifenthrin and deltamethrin treated shoots. At 24 hr and 48 hr of exposure periods yet the mortality in imidacloprid treatments were significantly higher than pyrethroid treatments. The highest mortality was recorded in imidacloprid @ 60 g a.i./ha treatment (57.8 and 60.9 per cent) at 24 hr and 48 hr exposure periods, respectively and the lowest was in bifenthrin 60 g a.i./ha treatment. At 15 days after spraying mortality in all the treatments was low. However, the imidacloprid treatment registered significantly higher mortality than pyrethroids. But, among the concentrations of imidacloprid there were no significant difference. There was also no significant difference among the different concentrations of bifenthrin as well as deltamethrin (Table 3).

Considering persistent toxicity (PT) values for insecticides under test, imidacloprid 60 g a.i./ha was found to be the

most persistent with the highest PT value and bifenthrin 60 g a.i./ha was least persistent with the lowest PT value (Table 3). The relative persistence of toxicity (RPT) calculated on the basis of PT index was considered the parameter for final comparison of residual efficacy of different insecticides against *L. erysimi*. As the deltamethrin was considered as unity for calculation of relative toxicity, so, the PT value of deltamethrin was taken as standard. Imidacloprid concentrations were more persistent than deltamethrin, whereas different concentrations of bifenthrin were less persistent (Table 3). On the basis of RPT value different treatments can be arranged in descending order as imidacloprid @ 60 g ai/ha > imidacloprid @ 40 g ai/ha > imidacloprid @ 20 g ai/ha > deltamethrin @ 15 g ai/ha > bifenthrin @ 100 g ai/ha > bifenthrin @ 80 g ai/ha > bifenthrin @ 60 g a.i./ha. The results are in tune with the findings of Patil and Lingappa (2000), who reported that imidacloprid (0.7 per cent) was persistent up to 15 days and caused 24.7 per cent mortality in adults of *Cheilomenes sexmaculatus*. It was concluded that imidacloprid provides very good control up to five days of 4th instar nymph of *L. erysimi* in comparision with deltamethrin and bifenthrin. Then the mortality gradually declined and hence, for longer protection their application needs to be repeated after 15 days.

The mean recoveries of imidacloprid from toria leaves were by and large similar to those obtained by Dikshit *et al*. (2005) from mustard herbage (80-84.6 per cent) and grains (79.5-82.4 per cent), Gopal *et al*. (2002) from mustard leaves (85-90 per cent), Dikshit *et al*. (2002) from okra (88-92 per cent) fruits, when treated with imidacloprid. The residues of imidacloprid 20, 40, 60 g a.i./ha in/on toria when sprayed for the control of *L. erysimi* are presented in Fig 1. Initial average deposit of imidacloprid 20 g a.i./ha in/on aerial parts of toria plants was 0.830 µg/g. after one day of spraying. After one day the initial deposit declined to the level of 0.494 µg/g, indicating 40.50 per cent dissipation. The residues reached to 0.254 and 0.059 µg/g after 3 and 5 days, respectively and the corresponding dissipation rate was 69.39 and 92.9 per cent. No detectable residue was found 5 days after spraying and in seed at harvest. From the above data, it can be inferred that the rate of dissipation was faster in the first day. The half life calculated was 1.44 days. Codex (FAO/WHO 2004) has proposed draft maximum residue limit (MRL) of 0.05 and 0.50 mg/kg for seed and leaves, respectively. It is evident from the data that the initial deposit was slightly higher (0.830 µg/g) than the proposed MRL. Considering the MRL, half life, initial deposit, to avoid any health hazard and to minimize any hazard from over dosing, a waiting period of 4 days may be suggested for imidacloprid @ 20 g a.i./ha.

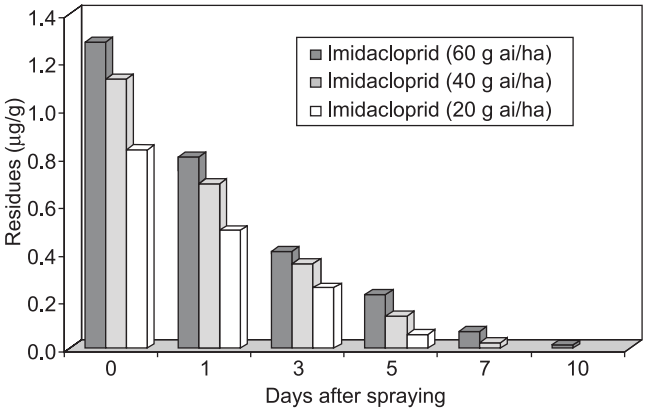

Fig 1 Residues of imidacloprid (20, 40, 60 g ai/ha) in rapeseed

The average initial deposit of imidacloprid @ 40 g a.i./ha in/on toria leaves and pods was 1.126 µg/g. The initial deposit declined to 0.689, 0.354, 0.136 and 0.025 µg/g after 1, 3, 5 and 7 days of application, respectively. The corresponding rate of dissipation was 38.8, 68.6, 87.9 and 97.8 per cent. Maximum dissipation of deposit took place in the first three days of spraying. After seven days of application residues were below detectable level and no detectable residue was present in the samples of seed drawn at harvest. The half life value calculated was 1.50 days. Considering the MRL (0.05 and 0.50 mg/kg) for seeds and leaves given by FAO/WHO (2004), it is evident from the data presented in Fig 1 that three days after spraying, the residues were below the prescribed level. To avoid any health hazard due to over dosing and keeping in view the MRL, a waiting period of five days may be suggested for imidacloprid @ 40 g a.i./ha when used on toria.

Imidacloprid @ 60 g a.i./ha residues on aerial plant parts and seeds at various time intervals after spraying had an average initial deposit of 1.280 µg/g (Fig 1). After one, three and five days, it came down to 0.800, 0.407 and 0.225 µg/g resulting in 37.5, 68.2 and 82.4 per cent dissipation. After seven and ten days, it was 0.071 and 0.013 µg/g indicating 94.4 and 99.0 per cent dissipation. No residue could be detected on 15th day of application as well as from seeds at harvest. The data also indicated that the dissipation of residues was faster in the first three days and then became slower at later stages. The half life was 1.67 days. The initial deposit was higher than the MRL values given by FAO/WHO (2004). But after three days, it became below MRL. Therefore, considering the MRL, toxicity and hazard due to over dosing, six days waiting period may be suggested as safe for toria leaves.

Gopal *et al*. (2002) reported higher initial deposit of 1.45 and 3.45 mg/kg from imidacloprid @ 20 and 40 g a.i./ha, respectively, in mustard which persisted for 16 days. The higher initial deposit of imidacloprid 1.69 and 2.56 µg/g was also observed by Battu *et al*. (2007) in cotton leaves when treated with imidacloprid @ 18 and 36 g a.i./ha that resulted in faster dissipation and became non detectable after 5th and 7th day, respectively. The present findings were more or less similar with this result. The present findings are in tune with

the work of Kharbade *et al*. (2003), who reported that the initial deposit of imidacloprid @ 100, 150 and 300 ml/ha on green chillies were 0.38, 0.56 and 1.21 ppm, which dissipated to below detectable limit of 0.05 ppm in 4.19, 5.48 and 8.16 days, respectively. The half life was 1.47, 1.54 and 1.78 days, respectively. The waiting period of 4 and 6 days for 100 and 200 ml/ha of imidacloprid was also suggested by them.

REFERENCES

Anonymous. 2009. *Package of Practices for Rabi crops of Assam*, 138 pp. Assam Agricultural University and Department of Agriculture, Assam

Battu R .S, Sahoo S K, Jyot G, Garg A and Sandhu K S. 2007. Persistence of acephate and imidacloprid on cotton leaves. *Pesticide Research Journal* **19** (1): 101–3.

Chinniah C and Ali K A. 2000. Relative efficacy of insecticides/ acaricides against sucking pests of okra. *Pest Management and Economic Zoology* **8** (2): 111–6.

Choudhury K. 2005. Efficacy of bifenthrin against tea mosquito bug, *Helopeltis theivora* Waterhouse and its dissipation in tea leaf. MSc (Agri.) thesis, Assam Agricultural University, Jorhat.

FAO (Food and Agriculture Organization). 2011. Food and Agricultural Commodities Production. In: http:// www.faostat.fao.org/site/339/default.aspx/ Accessed 09 Feb 2011, 1041 hrs IST

FAO/WHO. 2004. Codex Alimentarius Commission, Draft and revised draft maximum residue limit for pesticides (advanced to step 8 of the Codex procedure), Appendix II, 36th session of Codex Committee meeting held in India.

Gajbhiye V T, Kumar R, Gupta R K and Kalpana. 2000. Translocation and persistence of imidacloprid in tomato. *Pesticide Research Journal* **12**(1): 127–9.

Gopal M, Mukherjee I and Chander S. 2002. Behaviour of β-cyfluthrin and imidacloprid in mustard crop: Alternative insecticide for aphid control. *Bulletin of Environment Contamination and Toxicology* **68:** 406–11.

Helal A, Mukharjee I, Gopal M, Ameta O P, Patel B S and Somchoudhary A K. 2005. Multilocational field trials using imidacloprid as seed treatment to propose its MRL in mustard (*Brassica campestris* Linn.) leaves. *Pestology* **29** (7): 15–9.

JRG. 2010. Fundamental Report on R&M seed. JRG House, Ashoka Road, Kaloor, Kochi, Kerala.

Jain K L and Ameta O P. 2006. Bioefficacy of imidacloprid and betacyfluthrin against insect pests of chilli. *Pestology* **30** (1): 36–9.

Kendappa G N, Mallikarjunappa S, Sankar G and Mithyantha M S. 2002. Efficacy of some newer insecticides against green peach aphid, *Myzus persicae* (Sulzer) on tobacco. *Pestology* **26** (9): 13–4.

Kodandaram M H and Dhingra S. 2003. Comparative toxicity of ester and non-ester pyrethroids against *Spodoptera litura* (Fab.). *Pesticide Research Journal* **15** (1): 23–5.

Kharbade S B, Kale V D and Dethe M D. 2003. Residues of imidacloprid on chillies. *Pestology* **2** (1): 18–19.

Kumar R, Dikshit A K and Dureja P. 2000. Metabolism of imidacloprid in *Brassica*. *Pesticide Research Journal* **12** (1): 91–5.

Kumar R, Dikshit A K and Prasad S K. 2001. Bioefficacy and residues of imidacloprid in mustard. *Pesticide Research Journal* **13** (2): 213–7.

Kumar A. 2004. Build up of *Lipaphis erysimi* (Kalt) on mustard crop. *Insect environment*. **10** (1): 21–2.

Lal O P. 1996. Integrated pest management for sustainable crop production. (*In*) *Agrochemicals and Sustainable Agriculture,* pp 29–44. Roy N K (Ed.). APC Publication Pvt Ltd, New Delhi.

Nemade P W, Wadnerkar D W, Shinde B D, Bansod R S and Zanwar P R. 2007. Evaluation of seed treatment and foliar application effects of imidacloprid against sucking pests of okra. *Pestology* **31**(3): 23–8.

Patil C S and Lingappa S. 2000. Persistent toxicity of imidacloprid to *Cheilomenes sexmaculata* (Fabricius). *Insect Environment* **6** (2): 68–9.

Singh D S and Singh J P. 1997. Relative toxicity of pyrethroid and non pyrethroid insecticides to the adults of grey weevil, *Myllocerus undecimpustulatus maculosus*. *Indian Journal of Entomology* **59** (4): 354–8.

Singh N N, Prasad M N, Rai V N.1989. Population fluctuation of *Lipaphis erysimy* (Kaltenback) in relation to abiotic factors. *Journal of Aphidology* **3**: 102–8.

Singh J P and Singh D S. 2001. Relative efficacy of some insecticides and biopesticides as contact poisons against green peach aphid, *Myzus persicae*. *Indian Journal of Entomology* **63** (3): 240–3.

Steel R G D and Torrie J H. 1960. *Principle and procedures of Statistics,* 481 pp. McGraw-Hill Book Company INC, New York.