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Original Research Article

Comparative Toxicity of Insecticides against Two Important Insect Pests of Cauliflower Crop

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Abstract

Study was conducted to test four insecticides, profenofos, emamectin benzoate, λ-cyhalothrin and lufenuron against two field populations of *Plutella xylostella and Spodoptera litura* at different larval instars during 2010-11. The field populations collected from Rawalpindi and Taxila cauliflower fields was tested using leaf dip bioassay method under laboratory conditions. Results showed that emamectin benzoate was the most toxic insecticide for both *P. xylostella* and *S. litura*. However, profenofos was the second most toxic insecticides to different larval instars of *S. litura* and λ-cyhalothrin to *P. xylostella*. High LC_{50} values for lufenuron for this limited time exposure might be due to its slow acting as chitin synthesis inhibitor. Emamectin benzoate can be suggested as the most effective insecticides against both field populations along with profenofos and λ-cyhalothrin.

Keywords: *Spodoptera litura*, *Plutella xylostella*, comparative toxicity, mode of action, age-dependent

Introduction

Cruciferous family especially cabbages and cauliflowers are the most important winter vegetables grown extensively in temperate and tropical areas of the world (Liu et al., 2003). Two lepidopteran insects, Diamondback moth diamondback moth (DBM) (*Plutella xylostella* L.) and tobacco caterpillar (*Spodoptera litura* Fab.) are the most destructive insect pest of cruciferous plants mostly for cabbage and cauliflower over the world (Shankar et al., 1996; MalliKarjuna et al., 2004). They feed mainly on leaves resulting in reduced superiority and quantity of food. Its serious attack can cause 30-100% crop failure if no insecticide is used for its management (Verkerk and Wright, 1996). Frequently usage of insecticides for long period, they have developed resistance against many insecticides which make it prominent insect pest in one of the 20 resistant insect species (Shelton et al., 2000; Mota-Sanchez et al., 2002). Variation in detoxification enzymes activity among *S. litura* strains could be attributed due to insecticide usage pattern (Karuppaiah et al., 2017).

Selection of insecticide for the management of diamondback moth (DBM) and tobacco caterpillar required continuous testing under both field and laboratory condition, so it is important to select appropriate insecticide according to insect pest. Many insecticides having longer residual action on plants or insects like prothiophos, cartap and fenvalerate mixture are suitable for their management (Nakagome and Kato, 1981). Organophosphates have been considered as the most important group of insecticide due to variations in chemical structures (Liu et al., 2003). In Pakistan farmers relay only on insecticides to control insect pests and due to indiscriminate use of insecticides against *S. litura* resistance problems occurred (Tong et. al., 2013; Basit et al., 2013). Commonly used insecticides against *S. litura* showed that resistance ratios were high for endosulfan, cypermethrin, profenofos, chlorpyriphos, quinalphos, phoxim, triazophos, methomyl or thiodicarb and low to medium for deltamethrin and β-cyfluthrin (Mushtaq et al., 2008). One of the major reasons for the development of resistance to insecticides by DBM is the increase in number of sprays. Farmer still uses the broad spectrum pyrethroids, organophosphates, organochlorines and many other conventional insecticides against DBM (Kumar, 1995). Eco-friendly and less toxic new insecticides are also available in the market. (Vastrad et al., 2003) reported that thiodicarb, fipronil, lufenuron, spinosad, carbosulfan and indoxacarb are still performing well as compared to malathion. In Malaysia, high uses of abamectin in crucifer crops against diamondback moth have developed serious problem of resistance (Verkerk and Wright, 1996). To find out most effective insecticide and information about insecticide availability in future this study was planned by using conventional insecticides at different stages of diamondback moth and tobacco caterpillar.

Materials and Methods

Field collection

Two field populations of *S. litura* and *P. xylostella* were collected from Rawalpindi and Taxila cauliflower/cabbage fields during 2010-11. Larvae and eggs were collected and kept in plastic jars along with host plant leaves for their safe transport to laboratory and kept separately from previously tested for initial susceptibility levels.

Laboratory rearing of DBM

The larvae were kept at 25±2°C, 65%RH and 16 hour photophase in plastic jars (1 kg) on cauliflower leaves. Pupae were collected daily and provided with 10% honey solution at adult stage. Two to three fresh leaves of cauliflower were provided on daily basis for eggs laying. Bioassays were performed after completion of one generation laboratory rearing to reduce field residual effect and to get sufficient number of larvae for bioassays.

Laboratory rearing of tobacco caterpillar

Fields collected larvae were reared on semi-synthetic gram-based diet in the laboratory at 25±2˚C and 60-65% relative humidity with a light (16 h): dark (8 h) photoperiod (Ahmad et al., 2007a). Small pieces of diet were put in six hole petri dishes and larvae were released on it, one larvae in each hole was placed under controlled laboratory condition. Diet was changed after 24 hour and pupae were collected on alternative days. Cells of petri dishes were cleaned for rearing of larvae till pupation. Mature pupae were collected and kept in separate plastic box lined with tissue paper. Emerged adults were kept in plastic jars and fed on a solution containing sucrose, vitamin solution in a soaked cotton wool ball (Ahmad et al., 2007b). Egg batches were collected daily and larval instars in next generation were used for bioassays.

Bioassays

Four commercial insecticides, λ-cyhalothrin (Karate® 2.5EC; Syngenta (Pvt) Ltd, Pakistan), profenofos (Curacron® 50EC; Syngenta (Pvt) Ltd, Pakistan), emamectin benzoate (Proclaim® 1.9EC, Syngenta (Pvt) Ltd, Pakistan) and lufenuron (Match® 05EC, Syngenta (Pvt) Ltd, Pakistan) were used. Top Film® (Helb Pesticides (Pvt) Ltd, Pakistan) as a surfactant was used at 5 ppm for increased adhesiveness to leaf surface in preparation of insecticide solutions and also in control. Standard leaf disc bioassay method (Sayyed et al., 2008: Ahmad et al., 2007a) was used during bioassay. Leaves of cauliflower crop collected from unsprayed fields, washed with water, dried and immersed in a test solution for 10-15 second and then allowed to dry at room temperature for one hour. After drying, the leaf discs were placed in petri dishes containing moistened filter paper.

Data analysis

Mortality rate of *S. litura* and *P. xylostella* were examined after 48 and 72 hours of insecticide exposure. Insects were considered as dead when they failed to show any movement with gentle touch with blunt needle. Abbott's formula was used to calculate the corrected mortality (Abbott, 1925) and analyzed by Probit analysis (Finney, 1971) using POLO-PC software (LeOra software, 1987). These values were compared from significance difference for these insecticides at particular age level and for different populations under study of *p. xylostella* and *S. litura* (Travis and Rick, 2000).

Results and Discussion

Comparison of LC_{50} values of four insecticides, profenofos, emamectin benzoate, λ-cyhalothrin and lufenuron against first instar larvae of *P. xylostella* population collected from Taxila revealed that emamectin benzoate to be the most effective insecticide with least LC_{50}(0.79 and 0.59) value after 48 and 72 hours, respectively follow by λ-cyhalothrin**,** profenofos and lufenuron. Similarly at 2nd and 3rd larval instars of Taxila population, lufenuron was most toxic insecticide with least LC_{50} (0.73, 0.40 and 0.60, 0.48) respectively after 48 and 72 hours. At 3rd instars larvae of Taxila population profenofos was most effective with least LC_{50} (0.82 and 0.63) respectively (Table 1).

The results at Rawalpindi populations showed that profenofos was most effective insecticides against 1st and 3rd instars larvae with least LC_{50} (0.41, 0.36 and 0.74, 0.57 respectively) and lufenuron was less effective with high LC_{50} values. Similarly at 2nd instars larvae emamectin benzoate was most effective (Table 1). Overall results revealed that among these four insecticides against *P. xylostella* profenofos was most effective with least CF1 and CF2 values (Table 1).

Comparison of LC_{50} values of four insecticides against first instar larvae of *S. litura* population collected from Taxila revealed that emamectin benzoate was most effective against 1st (0.03 and 0.02), 2nd (0.23 and 0.16), 3rd (0.89 and 0.66), and 4th(2.38 and 1.83) instars larvae after 48hr and 72hr respectively with least $LC_{50.}$ Similar result was found from Rawalpindi population that emamectin was most effect against 1st, 2nd, 3rd, and 4th (0.05 and 0.04, 0.13 and 0.09, 1.57 and 0.93, 2.01 and 1.79 after 48hr and 72hr respectively) instars larvae (Table 2). Overall results showed that emamectin benzoate was most effective on both field collected population of Rawalpindi and Taxila after 48hr and 72hr with least LC_{50} and CF1 and CF2 values (Table 2).

Overall finding of these four insecticides on both tested insect *Plutella xylostella* and *Spodoptera litura* showed that emamectin benzoate was most effective with least CF3 values (Table 2). Comparison of these four insecticides revealed that lufenuron was most effective at Taxila population and profenofos at Rawalpindi population of *P. xylostella*, similarly emamectin benzoate was most effective at both population of *S. litura* collected from Taxila and Rawalpindi (Table 1, 2).

Susceptibility level of the tested populations was comparatively more than that used by as local reference strain (Rafiq, 2005). This might be the variation in the less use of these insecticides due to less incidence of *P. xylostella* for the last couple of years. The number of application may have decreased on cauliflower and cabbages due to less population pressure, and less exposure may have resulted in number of susceptible individuals in the field population. This could be the possible reason for the increase in susceptibility to these insecticides, and the variation in different larval instars with non-significant variation might be due to this susceptibility (Mazlan and Mumford, 2005; Ronald et al., 2000)

Variation in susceptibility to insecticides is considered as an important factor in different population of insect pests (Mohan and Gujar, 2003; Rafiq, 2005). In most of these resistance cases, insecticide to insecticides is compared to the LC_{50} or mortality values of these with a reference population either for laboratory or field studies (Sexena et al., 1989; Vastrad et al., 2003). This helps to identify the crop areas with susceptible to resistant populations. Information regarding less resistance to the tested *P. xylostella* in field populations can be utilized for area-wide management of this important insect pest. It also foresee the importance of insecticide monitoring especially at the second instar larvae of *P. xylostella* collected from different ecological and cropping zones for establishment of management practices as per different requirements of the cruciferous growers.

Comparison to the reference strains (Ahmad, 2008) proved the field population tested to be more susceptible as compared to that of cotton areas where this pest is under intense selection with indiscriminate use of insecticides (Khan and Mehmood, 1999). The reason may be less use of insecticides and small land holding of vegetable growers in the collection areas of Rawalpindi and Taxila cropping fields. Increase in susceptibility might be due to less population pressure of this insect pest on different vegetable grown in this area that may have resulted in decreased selection pressure with non-significant susceptibility variation (Sayyed et al., 2000; Ahmad, 2009). However, there existed quite variable response for different instars tested for these insecticides which might be their distinct variability in size, feeding potential and exposure rate.

Information of susceptibility to emamectin benzoate and profenofos suggests their use for management of this important insect pest in vegetables especially cauliflower and cabbages. This can also be utilized for other crop growing areas especially where cash crop like cotton are under intensive cultivation and need to be relied on chemical control. However, other insecticides like cyhalothrin and thiamethoxam were proved to be ineffective when used for this pest. Although increased dose rate may be helpful but it will be uneconomical in field situations and become source of more environmental pollution. Lufenuron may be considered either alone or in combination with these insecticides and binary combination of these effective insecticides with this insect growth regulator may also be tested for extraction of further possibilities of more options for pest management.

Table 1: Toxicity of four different insecticides to four larval instars of field collected diamondback moth, *Plutella xylostella* L. under laboratory conditions using leaf dip bioassay method

Insecticide	strain	Instars	Time	LC_{50} (FL at 95%)	LC_{90} (FL at 95%)	Slope ± SE	CF1	CF2	CF3
Profenofos	TXL	1st	48	1.57 (0.79-2.26)	4.86 (3.33-10.5)	2.60±0.65	3.83	3.83	52.3
			72	1.06 (0.44-1.53)	2.78 (1.98-5.38)	3.06±0.87	2.92	2.94	53
		2nd	48	0.85 (0.48-1.22)	3.25 (2.21-6.26)	2.19±0.44	2.07	2.07	28.3
			72	0.79 (0.46-1.09)	2.34 (1.68-4.05)	2.73±0.57	2.19	2.19	39.5
		3rd	48	0.80 (0.41-1.28)	7.62 (4.16-24.0)	1.31±0.25	1.95	1.95	26.6
			72	0.63 (0.30-1.00)	4.55 (2.72-11.3)	1.49±0.29	1.75	1.75	31.5
		4th	48	1.05 (0.64-1.95)	27.1 (9.42-394)	0.91±0.22	2.56	2.56	35
			72	0.76 (0.33-1.31)	11.3 (5.23-59.7)	1.09±0.24	2.11	2.11	38
	RWP	1st	48	0.41 (0.14-0.75)	5.24 (2.72-19.9)	1.16±0.26	1	1	13.6
			72	0.36 (0.14-0.62)	2.33 (1.41-5.49)	1.59±0.34	1	1	18
		2nd	48	1.03 (0.41-1.75)	9.15 (4.57-51.2)	1.35±0.34	2.51	2.51	34.3
			72	0.82 (0.32-1.36)	6.63 (3.57-27.5)	1.41±0.34	2.27	2.27	51.5
		3rd	48	0.74 (0.32-1.29)	14.8 (6.21-108)	0.99±0.22	1.80	1.80	24.6
			72	0.57 (0.18-1.05)	8.37 (3.93-45.4)	1.09±0.26	1.58	1.58	28.5
		4th	48	1.49 (0.85-2.65)	29.8 (11.1-283)	0.99±0.21	3.63	3.63	49.6
			72	0.94 (0.40-1.69)	16.9 (6.98-135)	1.02±0.23	2.61	2.61	47
Emamectin Benzoate	TXL	1st	48	0.79 (0.31-1.32)	6.23 (3.41-24.4)	1.43±0.35	1.21	1.92	26.3
			72	0.59 (0.28-0.89)	2.31 (1.56-4.63)	2.19±0.49	1.11	1.64	29.5
		2nd	48	0.78 (0.43-1.15)	3.89 (2.52-8.51)	1.83±0.36	1.2	1.90	26

			72	0.55 (0.23-0.87)	3.19 (1.99-7.79)	1.68±0.37	1.03	1.53	27.5
		3rd	48	1.24 (0.62-2.20)	23.0 (9.03-204)	1.00±0.22	1.90	3.02	41.3
			72	0.88 (0.39-1.53)	13.7 (6.09-84.2)	1.07±0.24	1.66	2.44	44
		4th	48	1.63 (0.53-4.86)	111 (19.4-113069)	0.69±0.22	2.50	3.97	54.3
			72	1.11 (0.25-2.94)	73.3 (14.3-52157)	0.70±0.23	2.09	3.08	55.5
	RWP	1st	48	0.89 (0.37-1.59)	13.9 (6.06-89.9)	1.07±0.24	1.37	2.17	29.6
			72	0.70 (0.27-1.26)	7.82 (3.90-32.8)	1.22±0.27	1.32	1.94	35
		2nd	48	0.65 (0.15-1.23)	9.57 (4.19-113)	1.09±0.31	1	1.58	21.6
			72	0.53 (0.12-0.99)	6.67 (3.25-47.6)	1.17±0.32	1	1.47	26.5
		3rd	48	0.94 (0.37-1.73)	15.1 (6.40-114)	1.06±0.25	1.44	2.29	31.3
			72	0.67 (0.24-1.21)	8.20 (4.03-37.8)	1.18±0.27	1.26	1.86	33.5
		4th	48	2.90 (1.46-9.65)	145 (27.1-31505)	0.76±0.21	4.46	7.07	96.6
			72	1.59 (0.63-4.19)	98.3 (19.1-29894)	0.72±0.21	3	4.41	79.5
λ-cyhalothrin	TXL	1st	48	1.26 (0.71-1.89)	7.08 (4.21-19.7)	1.71±0.35	1.93	3.07	42
			72	0.81 (0.33-1.28)	3.56 (2.27-84.6)	1.99±0.48	1.45	2.25	40.5
		2nd	48	0.88 (0.46-1.35)	4.51 (2.84-10.7)	1.82±0.38	1.35	2.14	29.3
			72	0.78 (0.36-1.15)	2.48 (1.71-4.77)	2.54±0.61	1.39	2.16	39
		3rd	48	1.29 (0.55-2.39)	19.4 (7.96-162)	1.08±0.26	1.98	3.14	26
			72	1.00 (0.39-1.79)	11.2 (5.36-56.3)	1.22±0.28	1.78	2.78	50
		4th	48	1.19 (0.52-2.31)	34.8 (11.0-738)	0.87±0.22	1.83	2.90	39.6
			72	0.92 (0.35-1.74)	17.6 (6.96-170)	1.00±0.24	1.64	2.55	46
	RWP	1st	48	0.65 (0.31-1.05)	6.36 (3.51-19.6)	1.29±0.25	1	1.58	21.6
			72	0.56 (0.25-0.90)	3.40 (2.10-7.80)	1.63±0.33	1	1.55	28
		2nd	48	1.63 (0.82-2.62)	10.5 (5.63-46.4)	1.59±0.38	2.51	3.97	54.3
			72	0.94 (0.31-1.68)	12.1 (5.28-136)	1.15±0.32	1.68	2.61	47
		3rd	48	1.08 (0.43-2.14)	28.8 (9.58-548)	0.89±0.23	1.66	2.63	36
			72	0.78 (0.30-1.40)	11.4 (5.19-66.6)	1.10±0.25	1.39	2.16	39

		4th	48	1.91 (0.73-6.27)	152 (23.8-233875)	0.67±0.21	2.94	4.65	63.6
			72	0.91 (0.27-1.98)	57.7 (13.1-9231)	0.71±0.21	1.62	2.53	45.5
Lufenuron	TXL	1st	48	1.63 (0.87-2.40)	6.00 (3.93-14.2)	2.26±0.53	2.71	3.97	54.3
			72	1.34 (0.58-1.96)	3.82 (2.65-7.88)	2.81±0.76	3.35	3.72	67
		2nd	48	0.73 (0.24-1.28)	5.33 (2.93-20.9)	1.49±0.38	1.22	1.78	24.3
			72	0.40 (0.08-0.76)	3.53 (1.94-14.6)	1.36±0.38	1	1.11	20
		3rd	48	0.60 (0.20-1.13)	19.5 (6.95-297)	0.85±0.21	1	1.46	20
			72	0.48 (0.16-0.87)	9.15 (4.17-54.6)	1.00±0.23	1.2	1.33	24
		4th	48	1.34 (0.59-2.64)	30.1 (10.3-475)	0.95±0.23	2.23	3.26	44.6
			72	0.99 (0.38-1.81)	12.6 (5.73-74.6)	1.16±0.27	2.47	2.75	49.5
	RWP	1st	48	0.68 (0.34-1.09)	7.04 (3.82-22.3)	1.27±0.24	1.13	1.66	22.6
			72	0.54 (0.29-0.83)	2.97 (1.92-6.09)	1.74±0.32	1.35	1.5	27
		2nd	48	0.91 (0.32-1.59)	10.8 (4.92-92.7)	1.19±0.32	1.51	2.22	30.3
			72	0.76 (0.26-1.28)	7.99 (3.95-48.9)	1.24±0.32	1.19	2.11	38
		3rd	48	1.35 (0.55-2.81)	37.5 (11.5-1003)	0.88±0.23	2.25	2.92	45
			72	0.76 (0.23-1.50)	15.4 (6.02-167)	0.98±0.25	1.19	2.11	38
		4th	48	2.92 (1.23-9.69)	107 (22.1-26131)	0.82±0.24	4.86	7.12	97.3
			72	1.77 (0.64-4.81)	82.8 (17.5-20368)	0.77±0.23	4.43	4.92	88.5

CF1, compared with least value of each insecticide separately for each test insect
CF2, compared with least value of all insecticides for each insect separately
CF3, compared with least value of all insecticides of both test insects
TXL= Taxila
RWP= Rawalpindi

Table 2: Toxicity of four different insecticides to four larval instars of field collected, *Spodoptera litura* L. under laboratory conditions using leaf dip bioassay method

Insecticide	strain	Instars	Time	LC$_{50}$ (FL at 95%)	LC$_{90}$ (FL at 95%)	Slope ± SE	CF1	CF2	CF3
Profenofos	TXL	1st	48	1.81 (0.63-1.79)	28.3 (11.8-142)	0.91±0.15	2.82	60.3	60.3
			72	0.57 (0.31-0.89)	7.32 (4.15-18.5)	1.15±0.18	1.63	28.5	28.5
		2nd	48	2.21 (1.38-3.27)	32.1 (18.4-74.8)	1.10±0.14	3.45	73.6	73.6
			72	1.51 (0.84-2.34)	16.0 (9.91-32.4)	1.25±0.17	4.31	75.5	75.5
		3rd	48	2.57 (1.51-3.84)	22.5 (14.1-45.1)	1.36±0.19	4.01	85.6	85.6
			72	2.02 (1.04-3.15)	15.9 (10.2-31.0)	1.43±0.22	5.77	101	101
		4th	48	16.2 (8.84-27.0)	386 (167-1829)	0.93±0.16	23.3	540	540
			72	12.1 (6.19-20.1)	185 (95.9-587)	1.08±0.18	34.6	605	605
	RWP	1st	48	0.64 (0.38-0.95)	6.14 (3.80-12.7)	1.30±0.18	1	21.3	21.3
			72	0.35 (0.19-0.54)	4.61 (2.74-10.0)	1.14±0.16	1	17.5	17.5
		2nd	48	1.98 (1.15-3.10)	42.1 (21.8-120)	0.91±0.12	3.09	66	66
			72	0.57 (0.30-0.89)	7.34 (4.59-14.5)	1.16±0.16	1.63	19	19
		3rd	48	1.39 (0.86-2.04)	16.9 (10.5-34.6)	1.18±0.15	2.17	46.3	46.3
			72	0.62 (0.31-0.98)	7.68 (4.77-15.3)	1.17±0.17	1.77	31	31
		4th	48	10.5 (5.72-17.2)	263 (123-928)	0.92±0.14	16.4	350	350
			72	7.23 (3.81-11.7)	120 (65.7-308.4)	1.05±0.15	20.6	361	361
Emamectin Benzoate	TXL	1st	48	0.03 (0.02-0.04)	0.37 (0.22-0.81)	1.20±0.15	1	1	1
			72	0.02 (0.01-0.04)	0.23 (0.15-0.45)	1.38±0.19	1	1	1
		2nd	48	0.23 (0.14-0.36)	2.95 (1.62-8.07)	1.17±0.18	7.66	7.66	7.66
			72	0.16 (0.08-0.24)	1.59 (0.95-3.59)	1.28±0.19	8	8	8
		3rd	48	0.89 (0.58-1.28)	9.92 (5.75-23.5)	1.22±0.16	29.6	29.6	29.6
			72	0.66 (0.39-0.97)	4.69 (3.06-8.97)	1.51±0.22	33	33	33
		4th	48	2.38 (1.50-3.52)	30.5 (17.9-68.3)	1.15±0.14	79.3	79.3	79.3
			72	1.83 (1.00-2.85)	18.9 (11.6-38.9)	1.27±0.18	91.5	91.5	91.5

	RWP	1st	48	0.05 (0.02-0.06)	0.61 (0.34-1.49)	1.08±0.19	1.66	1.66	1.66
			72	0.04 (0.01-0.05)	0.35 (0.21-0.77)	1.38±0.23	2	2	2
		2nd	48	0.13 (0.07-0.20)	2.22 (1.21-5.69)	1.05±0.15	4.33	4.33	4.33
			72	0.09 (0.04-0.15)	0.09 (0.78-3.29)	1.09±0.16	4.5	4.5	4.5
		3rd	48	1.57 (0.86-2.49)	31.7 (16.9-85.3)	0.98±0.14	52.3	52.3	52.3
			72	0.93 (0.50-1.45)	13.4 (8.00-28.7)	1.10±0.15	46.5	46.5	46.5
		4th	48	2.01 (1.09-3.25)	34.6 (18.6-91.5)	1.04±0.15	67	67	67
			72	1.79 (0.92-2.87)	18.0 (11.1-37.6)	1.28±0.19	89.5	89.5	89.5
λ-cyhalothrin	TXL	1st	48	5.49 (2.24-9.20)	102 (49.7-488)	1.01±0.21	1	183	183
			72	5.06 (2.60-7.87)	46.2 (27.7-109)	1.34±0.23	1.23	253	253
		2nd	48	10.8 (6.77-16.4)	203 (106-560)	1.00±0.13	1.97	360	360
			72	7.78 (4.09-12.5)	113 (63.4-277)	1.10±0.16	1.89	389	389
		3rd	48	66.8 (42.4-100)	948 (499-2745)	1.11±0.16	12.2	2226	2226
			72	46.7 (26.7-71.8)	539 (308-1326)	1.21±0.18	11.4	2335	2335
		4th	48	71.6 (41.1-113)	985 (508-3089)	1.12±0.18	13	2386	2386
			72	51.0 (27.0-80.9)	528 (303-1309)	1.26±0.21	12.4	2550	2550
	RWP	1st	48	7.08 (2.87-12.5)	147 (64.9-856.4)	0.97±0.21	1.29	236	236
			72	4.11 (1.63-6.88)	37.9 (22.4-98.8)	1.33±0.27	1	205	205
		2nd	48	7.46 (3.98-11.8)	87.3 (51.8-191)	1.20±0.17	1.36	248	248
			72	7.58 (3.71-12.3)	7.58 (42.1-140)	1.32±0.21	1.84	379	379
		3rd	48	67.0 (43.5-113)	1190 (572-477)	1.02±0.17	12.2	2233	2233
			72	39.8 (17.5-68.4)	500 (277-1327)	1.16±0.20	9.68	1990	1990
		4th	48	69.8 (33.3-130)	2192 (850-12895)	0.86±0.15	12.7	2326	2326
			72	19.7 (8.74-34.7)	405 (211-1146)	0.98±0.15	4.79	985	985
Lufenuron	TXL	1st	48	2.35 (1.35-3.71)	31.1 (16.1-97.2)	1.14±0.18	1.59	78.3	78.3
			72	1.68 (0.87-2.70)	17.7 (10.0-45.4)	1.25±0.21	1.69	84	84
		2nd	48	4.84 (2.95-7.25)	56.8 (33.8-124)	1.19±0.15	3.27	162	162

			72	4.17 (2.29-6.42)	36.5 (22.9-72.5)	1.36±0.20	4.21	208	208
		3rd	48	27.9 (15.9-43.9)	453 (230-1454)	1.05±0.16	18.9	930	930
			72	20.6 (11.2-32.2)	214 (126-497)	1.26±0.19	20.8	1030	1030
		4th	48	157 (86.5-248)	1633 (900-4631)	1.26±0.21	106	5233	5233
			72	94.1 (45.7-14)	640 (407-1316)	1.53±0.28	95.1	4705	4705
	RWP	1st	48	1.48 (0.88-2.26)	20.6 (11.5-51.3)	1.12±0.15	1	49.3	49.3
			72	0.99 (0.49-1.58)	8.98 (5.59-18.4)	1.34±0.22	1	49.5	49.5
		2nd	48	10.7 (5.54-17.7)	199 (101-611)	1.01±0.16	7.22	356	356
			72	7.67 (3.79-12.3)	66.2 (41.1-134)	1.37±0.22	7.75	383	383
		3rd	48	22.4 (12.5-35.9)	354 (189-963)	1.07±0.15	15.1	746	746
			72	15.5 (8.48-24.5)	201 (116-460)	1.15±0.16	15.7	775	775
		4th	48	41.3 (18.9-69.5)	435 (262-918)	1.25±0.19	27.9	1376	1376
			72	56.4 (27.1-96.8)	1231 (618-3793)	0.95±0.14	56.9	2820	2820

CF1, compared with least value of each insecticide separately for each test insect
CF2, compared with least value of all insecticides for each insect separately
CF3, compared with least value of all insecticides of both test insects
TXL= Taxila
RWP= Rawalpindi

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