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Toxicity of Pesticides to Predatory Mite, *Amblyseius longispinosus* (Evans)

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A B S T R A C T

An experiment was carried out during September-October 2014-15 and 2015-16 to investigate the toxicity of various pesticides to predatory mite, *A. longispinosus* under laboratory condition. Under the laboratory condition different pesticides showed different levels of mortality against egg, nymphs and adult stages of predatory mite, *A.longispinosus*.

Introduction

Phytophagous mites are known as serious pests of many agricultural, horticultural, and ornamental crops in India (Jhansi Rani and Jagan Mohan, 1997; Channa Basavanna, 1999). In the recent past, polyhouse cultivation of crops like rose, carnation, and several vegetables is gaining momentum in India. These plants are attacked by several pests of which the two spotted spider mite, *Tetranychus urticae* Koch, is the most important. Pest management by biological agents, such as phytoseiid predators, has received considerable attention recently, because the *T. urticae* developed resistance to most of the available acaricides (McMurtryand Croft, 1997; Shaila, 1999). The phytoseiid *Amblyseius longispinosus* (Evans) (Acari: Phytoseiidae) is widely distributed in the tropics and is the main predator of *T. urticae* in polyhouse ecosystem. The phytoseiid mite has been shown to be an effective predator of spider mites on crops like rose, cotton, bamboo, cucumber, and strawberry, both in the field (Hegde and Patil, 1994; Zhang *et al.*, 1999; Kongchuensin *et al.*, 2001; Abhilash and Sudharma, 2002) and under polyhouse conditions in tropical India (Mallik, 1974; Hegde *et al.*, 1995; Mallik *et al.*, 1998). In general, the effects of acaricides on predatory mites comprise mortality of eggs, nymphs and adults, lower prey consumption and reproductive capacity, egg viability decrease and change in sex ratio. Therefore, the present investigation was carried out to know the effect of some of the commonly available acaricides to the predatory mite, *A. longispinosus* under polyhouse condition on French bean.

Materials and Methods

The study on the toxicity of different pesticides were carried out at Acarology laboratory, Department of Agricultural Entomology, N. M. College of Agriculture, Navsari Agricultural University, Navsari during September-October 2014-15 and 2015-16.

Effect of different pesticides was tested against different stages of the phytoseiid mite, *A. longispinosus*. The predatory mite was collected from the stock culture maintained in the laboratory on French bean by feeding *T. urticae* as prey. Different concentration of pesticides were prepared separately in beakers and spread on the Petri-dishes surface (10 x 1.5 cm), the surface was dried under ceiling fan. Twenty numbers of different stages (*viz.*, eggs, nymph and adults) of the predatory mite, *A. longispinosus* were placed /released separately on the treated surface of Petri-dishes of various concentrations. They were placed in these treated Petri-dishes for 15 minutes and then transferred to another Petri-dishes having natural food *i.e*., *T. urticae*.

The mortality of predatory mite, *A. longispinosus* was recorded after 12, 24, 36, 48, 60 and 72 hours, for all the stages. Each concentration was repeated three times and each repetition includes 20 individuals of the predatory mite. On the basis of the mortality different pesticides were classified as: harmless (0–29% effect), slightly harmful (30–79% effect), moderately harmful (80–99% effect) and harmful (more than 99% effect) (Hassan, 1992).

Results and Discussion

The toxicity of various pesticides to different stages of phytoseiid mite, *A. alstoniae* are presented and discussed as under.

Toxicity acaricides to *A. longispinosus*

Toxicity to egg stage

The pooled data on effect of pesticides on eggs revealed that, interaction (Y x T) between the year of observation (Y) and the treatment (T) was found to be non-significant exhibiting similar response of the pesticides during two years (Table 1). Among thirty one pesticidal treatments, egg mortality recorded 12 hours post treatment interval was maximum when eggs were exposed to wettable sulphur 0.06 per cent (31.38%), it was at par with ethion 0.06 per cent (30.63%), and was followed by acephate 0.10 per cent (28.00%) whereas, lowest mortality recorded when eggs were exposed to fenazaquin 0.005 per cent, diafenthiuron 0.04 per cent and 0.05 (2.25, 2.25 and 2.75%, respectively) and were at par with each other. The mortality in all insecticidal treatments increased 24 hrs after their application. The greatest egg mortality was exhibited by wettable sulphur 0.06 per cent (48.00%) which was followed by acephate 0.10 per cent (37.45%), ethion 0.06 per cent (35.56 and propergite 0.067 per cent (33.11%) while, lowest per cent mortality recorded when eggs were exposed to fenazaquin 0.005 per cent (2.41%) and was followed by fenazaquin 0.10 (4.12%), it was at par with diafenthiuron 0.04 per cent (4.13%). At 36 hours post treatment interval highest egg mortality of 72.04 per cent was recorded with treatment of ethion 0.06 per cent it was followed by acephate 0.10 per cent (67.44%), propergite 0.067 per cent (57.47%) and wettable sulphur 0.06 per cent (54.47%) whereas, fenazaquin 0.005 per cent caused lowest egg mortality (2.08%) and it was followed by diafenthiuron 0.04 per cent (3.28%) and was at par with fenazaquin 0.010 per cent (3.61%). At 48 hours of post treatment interval acephate 0.10 per cent caused highest egg mortality (56.18%) which was at par with wettable sulphur 0.06 per cent

(54.60%) and was followed by ethion 0.06 per cent (53.51%). Significantly lowest egg mortality was recorded when eggs were exposed of fenazaquin 0.005 per cent (2.35%) it was followed by fenazaquin 0.010 per cent (3.18%) which was at par with diafenthiuron 0.04 per cent (3.71%). Perusal of mortality data obtained indicated that no egg mortality was recorded in control.

The toxicity of acaro-insecticides on the basis of mortality caused to eggs of predatory mite, *A. longispinosus* in descending order were acephate 0.10 per cent > wettable sulphur 0.06 per cent > ethion 0.06 per cent > acephate 0.09 per cent> wettable sulphur 0.05 per cent > propergite 0.067 per cent > chlorfenpyre 0.015 per cent > ethion 0.05 per cent > chlorfenpyre 0.01 per cent > chlorfenpyre 0.005 per cent > wettable sulphur 0.04 per cent > chlorantriliniprole 0.0285 per cent > acephate 0.08 per cent > ethion 0.04 per cent > propergite 0.057 per cent > chlorantriliniprole 0.0185 per cent > spiromesifen 0.0329 per cent > chlorantriliniprole 0.0085 per cent > fenpyroximate 0.06 per cent > spiromesifen 0.0229 per cent > propergite 0.047 per cent > diafenthiuron 0.06 per cent > fenpyroximate 0.05 per cent > diafenthiuron 0.05 per cent > fenpyroximate 0.04 per cent > spiromesifen 0.0129 per cent > fenazaquin 0.015 per cent > diafenthiuron 0.04 per cent > fenazaquin 0.01 per cent > fenazaquin 0.005 per cent. According to Hassan (1992) propergite 0.067 per cent, wettable sulphur 0.05 per cent and 0.06, ethion 0.05 per cent and 0.06, acephate 0.09 per cent and 0.10, chlorfenpyre 0.01 per cent and 0.015 were slightly harmful as they recorded more than 30 per cent egg mortality while, other were classified as harmless for eggs of phytoseiid mites. The present findings are closely supported by Nadimi (2008) who also reported fenpyroximate, diafenthiuron and abamectin as harmless to the eggs of *P. persimilis*. Further, Pokle and Shukla (2015) found diafenthiuron, fenazaquin and fenpyroximate were safe for egg stage of *A. longispinosus*, while pesticides like wettable sulphur, ethion and acephate were found highly toxic to eggs of *A. longispinosus*. These reports are more or less closely support the present findings.

Toxicity to nymphs

The two year pooled data on per cent mortality of the predatory mite, *A. longispinosus* nymphs over two years is summarized in table 2. Data revealed that, interaction (Y x T) between the year of observation (Y) and treatment (T) was found to be non-significant exhibiting similar response of the pesticides to the predatory mite, *A. longispinosus* nymphs during two years. It was observed at 12 hours post treatment interval that, the treatment of nymphs with wettable sulphur 0.06 per cent caused highest per cent mortality of nymphs i.e. 32.13 per cent as compared to all other chemicals under the present study which was at par with ethion 0.06 per cent (31.00%) and was followed by acephate 0.10 per cent (29.75%). Significantly lowest per cent mortality of nymphs was recorded when nymphs exposed to fenazaquin 0.005 per cent (2.63%), it was followed by fenazaquin 0.010 per cent (3.63%) and was at par with diafenthiuron 0.04 per cent (3.88%). At 24 hours of post treatment interval the toxicity of acaro-insecticides to nymphs increased and highest per cent mortality was recorded when nymphs were exposed to wettable sulphur 0.06 per cent (34.21%), it was closely followed by acephate 0.10 per cent (24.67%) and was at par with chlorfenpyre 0.015 per cent (23.33%) while, lowest mortalities were recorded with treatment spiromesifen 0.0129 per cent (2.47%), it was at par with fenazaquin 0.005 per cent (2.88%), it was followed by fenazaquin 0.01 per cent (3.66%). At 36 hours of post treatment interval acephate 0.10 per cent reported highest per cent mortality of nymphs

(50.49%), and was followed by wettable sulphur 0.06 per cent (41.41%) and ethion 0.06 per cent (33.41) however, fenazaquin 0.005 per cent reported lowest mortality of nymphs (2.43%) and was at par with diafenthiuron 0.04 per cent (3.08%), it was followed by spiromesifen 0.0129 per cent (3.30%). Exposure of nymphs to ethion at 0.06 per cent dose recorded highest per cent mortality (45.88%) at 48 hours post treatment interval followed by acephate 0.10 per cent and chlorfenpyre 0.015 per cent causing 38.99 and 35.81 per cent mortality of nymphs, respectively whereas, fenazaquin 0.005 per cent recorded lowest per cent mortality (2.44%) which was at par with spiromesifen 0.0129 per cent (3.04%) and it was followed by fenazaquin 0.010 per cent (3.60%). Exposure to acephate at 0.10 dose caused 61.98 per cent mortality after 60 hours of treatment, it was followed by ethion 0.06 per cent (47.73%) and wettable sulphur 0.06 per cent (44.67%) while, diafenthiuron 0.04 per cent, fenazaquin 0.005 per cent and 0.010 per cent caused lowest per cent mortality (2.51, 2.56 and 3.3%, respectively) they were at par with each others. The mortality was highest (78.08%) when nymphs were exposed to acephate 0.10 per cent after 72 hours and it was followed by wettable sulphur 0.06 per cent, acephate 0.09 per cent and wettable sulphur 0.05 per cent causing 59.00, 56.40 and 51.22 per cent mortality, respectively. Significantly lowest mortality was recorded by treatment comprises diafenthiuron 0.04 per cent, fenazaquin 0.005 per cent, spiromesifen 0.0129 per cent and fenazaquin 0.010 per cent (2.45, 2.46, 2.60 and 3.27%, respectively), they were at par with each other. Perusal of mortality data obtained indicated that other chemicals also showed mortality at various concentrations and at different time intervals and no mortality of nymphs was recorded in control.

The toxicity of acaro-insecticides on the basis of mortality caused to the predatory mite, *A. longispinosus* nymphs in the descending order were ethion 0.06 per cent > acephate 0.10 per cent > wettable sulphur 0.06 per cent > acephate 0.09 per cent > wettable sulphur 0.05 per cent > chlorfenpyre 0.015 per cent > ethion 0.05 per cent > chlorfenpyre 0.01 per cent > ethion 0.04 per cent > chlorantriliniprole 0.0285 per cent > wettable sulphur 0.04 per cent> acephate 0.08 per cent > chlorfenpyre 0.005 per cent > chlorantriliniprole 0.0185 per cent > propergite 0.067 per cent > chlorantriliniprole 0.0085 per cent > fenpyroximate 0.06 per cent > propergite 0.057 per cent > fenpyroximate 0.05 per cent > diafenthiuron 0.06 per cent > spiromesifen 0.0329 per cent > propergite 0.047 per cent > fenpyroximate 0.04 per cent > fenazaquin 0.015 per cent > diafenthiuron 0.05 per cent > spiromesifen 0.0229 per cent > fenazaquin 0.01 per cent > spiromesifen 0.0129 per cent > fenazaquin 0.005 per cent > diafenthiuron 0.04 per cent. According to Hassan (1992) wettable sulphur 0.05 per cent and 0.06, ethion 0.05 per cent, acephate 0.09 per cent and 0.10 per cent, chlorfenpyre 0.015 per cent were slightly harmful as they recorded more than 30 per cent nymph mortality, ethion 0.010 caused more than 79 per cent mortality of nymphs which was classified as moderately harmful while, other were classified as harmless for the nymphs of predatory mite. Further, Naik (2000) reported dicofol as very toxic to mobile stages of *A. longispinosus* however Pokle and Shukla (2015) reported that diafenthiuron, fenazaquin and fenpyroximate were safe to the nymphs of *A. longispinosus* however acaricides like wettable sulphur, ethion and acephate were highly toxic to the immature of *A. longispinosus*. These reports are more or less closely confirms the present findings.

Table.1 Effect of different pesticides on eggs of *A. longispinosus*

Treatments		Pre treatment	Pooled of 2 years			
			12hrs	24hrs	36 hrs	48 hrs
T1	Propergite 0.047 %	50	9.00 (17.41)j	11.42 (19.73)l	12.34 (20.55)lm	9.53 (17.96)l
T2	Propergite 0.057 %	50	13.50 (21.54)g	20.98 (27.24)g	25.66 (23.08)i	18.10 (25.16)i
T3	Propergite 0.067 %	50	21.50 (27.60)c	33.11 (35.11)d	57.47 (26.49)c	43.83 (41.44)d
T4	Spiromesifen 0.0129 %	50	5.00 (12.88)l	4.51 (12.22)p	4.45 (10.35)s	4.24 (11.84)no
T5	Spiromesifen 0.0229 %	50	8.00 (16.41)j	8.16 (16.57)m	8.88 (12.05)p	10.17 (18.57)l
T6	Spiromesifen 0.0329 %	50	11.63 (19.91)hi	12.73 (20.88)k	11.55 (12.56)mn	12.38 (20.57)k
T7	Wet Sulphur 0.04 %	50	20.13 (26.64)cd	17.31 (24.57)hi	21.94 (23.57)j	24.09 (29.37)g
T8	Wet Sulphur 0.05%	50	26.75 (31.12)b	30.79 (33.69)e	42.94 (25.63)e	45.38 (42.33)d
T9	Wet Sulphur 0.06 %	50	31.38 (34.05)a	48.00 (43.84)a	54.71 (32.28)d	54.60 (47.62)ab
T10	Difenthiuron 0.04 %	50	2.25 (8.59)n	4.13 (11.68)p	3.28 (9.49)t	3.71 (11.02)op
T11	Difenthiuron 0.05 %	50	2.75 (9.47)n	5.61 (13.66)o	5.28 (11.84)rs	5.08 (13.01)n
T12	Difenthiuron 0.06 %	50	4.63 (12.38)l	8.16 (16.55)m	7.04 (12.90)q	8.96 (17.39)lm
T13	Fenpyroximate 0.04 %	50	6.75 (15.04)k	4.79 (12.62)p	5.88 (14.02)r	4.54 (12.27)no
T14	Fenpyroximate 0.05 %	50	8.50 (16.93)j	7.13 (15.47)n	8.83 (15.38)p	7.78 (16.16)m
T15	Fenpyroximate 0.06 %	50	11.63 (19.91)hi	8.70 (17.10)m	10.12 (18.89)o	11.94 (20.19)k
T16	Ethion 0.04 %	50	12.88 (20.98)gh	16.32 (23.80)ij	19.43 (26.73)k	19.41 (26.12)hi
T17	Ethion 0.05 %	50	21.13 (27.34)cd	20.24 (26.72)g	38.86 (27.11)f	39.76 (39.07)e
T18	Ethion 0.06 %	50	30.63 (33.58)a	35.56 (36.59)c	72.04 (33.84)a	53.51 (46.99)b
T19	Acephate 0.08 %	50	11.25 (19.57)i	17.00 (24.33)hi	19.25 (23.90)k	20.07 (26.60)h
T20	Acephate 0.09 %	50	19.75 (26.37)d	25.18 (30.10)f	35.11 (30.00)g	47.82 (43.73)c

T21	Acephate 0.10 %	50	28.00 (31.93)b	37.45 (37.71)b	67.44 (41.89)b	56.18 (48.53)a
T22	Fenazaquin 0.005 %	50	2.25 (8.59)n	2.41 (8.90)q	2.08 (9.05)u	2.35 (8.80)q
T23	Fenazaquin 0.01 %	50	3.50 (10.75) m	4.12 (11.69)p	3.61 (12.32)t	3.18 (10.18)p
T24	Fenazaquin 0.015 %	50	6.13 (14.29)k	6.66 (14.91)n	4.96 (14.22)rs	4.22 (11.81)no
T25	Chlorantriliniprole 0.0085 %	50	8.63 (17.06)j	8.42 (16.82)m	10.63 (19.14)no	12.23 (20.44)k
T26	Chlorantriliniprole 0.0185 %	50	10.88 (19.24)i	10.85 (19.20)l	13.68 (25.13)l	15.92 (23.49)j
T27	Chlorantriliniprole 0.0285 %	50	15.50 (23.17)f	13.78 (21.77)k	18.72 (29.30)k	20.73 (27.07)h
T28	Chlorfenpyre 0.005 %	50	11.63 (19.91)h i	15.31 (23.01)j	18.70 (19.60)k	24.52 (29.66)g
T29	Chlorfenpyre 0.01 %	50	15.75 (23.36)f	18.41 (25.37)h	23.05 (24.38)j	31.34 (34.02)f
T30	Chlorfenpyre 0.015 %	50	17.25 (24.52)e	21.47 (27.58)g	30.53 (33.55)h	43.75 (41.39)d
T31	Control	50	0.25 (2.86)o	0.25 (2.86)r	0.25 (2.86)v	0.25 (2.86)r
Treatment		**SEm±**	0.08	0.08	0.09	0.09
		C.D. 5%	0.23	0.23	0.24	0.26
Year		**SEm±**	0.32	0.31	0.34	0.36
		C.D. 5%	0.90	0.89	0.95	1.04
Y x T		**SEm±**	0.45	0.44	0.47	0.52
		C.D. 5%	**NS**	**NS**	**NS**	**NS**
C.V. (%)			4.54	4.08	3.75	4.07

Figures in the parentheses are arc sine transformed values.
In each column means followed by same alphabet are not statistically different from each other

Table.2 Effect of different pesticides on nymphs of *A. longispinosus* (Pooled)

Treatments		Pre treatment	Pooled of 2 years					
			12hrs	24hrs	36 hrs	48 hrs	60hrs	72hrs
T1	Propergite 0.047 %	50	8.75 (17.18)klm	7.25 (15.60)lm	9.01 (17.44)k	9.16 (17.57)jk	6.20 (14.38)mno	4.48 (12.13)no
T2	Propergite 0.057 %	50	10.53 (18.92)j	11.31 (19.61)j	14.52 (22.38)i	8.93 (17.38)k	12.95 (21.08)k	7.54 (15.92)m
T3	Propergite 0.067 %	50	16.31 (23.80)fg	19.90 (26.47)d	19.92 (26.49)g	12.76 (20.89)i	24.40 (29.58)g	12.66 (20.82)k
T4	Spiromesifen 0.0129 %	50	5.38 (13.34)no	2.47 (9.02)p	3.30 (10.37)n	3.04 (9.97)no	3.43 (10.59)q	2.60 (9.24)q
T5	Spiromesifen 0.0229 %	50	9.13 (17.55)kl	3.71 (11.01)o	4.66 (12.46)m	4.92 (12.80)m	5.87 (13.96)no	3.83 (11.22)op
T6	Spiromesifen 0.0329 %	50	9.88 (18.29)jk	4.69 (12.46)n	8.36 (16.76)k	6.06 (14.20)l	7.39 (15.74)m	4.94 (12.79)no
T7	Wet Sulphur 0.04 %	50	17.38 (24.62)f	11.76 (20.03)ij	13.41 (21.45)i	15.34 (23.03)h	24.44 (29.60)g	23.92 (29.27)h
T8	Wet Sulphur 0.05%	50	25.00 (29.98)c	22.15 (28.05)c	21.55 (27.64)efg	27.74 (31.76)d	35.80 (36.73)d	51.22 (45.68)d
T9	Wet Sulphur 0.06 %	50	32.13 (34.51)a	34.21 (35.76)a	41.41 (40.04)b	35.49 (36.55)c	44.67 (41.92)c	59.00 (50.17)b
T10	Difenthiuron 0.04 %	50	3.88 (11.31)p	4.12 (11.66)no	3.08 (10.02)no	5.22 (13.16)lm	2.51 (9.10)r	2.45 (8.99)q
T11	Difenthiuron 0.05 %	50	6.13 (14.32)n	6.45 (14.66)m	4.87 (12.72)m	8.43 (16.84)k	4.39 (12.01)i	3.87 (11.24)op
T12	Difenthiuron 0.06 %	50	8.63 (17.03)lm	7.29 (15.61)lm	6.56 (14.79)l	10.48 (18.87)j	5.52 (13.57)o	5.05 (12.93)n
T13	Fenpyroximate 0.04 %	50	4.75 (12.54)o	7.23 (15.56)lm	8.89 (17.33)k	6.17 (14.33)l	6.90 (15.17)mn	4.26 (11.82)nop
T14	Fenpyroximate 0.05 %	50	5.88 (13.96)n	7.68 (16.04)l	11.62 (19.89)j	9.22 (17.64)jk	8.96 (17.40)l	7.42 (15.78)m
T15	Fenpyroximate 0.06 %	50	7.69 (16.04)m	8.86 (17.30)k	11.91 (20.14)j	10.42 (18.81)j	11.81 (20.09)k	9.50 (17.93)l
T16	Ethion 0.04 %	50	15.00 (22.76)gh	9.63 (18.06)k	16.34 (23.81)h	18.39 (25.38)g	20.22 (26.71)i	29.57 (32.92)f
T17	Ethion 0.05 %	50	24.13 (29.40)cd	13.33 (21.40)gh	23.83 (28.68)de	25.44 (30.27)e	28.90 (32.50)f	41.70 (40.20)e
T18	Ethion 0.06 %	50	31.00 (33.82)ab	18.49 (25.45)d	33.41 (35.29)c	45.88 (42.62)a	47.73 (43.68)b	79.04 (62.74)a
T19	Acephate 0.08 %	50	12.50 (20.69)i	15.80 (24.17)e	13.82 (21.79)i	15.50 (23.17)h	22.99 (28.63)gh	22.16 (28.06)hi
T20	Acephate 0.09 %	50	20.00 (26.54)e	18.24 (24.21)e	23.16 (28.75)de	26.50 (30.96)de	44.37 (41.75)c	56.40 (48.66)c

T21	Acephate 0.10 %	50	29.75 (33.04)b	24.67 (29.75)b	50.49 (45.27)a	38.99 (38.62)b	61.98 (51.91)a	78.08 (62.09)a
T22	Fenazaquin 0.005 %	50	2.63 (9.24)q	2.88 (9.69)p	2.43 (8.92)o	2.44 (8.93)o	2.56 (9.18)r	2.46 (9.00)q
T23	Fenazaquin 0.01 %	50	3.63 (10.91)p	3.66 (10.92)o	3.75 (11.07)n	3.60 (10.86)n	3.34 (10.43)qr	3.27 (10.31)pq
T24	Fenazaquin 0.015 %	50	4.88 (12.67)o	4.59 (12.25)n	5.01 (12.87)m	4.58 (12.32)m	3.89 (11.29)pq	4.23 (11.80)nop
T25	Chlorantriliniprole 0.0085 %	50	10.75 (19.11)j	9.96 (18.36)k	10.71 (19.07)j	8.62 (17.05)k	12.26 (20.48)k	10.30 (18.69)l
T26	Chlorantriliniprole 0.0185 %	50	14.00 (21.95)h	12.88 (21.01)hi	14.26 (22.16)i	12.26 (20.49)i	17.18 (24.48)j	17.17 (24.45)j
T27	Chlorantriliniprole 0.0285 %	50	16.38 (23.84)fg	14.71 (22.53)fg	22.34 (28.18)ef	17.79 (24.93)g	23.53 (29.00)gh	26.17 (30.75)g
T28	Chlorfenpyre 0.005 %	50	16.38 (23.85)fg	15.87 (23.44)ef	20.59 (26.96)fg	21.38 (27.53)f	21.79 (27.81)hi	21.42 (27.55)i
T29	Chlorfenpyre 0.01 %	50	19.00 (25.82)e	18.86 (25.72)d	25.08 (30.04)d	27.91 (31.87)d	31.58 (34.17)e	29.83 (33.08)f
T30	Chlorfenpyre 0.015 %	50	22.63 (28.39)d	23.33 (28.85)bc	31.77 (34.29)c	35.81 (36.74)c	42.57 (40.71)c	50.69 (45.38)d
T31	Control	50	0.25 (2.86)r	0.25 (2.85)q	0.25 (2.86)p	0.25 (2.86)p	0.25 (2.86)s	0.25 (2.86)r
Treatment		**SEm±**	**0.09**	**0.09**	**0.09**	**0.09**	**0.09**	**0.10**
		C.D. 5%	**0.26**	**0.26**	**0.27**	**0.25**	**0.26**	**0.28**
Year		**SEm±**	**0.36**	**0.36**	**0.37**	**0.34**	**0.36**	**0.39**
		C.D. 5%	**1.02**	**1.03**	**1.06**	**0.98**	**1.02**	**1.11**
Y x T		**SEm±**	**0.51**	**0.51**	**0.53**	**0.49**	**0.51**	**0.55**
		C.D. 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
C.V. (%)			**5.00**	**5.43**	**4.89**	**4.50**	**4.27**	**4.41**

Figures in the parentheses are arc sine transformed values.
In each column means followed by same alphabet are not statistically different from each other

Table.3 Effect of different pesticides on adults of *A. longispinosus*

Treatments		Pre treatment	Pooled of 2 years					
			12hrs	24hrs	36 hrs	48 hrs	60hrs	72hrs
T1	Propergite 0.047 %	50	4.05 (11.57)o	6.57 (14.81)op	7.27 (15.61)l	3.81 (11.14)p	6.79 (15.06)mn	5.44 (13.47)qr
T2	Propergite 0.057 %	50	5.25 (13.20)mn	8.74 (17.18)lm	10.68 (19.04)j	11.29 (19.59)jk	13.72 (21.71)k	11.50 (19.78)no
T3	Propergite 0.067 %	50	11.00 (19.35)k	13.95 (21.91)ij	16.74 (24.13)h	16.65 (24.05)hi	31.07 (33.86)g	34.00 (35.65)j
T4	Spiromesifen 0.0129 %	50	2.25 (8.59)q	3.33 (10.42)q	2.38 (8.83)o	2.50 (9.04)q	4.30 (11.94)pq	2.65 (9.33)uv
T5	Spiromesifen 0.0229 %	50	3.75 (11.08)op	5.46 (13.46)p	5.70 (13.76)m	4.36 (12.02)op	5.93 (14.06)no	3.44 (10.62)stu
T6	Spiromesifen 0.0329 %	50	6.25 (14.46)m	7.88 (16.24)mn	7.47 (15.82)l	6.05 (14.19)n	7.75 (16.06)m	5.47 (13.47)qr
T7	Wet Sulphur 0.04 %	50	13.25 (21.33)hi	15.57 (23.22)hi	19.19 (25.97)g	22.97 (28.62)f	26.26 (30.81)h	44.60 (41.88)h
T8	Wet Sulphur 0.05%	50	16.63 (24.04)f	22.54 (28.33)ef	28.30 (32.12)e	40.24 (39.35)d	40.53 (39.53)e	64.74 (53.56)f
T9	Wet Sulphur 0.06 %	50	21.50 (27.61)d	33.26 (35.20)c	44.12 (41.60)b	81.80 (64.73)a	46.04 (42.71)d	88.90 (70.55)b
T10	Difenthiuron 0.04 %	50	3.00 (9.90)pq	2.32 (8.72)r	2.28 (8.65)o	2.56 (9.13)q	2.49 (9.02)r	2.35 (8.81)v
T11	Difenthiuron 0.05 %	50	5.25 (13.20)mn	4.10 (11.57)q	3.51 (10.73)n	4.81 (12.52)op	3.89 (11.30)q	3.17 (10.16)tuv
T12	Difenthiuron 0.06 %	50	8.75 (17.17)l	7.97 (16.36)mn	5.89 (13.98)m	7.69 (16.09)m	5.70 (13.77)no	4.40 (12.04)rs
T13	Fenpyroximate 0.04 %	50	5.50 (13.53)m	7.18 (15.50)no	5.92 (14.02)m	6.20 (14.36)n	7.82 (16.22)m	7.07 (15.36)p
T14	Fenpyroximate 0.05 %	50	16.25 (23.75)f	9.06 (17.50)klm	8.47 (16.90)kl	9.44 (17.87)l	11.86 (20.12)l	10.25 (18.64)o
T15	Fenpyroximate 0.06 %	50	11.50 (19.78)jk	13.60 (21.63)j	10.84 (19.19)j	12.47 (20.66)j	15.67 (23.30)j	12.40 (20.59)n
T16	Ethion 0.04 %	50	17.00 (24.32)ef	20.65 (27.01)fg	27.37 (31.53)e	21.80 (27.82)fg	31.75 (34.28)g	74.95 (59.96)e
T17	Ethion 0.05 %	50	18.75 (25.64)e	27.23 (31.44)d	33.38 (35.28)c	27.63 (31.69)e	49.87 (44.91)c	87.57 (69.34)b
T18	Ethion 0.06 %	50	23.50 (28.97)c	41.51 (40.09)a	53.97 (47.26)a	55.92 (48.38)b	58.09 (49.64)b	97.51 (81.44)a
T19	Acephate 0.08 %	50	31.75 (34.28)b	19.36 (26.08)g	22.55 (28.33)f	25.24 (30.14)e	29.93 (33.15)g	54.42 (47.52)g
T20	Acephate 0.09 %	50	33.25 (35.20)b	23.92 (29.26)e	30.43 (33.47)d	40.96 (39.77)d	44.72 (41.95)d	78.12 (62.10)d
T21	Acephate 0.10 %	50	36.75 (37.30)a	35.53 (36.57)b	44.94 (42.08)b	49.53 (44.71)c	63.36 (52.73)a	81.67 (64.63)c
T22	Fenazaquin 0.005 %	50	3.00 (9.90)pq	5.84 (13.93)p	2.43 (8.92)o	2.62 (9.25)q	3.83 (11.18)q	4.02 (11.51)st
T23	Fenazaquin 0.01 %	50	4.38 (12.05)no	8.54 (16.94)lm	3.56 (10.80)n	3.83 (11.23)p	5.39 (13.37)op	5.45 (13.47)qr
T24	Fenazaquin 0.015 %	50	6.38 (14.60)m	9.55 (17.98)kl	5.71 (13.77)m	5.29 (13.28)no	7.38 (15.71)m	6.30 (14.51)pq
T25	Chlorantriliniprole 0.0085 %	50	9.25 (17.67)l	10.22 (18.62)k	9.47 (17.91)jk	10.56 (18.91)kl	11.38 (19.68)l	12.05 (20.28)n
T26	Chlorantriliniprole 0.0185 %	50	11.75 (20.02)ijk	13.04 (21.15)j	12.43 (20.62)i	14.70 (22.52)i	15.42 (23.09)jk	19.02 (25.84)m
T27	Chlorantriliniprole 0.0285 %	50	13.00 (21.12)hij	15.64 (23.28)hi	15.85 (23.44)h	18.41 (25.39)h	21.74 (27.77)i	31.53 (34.14)k
T28	Chlorfenpyre 0.005 %	50	14.25 (22.17)gh	16.70 (24.11)h	19.38 (26.10)g	15.71 (23.30)i	16.12 (23.62)j	25.23 (30.14)l

T29	Chlorfenpyre 0.01 %	50	15.75 (23.37)fg	19.52 (26.20)g	23.14 (28.74)f	20.48 (26.89)g	23.99 (29.30)h	40.88 (39.73)i
T30	Chlorfenpyre 0.015 %	50	17.50 (24.71)ef	22.44 (28.26)ef	27.68 (31.72)e	26.22 (30.78)e	35.03 (36.27)f	54.49 (47.56)g
T31	Control	50	0.25 (2.86)r	0.25 (2.86)s	0.25 (2.86)p	0.25 (2.86)r	0.25 (2.86)s	0.25 (2.86)w
Treatment		**SEm±**	**0.09**	**0.09**	**0.09**	**0.10**	**0.10**	**0.11**
		C.D. 5%	**0.25**	**0.25**	**0.25**	**0.29**	**0.29**	**0.31**
Year		**SEm±**	**0.34**	**0.35**	**0.35**	**0.41**	**0.41**	**0.43**
		C.D. 5%	**0.97**	**1.00**	**0.99**	**1.15**	**1.15**	**1.23**
Y x T		**SEm±**	**0.48**	**0.50**	**0.49**	**0.57**	**0.57**	**0.61**
		C.D. 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
C.V. (%)			**4.96**	**4.71**	**4.45**	**4.93**	**4.57**	**3.88**

Figures in the parentheses are arc sine transformed values.
In each column means followed by same alphabet are not statistically different from each other

Toxicity to adults

The pooled data on per cent mortality of the predatory mite, *A. longispinosus* adults over two years is summarized in table 3. Data revealed that, interaction (Y x T) between year of observation (Y) and treatment (T) was found to be non-significant exhibiting similar response of the acaro-insecticides to the predatory mite, *A. longispinosus* adults during two years. It was observed that at 12 hours post treatment interval, exposure of adults to acephate 0.10 per cent caused highest per cent mortality of adults (36.75%) as compared to all other chemicals under the present study and it was followed by acephate 0.09 per cent (33.25%), it was at par with acephate 0.08 per cent (31.73%). Significantly lowest per cent mortality of adults was recorded when adults were exposed to spiromesifen 0.0129 per cent (2.25%), diafenthiuron 0.04 per cent (3.00%) and fenazaquin 0.005 per cent (3.00%) they were at par with each other. At 24 hours post treatment interval the toxicity of acaro-insecticides to adults increased and highest per cent mortality was recorded with ethion 0.06 per cent (41.61%) and it was followed by acephate 0.10 per cent, wettable sulphur 0.06 per cent and ethion 0.05 per cent causing 35.33, 33.26 and 23.23 per cent mortality, respectively while, lowest mortalities were recorded in diafenthiuron 0.04 per cent (2.32%), which was followed by spiromesifen 0.0129 per cent (3.33%) and was at par with diafenthiuron 0.05 per cent (4.10%). At 36 hours of post treatment interval ethion 0.06 per cent reported highest per cent mortality of adults (53.97%), which was followed by acephate 0.10 per cent (44.94%) and was at par with wettable sulphur 0.06 per cent (44.12%) however, exposure to diafenthiuron 0.04 per cent recorded lowest mortality of adults (2.28%), it was at par with spiromesifen 0.0129 per cent and fenazaquin 0.005 per cent causing 2.38 and 2.43 per cent mortality, respectively. Adult exposure to wettable sulphur at 0.06 per cent dose recorded highest per cent mortality (81.80%) after 48 hours of treatment, it was followed by ethion 0.06 per cent (55.92%), acephate 0.10 per cent (49.53%) and wettable sulphur 0.05 per cent (40.24%) whereas, spiromesifen 0.0129 per cent, diafenthiuron 0.04 per cent and fenazaquin 0.005 per cent reported lowest per cent mortality of adults (2.50, 2.56 and 2.62%, respectively) which were at par with each other. Acephate 0.10 per cent caused 63.36 per cent adult mortality after 60 hours of treatment, which was followed by ethion 0.06 per cent (58.09%) and ethion 0.05 per cent (49.87%) while, diafenthiuron 0.04 per cent recorded lowest per cent mortality of adults (2.49%) and was followed by fenazaquin 0.005 per cent (3.83%) which was at par with diafenthiuron 0.05 per cent (3.89%). Mortality was highest (97.51%)

when adults exposed to ethion 0.06 per cent after 72 hours which was followed by wettable sulphur (88.90%) and was at par with ethion 0.05 per cent (87.57%). Significantly lowest per cent mortality was recorded when adults were exposed to diafenthiuron 0.04 per cent (2.34%), it was at par with spiromesifen 0.0129 per cent (2.65%) and diafenthiuron 0.05 per cent (3.17%). Perusal of mortality data obtained indicated that other chemicals also showed mortality at various concentrations and at different time intervals and no mortality of adults was recorded in control.

The toxicity of pesticides on the basis of mortality caused to the predatory mite, *A. longispinosus* adults in descending order were ethion 0.06 per cent> wettable sulphur 0.06 per cent>ethion 0.05 per cent>acephate 0.10 per cent>acephate 0.09 per cent>ethion 0.04 per cent> wettable sulphur 0.05 per cent>chlorfenpyre 0.015 per cent>acephate 0.08 per cent> wettable sulphur 0.04 per cent>chlorfenpyre 0.01 per cent>propergite 0.067 per cent>chlorantriliniprole 0.0285 per cent>chlorfenpyre 0.005 per cent>chlorantriliniprole 0.0185 per cent> fenpyroximate 0.06 per cent>chlorantriliniprole 0.0085 per cent>propergite 0.057 per cent> fenpyroximate 0.05 per cent> fenpyroximate 0.04 per cent> fenazaquin 0.015 per cent>spiromesifen 0.0329 per cent> fenazaquin 0.01 per cent>propergite 0.047 per cent> diafenthiuron 0.06 per cent> fenazaquin 0.005 per cent>spiromesifen 0.0229 per cent> diafenthiuron 0.05 per cent>spiromesifen 0.0129 per cent> diafenthiuron 0.04 per cent. According to Hassan (1992) propergite 0.067 per cent, wettable sulphur 0.04 per cent and 0.05 per cent, ethion 0.04 per cent, acephate 0.08 per cent and 0.09 per cent, chloraniliprole 0.0285, chlorfenpyre 0.01 per cent and 0.015 per cent were slightly harmful to adults of the predatory mite, *A. longispinosus* as they recorded more than 30 per cent adult mortality, wettable sulphur 0.06 per cent, ethion 0.05 per cent, 0.06 per cent and acephate0.10 per cent were classified as moderately harmful to adults while, other were classified as harmless for predatory mite, *A. longispinosus* adults. In past, Naik (2000) reported that wettable sulphur and dicofol was highly toxic to the adults of *A. longispinosus*, further Pokle and Shukla (2015) from their investigation reported diafenthiuron, fenazaquin and fenpyroximate as safe to adults of *A. longispinosus* whereas acaricides like wettable sulphur, acephate and ethion at different concentrations were highly toxic to the adults of *A. longispinosus* both under laboratory and greenhouse conditions. These findings are more or less in line with the present research where same trends were observed.

It is very important to understand the effect of pesticides sprayed on leaf surfaces different time interval on the mortality of *A. longispinosus* for their successful integration into biological control programs as well as in integrated pest management. The recent introduction of several new acaricides into agri-horticultural crops has made knowledge of the specific residual effects of these chemicals crucial to the use of predatory mite *A. longispinosus* in the protected agriculture.

The effects of toxicity of different pesticides under laboratory conditions, assessed by calculating per cent mortality of eggs, nymphs and adults of *A. longispinosus* resulting 12 h, 24 h, 36 h, 48 h, 60 h and 72 h after treatment. The effect was classified by IOBC classification (Hassan, 1992) indicated that propergite 0.067 per cent was slightly harmful (>30% mortality) to adults of *A. longispinosus* while, other concentrations of propergite *viz.*, 0.047 and 0.057 per cent were harmless (<30% mortality) to the phytoseiid mite. Spiromesifen at the concentrations 0.0129,

0.0229 and 0.0329 per cent were harmless (<30% mortality) to all stages of *A. longispinosus*. Wettable sulphur 0.04 per cent was classified as slightly harmful (>30% mortality) to adults of *A. longispinosus*. Wettable sulphur 0.05 per cent was slightly harmful (>30% mortality) to all stages of *A. longispinosus*. Wettable sulphur 0.06 per cent was slightly harmful (>30% mortality) to nymphs of *A. longispinosus*, while moderately harmful (>79% mortality) to adults. Diafenthiuron at 0.04, 0.05 and 0.06 per cent concentrations were harmless (<30% mortality) to eggs, nymphs and adults of *A. longispinosus*. However, fenpyroximate at 0.04, 0.05 and 0.06 per cent concentrations was harmless (<30% mortality) to eggs, nymphs and adults of *A. longispinosus*. Ethion 0.04 per cent was slightly harmful (>30% mortality) to adults of *A. longispinosus* while ethion at 0.05 per cent concentration was slightly harmful (>30% mortality) to eggs and nymphs *A. longispinosus*. Ethion at 0.06 per cent concentration was slightly harmful (>30% mortality) to eggs of *A. longispinosus* while it was moderately harmful (>79% mortality) to nymphs and adults of *A. longispinosus*. Acephate at 0.08 per cent concentration was slightly harmful (>30% mortality) to adults of *A. longispinosus*. It was slightly harmful (>30% mortality) to all stages of *A. longispinosus* at 0.09 per cent concentration. Acephate at 0.10 per cent concentration was slightly harmful (>30% mortality) to the nymphs of *A. longispinosus*, while it was moderately harmful (>79% mortality) adults of *A. longispinosus*. All the concentration of fenazaquin tested *viz*., 0.005, 0.010 and 0.015 per cent were harmless (<30% mortality) to *A. longispinosus*. Chlorantriliniprole at 0.0285 per cent was slightly harmful (>30% mortality) to adults of *A. longispinosus* while other concentrations of chlorantriliniprole *viz*., 0.0058 and 0.0185 per cent were harmless (<30% mortality). Chlorfenpyre at 0.010 per cent was slightly harmful (>30% mortality) to adults of *A. longispinosus* while, chlorfenpyre at 0.015 per cent concentration was slightly harmful (>30% mortality) to adults of the *A. longispinosus*. Further, Chlorfenpyre was harmless (<30% mortality) to phytoseiid mites at 0.005 per cent concentration. The relative toxicity of pesticides to pests, predators and immature stages (e.g. neonates) of the predators should provide an adequate indication for selectivity of pesticides, which is essential for development of effective and sustainable pest management programs (Jeppson *et al.,* 1975).

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