

Effect of Selected Insecticides on *Helicoverpa armigera* Hubner (Lepidoptera: Noctuidae) on Tomato (*Lycopersicon esculentum* Miller) and Their Successful Management

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Abstract

Helicoverpa armigera H. is a polyphagous notorious pest of a number of economic crops including tomato. In tomato, it can reduce its yield as high as 70% due to fruit boring. Although some predators and parasitoids have been recorded in the field for their natural control, their manipulation to a successful crop management is still awaited. To overcome this pest, insecticides play a significant role in its effective crop management program globally. Tomato is an absolutely perishable commodity and needs the specified period required between the application, of conventional pesticides of organophosphate group, and consumption which can hardly be afforded. Therefore, nine insecticides from the new chemistries, which were relatively safer to human and environment, i.e. Coragen (chlorantraniliprole), steward (indoxacarb), Belt (flubendamide), Delegate (spintoram), Volium Flexy (chlorantraniliprole + thiamethaxim), Fipronil (grafter), Proclaim (emamectin benzoate), Pirate (chlofenapyr) and Lufenuron (lufenuron), were tested on tomato crop heavily infested by this pest in the farmers field in districts Lodhran and Bahawalpur (Pakistan) in the month of April 2014. The mortality was compared after 4, 7 and 10 days and treatments were compared with control as well with one another. The average maximum % mortality, i.e. 89.36 and 85.09 of the pest, was observed with Volium Flexy, and Delegate also worked well even after 7 and 10 days. Similarly, the results on the basis of damaged fruits and percent loss of yield pointed out that Chlorantraniliprole, Flubendiamide and Indoxacarb had resulted better as compared with others, although the difference was statistically non significant. These new chemistry pesticides are suggested to be used at tomato crop against *Helicoverpa armigera* which are best fitted in the IPM program for the control of the pest.

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Keywords

Spintoram, Chlorantraniliprole, *Helicoverpa armigera*, Tomato, Pakistan

1. Introduction

Helicoverpa armigera (Hubner) (Lepidoptera: Noctuidae) is a polyphagous pest, causing significant yield loss to field crops including tomato crop [1]. It is estimated that annual crop losses globally due to *H. armigera* alone are about 5 billion dollar [2]. In Pakistan, fruit losses due to *H. armigera* are 32% - 35% [3] and 53% [4] in tomato fruit. Severity of the pest incidence can be judged from the fact that in Pakistan 80% of the total insecticides are used to overcome this pest [5]. Host plant resistance plays an important role in the minimization of losses to crops. Bt varieties are available in modern world, but there are reservations regarding adoption of Bt crops, particularly vegetables like tomato which is directly consumed in the food of human beings worldwide. Besides the hesitation in adoption of Bt tomato varieties, there are also some economic barriers. Since the most of the farming community in the developing countries is poor, storage facilities are lacking, and there is scarcity of skills and industry for transformation of raw material to value added products so marketing of such perishable commodities is uncertain and miserable therefore farmers cannot afford costly Bt varieties. In these circumstances there are few chances of resistant transgenic tomato varieties and the crop has to be tackled with alternate crop protection practices in future scenario as well.

Since alternate crop protection measures have very limited success stories, farmers have to depend upon the use of pesticides to overcome the pest quickly and effectively. However, the haphazard use of pesticides has resulted in numerous environmental and health problems [6]. Since tomato is an edible and extremely perishable commodity, the recommended period between the application of pesticide and marketing even consumption of the commodity is hardly observed. So there are fewer chances that farmers follow the ethics of plant protection and produce a product which can be fairly safe from health hazards. Therefore, it needs time to explore the efficacy of new chemistries which are relatively safer for the human health and environment, and share with farmers, extension workers and researchers the potential safe products and their efficacy against *H. armigera* which is worldwide regular pest of this crop. The safe and effective pesticides can be recommended on this important crop, as it is grown domestically in the pots and kitchen gardens as well as commercially in tunnels and fields all over the world. At the end of results, LD 50 of the products used in research trial has also been shared, so that the readers can compare the level of safety of the products. LD 50 stands for lethal dose of 50% of the test animals (usually rats or rabbits) from which they die. It is a measure of safety of the product, particularly its safety to mammals.

2. Materials and Methods

The present study was carried out to determine the efficacy of different insecticides against the larval population density of *Helicoverpa armigera* on tomato in Farmer's field at two different locations Lodhran and Bahawalpur Districts (Punjab: Pakistan) during 2014. Bahawalpur is at 29.3955 latitude and 71.68 longitude [7] and Lodhran is its adjacent district across Sutluj river. The experiment was laid out in a Randomized Complete Block Design with ten treatments including a control with three replications. The plot size was 4.5 m × 21 m and row to row distance was 60 cm. The variety under trial was T-1359, provided by Syngenta (Pakistan) Ltd. Originally plant to plant distance was 45 cm, but number of plants varied because of soil and irrigation factors. At some place multiple transplanting had succeeded where as in some places the single plants were not available after being dried. Similarly plant vigor was also variable. These factors were tried to homogenize by blocking and replication.

Nine insecticides, viz., Coragen (chlorantraniliprole), FMC United Pvt. Ltd., manufactured by Dupont, USA @ 100 ml + 15 ml surfactant/acre, Steward (indoxacarb) FMC United Pvt. Ltd., @ 175 ml/acre, Belt (flubendiamide) Bayer Crop sciences @ 50 ml/acre, Delegate (spintoram) Ali Akbar enterprises Pvt. Ltd. Manufactured by Dow agro sciences, USA @ 60 g/acre, Volium Flexy (chlorantraniliprole + thiamethaxim) Syngenta (Pakistan) Ltd. @ 80 ml/acre, Grafter (fipronil) Agri Gold Pvt. Ltd manufactured by Vifam biotechnology Group,

China @ 480 ml/acre, Proclaim (emamectin benzoate) Syngenta (Pakistan) Ltd. @ 200 ml/acre, Pirate (chlorfenapyr) Swat Agro chemicals. Manufactured by BASF, USA, @ 320 ml/acre and Lufenuron (lufenuron) Agri Gold Pvt. Ltd. manufactured by Jiangsu Flag chemicals, China @ 800 ml/acre. These are the doses recommended by the manufacturer or distributor firms. All these insecticides are commonly available in the market and their trade names have been included in the article so that common men and less educated farmers can easily recognize it with its brand name which is usually advertised by the distributor firms through electronic and print media as well as wall other advertising tools. For spraying 100 litres of tubewell/hand pump water was used to make a sprayable material in one acre (43,560 sq ft measures 1 acre, 1 hectare is equivalent to 2.47 acres). It may be added that usual ground water in this area contains 4 - 6 ppm total dissolved salts (TDS) and an alkaline pH up to 8.7. The hand operated knapsack sprayer was used for spraying. All the insecticides were tried on a relatively ignored field of tomato crop having maximum population of *Helicoverpa armigera*, so that effect of the tested pesticides could be judged fairly. The maximum average temperature for the period under study (10 days) was recorded to be 33.38°C and 34.85°C for Lodhran and Bahawalpur respectively. The minimum average temperature for the same period was 21.63°C and 20.48°C for Lodhran and Bahawalpur respectively. Average relative humidity RH for morning and evening was 68.9, 23.4 and 70.5, 32.8 for Lodhran and Bahawalpur respectively. There was no rainfall during this period on both sites.

The criteria of selection of pesticides were that it should be new chemistry, is relatively safer to mammals, safer to the environment and claims the mortality of *H. armigera*. The data on living larvae was recorded before spray and then after 4, 7 and 10 days post treatment. For the purpose of data collection, method of on site count was adopted. The number of live larvae was noted on randomly selected 15 plants from each experimental plot number of damaged fruits as well as total fruits were also noted. The yield losses were compared on qualitative bases, the fruit bored by *H. armigera* larva (caterpillar) was rendered as damaged because it has almost zero market value. It not only gets destroyed soon due to attack of saprophytic fungi but it also serves as the source of contamination and invasion of further fungal infection for healthy one packed in the cartoon or collected in the heap. The mortality of both the sites was aggregated and averaged for computing commutative average mortality of the pest. Then percent loss in yield has also been quantified through simple mathematical calculation percent of damaged fruits/total fruits, *i.e.*

$$\% \text{ damaged fruits} = (\text{Damaged fruits} / \text{Total fruits}) \times 100.$$

All the treatments were compared with control and one another to assess the performance of the treatment in uncontrolled field condition. The data were finally subjected to statistical analysis using Statistix version 8.1 and means were compared by using Tukey's HSD.

3. Results

3.1. % Mortality of *Helicoverpa armigera* 4 Days after Spray in District Lodhran

The data on the effectiveness of various insecticides sprayed to overcome the *Helicoverpa armigera* revealed a highly significant difference among treatments in district Lodhran during 2014 ($F = 472.14$; $df = 9, 18$; $P < 0.01$; **Table 1**). The results showed that the insecticide Volium Flexy and Delegate gave statistically similar % mortality of *Helicoverpa armigera*, *i.e.* 90 and 85.33 followed by Steward, belt, chlorfenpyr and Coragen having 74.33, 72.67%, 70.50% and 70% mortality of *Helicoverpa armigera* 4 days after spray. The insecticides Emamectin and Lufenuron gave statistically similar mortality *i.e.* 61.67% and 58.33%. Minimum mortality of *Helicoverpa armigera* was recorded in fipronil having 52.33% mortality of *Helicoverpa armigera*.

3.2. % Mortality of *Helicoverpa armigera* 7 Days after Spray

The data on the % mortality of *Helicoverpa armigera* 7 days after spray revealed a highly significant difference among treatments in district Lodhran during 2014 ($F = 435.83$; $df = 9, 18$; $P < 0.01$; **Table 1**). The results showed that the insecticide Volium Flexy and Delegate gave similar % mortality of *Helicoverpa armigera*, *i.e.* 89.33 and 86.67 statistically similar to Coragen, *i.e.* 83.33% followed by belt and Emamectin having 80 and 79.33% mortality of *Helicoverpa armigera* 7 days after spray. Steward having 76.67% mortality of *Helicoverpa armigera*. The insecticides chlorfenpyr gave, *i.e.* 61.67 which is statistically similar to lufenuron having 58.33% followed by fipronil with 53.00 which is minimum mortality of *Helicoverpa armigera*.

Table 1. Data regarding average % mortality of *Helicoverpa armigera* on tomato in district lodhran.

Insecticides		Dose/100 liter of water	AV. % mortality of <i>helicoverpa</i> on tomato after		
Trade name	Common name		4 days Mean \pm SE	7 days Mean \pm SE	10 days Mean \pm SE
Coragen	Chlorantraniliprole	100 ml + 15 g surfactant	70.00 \pm 0.57 ^b	83.33 \pm 0.66 ^{ab}	51.92 \pm 1.23 ^{bc}
Steward 150 EC	Indoxacarb	175 ml	74.33 \pm 0.29 ^b	76.70 \pm 1.15 ^c	45.67 \pm 1.56 ^c
Belt 39.4	Flubendiamide	50 ml	72.67 \pm 0.62 ^b	80.00 \pm 0.50 ^{bc}	49.00 \pm 0.87 ^{bc}
Delegate 25 EC	Spintoram	60 g	85.33 \pm 0.81 ^a	86.67 \pm 0.71 ^a	62.67 \pm 0.56 ^a
Volium Flexy 300 EC	Thiamethaxim + chlorantraniliprole	80 ml	90.00 \pm 0.89 ^a	89.33 \pm 0.31 ^a	55.00 \pm 1.35 ^{ab}
Fipronil	Fipronil	480 ml	52.33 \pm 0.35 ^d	53.00 \pm 0.22 ^e	23.00 \pm 0.51 ^d
Emamectin 1.9 EC	Emamectin benzoate	200 ml	61.67 \pm 0.54 ^c	79.33 \pm 0.76 ^{bc}	49.67 \pm 1.47 ^{bc}
Chlorofenapyr	Pirate	320 ml	70.50 \pm 0.34 ^b	61.67 \pm 0.82 ^d	29.00 \pm 0.10 ^d
Lufenuron 5 EC	Lufenuron	800 ml	58.33 \pm 0.92 ^c	58.33 \pm 0.64 ^{de}	27.00 \pm 0.59 ^d
	Control		3.85 \pm 0.26 ^e	5.33 \pm 0.19 ^f	4.33 \pm 0.27 ^e
Tukey's HSD @ 5%			5.60	6.09	9.05
F-value			472.14	435.83	102.36

Means sharing similar letters are not significantly different by Tukey's Test at $P = 0.05$; HSD = Honestly Significant Difference; Value * = Significant at $P \leq 0.05$; ** = Significant at $P \leq 0.01$.

3.3. % Mortality of *Helicoverpa armigera* 10 Days after Spray

The data on the % mortality of *Helicoverpa armigera* 10 days after spray revealed a highly significant difference among treatments in district Lodhran during 2014 ($F = 102.36$; $df = 9, 18$; $P < 0.01$; **Table 1**). The results showed that the insecticide Delegate gave maximum mortality of *Helicoverpa armigera*, i.e. 62.67 which is statistically similar to Volium Flexy having 55.0% followed by Coragen, Emamectin and belt having 51.92, 49.67 and 49.00% mortality of *Helicoverpa armigera* 10 days after spray. Steward having 45.67% mortality of *Helicoverpa armigera*. The minimum mortality was recorded from the insecticides chlorfenpyr, lufenuron and fipronil i.e. 29.0%, 27.0% and 23.0% mortality of *Helicoverpa armigera*.

3.4. % Mortality of *Helicoverpa armigera* 4 Days after Spray in District Bahawalpur

The data on the effectiveness of various insecticides to overcome the *Helicoverpa armigera* revealed a highly significant difference ($F = 358.05$; $df = 9, 18$; $P < 0.01$; **Table 2**) among treatments in district Bahawalpur during 2014. The results showed that the insecticide Volium Flexy and Delegate gave statistically similar % mortality of *Helicoverpa armigera*, i.e. 89.66 and 86.00 followed by Steward, Coragen and belt having 75.67%, 72.00%, 72.00% mortality of *Helicoverpa armigera* 4 days after spray. The insecticide chlorfenpyr gave 68.67% mortality. Minimum mortality of *Helicoverpa armigera* was recorded in emamectin, fipronil and Lufenuron having 58.67%, 56.67% and 55.00% mortality of *Helicoverpa armigera* which are statistically similar.

3.5. % Mortality of *H. armigera* 7 Days after Spray in District Bahawalpur

The data on the effectiveness of various insecticides to overcome the *H. armigera* revealed a highly significant difference ($P < 0.01$; **Table 2**) among treatments after 7 days post treatment in district Bahawalpur during 2014. The results showed that the insecticide Volium Flexy gave maximum mortality of *H. armigera*, i.e. 87.33% which is statistically similar to Delegate with 84.67% mortality of *H. armigera* followed by coregan, i.e. 81.33. The insecticides belt and emamectin gave statistically similar mortality, i.e. 78% and 77.33% followed by Steward 74.67%. The insecticide chlorfenpyr gave 59.67% mortality which is statistically similar to lufenuron having 56.33%. Minimum mortality of *H. armigera* was recorded in fipronil having 51.00% mortality of *H. armigera*.

Table 2. Data regarding average % mortality of *H. armigera* on tomato in district Bahawalpur.

Insecticides		Dose/100 liter of water	AV. % mortality of h. on tomato after		
Trade name	Common name		4 days Mean \pm SE	7 days Mean \pm SE	10 days Mean \pm SE
Coragen	Chlorantraniliprole	100 ml + 15 g surfactant	72.07 \pm 0.99 ^{bc}	81.33 \pm 0.66 ^a	48.63 \pm 1.01 ^{bc}
Steward 150 EC	Indoxacarb	175 ml	75.69 \pm 0.49 ^b	74.60 \pm 1.15 ^d	43.23 \pm 0.76 ^c
Belt 39.4	Flubendiamide	50 ml	72.37 \pm 1.10 ^{bc}	78.10 \pm 0.50 ^{cd}	46.38 \pm 0.87 ^{bc}
Delegate 25 EC	Spintoram	60 g	87.03 \pm 1/43 ^a	84.65 \pm 0/71 ^{ab}	60.20 \pm 0.56 ^a
Volium Flexy 300 EC	Thiamethaxim + chlorantraniliprole	80 ml	89.67 \pm 0.56 ^a	87.39 \pm 0.31 ^a	52.33 \pm 0.65 ^b
Fipronil	Fipronil	480 ml	56.57 \pm 2.21 ^d	51.08 \pm 0.22 ^f	20.33 \pm 0.51 ^d
Emamectin 1.9 EC	Emamectin benzoate	200 ml	58.61 \pm 1.45 ^d	77.33 \pm 0.76 ^{cd}	47.00 \pm 0.78 ^{bc}
Chlorfenapyr	Pirate	320 ml	68.68 \pm 1.71 ^c	59.66 \pm 0.82 ^e	26.33 \pm 0.10 ^d
Lufenuron 5 EC	Lufenuron	800 ml	55.05 \pm 1.03 ^d	56.30 \pm 0.64 ^{ef}	24.33 \pm 0.58 ^d
	Control		4.31 \pm 0.10 ^e	5.00 \pm 0.36 ^g	4.67 \pm 0.18 ^e
Tukey's HSD @ 5%			6.41	5.90	6.58
F-value			358.05	447.55	179.52

Means sharing similar letters are not significantly different by Tukey's Test at $P = 0.05$; HSD = Honestly Significant Difference; Value * = Significant at $P \leq 0.05$. ** = Significant at $P \leq 0.01$.

3.6. % Mortality of *H. armigera* 7 Days after Spray in District Bahawalpur

The data on the effectiveness of various insecticides to overcome the *H. armigera* revealed a highly significant difference ($P < 0.01$; **Table 2**) among treatments after 7 days post treatment in district Bahawalpur during 2014. The results showed that the insecticide Volium Flexy gave maximum mortality of *H. armigera*, i.e. 87.33% which is statistically similar to Delegate with 84.67% mortality of *H. armigera* followed by coregan, i.e. 81.33. The insecticides belt and emamectin gave statistically similar mortality, i.e. 78% and 77.33% followed by Steward 74.67%. The insecticide chlorfenpyr gave 59.67% mortality which is statistically similar to lufenuran having 56.33%. Minimum mortality of *H. armigera* was recorded in fipronil having 51.00% mortality of *H. armigera*.

3.7. Cumulative Average % Mortality of *H. Armigera* 4 Days after Spray in District Lodhran and Bahawalpur

The data on the effectiveness of various insecticides to overcome the *H. armigera* revealed a highly significant difference ($P < 0.01$; **Table 3**) among treatments after 4 days after spray cumulative in districts Lodhran and Bahawalpur during 2014. The results showed that the insecticide Volium Flexy and Delegate gave maximum mortality of *H. armigera*, i.e. 89.83% and 85.67% followed by steward having 75% mortality which is statistically similar to belt and Coragen with 72.33% and 71% mortality of *H. armigera* statistically similar to chlorfenpyr having 59.58. The insecticides emamectin gave 60.17% mortality statistically similar to lufenuran, i.e. 56.67% followed by fipronil 54.50% mortality which is the lowest.

3.8. Cumulative Average % Mortality of *H. armigera* 7 Days after Spray in District Lodhran and Bahawalpur

The data in the table revealed a highly significant difference ($F = 444.15$; $df = 9, 18$; $P < 0.01$; **Table 3**) among treatments after 7 days after spray cumulative in districts Lodhran and Bahawalpur during 2014. The results showed that the insecticide Volium Flexy gave maximum mortality of *H. armigera*, i.e. 88.33 which is statistically similar to Delegate with 85.67% followed by Coragen having 82.33% mortality which is statistically similar to steward with 75.67% mortality of *H. armigera*. The insecticide chlorfenpyr gave 60.67% mortality which is statistically similar to lufenuran having 57.33% mortality followed by fipronil 52.00% mortality which is the lowest.

3.9. Comparisons on the Bases of Cumulative Fruit Losses by *H. armigera* 10 Days after Spray at Research Sites and their Comparisons with Control

There was significant difference among treatments (P value 0.0017) on the bases of losses in fruit of tomato crop. The average number of the damaged fruit of tomato fruits in each treatment after 10 DAS is reflected as under in descending order. Anyhow, total loss in yield has also been indicated against each treatment in the next column.

The average percent yield loss has been provided against each pesticide correspondingly. It is evident from the results that control has maximum average population larvae 6.67 which is significantly different from Indoxacarb, flubendiamide and chlorantraniliprole having 1.0, 1.0 and 0.67 respectively (**Table 4**).

Table 3. Data regarding commutative average % mortality of *H. armigera* on tomato in districts (Bahawalpur and Lodhran).

Insecticides		Dose/100 liter of water	AV. % mortality of h. on tomato after		
Trade name	Common name		4 days Mean \pm SE	7 days Mean \pm SE	10 days Mean \pm SE
Coragen	Chlorantraniliprole	100 ml + 15 g surfactant	71.07 \pm 0.21 ^{bc}	82.23 \pm 1.99 ^{bc}	50.57 \pm 0.72 ^{bc}
Steward 150 EC	Indoxacarb	175 ml	75.53 \pm 0.11 ^b	75.65 \pm 3.45 ^d	44.23 \pm 0.68 ^c
Belt 39.4	Flubendiamide	50 ml	72.11 \pm 0.85 ^{bc}	79.3 \pm 1.49 ^{cd}	47.31 \pm 0.97 ^{bc}
Delegate 25 EC	Spintoram	60 g	85.09 \pm 1.04 ^a	85.61 \pm 1.27 ^{ab}	61.07 \pm 0.36 ^a
Volium Flexy 300 EC	Thiamethaxim + chlorantraniliprole	80 ml	89.36 \pm 0.22 ^a	88.39 \pm 0.93 ^a	53.37 \pm 0.88 ^b
Fipronil	Fipronil	480 ml	54.24 \pm 1.18 ^c	52.07 \pm 0.67 ^f	21.38 \pm 0.44 ^d
Emamectin 1.9 EC	Emamectin benzoate	200 ml	60.62 \pm 0.91 ^d	78.34 \pm 2.28 ^{cd}	48.03 \pm 1.00 ^{bc}
Chlorofenapyr	Pirate	320 ml	69.69 \pm 0.80 ^c	60.66 \pm 2.46 ^e	27.32 \pm 0.16 ^d
Lufenuron 5 EC	Lufenuron	800 ml	56.02 \pm 0.11 ^{de}	57.32 \pm 1.93 ^{ef}	25.31 \pm 0.56 ^d
	Control		4.09 \pm 0.10 ^f	5.01 \pm 0.83	4.50 \pm 0.21 ^e
	Tukey HSD @ 5%		5.06	5.98	6.43
	F-value		574.61	444.15	195.14

Means sharing similar letters are not significantly different by Tukey HSD Test at P = 0.05; HSD = Honestly Significant Difference; Value * = Significant at P \leq 0.05; ** = Significant at P \leq 0.01.

Table 4. Comparisons of treatments regarding average population of larvae on 15 tomato plants per treatment and percent quantitative yield loss in each treatment.

Treatment No.	Description of treatments	Mean damaged fruits on 15 plants/treatment	Mean % loss of yield /treatment	Oral MT mg/ml per Kg BW	Dermal MT mg/ml per Kg BW
10	Control	6.67 ^a	23.41 ^a	0	0
8	Chlorfenapyre	6.0 ^b	18.01 ^b	560	>2000
9	Lufenuron	5.33 ^{ab}	19.80 ^{ab}	>2000	>2000
5	Thiamethaxim + chlorantraniliprole	4.33 ^{abc}	19.21 ^{ab}	>5000 + >5000	>2000 + >5000
7	Emamectin benzoate	2.67 ^{abc}	13.16 ^{ab}	>2950	>2000
6	Fipronil	2.33 ^{abc}	9.98 ^{ab}	500	2000
4	Spintoram	1.33 ^{bc}	8.15 ^{ab}	>5000	>5000
2	Indoxacarb	1.00 ^{bc}	4.86 ^b	>1867	>5000
3	Flubendiamide	1.00 ^{bc}	4.63 ^b	>2000	>4000
1	Chlorantraniliprole	0.67 ^c	3.42 ^b	>5000	>5000

MT = Mammalian Toxicity; BW = Body weight ([11]); Means sharing similar letters are not significantly different by Tukey HSD Test at P = 0.05; HSD = Honestly Significant Difference; Value * = Significant at P \leq 0.05.

4. Discussion

The perusal of the results reveal that that after four days of the application, Thiamethaxim + chlorantraniliprole and Spintoram have performed better and these products have maintained their position up till 10 days after application of pesticides. It shows that these products have relatively better persistence and contact mortality of the pest. Whereas, the results on the basis of damaged fruits and percent loss of yield point out that Chlorantraniliprole, Flubendiamide and Indoxacarb have resulted better as compared to others although the difference is statistically non significant, that these products are relatively fast in action and may have caused the mortality of pest earlier therefore the damage stopped but after four days other products proved even more effective then these one but since there is a non significant difference so the result of above mentioned five pesticides as well as flubendiamide are almost at par. The results of flubendiamide against the pest are confirmation of results shared by [8].

A limited information is available regarding the efficacy of new chemistry on tomato anyhow, the results of this study are in conformity with [9] who reported that indoxacarb when tested with some other biopesticides reduced the population of *Helicoverpa armigera* (Hubner) from 10.75 to 0.75 after 1 spray and it was rapid in action. has also reported similar results rather better in view of being ecofriendly, this product also fell on our criteria but unfortunately it could not be tested in this study. [9] had included endosulfan and other products but these products do not fit on our criteria because as a general perception pesticides of Chlorinated Hydrocarbons (CHC) and organophosphates (OP) are more Hazardous to humans as compared to new chemistry. For example acute oral toxicity of endosulfan, chlorpyrifos and profenophos which were conventionally used against this pest is 160 mg, 96 - 270 mg and 358 respectively but the acute oral toxicity of the pesticides we have tested are usually more than >2000 except fipronil and indoxacarb, see Table 4.

5. Conclusion

It can be concluded from this study that Thiamethaxim + chlorantraniliprole, Spintoram, Chlorantraniliprole, Flubendiamide and Indoxacarb are effective and relatively safer choices for control of tomato fruit borer *Helicoverpa armigera* (Hubner). If the crop is infested and is to be managed, these pesticides can be recommended at proper doses. But if the crop has pest population below economic threshold and further protection from pest is needed, Lufenuron and emamectin can also be used. It is strongly recommended that using conventional pesticides from CHC and OP group should be discouraged for management of *Helicoverpa armigera* (Hubner), at least on vegetables. The study will serve a step towards modern agriculture, like organic farming [10], for general farming community with an aim to provide the working labor and consumers much safer products.

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