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Bioefficacy of selected insecticides against tomato fruit borer, *Helicoverpa armigera* (Hubner)

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Abstract
Selected insecticides *viz*. Azadirachtin 10000 ppm, Chlorantraniliprole 18.5 SC, Cyantraniliprole 10.26 OD, Flubendiamide 39.35 SC, Indoxacarb 14.5 SC, Lambda cyhalothrin 5 EC, Novaluron 10 EC were evaluated for their effectiveness against tomato fruit borer by conducting field trial at Post Graduated Institute, MPKV, Rahuri during the year 2018. Three sprays of each insecticide were applied at the occurrence of the pest. The result revealed that lowest larval population (0.59 larva/plant) of *H. armigera* was recorded in treatment of chlorantraniliprole 18.5% SC. Indoxacarb 14.5% SC (0.73 larva/plant) was the next promising treatment which was followed by flubendiamide 39.35% SC exhibiting 0.80 larva/plant. Treatments *viz.,* cyantraniliprole 10.26% OD, lambda cyhalothrin 5% EC and azadirachtin 10000 ppm found to be moderately effective against *H. armigera* and recorded larval population ranging from 0.93 to 1.15 larvae per plant. Novaluron 10% EC was the least effective, with maximum (1.19 larvae/plant) population of *H. armigera.*

Keywords: Selected insecticides, fruit borer *H. armigera*, tomato, chlorantraniliprole

Introduction
Globally, tomato is cultivated over an area of 4.8 million ha with an annual production of 282.830 million MT with the productivity of 37.66 MT ha^{-1} (Anon., 2017) [2]. In India, tomato is mainly grown in *kharif* and *rabi* seasons whereas in some regions it is produced throughout the year. It occupies an area of about 0.78 million ha producing over 19.37 million MT with the productivity of 24.65 MT ha^{-1}. In Maharashtra, approximately 43640 ha area is covered under tomato with a production of 0.95 million MT with an average productivity of 21.93 MT ha^{-1} (Anon., 2017) [2].
Tomato growers regularly experienced the economic damage caused by various pests. The tomato fruit borer is most destructive polyphagous insect and assumed a status of ‘key pest’ in all parts of world. It feeds and breeds on 181 species of host plants (Manjunath *et al*., 1989) [4]. Fruit borer *Helicoverpa armigera* Hubner (Lepidoptera: Noctuidae) causes considerable losses in quantity as well as quality of tomato fruits (Singh and Chahal, 1978; Tewari and Moorthy, 1984; Reddy and Zehrm, 2004) [5, 6, 8]. Early instar larvae feed on flower buds and foliage while matured instars bore into fruit resulting in yield reduction (Rath and Nath, 1997) [7]. The *Helicoverpa* larvae damages the tomato crop earlier by making scratches on leaves and developing fruits, affected leaves are dried. The third instar larvae feed on leaves, flower buds and flowers. At fruiting stage, they prefer to feed on fruits. Third and fourth instar feed on the developing fruits with whole body inside the fruit, whereas, only the apical half portion of fifth instar larvae remains inside the fruit (Kumar 1996) [11]. As a result, the fruits become unfit for human consumption.
The rapid growth, potential natural dispersal and resistance to insecticides render this pest as the most serious threat for tomato production systems worldwide (Desneux *et al.,* 2010) [9]. Various methods have been tried for the control of insect-pests. But use of chemical method is an important approach for their control because of its quick action, effectiveness and adaptability to various situations. Several insecticides have been recommended and used for the effective management of tomato insect-pests. But according to several reports many of these label claimed insecticides could not achieved effective results. Therefore, keeping the above information in view Bio-efficacy of selected insecticides against this pest was conducted.

Material and Methods

The experiment was conducted at Research Farm, Post Graduate Institute, MPKV, Rahuri during 2018-19. The field was prepared with deep ploughing and harrowing. The trial was laid out in a randomized block design (RBD) with three replications and eight treatments. The seed of Phule Kesari was used for nursery sowing. The treatment plots of size 3.6 m x 3.6 m were prepared and the distance between replication was kept 0.6 m. Insecticides of different chemical groups were selected and the treatments were imposed as foliar sprays against the tomato fruit borer. Total three sprays were given at an interval of 10 days, initiating the first spray on appearance of fruit borer infestation. Quantity of spray fluid required per plot was calculated by spraying untreated control plot with water, taking into consideration the recommended rate of 500 lit/ha. Five plants in each plot were randomly selected and tagged for recording observations on survival larval population. The larval population was recorded one day before spray as pretreatment count. Post treatment count was taken at three, seven and ten days after each spraying. Percent reduction in larval population over control after three sprays was also worked out.

Results and Discussion

Effect of different insecticides on larval population of fruit borer (*Helicoverpa armigera*) after first spray

The data recorded on larval population of *H. armigera* after first spray presented in Table 1 and depicted in Fig. 1. The larval population was found to be non-significant indicating uniformality in population in all the treatments a day before spraying. The data recorded at 3 DAS indicated that all the insecticidal treatments recorded significantly lower larval population as compared to control (0.93 larvae/plant). Among the different insecticidal treatments, lowest larval population (0.33 larva/plant) of *H. armigera* was recorded in the treatment with chlorantraniliprole 18.5% SC followed by indoxacarb 14.5% SC (0.47 larva/plant) which was at par with the treatment of flubendiamide 39.35% SC followed by cyantraniliprole 10.26% OD which exhibited 0.60 larva/plant. Rest of the treatments *viz.,* lambda cyhalothrin 5% EC and novaluron 10% EC were found middle in the order as they both showed 0.73larva/plant, respectively. Whereas treatment with azadirachtin 10,000 ppm was found to be the least effective recording highest larval population (0.87 larvae/plant) of *H. armigera.* The perusal of data recorded at 7 DAS revealed that treatment chlorantraniliprole 18.5% SC maintains its superiority over other treatments by recording the lowest larval population (0.40 larva/plant). The next effective treatment was indoxacarb 14.5% SC (0.53 larva/plant) and it was statistically at par with the treatment of flubendiamide 39.35% SC (0.60 larva/plant).

The data on larval population recorded at 10 DAS indicated that the treatment of chlorantraniliprole 18.5% SC proved to be the most effective with lowest larval population (0.53 larva/plant) followed by indoxacarb 14.5% SC (0.67 larva/plant) and it was at par with flubendiamide 39.35% SC (0.73 larva/plant). Whereas the maximum larval population (1.00 larva/plant) was recorded in the treatment novaluron 10% EC. While, rest of the treatments *viz.,* cyantraniliprole 10.26% OD, lambda cyhalothrin 5% EC, azadirachtin 10000 ppm recorded 0.87, 0.87 and 0.93 larva per plant against 1.27 larva/plant in untreated control.

Effect of different insecticides on larval population of fruit borer (*Helicoverpa armigera*) after second spray

The data (Table 2) recorded on larval population at 3 DAS of second spraying indicated that all the insecticidal treatments recorded significantly lowest larval population as compared to control. Among the different insecticidal treatments, the lowest (0.47 larva/plant) larval population of *H. armigera* was recorded in chlorantraniliprole 18.5% SC. Next promising treatment was indoxacarb 14.5% SC (0.60 larva/plant) which was found to be as good as flubendiamide 39.35% SC (0.67 larva/plant). The subsequent effective treatments were *viz.,* cyantraniliprole 10.26% OD, lambda cyhalothrin 5% EC and azadirachtin 10000 ppm which recorded 0.80, 0.93 and 1.00 larva/plant of *H. armigera,* respectively. However, the treatment novaluron 10% EC exhibited highest larval population (1.07 larva/plant) of *H. armigera.*

At 7 DAS, the treatment chlorantraniliprole 18.5% SC maintained its superiority over the treatments by recording the minimum larval population (0.60 larva/plant). Indoxacarb 14.5% SC (0.73 larva/plant) was next better treatment which was found on par with flubendiamide 39.35% SC (0.80 larva/plant). The treatments of cyantraniliprole 10.26% OD, azadirachtin 10000 ppm and lambda cyhalothrin 5% EC exhibited 0.87, 0.93 and 1.00 larval population of *H. armigera,* respectively and found at par with each other. The treatment novaluron 10% EC exhibited highest larval population (1.13 larva/plant) of *H. armigera.*

The data on larval population obtained at 10 DAS (Table 2) indicated that the treatment of chlorantraniliprole 18.5% SC found to be the most effective against *H. armigera* recording 0.73 larva/plant. Indoxacarb 14.5% SC (0.93 larva/plant) and flubendiamide 39.35% SC (1.00 larva/plant) were statistically at par with each other. The upcoming better treatments for minimizing larval population was cyantraniliprole 10.26% OD (1.13 larva/plant), azadirachtin 10000 ppm (1.20 larva/plant) and lambda cyhalothrin 5% EC (1.27 larva/plant).The treatment novaluron 10% EC exhibited highest larval population (1.33 larva/plant) of *H. armigera.* However, in untreated control recorded significantly higher larval population 1.73 larva/plant of *H. armigera*.

Effect of different insecticides on larval population of fruit borer (*Helicoverpa armigera*) after third spray

Data recorded at 3 DAS indicated that all the insecticidal treatments recorded significantly less larval population as compared to control. Lowest larval population (0.67 larva/plant) of *H. armigera* was recorded in treatment of chlorantraniliprole 18.5% SC. Indoxacarb 14.5% SC (0.80 larva/plant) was next promising treatment which was followed by flubendiamide 39.35% SC exhibiting 0.93 larva/plant of tomato fruit borer. Treatments *viz.,* cyantraniliprole 10.26% OD, azadirachtin 10000 ppm and lambda cyhalothrin 5% EC found to be moderately effective against *H. armigera* and recorded larval population ranging from 1.07 to 1.20 larvae per plant of *H. armigera*. Novaluron 10% EC was least effective, with maximum (1.33 larvae per plant) population of *H. armigera*.

It is evident from the data that the larval population of *H. armigera* varied from 0.73 to 1.47 larvae per plant in different insecticidal treatments at 7 DAS. Minimum larval population (0.73 larva/plant) was noted in the treatment chlorantraniliprole 18.5% SC. Treatment novaluron 10% EC (1.47 larva/plant) showed comparatively maximum larval population of *H. armigera*. The rest of the treatments indoxacarb 14.5% SC, flubendiamide 39.35% SC, cyantraniliprole 10.26% OD, azadirachtin 10000 ppm and lambda cyhalothrin 5% EC recorded 0.93, 1.00, 1.07, 1.13 and 1.33 larval population per plant, respectively.

At 10 DAS, chlorantraniliprole 18.5% SC maintains its dominance by exhibiting lowest larval population (0.80 larva/plant). The next promising treatments were indoxacarb 14.5% SC (1.00 larva/plant) and flubendiamide 39.35% SC (1.07 larva/plant) which were statistically at par with each other. While, remaining treatments which recorded intermediate population of *H. armigera* were cyantraniliprole 10.26% OD (1.27 larva/plant), lambda cyhalothrin 5% EC (1.40 larva/plant) and novaluron 10% EC (1.60 larva/plant). However, maximum larval population (1.73 larva/plant) was recorded in treatment of azadirachtin 10000 ppm which was observed least effective against *H. armigera*.

Effect of different insecticides on larval population of fruit borer (*Helicoverpa armigera*) after three sprays

The data on cumulative effect of different treatments on larval population after three sprays presented in Table 3 and depicted in Fig. 3. All the insecticidal treatments recorded significantly less larval population as compared to control. Lowest larval population (0.59 larva/plant) of *H. armigera* was recorded in treatment of chlorantraniliprole 18.5% SC. Indoxacarb 14.5% SC (0.73 larva/plant) was next promising treatment which was followed by flubendiamide 39.35% SC exhibiting 0.80 larva/plant of tomato fruit borer. Treatments *viz.*, cyantraniliprole 10.26% OD, lambda cyhalothrin 5% EC and azadirachtin 10000 ppm found to be moderately effective against *H. armigera* and recorded larval population ranging from 0.93 to 1.15 larvae per plant of *H. armigera*. Novaluron 10% EC was least effective, with maximum (1.19 larvae per plant) population of *H. armigera.*

The results of present investigation are in close agreement with the result of Patel *et al.* (2016) who reported that chlorantraniliprole 35 WG @ 30 g a.i./ha recorded the reduced larval population of *H. armigera* on tomato. Ambule *et al.* (2015) [1] reported that flubendiamide 20% WG recorded minimum (0.43 larva/plant) larval population and which was at par with chlorantraniliprole 18.5% SC which recorded the 0.58 larva/plant.

Abbas *et al.* (2015) recorded the maximum larval mortality (89.36%) in tomato when sprayed with chlorantraniliprole + thiamethoxam. The results of above researchers lend support the present findings.

Table 1: Efficacy of selected insecticides on larval population of tomato fruit borer after first spray

Sr. No.	Treatments	Mean larval population of *H. armigera*				
		Pre count	3 DAS	7 DAS	10 DAS	Mean
1	Azadirachtin 10000 ppm	0.67 (1.08)	0.87 (1.17)	0.80 (1.14)	0.93 (1.20)	0.87 (1.17)
2	Chlorantraniliprole 18.5 SC	0.53 (1.02)	0.33 (0.91)	0.40 (0.95)	0.53 (1.02)	0.42 (0.96)
3	Cyantraniliprole 10.26 OD	0.53 (1.02)	0.60 (1.05)	0.73 (1.11)	0.87 (1.17)	0.73 (1.11)
4	Flubendiamide 39.35 SC	0.53 (1.02)	0.47 (0.98)	0.60 (1.05)	0.73 (1.11)	0.60 (1.05)
5	Indoxacarb 14.5 SC	0.60 (1.05)	0.47 (0.98)	0.53 (1.02)	0.67 (1.08)	0.56 (1.03)
6	Lambda cyhalothrin 5 EC	0.47 (0.98)	0.73 (1.11)	0.80 (1.14)	0.87 (1.17)	0.80 (1.14)
7	Novaluron 10 EC	0.53 (1.02)	0.73 (1.11)	0.93 (1.20)	1.00 (1.22)	0.91 (1.19)
8	Untreated control	0.53 (1.02)	0.93 (1.20)	1.13 (1.28)	1.27 (1.33)	1.13 (1.28)
	S.E. ±		0.03	0.04	0.03	0.012
	CD at 5%		0.09	0.11	0.09	0.035

(Figures in the parenthesis are square root transformed values)

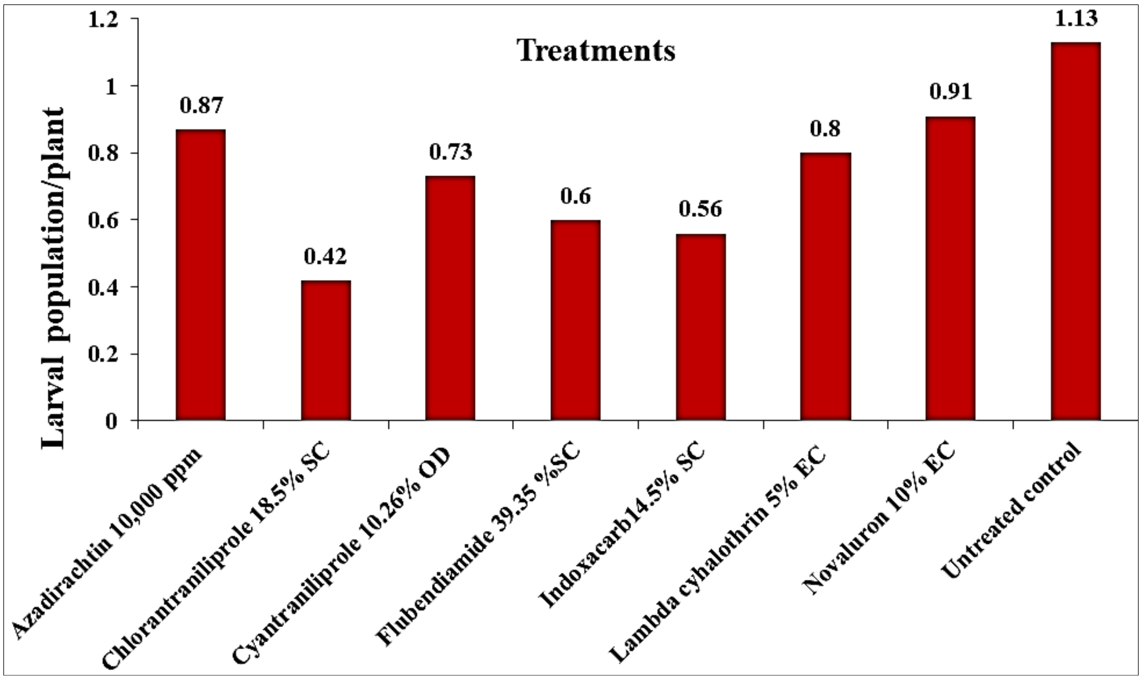

Fig 1: Efficacy of selected insecticides on larval population of tomato fruit borer after first spray

Table 2: Efficacy of selected insecticides on larval population of tomato fruit borer after second spray

Sr. No.	Treatments	Mean larval population of *H. armigera*			
		3 DAS	7 DAS	10 DAS	Mean
1	Azadirachtin 10000 ppm	1.00 (1.22)	0.93 (1.20)	1.20 (1.30)	1.04 (1.24)
2	Chlorantraniliprole 18.5 SC	0.47 (0.98)	0.60 (1.05)	0.73 (1.11)	0.60 (1.05)
3	Cyantraniliprole 10.26 OD	0.80 (1.14)	0.87 (1.17)	1.13 (1.28)	0.93 (1.20)
4	Flubendiamide 39.35 SC	0.67 (1.08)	0.80 (1.14)	1.00 (1.22)	0.82 (1.15)
5	Indoxacarb 14.5 SC	0.60 (1.05)	0.73 (1.11)	0.93 (1.20)	0.73 (1.11)
6	Lambda cyhalothrin 5 EC	0.93 (1.20)	1.00 (1.22)	1.27 (1.33)	1.07 (1.25)
7	Novaluron 10 EC	1.07 (1.25)	1.13 (1.28)	1.33 (1.35)	1.18 (1.29)
8	Untreated control	1.33 (1.35)	1.47 (1.40)	1.73 (1.49)	1.51 (1.42)
	S.E. ±	0.04	0.04	0.04	0.01
	CD at 5%	0.11	0.12	0.12	0.04

(Figures in the parenthesis are square root transformed values)

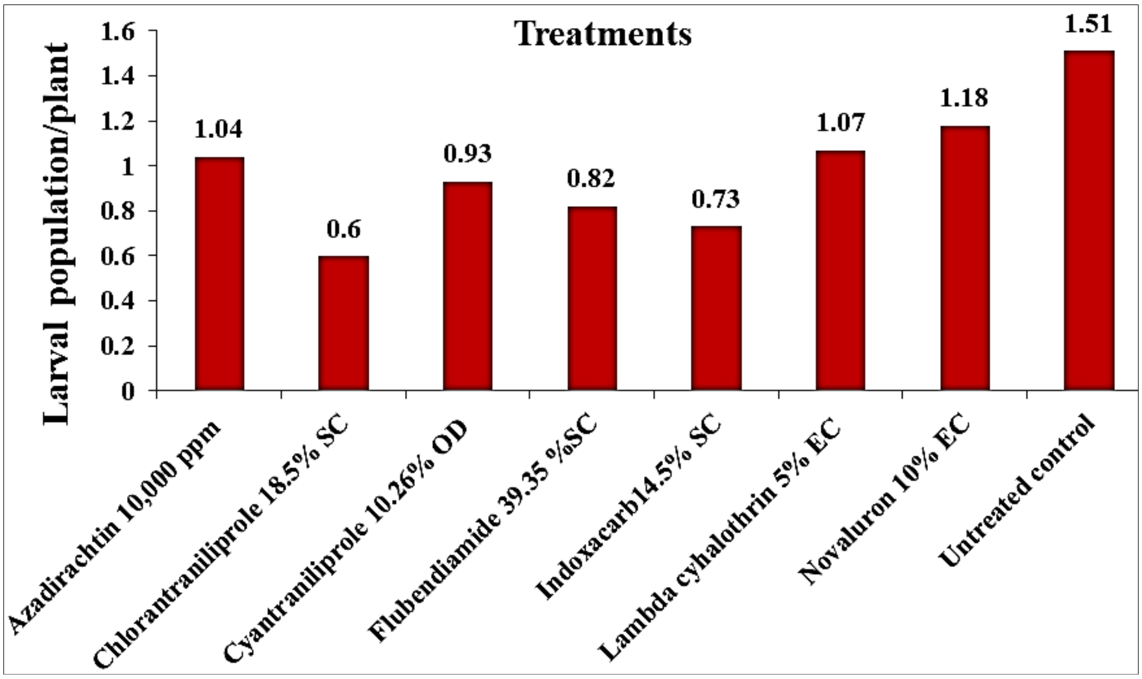

Fig 2: Efficacy of selected insecticides on larval population of tomato fruit borer after second spray

Table 3: Efficacy of selected insecticides on larval population of tomato fruit borer after third spray

Sr. No.	Treatments	Mean larval population of *H. armigera*			
		3 DAS	7 DAS	10 DAS	Mean
1	Azadirachtin 10000 ppm	1.20 (1.30)	1.13 (1.28)	1.73 (1.49)	1.53 (1.42)
2	Chlorantraniliprole 18.5 SC	1.67 (1.08)	0.73 (1.11)	0.80 (1.14)	0.73 (1.11)
3	Cyantraniliprole 10.26 OD	1.07 (1.25)	1.07 (1.25)	1.27 (1.33)	1.13 (1.28)
4	Flubendiamide 39.35 SC	0.93 (1.20)	1.00 (1.22)	1.07 (1.25)	0.98 (1.22)
5	Indoxacarb 14.5 SC	0.80 (1.14)	0.93 (1.20)	1.00 (1.22)	0.89 (1.18)
6	Lambda cyhalothrin 5 EC	1.20 (1.30)	1.33 (1.35)	1.40 (1.38)	1.31 (1.35)
7	Novaluron 10 EC	1.33 (1.35)	1.47 (1.40)	1.60 (1.45)	1.47 (1.40)
8	Untreated control	1.87 (1.54)	2.00 (1.58)	2.53 (1.74)	2.20 (1.64)
	S.E. ±	0.04	0.04	0.05	0.02
	CD at 5%	0.12	0.13	0.14	0.06

(Figures in the parenthesis are square root transformed values)

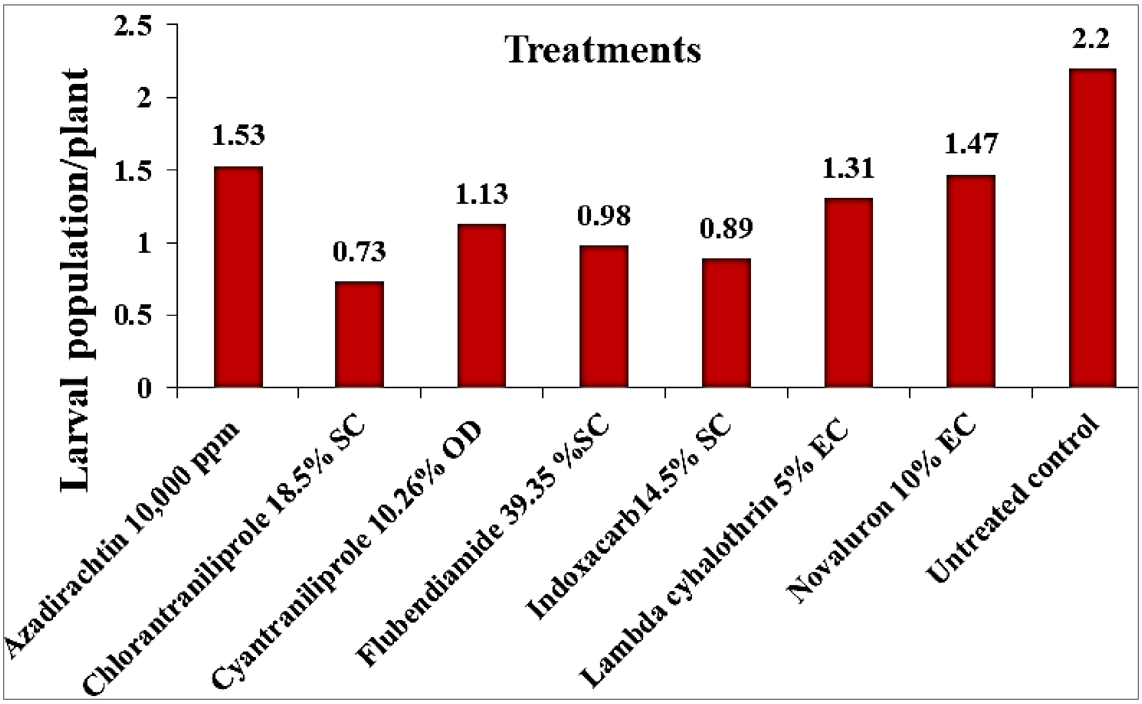

Fig 3: Efficacy of selected insecticides on larval population of tomato fruit borer after third spray

Table 4: Cumulative effect of selected insecticides on larval population of tomato fruit borer

Sr. No	Treatments	Mean larval population of *H. armigera*			
		I spray	II spray	III spray	Mean
1	Azadirachtin 10000 ppm	0.87 (1.17)	1.04 (1.24)	1.53 (1.42)	1.15 (1.28)
2	Chlorantraniliprole 18.5 SC	0.42 (0.96)	0.60 (1.05)	0.73 (1.11)	0.59 (1.04)
3	Cyantraniliprole 10.26 OD	0.73 (1.11)	0.93 (1.20)	1.13 (1.28)	0.93 (1.20)
4	Flubendiamide 39.35 SC	0.60 (1.05)	0.82 (1.15)	0.98 (1.22)	0.80 (1.14)
5	Indoxacarb 14.5 SC	0.56 (1.03)	0.73 (1.11)	0.89 (1.18)	0.73 (1.11)
6	Lambda cyhalothrin 5 EC	0.80 (1.14)	1.07 (1.25)	1.31 (1.35)	1.06 (1.25)
7	Novaluron 10 EC	0.91 (1.19)	1.18 (1.29)	1.47 (1.40)	1.19 (1.30)
8	Untreated control	1.13 (1.28)	1.51 (1.42)	2.20 (1.64)	1.61 (1.45)
	S.E. ±	0.012	0.01	0.02	0.02
	CD at 5%	0.035	0.04	0.06	0.07

(Figures in the parenthesis are square root transformed values)

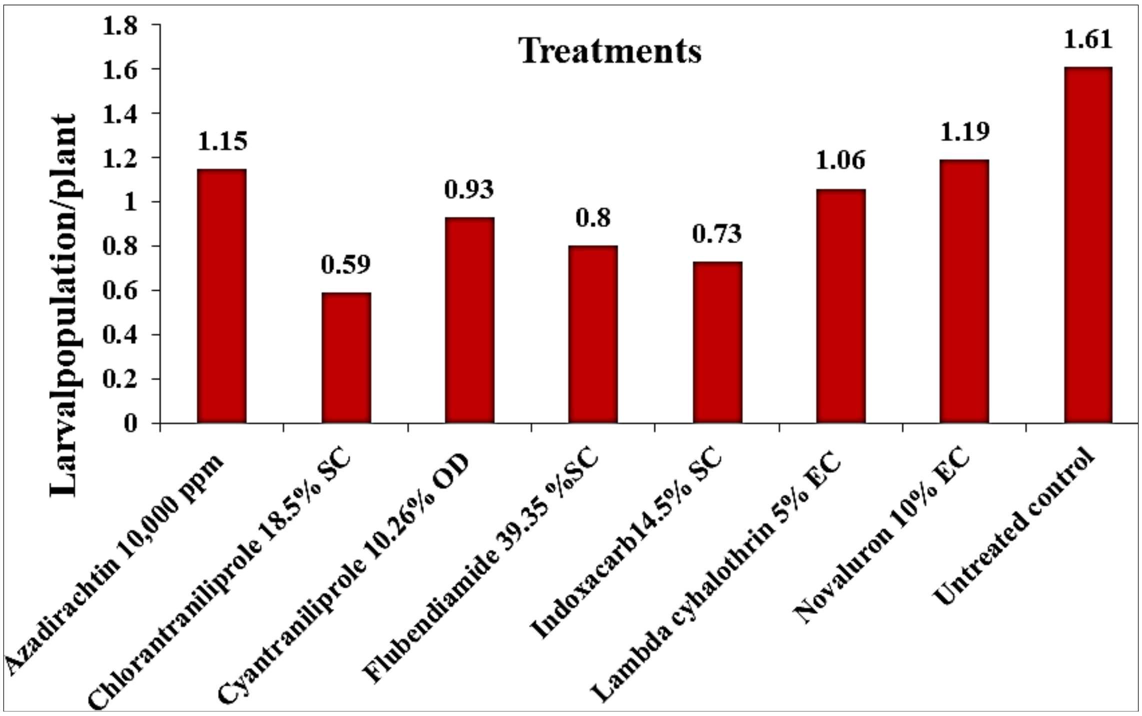

Fig 4: Cumulative effect of selected insecticides on larval population of tomato fruit borer after three spray

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