The Pharma Innovation Journal 2022; SP-11(6): 1100-1105

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(6): 1100-1105

www.thepharmajournal.com
Received: 07-04-2022
Accepted: 11-05-2022

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Bio-efficacy of new insecticide molecules against tomato fruit borer, *Helicoverpa armigera* (Hubner) under field conditions

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Abstract
The field experiment conducted at research farm of Tirhut College of Agriculture (TCA), Dholi which lies in the district of Muzaffarpur, a sub campus of "Dr. Rajendra Prasad central agricultural University (RPCAU)" Pusa, Samastipur, Bihar for evaluating bio-efficacy of two doses of chlorantraniliprole 18.5 SC (30 and 60 g *a.i.*/ha) and two dose of indoxacarb 14.5 SC (75 and 150 g *a.i.*/ha) against tomato fruit borer (*Helicoverpa armigera*) during *Rabi*, 2020 in tomato crop. Result revealed that chlorantraniliprole 18.5 SC @ 60 g *a.i.*/ha was reduce larval population of *H. armigera* as well as lowest per cent of fruit damage compared to control. The treatment chlorantraniliprole 18.5 SC @ 60 g *a.i.*/ha was found most effective against fruit borer on tomato crop, which was statistically at par with chlorantraniliprole 18.5 SC @ 30 g *a.i.*/ha and both significantly superior from rest of the treatments.

Keywords: Chlorantraniliprole, tomato, indoxacarb, tomato fruit borer

Introduction
Tomato (*Lycopersicon esculentum* Mill) is one of the most important nutritious and remunerative vegetable widely grown throughout the world and tops in the list of canned vegetables (Choudhary 1996) [1]. It is grown under tropical and subtropical and temperate regions. Tomato fruit can be consumed both in row form as well as in cooked form and also fruits are used for the preparation of ketchup, puree, paste, powder, soup and juice extensively. The various type of biotic and abiotic factors responsible for the reduction of production and productivity of tomato. The influence of biotic factors and infestation of insect pest is considered as a one of the most important reasons. There are about a hundred of insect pests infesting tomato have been recorded all around the world (Taleker *et al*., 1983) [10]. Besides causing direct damage both quantitatively and qualitatively, they also cause damage indirectly by acting as a vector of various important plant viruses that causes important diseases (Dharumarajan *et al*., 2009) [2]. The commom insect pest that are regularly associated with tomato crops are tomato fruit borer, *Helicoverpa armigera* (Hubner), tobacco caterpillar, *Spodoptera litura* (Fabricius), leaf miner, *Liriomyza trifolii* (Burgess), hadda beetle, *Henosepilachna vigintioctopunctata* (Fabricius), lace wing bug, *Urentius hystricellus* (Richter), aphid, *Aphis gossypii* (Glover) and whitefly *Bemisia tabaci* (Gennadius) (Meena and Raju, 2014) [4]. In India, *H. armigera* is most serious one and is responsible for huge economic losses (Singh *et al*., 2011) [9] by reducing the quantity, quality thereby market value (Reddy and Zeharm, 2004) [7]. The pest is found to be associated with crop both during the vegetative and reproductive stage and is responsible for 50-80 per cent yield losses in tomato under favourable climatic conditions (Wade *et al*., 2020) [11]. In India around 5 to 55 per cent losses due to fruit borer in tomato growing regions. Under favourable condition, damage cause by the pest up to 88 per cent. (Selvanaryanan and Narayanasamy, 2006) [8]. To control the fruit borer, different pesticides are being used in large quantities by farmers because other crop protection techniques have very limited success criteria, so farmers are depending upon the use of pesticides to control the pest quickly and effectively. However, the indiscriminate use of synthetic pesticides has resulted in reduction of biodiversity, outbreak of secondary pests, development of pesticide resistance, pesticide-induced resurgence and contamination of food and the ecosystem. The judicious use of pesticide accumulates the toxic pesticide residue on an agriculture produce and poses serious threat to health of the consumers. Therefore, now a days newer chemicals are required which are selective, eco-friendly and can replace older chemicals on tomato.

Materials and Methods
The investigations entitled "Bio-efficacy of new insecticide molecules against tomato fruit borer, *Helicoverpa armigera* (hubner) under field conditions" were carried out under field conditions. The field experiment was conducted during *rabi* season of 2020 at research farm of Tirhut College of Agriculture (TCA), Dholi which lies in the district of Muzaffarpur, a sub campus of "Dr. Rajendra Prasad central agricultural University (RPCAU)" Pusa, Samastipur, Bihar.

Tomato (var. Kashi Vishesh) was raised in randomized block design (RBD) according to the recommended agronomic practices for this region. The seedlings were transplanted on first week of November at appropriate spacing of 30 cm x 45cm in plots size of 25 m^2 with recommended standard agronomical practices except crop protection measures. There were five treatments including control replicated four times. The insecticidal treatments chlorantraniliprole (Coragen$^{(R)}$ 18.5 per cent SC) and Indoxacarb (Isacarb$^{(R)}$ 14.5 per cent SC) were applied on tomato crop at dosages of 30 and 60; 75 and 150 g a.i./ ha, respectively by using High Pressure Lithium Battery Operated Knapsack Sprayer holds capacity of 15 L. The first application was applied at 50 per cent flowering/ fruit initiation stage & subsequently two sprays were done at 10 days interval. From each plot 5 plants were selected randomly and tagged. The observations were recorded at 3, 5, and 10 days after spraying (DAS) for mean larval population of *H. armigera* was recorded on the basis of number.

Results
Effect of different insecticides on larval population of fruit borer (*H. armigera*) after first spray
The data recorded on larval population of *H. armigera* presented in (Table 1) and depicted in (Fig. 1). The larval population was found to be nonsignificant indicating uniformality in population in all the treatments at 24 hours before spraying. The data recorded at 3 DAS indicated that all the insecticidal treatments recorded significantly lower larval population as compared to control (2.65 larvae/plant). Among the different insecticidal treatments, lowest larval population (1.30 larvae/plant) was recorded in the treatment with chlorantraniliprole 18.5 SC @ 60 g *a.i.*/ha followed by chlorantraniliprole 18.5 SC @ 30 g *a.i.*/ha (1.50 larvae/ plant), indoxacarb 14.5 SC @ 150 *a.i.*/ha (1.70 larvae/plant) and indoxacarb 14.5 SC @ 75 *a.i.*/ha (1.90 larvae/plant). chlorantraniliprole 18.5 SC @ 60 g *a.i.*/ha which was at par with treatment chlorantraniliprole 18.5 SC @ 60 g *a.i.*/ha and indoxacarb 14.5 SC @ 150 *a.i.*/ha. As treatment with indoxacarb 14.5 SC @ 75 *a.i.*/ha was found least effective recording highest larval population (1.90 larvae/plant).

At 7 DAS, revealed that treatment chlorantraniliprole 18.5 SC @ 60 g *a.i.*/ha maintains its superiority over other treatments by recording lowest larval population (1.50 larvae/plant) followed by chlorantraniliprole 18.5 SC @ 30 g *a.i.*/ha (1.70 larvae/plant) and indoxacarb 14.5 SC @ 150 *a.i.*/ha (1.80 larvae/plant). Whereas maximum larval population (2.00 larvae/plant) was found with least effective treatment indoxacarb 14.5 SC @ 75 *a.i.*/ha.

The data on larval population on 10 DAS indicated that the treatment of chlorantraniliprole 18.5 SC @ 60 g *a.i.*/ha proved to be the most effective with lowest larval population of 1.65 larvae/plant followed by chlorantraniliprole 18.5 SC @ 30 g *a.i.*/ha (1.80 larvae/plant), indoxacarb 14.5 SC @ 150 *a.i.*/ha (1.90 larvae/plant) and indoxacarb 14.5 SC @ 75 *a.i.*/ha (2.15 larvae/plant).

Effect of different insecticides on larval population of fruit borer (*H. armigera*) after second spray
The data (Table 2) & (Fig. 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 larval population (1.05 larva/plant) of *H. armigera* was recorded chlorantraniliprole 18.5 SC @ 60 g *a.i.*/ha. Next promising treatment was chlorantraniliprole 18.5 SC @ 30 g *a.i.*/ha (1.15 larvae/ plant) followed by indoxacarb 14.5 SC @ 150 *a.i.*/ha (1.30 larvae/plant) and indoxacarb 14.5 SC @ 75 *a.i.*/ha (1.40 larvae/plant). However, the treatment indoxacarb 14.5 SC @ 75 *a.i.*/ha exhibited highest larval population (1.40 larvae/plant) of tomato fruit borer. At 3 DAS, among the treatments there are no significant difference found.

At 7 DAS, the treatment chlorantraniliprole 18.5 SC @ 60 g *a.i.*/ha maintained its superiority over the treatments by recording the minimum larval population (1.10 larva/plant). Chlorantraniliprole 18.5 SC @ 30 g *a.i.*/ha (1.30 larvae/plant) was next better treatment followed by indoxacarb 14.5 SC @ 150 *a.i.*/ha (1.40 larvae/plant). Whereas, the treatment of indoxacarb 14.5 SC @ 75 *a.i.*/ha showed highest larval population of 1.41 larva/plant of *H. armigera*.

The data on larval population obtained at 10 DAS indicated that the treatment of chlorantraniliprole 18.5 SC @ 60 g *a.i.*/ha found to be effective against *H. armigera* recording (1.25 larvae/plant) followed by chlorantraniliprole 18.5 SC @ 30 g *a.i.*/ha (1.35 larvae/ plant), indoxacarb 14.5 SC @ 150 *a.i.*/ha (1.50 larvae/plant) and indoxacarb 14.5 SC @ 75 *a.i.*/ha (1.65 larvae/plant). The treatment indoxacarb 14.5 SC @ 75 *a.i.*/ha exhibited highest larval population (1.65 larvae/plant) of *H. armigera*. However, in untreated control recorded significantly higher larval population (3.05 larvae/plant) of tomato fruit borer. At 10 DAS among treatments, chlorantraniliprole 18.5 SC @ 60 g *a.i.*/ha, chlorantraniliprole 18.5 SC @ 30 g *a.i.*/ha, indoxacarb 14.5 SC @ 150 *a.i.*/ha, and indoxacarb 14.5 SC @ 75 *a.i.*/ha are no significant difference found.

Effect of different insecticides on larval population of fruit borer (*H. armigera*) after third spray
The data (Table 3) & (Fig. 3) recorded at 3 DAS indicated that all insecticidal treatments recorded significantly less larval population as compared to control. Lowest larval population (0.70 larvae/plant) of fruit borer was recorded in treatment of chlorantraniliprole 18.5 SC @ 60 g *a.i.*/ha. Chlorantraniliprole 18.5 SC @ 30 g *a.i.*/ha (0.90 larvae/plant) was next promising treatment which was followed by indoxacarb 14.5 SC @ 150 *a.i.*/ha (1.10 larvae/plant) and indoxacarb 14.5 SC @ 75 *a.i.*/ha showed 1.20 larvae/plant of tomato fruit borer. Treatment, chlorantraniliprole 18.5 SC @ 60 g *a.i.*/ha which was at par with chlorantraniliprole 18.5 SC @ 30 g *a.i.*/ha.

At 7 DAS, the larval population of *H. armigera* varied from 0.85 to 1.25 larvae per plant in different insecticidal treatments. Minimum Larval population (0.85 larvae/plant) was recorded in the treatment chlorantraniliprole 18.5 SC @ 60 g *a.i.*/ha. Treatment, indoxacarb 14.5 SC @ 75 *a.i.*/ha (1.25 larvae/plant) showed maximum larval population of *H. armigera*. The rest of the treatments, chlorantraniliprole 18.5 SC @ 30 g *a.i.*/ha and indoxacarb 14.5 SC @ 150 *a.i.*/ha

recorded 1.00, 1.15 larval population per plant, respectively.
At 10 DAS, chlorantraniliprole 18.5 SC @ 60 g *a.i.*/ha maintains its dominance by exhibiting lowest larval population (1.05 larvae/plant). The next best treatment was chlorantraniliprole 18.5 SC @ 30 g *a.i.*/ha (1.15 larvae/plant) followed by the treatment indoxacarb 14.5 SC @ 150 *a.i.*/ha (1.30 larvae/plant). While, the treatment chlorantraniliprole 18.5 SC @ 60 g *a.i.*/ha which was significantly at par with chlorantraniliprole 18.5 SC @ 30 g *a.i.*/ha followed by the treatment indoxacarb 14.5 SC @ 150 *a.i.*/ha. However, maximum larval population (1.45 larvae/plant) was recorded in treatment of indoxacarb 14.5 SC @ 75 *a.i.*/ha which was observed least effective against *H. armigera*.

Effect of different insecticides on larval population of fruit borer (Pooled of three sprays)
The pooled data of 3 sprays were calculated to evaluate the bio-efficacy of different insecticide treatments against larval population of fruit borer in tomato are presented in (Table 4) and depicted in (Fig. 4) revealed that pre-treatment larval population of fruit borer in all the treatments along with control ranged from 2.30 to 2.60 larvae/plant and there was no significant difference observed among all treatments including control.
At 3 DAS, all the insecticidal treatments recorded significantly less larval population as compared to control. Lowest larval population (1.02 larvae/plant) of *H. armigera* was recorded in treatment of chlorantraniliprole 18.5 SC @ 60 g *a.i.*/ha. Chlorantraniliprole 18.5 SC @ 30 g *a.i.*/ha (1.18 larvae/plant) was next best treatment which was followed by indoxacarb 14.5 SC @ 150 *a.i.*/ha (1.37 larvae/plant). Indoxacarb 14.5 SC @ 75 *a.i.*/ha was least effective, with maximum (1.50 larvae/plant) population of *H. armigera*. While, the treatment chlorantraniliprole 18.5 SC @ 60 g *a.i.*/ha which was significantly at par with chlorantraniliprole 18.5 SC @ 30 g *a.i.*/ha. and both significantly superior from rest of the treatments.
At 7 DAS, the treatment chlorantraniliprole 18.5 SC @ 60 g *a.i.*/ha maintains its superiority over other treatments by recording lowest larval population (1.15 larvae/plant) followed by chlorantraniliprole 18.5 SC @ 30 g *a.i.*/ha (1.33 larvae/plant) and indoxacarb 14.5 SC @ 150 *a.i.*/ha (1.45 larvae/plant). Whereas, maximum larval population (1.58 larvae/plant) was found with least effective treatment indoxacarb 14.5 SC @ 75 *a.i.*/ha.
At 10 DAS, chlorantraniliprole 18.5 SC @ 60 g *a.i.*/ha maintains its dominance by exhibiting lowest larval population (1.32 larvae/plant). The next best treatment was chlorantraniliprole 18.5 SC @ 30 g *a.i.*/ha (1.43 larvae/plant) followed by the treatment indoxacarb 14.5 SC @ 150 *a.i.*/ha (1.57 larvae/plant). While, the treatment chlorantraniliprole 18.5 SC @ 60 g *a.i.*/ha which was significantly at par with chlorantraniliprole 18.5 SC @ 30 g *a.i.*/ha. However, maximum larval population (1.75 larvae/plant) was recorded in treatment of indoxacarb 14.5 SC @ 75 *a.i.*/ha which was observed least effective against *H. armigera* in tomato crop.

Table 1: Bio-efficacy of insecticides against fruit borer of tomato during *rabi* 2020-21(First spray)

S. No	Treatment	No. of larvae/plant			
		PTP	3 DAS	7 DAS	10 DAS
T-1	Chlorantraniliprole 18.5 SC @ 30 g a.i./ha	2.35 (1.69)	1.50 (1.41)	1.70 (1.48)	1.80 (1.51)
T-2	Chlorantraniliprole 18.5 SC @ 60 g a.i./ha	2.30 (1.67)	1.30 (1.34)	1.50 (1.41)	1.65 (1.46)
T-3	Indoxacarb 14.5 SC @ 75 g a.i./ha	2.35 (1.68)	1.90 (1.55)	2.00 (1.58)	2.15 (1.63)
T-4	Indoxacarb 14.5 SC @ 150 g a.i./ha	2.50 (1.73)	1.70 (1.48)	1.80 (1.51)	1.90 (1.55)
T-5	Control	2.60 (1.76)	2.65 (1.77)	2.75 (1.80)	2.90 (1.84)
	S.Em+	0.05	0.05	0.04	0.05
	CD (P=0.05)	0.169	0.153	0.145	0.166
	CV (%)	9.07	9.26	8.49	9.47

Table 2: Bio-efficacy of insecticides against fruit borer of tomato during *rabi* 2020-21(Second spray)

S. No	Treatment	No. of larvae/ plant			
		PTP	3 DAS	7 DAS	10 DAS
T-1	Chlorantraniliprole 18.5 SC @ 30 g *a.i.*/ha	1.80 (1.51)	1.15 (1.28)	1.30 (1.34)	1.35 (1.36)
T-2	Chlorantraniliprole 18.5 SC @ 60 g a.i./ha	1.65 (1.46)	1.05 (1.24)	1.10 (1.26)	1.25 (1.32)
T-3	Indoxacarb 14.5 SC @ 75 g a.i./ha	2.15 (1.63)	1.40 (1.38)	1.50 (1.41)	1.65 (1.46)
T-4	Indoxacarb 14.5 SC @ 150 g a.i./ha	1.90 (1.55)	1.30 (1.34)	1.40 (1.38)	1.50 (1.41)
T-5	Control	2.90 (1.84)	2.90 (1.84)	2.95 (1.86)	3.05 (1.88)
	S.Em+	0.05	0.04	0.051	0.04
	CD (P=0.05)	0.166	0.144	0.154	0.147
	CV (%)	9.47	9.30	9.55	9.02

Table 3: Bio-efficacy of insecticides against fruit borer of tomato during *rabi* 2020-21(Third Spray)

S. No	Treatment	No. of larvae/ plant			
		PTP	3 DAS	7 DAS	10 DAS
T-1	Chlorantraniliprole 18.5 SC @ 30 g a.i./ha	1.35 (1.36)	0.90 (1.18)	1.00 (1.22)	1.15 (1.28)
T-2	Chlorantraniliprole 18.5 SC @ 60 g a.i./ha	1.25 (1.32)	0.70 (1.09)	0.85 (1.16)	1.05 (1.24)
T-3	Indoxacarb 14.5 SC @ 75 g a.i./ha	1.65 (1.46)	1.20 (1.30)	1.25 (1.32)	1.45 (1.40)
T-4	Indoxacarb 14.5 SC @ 150 g a.i./ha	1.50 (1.41)	1.10 (1.26)	1.15 (1.28)	1.30 (1.34)
T-5	Control	3.05 (1.88)	2.90 (1.84)	3.00 (1.87)	3.05 (1.88)
	S.Em+	0.04	0.04	0.04	0.04
	CD (P=0.05)	0.147	0.139	0.139	0.146
	CV (%)	9.02	9.54	9.27	9.33

Table 4: Bio-efficacy of insecticides against fruit borer of tomato during *rabi* 2020-21 (Pooled)

S. No	Treatment	No. of larvae/plant			
		PTP	3 DAS	7 DAS	10 DAS
T-1	Chlorantraniliprole 18.5 SC @ 30 g a.i./ha	2.35 (1.69)	1.18 (1.29)	1.33 (1.35)	1.43 (1.38)
T-2	Chlorantraniliprole 18.5 SC @ 60 g a.i./ha	2.30 (1.67)	1.02 (1.22)	1.15 (1.28)	1.32 (1.34)
T-3	Indoxacarb 14.5 SC @ 75 g a.i./ha	2.35 (1.68)	1.50 (1.41)	1.58 (1.44)	1.75 (1.49)
T-4	Indoxacarb 14.5 SC @ 150 g a.i./ha	2.50 (1.73)	1.37 (1.36)	1.45 (1.39)	1.57 (1.43)
T-5	Control	2.60 (1.76)	2.82 (1.82)	2.90 (1.84)	3.00 (1.87)
	S.Em+	0.05	0.03	0.03	0.02
	CD (P=0.05)	0.169	0.073	0.073	0.070
	CV (%)	NS	9.30	9.18	8.52

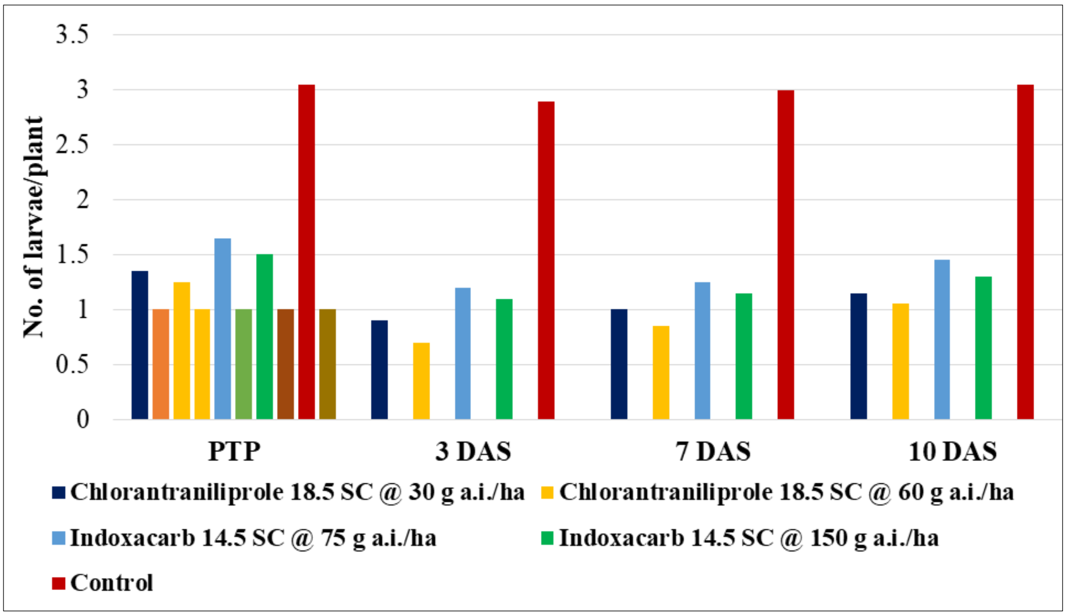

Fig 1: Bio-efficacy of insecticides against fruit borer of tomato during *rabi* 2020-21 (First spray)

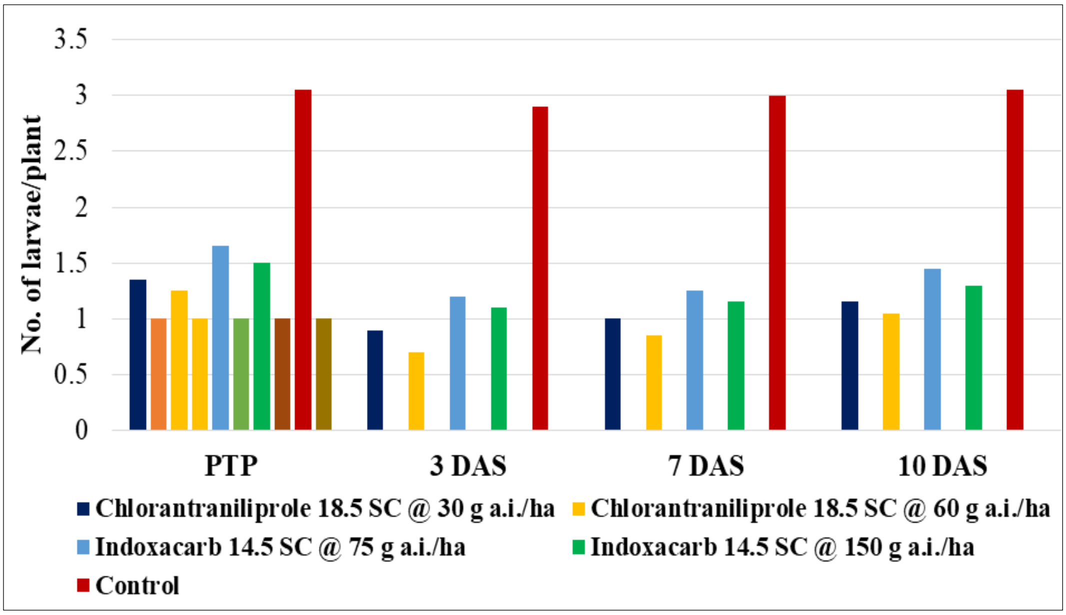

Fig 2: Bio-efficacy of insecticides against fruit borer of tomato during *rabi* 2020-21 (Second spray)

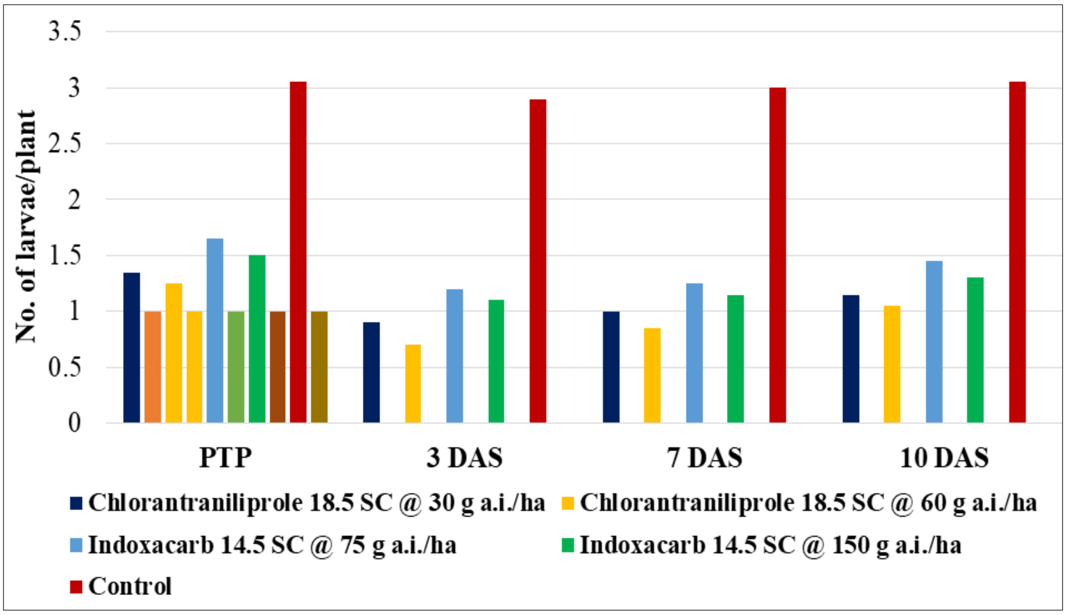

Fig 3: Bio-efficacy of insecticides against fruit borer of tomato during *rabi* 2020-21 (Third Spray)

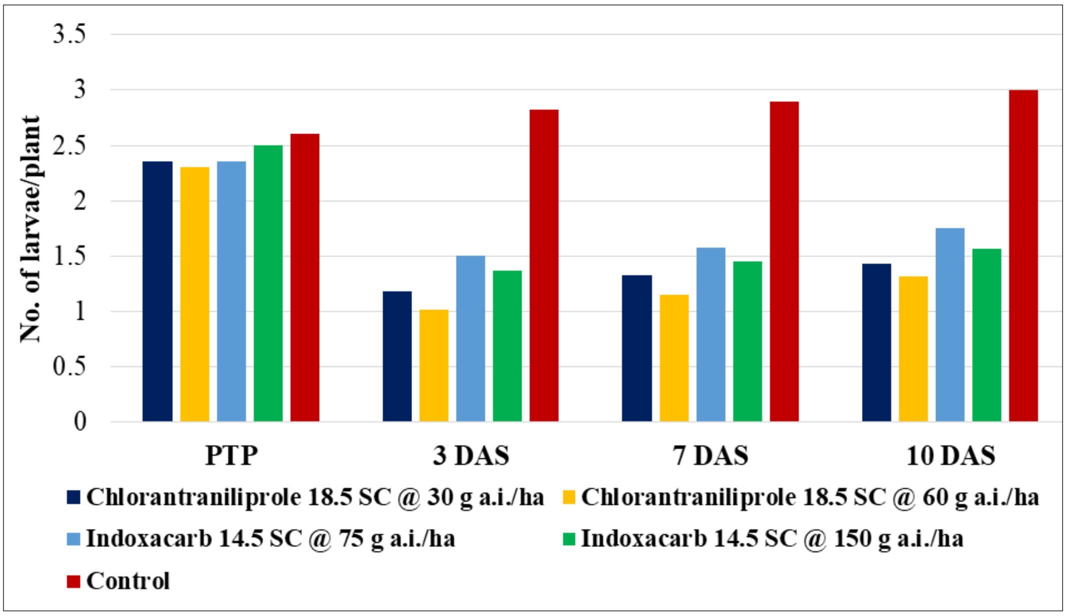

Fig 4: Bio-efficacy of insecticides against fruit borer of tomato during *rabi* 2020-21(Pooled)

Discussion

Pooled data of 3 sprays at 10 DAS are presented in table 4 and fig. 4, revealed that all the insecticide treatments were found significantly superior up to 10 days of treatment in reducing larval population on tomato crop as compared to control (3.00 larvae/plant). Among all the insecticide treatments, Chlorantraniliprole 18.5 SC @ 60 g *a.i.*/ha (T_2) was found most effective with minimum larval population (1.32 larvae/plant) followed by Chlorantraniliprole 18.5 SC @ 30 g *a.i.*/ha (T_1) followed by Indoxacarb 14.5 SC @ 150 g *a.i.*/ha (T_4) followed by Indoxacarb 14.5 SC @ 75 g *a.i.*/ha (T_3) was found least effective with maximum larval population (1.75 larvae/plant) were applied. The treatment T_2 was found most effective against fruit borer on tomato crop, which was statistically at par with T_1 and both significantly superior from rest of the treatments. Present results are supported by finding of Patil *et al.* (2018) chlorantraniliprole 18.5 SC (0.055%) was found most effective against fruit borer followed by spinosad 45 SC (0.018%) and indoxacarb 14.5 SC (0.0145%) in tomato crop. Patel *et al.* (2016) also found that the chlorantraniliprole 35 WG @ 30 g *a.i.*/ha reduce larval population of *H. armigera* as well as lowest per cent of fruit damage compared to standard checks in tomato crop. Ghosal *et al.* (2012) also found that the highest percentage of reduction (98.04%) of *H. armigera* population was recorded in rynaxypyr @ 40 g *a.i.* ha-1 followed by spinosad (90.42%), flubendiamide (86.80%), indoxacarb (80.77%) and rynaxypyr @ 20 g *a.i.* ha-1 (80.69%).

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