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Management of tomato fruit borer [*Helicoverpa armigera* (Hubner)] in trans Yamuna region of Prayagraj (U.P)

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Abstract
A field experiment was conducted during *Rabi* season of 2021-2022 at the Central Research Farm of Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj to evaluate the efficacy of Chlorantraniliprole and bio-agents against fruit borer, *Helicoverpa armigera* (Hubner) on tomato (*Lycopersicon esculentum* Mill.) in trans Yamuna region of Prayagraj (U.P). Three applications of eight treatments including control (water spray) against *Helicoverpa armigera* were used. Among all the treatments highest per cent larva reduction of fruit borer was recorded in T_2 - Chlorantraniliprole (76.35%) followed by T_5 – Chlorantraniliprole + Nisco sixer plus (69.73%), T_6 - Chlorantraniliprole + Neem oil (66.80%), T_1 - Spinosad (62.17%), T_4 – Nisco sixer plus (53.05%), T_3 - NSKE (45.04%) and T_7- Neem oil (43.36%). When cost benefit ratio was worked out the best and most economical treatment was T_2 – Chlorantraniliprole (1:11.70) followed by T_6 - Chlorantraniliprole + Neem oil (1:10.83), T_5 - Chlorantraniliprole + Nisco sixer plus (1:10.68), T_1 – Spinosad (1:10.66), T_4 – Nisco sixer plus (1:10.05), T_3 – NSKE (1:8.22) and T_7 – Neem oil (1:7.93) as compared to T_0 - Control (1:5.35) respectively.

Keywords: Helicoverpa, management, tomato fruit borer

Introduction
Tomato (*Solanum lycopersicon* Miller) is one of the most important and remunerative vegetable crops grown in tropical and subtropical regions of the world for fresh market and processing, constituting an important part of our human diet. It is considered as the most important 'protective food' because of its special nutritive value and wide usage in Indian culinary tradition. In recent years, tomato is known as an important source of lycopene, which is a powerful antioxidant that acts as an anticarcinogenic. Tomatoes are used directly as raw vegetables in sandwiches and several processed products like paste, puree, soup, juices, ketchup, drinks, whole peeled tomatoes, sauces and chutneys are prepared on large scale. The pulp and juice are digestable, apromoter of gastric secretion and blood purifier. It is reported to have antiseptic properties against intestinal infection. (Sharma *et al*., 2019) [15]. It is considered as an important commercial and dietary vegetable crop. It is the rich source of vitamins A, B and C and also contains good amounts of potassium, iron, and phosphorus and major source of lycopene. This lycopene is an antioxidant known to combat cancer, heart diseases and premature aging. Due to environmental and health problems caused by pesticides, alternative control measures that are eco-friendly and economically acceptable, should be focused. For that reason, the entomologists gave great importance to IPM (integrated pest management) program. Among the steps of IPM, usage of resistant varieties is the premier (Khanam *et al*., 2003) [4]. More than 100 insect pests and 25 non-insect pests are reported to ravage the tomato fields and among them, fruit borers are of much significance and causes extensive damage to fruits. Among fruit borers *Helicoverpa armigera* (Hubner) is responsible for considerable losses in quantity as well as quality of tomato fruits (Reddy and Zehr, 2004) [11]. Sticky and toxic chemicals are released by glandular trichomes on tomato leaves result mortality of the larvae. Trichome density and leaf pubescence could be a physical barrier to natural movement and development of the fruit borer (Selvanarayanan and Narayanasamy, 2006a) [14].

Materials and Methods
The experiment was conducted during rabi season November 2021 to March 2022 at Central Research Field (CRF) of Sam Higginbottom University of Agriculture, Technology and Sciences, Naini, Prayagraj, Uttar Pradesh, India, in a randomized block design with eight

treatments replicated three times using variety Pusa Ruby seeds in a plot size of 2 m × 2 m at a spacing of 60cm × 60cm with a recommended package of practices excluding plant protection. The site selected was uniform, cultivable with typical sandy loam soil having good drainage.

Repeated observations were taken to see the incidence of *Helicoverpa armigera* (Hub.) to take up first spray. First application was made as soon as the infestation of *Helicoverpa armigera* was above ETL (Economic threshold level) (at 1 larva/meter row length or 2% fruit damaged) and applications of treatments were undertaken at 15 days interval.

Eight treatments consisting of T_1 – Spinosad @ 0.5 ml/litre, T_2 – Chlorantraniliprole @ 0.5 ml/litre, T_3 – NSKE @ 5 ml/litre, T_4 – Nisco sixer plus @ 2 ml/litre, T_5 - Chlorantraniliprole + Nisco sixer plus @ 0.25 ml/litre + 2 ml/litre, T_6 - Chlorantraniliprole + Neem oil @ 0.25 ml/litre + 5 ml/litre, T_7 – Neem oil @5ml/litre, T_0 -Untreated control were tested to compare the efficacy against *Helicoverpa armigera* and their influence on economics of treatments.

For the efficacy of treatments observation was recorded on the number of fruit borer on 5 randomly selected plants in each plot a day before spray and on 3rd, 7th and 14th days after spraying on selected plants in a plot. The percentage reduction of fruit borer infestation over untreated check in different treatments was calculated using Abbot's (1925) formula as given below. The statistical analysis of data obtained from the experiments was carried out in WASP AGRI STAT PACKAGE 2.0.

$$\text{Percent reduction} = \frac{C-T}{C} \times 100$$

Where,

C = Percentage fruit infested on control

T = Percentage fruit infested on treatments

In order to work out cost effective treatment modules against tomato fruit borer on tomato the "Incremental Cost Benefit Ratio" was worked out based on the total tomato fruit yield in terms of rupees per hectare, cost of inputs including treatment modules and labour charges, cost of application etc. and net monetary returns were calculated at the prevailing market rates during the period of experimentation. (Reddy and Zehr, 2004) [11]

$$\text{B: C ratio} = \frac{\text{Gross returns}}{\text{Cost of treatment}}$$

Where,

B: C = Benefit Cost Ratio

Results and Discussion

The data on the per cent larva reduction on (3rd,7th and 14th day after spray) showed that all the treatments were significantly superior over control. Among all the treatments the highest per cent larva reduction was recorded in T_2 - Chlorantraniliprole (66.63%) followed by T_5 – Chlorantraniliprole + Nisco sixer plus (59.93%), T_6 – Chlorantraniliprole + Neem oil (58.94%), T_1 - Spinosad (55.33%), T_4 -Nisco sixer plus (44.11%) and T_3 - NSKE (36.34%), T_7 – Neem oil (34.62%) respectively. Treatment T_7 – Neem oil (34.62%) was reported with minimum per cent larva reduction. Treatments (T_2, T_5), (T_5, T_6, T_1) and (T_3, T_7) were found statistically at par with each other.

Table 1: Effect of Chlorantraniliprole and biopesticides against tomato fruit borer (*H. armigera*) during *rabi* season of 2021-2022. (First spray)

Treatments		Number of larvae/5 plants	Percent population reduction over control			Overall mean
			3 DAS	7 DAS	14 DAS	
T_1	Spinosad 45 SC	3.00	45.32	62.85	58.45	55.33
T_2	Chlorantraniliprole 18.50% SC	3.27	58.38	72.53	69.01	66.64
T_3	NSKE 10%	2.93	26.24	41.98	40.87	36.36
T_4	Nisco sixer plus	3.13	30.50	51.42	50.60	44.02
T_5	Chlorantraniliprole + Nisco sixer plus	2.87	50.97	66.02	64.73	60.57
T_6	Chlorantraniliprole + Neem Oil	2.87	49.12	64.36	63.28	58.92
T_7	Neem oil	2.80	24.28	40.39	39.43	34.70
T_0	Control	3.20	0.00	0.00	0.00	0.00
Overall Mean		2.45	35.30	49.97	48.20	44.49
F-Test		NS	S	S	S	S
S.Ed (±)		0.20	0.18	0.20	0.18	2.96
C.D.(P=0.05)		0.43	11.54	10.15	7.65	6.20

The data on the per cent larva reduction on (3rd, 7th and 14th days after spray) revealed that all the treatments were significantly superior over control. Among all the treatments the highest per cent larva reduction was recorded in T_2 - Chlorantraniliprole (86.06%) followed by T_5 – Chlorantraniliprole + Nisco sixer plus (78.90%), T_6 - Chlorantraniliprole + Neem oil (74.68%), T_1 - Spinosad (68.82%), T_4-Nisco sixer plus (62.07%), T_3 - NSKE (53.72%) and T_7 - Neem oil (52.02%) respectively. Treatment T_7 - Neem oil (52.02%) was reported with minimum per cent larva reduction. Treatments (T_3, T_7) were found statistically at par with each other.

Table 2: Effect of Chlorantraniliprole and biopesticides against tomato fruit borer (*H. armigera*) during *rabi* season of 2021-2022. (Second spray)

Treatments		Number of larvae/5 plants	Per cent population reduction over control			Overall mean
			3 DAS	7 DAS	14 DAS	
T_1	Spinosad 45 SC	2.00	63.50	70.03	72.94	68.82
T_2	Chlorantraniliprole 18.50% SC	1.47	82.44	87.50	88.25	86.06
T_3	NSKE 10%	2.80	47.33	54.98	58.86	53.72
T_4	Nisco sixer plus	2.33	56.66	63.67	65.88	62.07
T_5	Chlorantraniliprole + Nisco sixer plus	1.67	74.33	81.24	81.15	78.90
T_6	Chlorantraniliprole + Neem Oil	1.73	70.20	75.20	77.66	74.68
T_7	Neem Oil	2.87	45.94	52.51	57.63	52.02
T_0	Control	4.73	0.00	0.00	0.00	0.00
Overall Mean		2.45	55.02	60.46	62.81	59.43
F-Test		S	S	S	S	S
S.Ed (±)		0.18	0.14	0.16	0.17	1.63
C.D.(P=0.05)		7.65	6.33	5.76	5.11	3.47

The data on the per cent larva reduction of tomato fruit borer on (1st and 2nd spray) showed that all the treatments were significantly superior over control. Among all the treatments the highest per cent larva reduction was recorded in T_2 - Chlorantraniliprole (76.35%) followed by T_5 – Chlorantraniliprole + Nisco sixer plus (69.73%), T_6 - Chlorantraniliprole + Neem oil (66.80%), T_1 - Spinosad (62.17%), T_4 - Nisco sixer plus (53.04%), T_3 - NSKE (45.04%) and T_7 – Neem oil (43.36%) respectively. Treatment T_7 – Neem oil (43.36%) was reported with minimum per cent larva reduction. Treatments (T_2, T_5, T_6), (T_5, T_6, T_1), (T_1, T_4) and (T_4, T_3, T_7) were found statistically at par with each other.

Table 3: Effect of Chlorantraniliprole and biopesticides against tomato fruit borer (*H. armigera*) during *rabi* season of 2021-2022. (Overall mean)

Treatments		Per cent population reduction over control		Overall mean
		1st spray	2nd spray	
T_1	Spinosad 45 SC	55.53	68.82	62.17
T_2	Chlorantraniliprole 18.50% SC	66.64	86.06	76.35
T_3	NSKE 10%	36.36	53.72	45.04
T_4	Nisco sixer plus	44.02	62.07	53.04
T_5	Chlorantraniliprole + Nisco sixer plus	60.57	78.90	69.73
T_6	Chlorantraniliprole + Neem Oil	58.92	74.68	66.80
T_7	Neem oil	34.70	52.92	43.36
F-test		S	S	S
S.Ed (±)		2.96	1.63	1.44
C.D.(P=0.05)		6.20	3.47	10.56

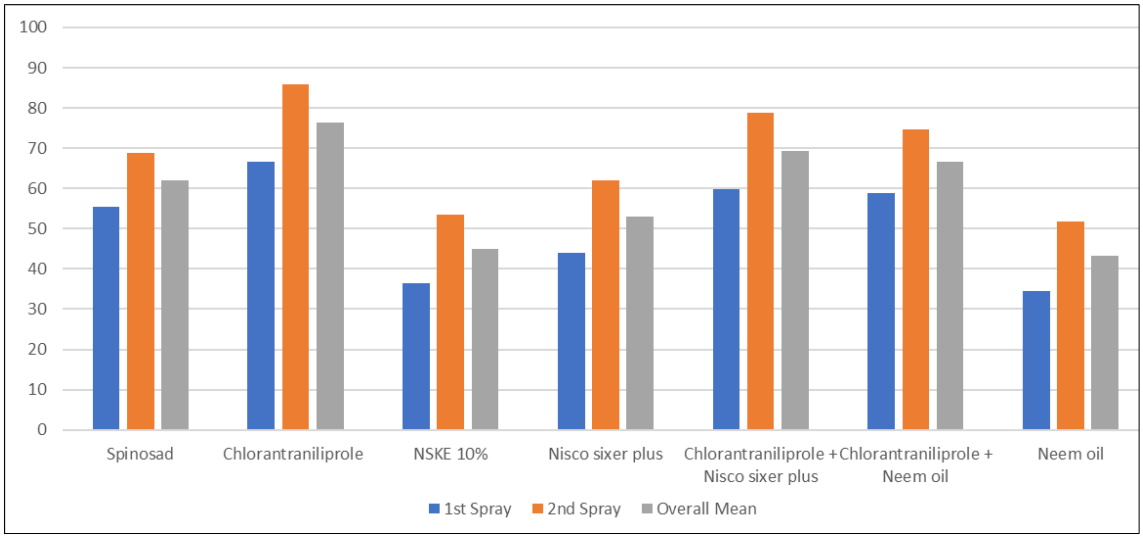

Fig 1: Effect of Chlorantraniliprole and biopesticides against tomato fruit borer *H. armigera* during *rabi* season of 2021-2022. (Overall mean)

In the experiment, eight different treatments consisting of Spinosad, Chlorantraniliprole, NSKE, Nisco sixer plus, Chlorantraniliprole + Nisco sixer plus, Chlorantraniliprole + Neem oil, Neem oil results revealed that all treatments were significantly superior over control. The results obtained in this experiment confirms the superiority of treated control Chlorantraniliprole with 76.35% reduction in larval population of fruit borer as it has also been consistently found by a number of other researchers. Patil *et al.* (2018) [9] reported that Chlorantraniliprole was found effective in reducing larval of fruit borer. The results are in agreement with the findings of Sapkal *et al.* (2018) [13], Reddy *et al.*

(2019) [10] who reported that Chlorantraniliprole was effective against fruit borer. Patil *et al.* (2018) [9] reported that Chlorantraniliprole was found effective on fruit borer, the results suggested that Chlorantraniliprole was the most effective treatment in controlling *Helicoverpa armigera* incidence which was also supported by Sapkal *et al*. (2018) [13]. Reddy *et al.* (2019) [10] also reported that Chlorantraniliprole recorded the highest per cent larva reduction (76.23%) of fruit borer among the rest of the treatments and is followed by the combination treatment of Chlorantraniliprole + Nisco sixer plus (69.73%) and Chlorantraniliprole + Neem oil (66.80%). The next effective treatment was recorded in Spinosad (62.17%) which was in confirmation with Ghosh *et al*. (2010) [3]. They reported maximum mortality rate in *Helicoverpa armigera* larvae with used of Spinosad. Choudhary *et al*. (2017) [1] reported similar results that Spinosad was effective in controlling larval population on tomato. Game *et al*. (2018) [2] also reported that Spinosad was also effective in reducing larval population of fruit borer on tomato which was also supported by Kumar *et al.* (2018) [7] on Spinosad as a component against fruit borer. After Spinosad, the next treatment was recorded in Nisco Sixer plus (53.04%) which finding was similar to the work made by Reddy *et al*. (2020) [12]. The results shows that Nisco sixer plus was effective against fruit borer in reduction of larval population. Among the neem products NSKE (45.04%) gave a higher reduction in larvae population as compared to Neem oil (43.36%) which was alike to the works made by Khuhro *et al*. (2014) [6], Shekhara *et al*. (2016) [16].

Table 4: Economics of treatment

Treatment	Average yield (q/ha)	Total value of yield (₹)	Common Cost (₹)	Treatment Cost (₹)	Total cost of cultivation (₹)	Gross Return (₹)	C:B Ratio
Spinosad	195	390000	29880	3545	33425	356575	1:10.66
Chlorantriniliprole	225	450000	29880	5540	35420	414580	1:11.70
NSKE	160	320000	29880	4800	34680	285320	1:8.22
Nisco Sixer plus	185	370000	29880	3600	33480	336520	1:10.05
Chlorantriniliprole + Nisco sixer plus	210	420000	29880	6070	35950	384050	1:10.68
Chlorantriniliprole + Neem Oil	200	400000	29880	3910	33790	366210	1:10.83
Neem Oil	140	280000	29880	1440	31320	248680	1:7.93
Control	95	190000	29880	—	29880	160120	1:5.35

Economics of treatments

The result obtained in this experiment (Table.4) confirms superiority of treated control T_2 – Chlorantraniliprole (225 q/ha and 1:11.70 respectively). This was supported by Patil *et al.* (2018) [9], Padhan and Raghuraman (2019) [8]. They suggested the used of Chlorantraniliprole for effective and economic control of *Helicoverpa armigera*. This was followed by Chlorantraniliprole + Neem oil (200 q/ha and 1:10.83) and Chlorantraniliprole + Nisco sixer plus (210 q/ha and 1:10.68) respectively. The next most economical treatment was recorded in Spinosad (195 q/ha and 1:10.66 respectively) treated plots. The findings were similar to Khorasiya *et al*. (2014) [5], Shekhara *et al*. (2016) [16]. After Spinosad, the next economical treatment was recorded in Nisco sixer plus (185 q/ha and 1:10.05 respectively) treated plots. The findings were similar to Tejaswari *et al*. (2021) [17]. Further, plots treated with NSKE (160 q/ha and 1:8.22 respectively) was recorded with a higher yield and benefit cost ratio as compared to Neem oil (140 q/ha and 1:7.93 respectively). The result so obtained was similar to the observations made by Shekhara *et al*. (2016) [16].

Conclusion

The finding of present investigation holds a good promise in tomato fruit borer management and it showed that Chlorantraniliprole effectively control the tomato fruit borer [*Helicoverpa armigera* (Hubner)] on tomato and it gave the highest cost benefit ratio in trans Yamuna region of Prayagraj (U.P). The other treatments *viz.*, Chlorantraniliprole + Nisco sixer plus, Chlorantraniliprole + Neem oil, Spinosad, Nisco sixer plus, NSKE and Neem oil can also provide adequate control in management of tomato fruit borer.

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