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Field efficacy and economics of some biopesticides against tomato fruit borer [*Helicoverpa armigera* (Hubner)]

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Abstract
The present investigation entitled, "Field efficacy and economics of some biopesticides against tomato fruit borer [*Helicoverpa armigera* (Hubner)]". Cultivar i.e. Pusa Ruby was conducted during November to March 2021-2022 at Central Research Farm of Sam Higginbottom University of Agriculture, Technology and Sciences, Naini, Prayagraj. Two application of eight treatments against *Helicoverpa armigera* were used. Among all the treatments highest per cent reduction of fruit borer was recorded in T1 – Chlorantraniliprole (68.34%) followed by T4- Spinosad (64.22%), T3 - Nisco Sixer plus (62.04%), T7 – HaNPV (57.93%), T6 – *Bacillus thuringiensis* (52.93%), T5 – *Beauveria bassiana* (49.69%), T2- Nimbecidine (46.58%). When cost benefit ratio was worked out the best and most economical treatment was T1 – Chlorantraniliprole (1:9.14) followed by T4 – Spinosad (1:8.84), T3 - Nisco Sixer plus (1:8.04), T7 – HaNPV (1:7.53), T6 – *Bacillus thuringiensis* (1:6.51), T5 – *Beauveria bassiana* (1:6.34), T2- Nimbecidine (1:5.67) as compared to T0- Control (1:4.58).

Keywords: Insecticides, *Helicoverpa armigera*, tomato, cost benefit ratio

Introduction

Tomato, *Lycopersicon esculentum* (Miller), belongs to family Solanaceae. It is one of the most important, popular and widely grown vegetable in the world due to its immense commercial and special nutritive value, ranking second in importance next to potato. Mostly, it is commercially recognized and treated as a vegetable. The fruits are eaten raw or cooked. Large quantities of tomatoes are used to prepare soup, juice, ketchup, pickle, paste and powder (Choudhary, 2002) [4]. The major producing states of tomato in India are Andhra Pradesh, Madhya Pradesh, Karnataka, Odisha, West Bengal, Chhattisgarh, Uttar Pradesh and Bihar. The highest tomato cultivating states is Andhra Pradesh in area about 100.2 thousand ha and production is about 2744.32 thousand MT but the highest productivity was occupied by Himachal Pradesh with 51.663 t ha (NHB Database; 2017-18) [1]. A large number of insect pest attacks on tomato from nursery to harvesting of the crop. Among the insect pests tomato fruit borer *Helicoverpa armigera (*Hubner) is a major pest in India. *Helicoverpa. armigera* has attained the status of national pest in recent years, in term of economic damage caused to different agricultural crops like cotton, maize, tobacco, pigeon pea, chickpea and pea (Cunningham, 1999) [5] throughout India. The larvae of *Helicoverpa armigera* feed on leaves and stems but, they prefer buds, inflorescences, fruits and pods, thus causing significant damage to both vegetative and reproductive plant parts (Moral Garcia, 2006) [12]. The adults of fruit borer lay eggs on the tomato foliage and initially the neonates damage flower buds, flowers and foliage; later they bore into the fruits (Liu *et al*., 2004 [10] and Perkins *et al*., 2009) [15] and cause drastic yield reduction.. Losses cause by this pest in India were reported to be 38% in India (Selvanarayanan and Narayanasamy, 2006) [20]

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 2m×2m 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 T1 – Chlorantraniliprole 18.50% SC @ 0.5ml/litre, T2- Nimbecidine
@5ml/litre, T3 - Nisco Sixer plus @2ml/llitre, T4 –Spinosad @ 0.5 ml/litre, T5 -*Beauveria bassiana*
@5ml/litre, T6 -*Bacillus thuringiensis* @5 ml/litre, T7 – HaNPV @0.5 ml/litre, T0 -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.

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

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. (Kumar *et al.* 2017)

$$\text{C: B} = \frac{\text{Net returns}}{\text{Total cost of treatment}}$$

Where,
C: B = Cost Benefit Ratio

Results and Discussion

The data regarding percent reduction of fruit borer, (*Helicoverpa armigera*) mean of (3, 7 & 14 day after spray) presented in table.1 showed that all the treatments were significantly superior over control. Among all the treatments the highest per cent reduction was observed in T1 – Chlorantraniliprole (64.22%) followed by T4 - Spinosad (59.67%), T3 - Nisco Sixer plus (57.52%), T7 – HaNPV (50.49%), T6 – *Bacillus thuringiensis* (48.33%), T5 – *Beauveria bassiana* (42.99%) and T2- Neem oil (40.30%). Where, T2- Neem oil (40.30%) was reported with minimum per cent reduction in larval population. The treatments (T1, T4, T3) (T3, T7) (T7, T6, T5) and (T5, T2) were found statistically at par with each other.

Table 1: Field efficacy of some biopesticides against tomato fruit borer [*Helicoverpa armigera* (Hubner)] on different days after 1st spray during *rabi* season 2021-2022.

S. No	Treatments	Number of larvae/ 5 plants	Per cent population reduction of *Helicoverpa armigera/* 5 plants			
			3DAS	7DAS	14DAS	Mean
T1	Chlorantraniliprole	3.20	57.62	73.44	61.61	64.22
T2	Nimbecidine	3.0	28.86	46.82	45.22	40.30
T3	Nisco Sixer plus	2.86	47.90	68.61	56.05	57.52
T4	Spinosad	3.26	48.14	71.93	58.94	59.67
T5	*Beauveria bassiana*	3.0	30.71	51.73	46.55	42.99
T6	*Bacillus thuringiensis*	3.26	36.48	57.79	50.72	45.33
T7	HaNPV	3.13	40.19	59.30	52.00	50.49
T8	Control	3.33	0.00	0.00	0.00	0.00
	F-test	NS	S	S	S	S
	S. Ed. (±)	0.22	4.24	3.36	3.04	3.55
	C.D. (P = 0.05)		9.09	7.20	6.51	7.62

The data regarding percent reduction of fruit borer, (*Helicoverpa armigera*) mean of (3, 7 & 14 day after IInd spray) presented in table.2 showed that all the treatments were significantly superior over control. Among all the treatments maximum reduction was observed in T1 –Chlorantraniliprole (72.65%) followed by T4 - Spinosad (68.92%), T3 - Nisco Sixer plus (66.31%), T7 – HaNPV (62.16%), T6 – *Bacillus thuringiensis* (57.59%), T5 – *Beauveria bassiana* (55.94%) and T2- Nimbecidine (52.25%) respectively. Where, T2- Nimbecidine (52.25%) was reported with minimum per cent reduction in larval population. The treatments (T4, T3) and (T6, T5) were found statistically at par with each other.

Table 2: Field efficacy of some biopesticides against tomato fruit borer [*Helicoverpa armigera* (Hubner)] on different days after 2nd spray during *rabi* season 2021-2022.

S.NO	Treatments	Number of larvae/5 plants	Per cent population reduction of *Helicoverpa armigera*/5 plants			
			3DAS	7DAS	14DAS	Mean
T1	Chlorantraniliprole	1.73	67.12	74.68	76.16	72.65
T2	Nimbecidine	2.66	51.28	53.13	52.34	52.25
T3	Nisco Sixer plus	2.13	61.74	68.32	68.89	66.31
T4	Spinosad	1.98	64.46	70.84	71.48	68.92
T5	*Beauveria bassiana*	2.60	52.61	56.92	58.29	55.94
T6	*Bacillus thuringiensis*	2.40	53.89	58.16	60.72	57.59

T7	HaNPV	2.33	57.84	63.24	65.40	62.16
T8	Control	4.86	0.00	0.00	0.00	0.00
	F-test		S	S	S	S
	S. Ed. (±)		2.76	1.82	2.63	1.42
	C.D. (P = 0.05)		5.91	3.89	5.63	3.05

The data on population reduction percent of fruit borer, (*Helicoverpa armigera*) on mean of 1st and 2nd spray presented in Table.3 and Fig.1 showed that all the treatments were significantly superior over control. Among all the treatments maximum reduction was observed in T1 – Chlorantraniliprole (68.43%) followed by T4 - Spinosad (64.29%), T3 - Nisco Sixer plus (61.91%), T7 – HaNPV (56.32%), T6 – *Bacillus thuringiensis* (52.96%), T5 – *Beauveria bassiana* (49.46%) and T2- Nimbecidine (46.27%) respectively. Where, T2- Nimbecidine (46.27%) was reported with minimum per cent reduction in larval population. The treatments (T1, T4, T3) (T3, T7, T6) and (T6, T5, T2) were statistically found at par with each other.

Table 3: Field efficacy of some biopesticides against tomato fruit borer [*Helicoverpa armigera (*Hubner)]. (Mean of 1st and 2nd spray)

S. No	Treatments	Mean per cent reduction of *Helicoverpa armigera*/5 plants		
		1st spray	2nd spray	Overall mean
T1	Chlorantraniliprole	64.22	72.65	68.43
T2	Nimbecidine	40.30	52.25	46.27
T3	Nisco Sixer plus	57.52	66.31	61.91
T4	Spinosad	59.67	68.92	64.29
T5	*Beauveria bassiana*	42.99	55.94	49.46
T6	*Bacillus thuringiensis*	48.33	57.59	52.96
T7	HaNPV	50.49	62.16	56.32
T8	Control	0.00	0.00	0.00
	F-test	S	S	S
	S. Ed. (±)	3.55	1.42	2.84
	C.D. (P = 0.05)	7.64	3.05	6.72

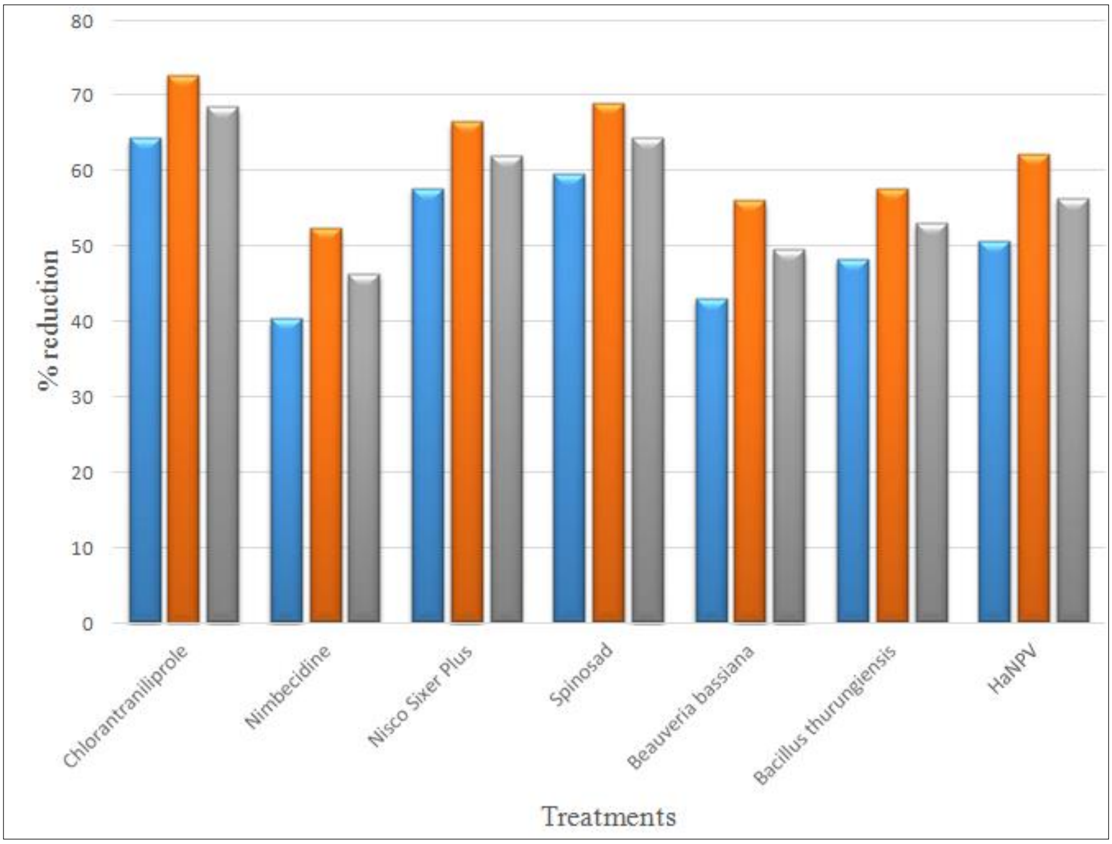

Fig 1: Field efficacy of some biopesticides against tomato fruit borer [*Helicoverpa armigera (*Hubner)]. *(Mean of 1st and 2nd spray*)

In the experiment, eight different treatments, consisting of Chlorantraniliprole, Nimbecidine, Nisco Sixer plus, Spinosad, *Beauveria bassiana*, *Bacillus thuringiensis*, HaNPV, results revealed that all treatments were significantly superior over control. Amo ng all the treatments highest percent reduction was recorded in Chlorantraniliprole (68.34%), it has been consistently found by a number of other researchers. Padhan and Raghuraman (2019) [13] reported that Chlorantraniliprole was found effective in reducing larval population against fruit borer. Hivare *et al*., (2019) [8] proved that Chlorantraniliprole was superior in recording the lowest larval population of *Helicoverpa armigera***.** There results are in agreement with the findings of Patil *et al.,* (2018) [14] who reported that Chlorantraniliprole was effective against tomato fruit borer. Sreekanth *et al*., (2013) [22] reported that Chlorantraniliprole was effective in controlling tomato fruit borer and Spinosad was found to be the next best treatment after Chlorantraniliprole. Sapkal *et al.*, (2018) [18] also reported similar results of Spinosad against tomato fruit borer. Game *et al.*, (2018) [5] reported that lowest per cent infestation of fruit borer was recorded in Spinosad. Superior performance Spinosad against tomato fruit borer was also reported in Maity *et al.*, (2020) [11] and Tejaswari and Kumar (2021) [23] After Spinosad, Nisco sixer plus (62.04%) was found the next effective treatment, the findings were also confirmed by Reddy *et al.*, (2020) [17] and Tejaswari and Kumar (2021) [23]. HaNPV (57.24%) corresponds to the conclusion of Singh *et al.,* (2017) [21] and Herald and Tayde (2019) [7]. *Bacillus thuringinensis* (52.93%) found to be effective in controlling the fruit borer which is also reported by Chandrasekaran *et al.,* (2015) [3]. *Beauveria bassiana* (49.69%) is the next effective treatment in reducing the population of fruit borer which is reported by Maity *et al.*, (2020) [11] followed by Nimbecidine (46.58%) which is least effective against fruit borer, similar findings were reported by Padhan and Raghuraman (2019) [13].

Table 4: Economics of treatment

Treatments	No. of spray	Average yield (q/ha)	Total value of yield (₹)	Common cost (₹)	Total cost of cultivation (₹)	Gross/Net Return (₹)	C:B Ratio
Chlorantriniliprole	2	225.54	451080	38910	44450	406630	1:9.14
Nimbecidine	2	141.35	282700	38910	42382	240318	1:5.67
Nisco Sixer Plus	2	195.07	390140	38910	43110	347030	1:8.04
Spinosad	2	215.27	430540	38910	47150	373390	1:8.84
Beauveria bassiana	2	150.15	300300	38910	40910	259390	1:6.34
Bacillus thuringiensis	2	158.78	317560	38910	42246	275314	1:6.51
HaNPV	2	175.65	351300	38910	41246	310144	1:7.53
Control	0	108.67	217340	38910	38910	178430	1:4.58

Economics of treatment

The result obtained in this experiment (Table.4) confirms superiority of treated control T1– Chlorantraniliprole with 225.54 q/ha yield and 1:9.14 cost benefit ratio. These results were similar to the findings reported by Sreekanth *et al*., (2014) [22] who reported the highest incremental cost benefit ratio was computed from chlorantraniliprole, Similar findings were also recorded by Reddy *et al*., (2020) [17]. Next best result was obtained in the treatment Spinosad with 215.27 q/ha and 1:8.84 cost benefit ratio. The findings were in correspond to the conclusion of Bhanuprakash *et al.,* (2019) [2] who recorded lowest fruit infestation and highest yield of tomato with the use of Spinosad among the insecticides against tomato fruit borer. After Spinosad next most economically treatment was recorded in Nisco Sixer Plus (195.07 q/ha and 1:8.04), this result is supported by Reddy *et al*., (2020) [17] resulting 175.00 q/ha and 1:8.3 cost benefit ratio, followed by HaNPV (175.65 q/ha and 1:7.53), this findings are supported by Singh *et al.,* (2017) [21] who evaluated biorational insecticides against tomato fruit borer, followed by *Bacillus thuringinensis* (158.78 q/ha and 1:6.51), this result is supported by Tejaswari and Kumar (2021) [23]. Herald and Tayde (2019) [7] also reported similar findings who evaluated biopesticides singly and in combinations for the management of tomato fruit borer. *Beauveria bassiana* and Nimbecidine gave lower yield of tomato and also lower cost benefit ratio (150.15 q/ha and 1:6.34) and (141.35 q/ha and 1:5.67). These findings are supported by Rani *et al.,* (2018) [16]. The minimum B:C ratio was recorded in Nimbecidine (141.35 q/ha and 1:5.67). Similar results were also reported by Kumar *et al.,* (2018) [9] with botanicals and biopesticides especially in reference to management of *Helicoverpa armigera*. These findings are supported by Sathish *et al.,* (2018) [19] who evaluated the incremental cost-benefit ratio of certain chemical and biopesticides against tomato fruit borer.

Conclusion

From the critical analysis of the present findings it was observed that that among all the treatments, minimum percent of larval reduction and B:C ratio were observed in Chlorantraniliprole (68.4 and 1:9.14) followed by T4 – Spinosad (64.22 and 1:8.84), Nisco Sixer plus (62.04 and 1:8.04), T7 – HaNPV (57.93 and 1:7.53), T6 – *Bacillus thuringiensis* (52.93 and 1:6.51), T5 – *Beauveria bassiana* (49.69 and 1:6.34), T2- Nimbecidine (46.58 and 1:5.67) as compared to T0- Control (1:4.58). Hence, this finding can be useful for the farmers in feasible manner for sustainable production of tomato. The present finding are limited to one crop season (November to march, 2021-2022) under Prayagraj agro climatic condition as such more trails are required for future thrust.

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