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Comparative efficacy of chemicals with biopesticides against tomato fruit borer, *Helicoverpa armigera* (Hubner) on Tomato, *Solanum lycopersicum* (L.) under field conditions

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Abstract

The present investigation entitled Comparative efficacy of chemicals with biopesticides against Tomato fruit borer, *Helicoverpa armigera* (hubner) on Tomato, *Solanum lycopersicum* (L.) under field conditions. cultivar i.e. Pusa Ruby was conducted during December to March 2019-20 at Central Research Farm, SHUATS, Naini, Prayagraj. The incidence of *Helicoverpa armigera* in tomato was starting from early stage of flowering till to the harvesting. The approaches for chemical management of tomato fruit borer were found effective than control. Two applications of seven insecticides viz; Neem oil @ 5%, Spinosad 45 SC @ 0.4%, *Bacillus thuringiensis* @ 5%, Neem seed kernel extract @ 5%, Flubendiamide 39.35 SC @ 0.2%, Chlorantraniliprole 18.5 SC @ 0.4%, and Nisco sixer plus @ 1% were evaluated against Tomato fruit borer, *Helicoverpa armigera*. Minimum percent of larval reduction and B:C ratio were observed in Spinosad (80.6 and 1:7.0) followed by Chlorantraniliprole (73.7 and 1:6.8) < Flubendiamide (65.5 and 1:6.4) < Nisco sixer plus (63.3 and 1:5.9) < Neem oil (62.6 and 1:5.6) < Neem seed kernel extract (61.2 and 1:5.6).

Keywords: Benefit cost ratio, *Helicoverpa armigera*, larval reduction, insecticides, tomato fruit borer

Introduction

Tomato, *Solanum lycopersicum* (L.) is one of the most important commercial vegetable crop grown all over the world and occupies the third position among vegetables in area and production in the world (Bhavana and Nagar, 2019) [2]. It belongs to the family Solanaceae and said to be the native of tropical America. The major tomato producing states of India are Maharashtra, Bihar, Karnataka, Uttar Pradesh, Himachal Pradesh, Orissa, Andhra Pradesh, Madhya Pradesh and Assam. The fruits are eaten raw or cooked. Large quantities of tomatoes are used to prepare soup, juice, ketchup, pickle, paste and powder (Choudary, 2002) [3]. Tomato is grown throughout world either outdoors or indoors, mainly in China, India, U.S.A., Italy, Turkey, Mexico and Japan etc. The important insect pest of tomato is fruit borer, *Helicoverpa armigera* (Hubner); whitefly, *Bemisia tabaci* (Gen.); jassids, *Amrasca devastans* (Ishida); leaf miner, *Liriomyza trifolii* (Blanchard); potato aphid, *Myzus persicae* (Thomas) and hadda beetle, *Epilachna dodecastigma* (Widemann). But in India fruit borer is one of the most important pests of tomato, limiting production and market value of crop produce. The fruit borer, *Helicoverpa armigera* (Hubner) is the most destructive pest of tomato in India, which is commonly known as gram pod borer, American bollworm and fruit borer (Meena and Raju, 2014.) [11]. It is known to cause serious damage to hundreds of economically important crops all over the world. In India it is reported to be feeding on 182 plant species across 47 families (Manjunath *et al.*, 1985) [10]. *Helicoverpa armigera* is a destructive polyphagous pest occurring on tomato, and many others crops, inflicting substantial loss every year. To control this insect pest and to save the crop, pesticides are being used in large quantities by human being. But the continuous and enormous use of same or similar groups of pesticides causes problem of pesticide residues in foodstuff and other environmental contamination. This has promoted the necessity for the development of new, safer, biodegradable insecticides and known insecticidal alternatives that could be feasible and effective for insect pest management. Spinosad is one of such new chemicals which are derived from fermentation broth of soil actinomycetes, *Saccharopolyspora spinosa*, containing a naturally occurring mixture of Spinosyn A and Spinosyn D.

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Spinosad have rapid contact and ingestion activity in insects, causing excitation of the nervous system, leading to cessation of feeding and paralysis (Faqiri and Kumar, 2016) [5].

Materials and Methods

The present investigation was conducted during the *Rabi* season 2019-2020 at SHUATS, at the Central research field, SHUATS (Sam Higginbottom University of Agriculture, Technology and Sciences), Prayagraj, Uttar Pradesh, (India) at a latitudinal-longitudinal extent of 25°27'N, 81°44'E. City rises to a height of about 98 meters from the sea level and is positioned at the meeting point of River Ganga and River Yamuna. The material used and methods used to carry out these investigations are described below:

The trails were laid out in RBD having eight treatments and three replications with the plot size 2 x 2m. The experiments were carried out in the tomato variety Pusa *rubi*. One round of spray was given at fifteen days interval using a hand operated sprayer during morning hours to avoid photo oxidation of chemicals. T1 Neem oil @ 5 ml, T2 Spinosad 45 SC @ 0.4%, T3 *Bacillus thuringiensis* @ 5%, T4 Neem seed kernel extract @ 5%, T5 Flubendiamide 39.5 SC @ 0.2ml, T6 Chlorantraniliprole 18.5 SC @ 0.4ml T7 Nisco sixer plus @ 1ml and T8 Control. Observations on percent population reduction were made in tomato fruit borer on 5 randomly selected plants in each replication along with the unsprayed control. Pre and post treatments observations were recorded on 3rd, 7th and 14th days of each spray. The percent population reduction of tomato fruit borer damage over control in field conditions was calculated. The data averaged into respective parameter requisite were subjected to suitable transformation. After analysis, data was accommodated in the table as per the needs of objectives for interpretation of results. The standard procedures in agriculture statistics given by Gomez and Gomez (1984) were consulted throughout. The interpretation of data was done by using the critical difference value calculated at 0.05 probability level. The level of significance will be expressed at 0.05 probabilities.

Results and Discussion

The results of studies undertaken during *Rabi*, 2019-20 on "Comparative efficacy of chemicals with biopesticides against tomato fruit borer, *Helicoverpa armigera* (hubner) on tomato, *Solanum lycopersicum* (L.) Under field conditions" are presented in the following heads.

Assessment of infestation: Number basis

First spray: percent larval reduction

The efficacy of certain chemical insecticide and bio pesticides against Tomato fruit borer are depicted in the Table 1.

Percent larval reduction of fruit borer 3 DAS

The data on the percent larval reduction of fruit borer on the three days after first spray revealed that all the treatments were significantly superior over control. Among all the treatments maximum reduction of fruit borer was observed with Spinosad (68.9) followed by Chlorantraniliprole (66.8), Flubendamide (57.1), Nisco sixer plus (56.3), Neem oil (55.3), Neem seed kernel extract (52.3) and *Bacillus thuringiensis* (40.7) is found to be least effective than all treatments.

Percent larval reduction of fruit borer 7 DAS

The data on the percent larval reduction of fruit borer on the seven days after first spray revealed that all the treatments were significantly superior over control. Among all the treatments maximum reduction of fruit borer was observed with Spinosad (82.7) followed by Chlorantraniliprole (80.6), Flubendamide (74.1), Nisco sixer plus (72.4), Neem oil (71.5), Neem seed kernel extract (68.7) and *Bacillus thuringiensis* (51.3) is found to be least effective than all treatments.

Percent larval reduction of fruit borer 14 DAS

The data on the percent larval reduction of fruit borer on the fourteen days after first spray revealed that all the treatments were significantly superior over control. Among all the treatments maximum reduction of fruit borer was observed with Spinosad (80.4) followed by Chlorantraniliprole (69.7), Flubendamide (65.7), Nisco sixer plus (62.3), Neem oil (61.5), Neem seed kernel extract (56.4) and *Bacillus thuringiensis* (53.9) is found to be least effective than all treatments.

Mean (3rd, 7th and 14th DAS) Percent larval reduction of fruit borer after first spray

The data on the mean (3rd, 7th and 14th DAS) percent larval reduction of fruit borer after first spray revealed that all the treatments were significantly superior over control. Among all the treatments maximum reduction of fruit borer was observed with Spinosad (77.8) followed by Chlorantraniliprole (72.4), Flubendamide (65.7), Nisco sixer plus (63.6), Neem oil (62.7), Neem seed kernel extract (61.4) and *Bacillus thuringiensis* (48.6) is found to be least effective than all treatments.

Table 1: Comparative efficacy of selected chemicals and biopesticides against tomato fruit borer, *H. armigera* on different days after 1st spray during *Rabi* season 2019-2020.

Treatments	Percent larval reduction				
	Before Spraying	3 DAS	7 DAS	14 DAS	Mean
T1 Neem oil	5.4	55.3(48.0)	71.5(57.7)	61.5(51.7)	62.8(52.4)
T2 Spinosad	5.0	68.9(56.1)	82.7(65.4)	80.4(63.7)	77.3(61.7)
T3 <i>Bacillus thuringiensis</i>	5.06	40.7(39.5)	51.3(45.7)	53.9(47.2)	48.6(44.2)
T4 Neem Seed Kernel Extract (NSKE)	5.6	52.3(46.3)	68.7(56.0)	63.2(52.6)	61.4(51.6)
T5 Flubendiamide	4.6	57.1(49.1)	74.1(59.6)	65.7(54.1)	65.6(54.2)
T6 Chlorantraniliprole	4.8	66.8(54.8)	80.6(63.9)	69.7(56.6)	72.4(58.4)
T7 Nisco Sixer Plus	4.4	56.2(48.5)	72.4(58.3)	62.3(52.1)	63.6(53.0)
T8 Control/water spray	5.8	0(0.00)	0(0.00)	0(0.00)	0(0.00)
F- test	NS	S	S	S	S
S. Ed (±)	0.539	4.678	3.067	3.218	2.955
C. D. (P = 0.05)	NS	10.131	6.643	6.670	6.339

Figures in parenthesis are arc sin transformed value

Second spray: percent larval reduction

The efficacy of certain chemical insecticide and bio pesticides against Tomato fruit borer are depicted in the Table 2. The data on percent larval reduction of fruit borer before spraying revealed that the results were statistically non-significant.

Percent larval reduction of fruit borer 3 DAS

The data on the percent larval reduction of fruit borer on the three days after second spray revealed that all the treatments were significantly superior over control. Among all the treatments maximum reduction of fruit borer was observed with Spinosad (80.4) followed by Chlorantraniliprole (64.2), Flubendamide (58.1), Nisco sixer plus (52.8), Neem oil (52.5), Neem seed kernel extract (51.2) and *Bacillus thuringiensis* (45.5) is found to be least effective than all treatments.

Percent larval reduction of fruit borer 7 DAS

The data on the percent larval reduction of fruit borer on the seven days after second spray revealed that all the treatments were significantly superior over control. Among all the treatments maximum reduction of fruit borer was observed with Spinosad (87.3) followed by Chlorantraniliprole (79.2), Flubendamide (68.5), Nisco sixer plus (68.0), Neem oil (67.7), Neem seed kernel extract (65.4) and *Bacillus*

thuringiensis (55.6) is found to be least effective than all treatments.

Percent larval reduction of fruit borer 14 DAS

The data on the percent larval reduction of fruit borer on the fourteen days after second spray revealed that all the treatments were significantly superior over control. Among all the treatments maximum reduction of fruit borer was observed with Spinosad (84.3) followed by Chlorantraniliprole (81.9), Flubendamide (69.5), Nisco sixer plus (68.2), Neem oil (67.3), Neem seed kernel extract (66.9) and *Bacillus thuringiensis* (58.5) is found to be least effective than all treatments.

Mean (3rd, 7th and 14th DAS) Percent larval reduction of fruit borer after second spray

The data on the mean (3rd, 7th and 14th DAS) percent larval reduction of fruit borer after second spray revealed that all the treatments were significantly superior over control. Among all the treatments maximum reduction of fruit borer was observed with Spinosad (84.0) followed by Chlorantraniliprole (75.1), Flubendamide (65.4), Nisco sixer plus (63.0), Neem oil (62.5), Neem seed kernel extract (61.1) and *Bacillus thuringiensis* (53.2) is found to be least effective than all treatments.

Table 2: Comparative efficacy of selected chemicals and bio-pesticides against tomato fruit borer, *H. armigera* on different days after 2nd spray during Rabi season 2019-2020.

Treatments		Percent larval reduction				
		Before Spraying	3 DAS	7 DAS	14 DAS	Mean
T1	Neem oil	3.4	52.5 (46.4)	67.7 (55.4)	67.3 (55.1)	62.5 (52.3)
T2	Spinosad	1.8	80.4 (63.8)	87.3 (69.2)	84.3 (66.7)	84.0 (66.5)
T3	<i>Bacillus thuringiensis</i>	4.0	45.5 (42.3)	55.6 (48.2)	58.5 (49.9)	53.2 (46.8)
T4	Neem Seed Kernel Extract (NSKE)	3.2	51.2 (45.6)	65.4 (53.9)	66.9 (54.9)	61.1 (51.5)
T5	Flubendiamide	2.7	58.1 (49.7)	68.5 (55.9)	69.5 (56.5)	65.4 (54.0)
T6	Chlorantraniliprole	2.6	64.2 (53.3)	79.2 (62.9)	81.9 (64.8)	75.1 (60.3)
T7	Nisco Sixer Plus	3.3	52.8 (46.6)	68.0 (55.5)	68.2 (55.7)	63.0 (52.6)
T8	Control/water spray	4.7	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
F- test		NS	S	S	S	S
S. Ed (±)		0.852	4.068	3.320	2.973	2.818
C. D. (P = 0.05)		NS	8.809	7.190	6.437	6.130

Figures in parenthesis are arc sin transformed value

Mean (1st and 2nd sprays) percent larval reduction.

It is evident from the table 3 that the data on the mean (1st and 2nd sprays) percent larval reduction of fruit borer from all the treatments were significantly superior over control. Among all the treatments maximum reduction of fruit borer was

observed with Spinosad (80.6) followed by Chlorantraniliprole (73.7), Flubendamide (65.5), Nisco sixer plus (63.3), Neem oil (62.6), Neem seed kernel extract (61.2) and *Bacillus thuringiensis* (50.9) is found to be least effective than all treatments.

Table 3: Comparative efficacy of certain bio-pesticides against tomato fruit borer, *H. armigera* during Rabi season (Mean of 1st and 2nd spray) 2019-20.

Treatments		Percent larval reduction		
		First spray	Second spray	Mean
T1	Neem oil	62.8 (52.4)	62.5 (52.3)	62.6 (52.3)
T2	Spinosad	77.3 (61.7)	84.0 (66.5)	80.6 (63.9)
T3	<i>Bacillus thuringiensis</i>	48.6 (44.2)	53.2 (46.8)	50.9 (45.5)
T4	Neem Seed Kernel Extract (NSKE)	61.4 (51.6)	61.1 (51.5)	61.2 (51.5)
T5	Flubendiamide	65.6 (54.2)	65.4 (54.0)	65.5 (54.0)
T6	Chlorantraniliprole	72.4 (58.4)	75.1 (60.3)	73.7 (59.1)
T7	Nisco Sixer Plus	63.6 (53.0)	63.0 (52.6)	63.3 (52.7)
T8	Control/water spray	0 (0.00)	0 (0.00)	0 (0.00)
F- test		S	S	S
S. Ed (±)		2.955	2.818	1.98
C. D. (P = 0.05)		6.339	6.130	4.648

All the treatments were found to be significantly superior to control in reducing percent larval reduction. The highest larval reduction was noticed in Spinosad 45 SC treated plots followed by Chlorantraniliprole 18.5 SC, Flubendiamide 39.35 EC, Nisco sixer plus, Neem oil, Neem seed kernel extract and *Bacillus thuringiensis* was least effective among all selected treatments.

The maximum larval reduction was recorded in Spinosad 45 SC. The results were supported by Game *et al.* (2018) [6] and Shinde *et al.* (2011) [19], Goshal *et al.* (2013), Meena and Raju (2013) [11] and Baber *et al.* (2016). Chlorantraniliprole 18.5 SC was found to be next best effective. The results was supported by Abbas *et al.* (2015) [1], Rani *et al.* (2018) [15] and Patel *et al.* (2016) [13]. Flubendiamide 39.35 EC was found to be next effective treatment and its results was supported by Sridhar *et al.* (2014) [21], Verma *et al.* (2015) [23] and Thiruveni and Karthik (2017) [22]. Nisco sixer plus was found to be next effective. It is organic in nature and control lepidopteran caterpillars. Botanicals like Neem oil and Neem seed kernel extract was less effective when compared to chemical insecticides. But lower toxicity to the environment as well as human being neem seed extract is the most promising insecticide for the effective management of tomato fruit worm larvae. Shah *et al.* (2013) [18], Rahman *et al.* (2014)

[14], Mustafiz *et al.* (2015) [12] and Dialoke (2017) [4]. *Bacillus thuringiensis* was least effective against tomato fruit borer supported by Kumar *et al.* (2017) [9]. The present investigation supports the observation of Kumar and Sarada (2015) [8] and Sreedhar (2019) [20] most effective treatment tomato fruit borer was Spinosad, Chlorantraniliprole and Flubendiamide.

Economics of treatment

The yield among the treatments were significant (Table 4). The highest yield was recorded in Spinosad 45 SC (230q/ha), followed by Chlorantraniliprole 18.5 SC (220q/ha), Flubendiamide 39.35 SC (196q/ha), Nisco sixer plus (171q/ha), Neem oil (160q/ha), Neem kernel seed extract (157q/ha), *Bacillus thuringiensis* (151q/ha) as compared to control T8 (113q/ha). When cost benefit ratio was worked out, interesting results was achieved. Among the treatment studied, the best and most economical treatment was Spinosad 45 SC (1:7.0), followed by Chlorantraniliprole 18.5 SC (1:6.8), Flubendiamide 39.35 SC (1:6.4) Nisco sixer plus (1:5.9), Neem oil (1:5.6), Neem seed kernel extract (1:5.6), *Bacillus thuringiensis* (1:5.2) as compared to control T8 (1:4.2).

Table 3: Economics of treatment

Treatments	Yield of q/ha	Cost of yield / Rs/q	Total Cost yield (Rs.)	Common cost (Rs.)	Treatment Cost (Rs.)	Total cost (Rs.)	C:B ratio
Neem oil	160	2500	4,00,000	67050	3238	70,288	1:5.6
Spinosad	230	2500	5,75,000	67050	14984	82,034	1:7.0
<i>Bacillus thuringiensis</i>	151	2500	3,77,500	67050	4300	71,350	1:5.2
Neem Seed Kernel Extract (NSKE)	157	2500	3,92,200	67050	2420	69,470	1:5.6
Flubendiamide	196	2500	4,90,600	67050	9060	76,110	1:6.4
Chlorantraniliprole	220	2500	5,50,000	67050	13392	80,442	1:6.8
Nisco Sixer Plus	171	2500	4,27,500	67050	4810	71,860	1:5.9
Control/water spray	113	2500	2,82,500	67050	-	67,050	1:4.2

Higher yield (230q/ha) and higher cost benefit ratio of (1:7) was obtained from spinosad treated plots and lowest (1:5.6) in control plot and proved to be best among treatments. The highest cost benefit ratio was obtained in treatment of Spinosad 45 SC @ 0.4ml/lit the result were supported by Kalita *et al.*, (2016) [7], Sekhara *et al.* (2016) and Game *et al.* (2018) [6]. The next highest cost benefit ratio was obtained in the treatment of chlorantraniliprole @ 0.005% the results were supported by Safna *et al.* (2018) [17] and Patel *et al.* (2018). The third highest cost benefit ratio was recorded in Flubendiamide 39.35 EC @ 0.2ml/lit the results was supported by Regmi *et al.* (2018) [16]. The fourth highest cost benefit ratio was recorded in neem oil @ 5ml followed by Neem seed kernel extract @ 5% the results was supported by Faqiri and Kumar (2016) [5]. The lowest yield can be identified in *Bacillus thuringiensis* @ 25g/ha which corroborates the present findings. The minimum cost benefit ratio was obtained in *Bacillus thuringiensis* (1:5.6) due to its less effectiveness compared to chemical insecticides with low efficacy against pest the results was supported by Kumar *et al.* (2017) [9].

Conclusion

From the critical analysis of the present findings it was observed that incidence of *Helicoverpa armigera* in tomato was starting from early stage of flowering till to the harvesting. The approaches for chemical management of

tomato fruit borer were found effective than control. So, it can be concluded that among all the treatments, minimum percent of larval reduction and B:C ratio were observed in Spinosad (80.6 and 1:7.0) followed by Chlorantraniliprole (73.7 and 1:6.8), Flubendiamide (65.5 and 1:6.4), Nisco sixer plus (63.3 and 1:5.9), Neem oil (62.6 and 1:5.6), Neem seed kernel extract (61.2 and 1:5.6), *Bacillus thuringiensis* (50.9 and 1:5.2), untreated control (water spray) (63.3 and 1:4.2) respectively. Hence, this finding can be useful for the farmers in feasible manner for sustainable production of tomato.

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