Int.J.Curr.Microbiol.App.Sci (2017) *6*(8): 1068-1081

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 6 Number 8 (2017) pp. 1068-1081**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2017.608.133

Comparative Efficacy of Certain Bio-Pesticides against Tomato Fruit Borer, *Helicoverpa armigera* (Hub.)

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Keywords

Helicoverpa armigera (Hub.), HaNPV, Spinosad, B:C Ratio and Tomato variety Selection - 22.

Article Info

Accepted:
14 June 2017
Available Online:
10 August 2017

A B S T R A C T

The field experiment on "Comparative efficacy of certain bio-pesticides against tomato fruit borer, *Helicoverpa armigera* (Hub.)" was conducted during 2014-15 at Central Research Farm and Department of Entomology SHIATS, Naini, Allahabad (U.P). The relative efficacy of biorational- insecticides *viz*., spinosad 45 SC (0.005%), quinalphos 25 EC (0.05%), HaNPV (350 LE/ha), *Beauveria bassiana* (0.3ml/lit), *Verticillium lecanii* (2.5kg/ha) and *Metarhizium anisopliae* (1000ml/ha) were evaluated against fruit borer (*Helicoverpa armigera*). The data on incremental percent reduction of different treatments revealed that the treatment Spinosad (74.97%), followed by quinalphos (66.31%), HaNPV (59.74%) >*Beauveria bassiana* (57.58%) > *Verticillium lecanii* (47.10%) > *Metarhizium anisopliae* (44.46%) found to be the most economically viable treatment. The highest cost benefit ratio was obtained from quinalphos (1:15.68) and the application of biorational- insecticides two spray at 15 days interval during *rabi* 2014-15.

Introduction

Tomato (*Lycopersicon esculentum* Mill) is one of the most important vegetables in the world, ranking second in importance to potato in many countries. It is a warm season crop. It is grown as an off-season vegetable in the hills of India and farmers fetch good income after sending their produce in the plains from June to September. Tomato supplies vitamin C and adds variety of colors and flavors to the foods. The fruits are eaten raw or cooked.

Large quantities of tomatoes are used to prepare soup, juice, ketchup, puree, pickle, paste and powder (Choudhary, 2002). About 16 insect and other pest species which caused damage to tomato crop in India Bhutani, (1977). Among the various pests, the tomato fruit borer, *Helicoverpa armigera* (Hub.) (Lepidoptera: Noctuidae) is the most destructive. The crop losses by *H. armigera* the extent of 80 per cent have been reported by Singh and Singh, (1975) and Yadav, (1980). The insect has developed resistance against many recommended insecticides (Srinivasan and Krishnamoorthy, 1992). Therefore, eco-friendly approaches have been evaluated for the management of *H. armigera* in tomato (Sivaprakasam, 1996, Khanam *et al.*, 2003 and Selvanarayanan and Narayanasamy, 2006). There are some encouraging reports on the use of bio-rational insecticides against tomato fruit borer (*Helicoverpa armigera*) by Tripathi and Singh, (2005) and Dhaka *et al.*, (2010). Such studies on tomato will be more fruitful because the fruits are free from toxic residues of insecticides. The pest is highly polyphagous and is reported on nearly 181 host plants Manjunath *et al.*, (1987). The efficacy of different sequential application of nucleopolyhedro virus of *H. armigera* (HaNPV), *Bacillus thuringiensis* var. *kurstaki* Berliner (*Bt. K.*), neemazol and spinosad as the alternatives to the synthetic chemical pesticides for the sustainable management of *Helicoverpa armigera* on tomato (Ravi *et al.*, 2008).

Materials and Methods

Layout and design

The experiment on "Comparative efficacy of certain bio-pesticides against tomato fruit borer, *Helicoverpa armigera* (Hub.)" in trans Yamuna region of Allahabad. In Allahabad region at field condition was carried out during October 2014 to April, 2015 at Agricultural Research Farm at SHIATS (Allahabad Agricultural Institute) Deemed University, Allahabad, Uttar Pradesh, India. The experiment was conducted in the randomized block design (RBD) with seven treatments schedules including control, and each treatment schedule was replicated two time at 15 days interval initiating first spray in the last week of February when the pest infestation started viz., 28 February and 14 March during *rabi* 2015, respectively. The tomato variety Selection -22 was transplanted on 27 January during *rabi* 2015. The plot size was 3.60 x 3.60 m^2 with row to row and plant to plant spacing of 45 x 45 cm, respectively.

The details of different treatment schedules are as follows

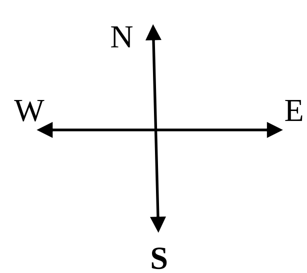
Management schedule of treatments

Pre-calibrated knap sack sprayer was used for spraying the biopesticides care was taken to check the drift of insecticides, by putting polythene sheet screen around each plot at the time of spraying. In all sprays were applied, first spray was done during the last week of February and subsequent second spray was applied at 15 days interval.

Observations

Pretreatment population of *Helicoverpa armigera* (Hub.) was recorded 24 hours before the scheduled spray.

Layout of Experimental Field



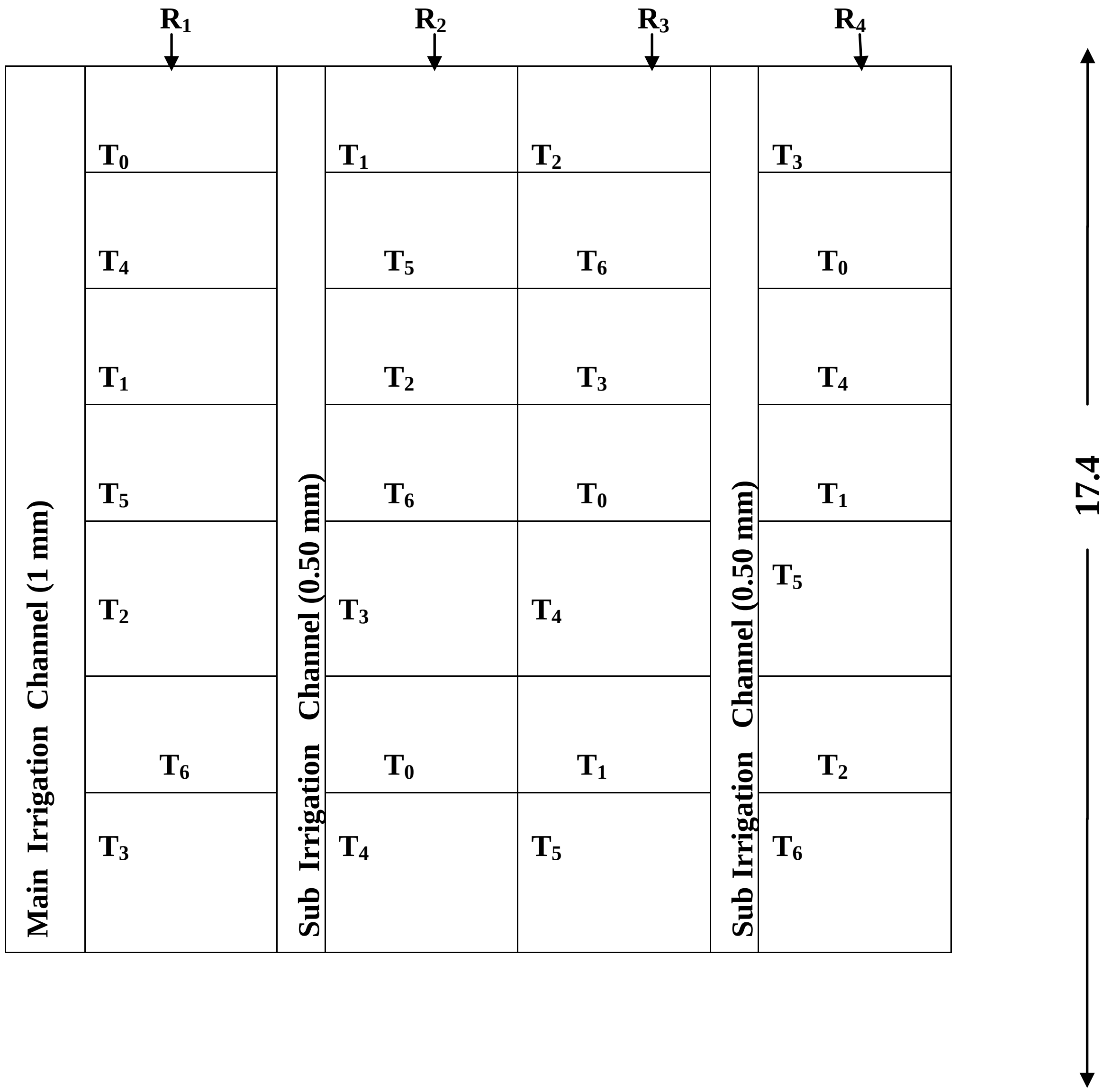


Table.1 Details of treatments

Treatment	Chemical name	Dose (concentration)	References
T_0	Control	--------	----------
T_1	*Verticillium lecanii*	2.5kg/ ha	Kaur and Singh (2013)
T_2	*Metarhizium anisopliae*	1000ml/ha	Lad *et al.*, (2009)
T_3	*Beauveria bassiana*	0.3ml/ litre	Sreekanth and Seshamahalakshmi (2010)
T_4	HaNPV	250 LE/ha	Kaur and Singh (2013)
T_5	Quinalphos (Organophosphate)	0.05% (2ml/lit.)	Naik *et al.*, (2013)
	Spinosad (Spinosyns)	0.005 % (0.1 ml/lit.)	Shinde *et al.*, (2011)

Post treatment population of *H. armigera* was recorded on 3, 7 and 10 day after each spray, on 5 plants were selected randomly in each plot and tagged from each plot.

Preparation of insecticidal solution

The insecticidal spray of desired concentration as per treatment was freshly prepared every time at the time of experimentation just before the start of spraying operations. The spray solution of a desired concentration was prepared by adopting the following formula (Katyayan, 2010).

$$V = \frac{CxA}{a.i.\%}$$

Where,
V = Volume/ weight of commercial insecticide ml or gm.

C = Concentration required.

A = Volume of solution to be prepared.
a.i. (%) = Percentage active ingredient

Application of spray solution

Spray solution was applied with the help of hand compression sprayer. Spraying was done at dawn and desk time and their must not be much wind currents.

Reduction per cent by fruit borer

The total numbers of infested and un infested plants at fruiting stage were counted from selected five plants of each plot. Thus the larvae was calculated using the following formula:

$$\text{Reduction percent} = \frac{\text{Control--Treatment}}{\text{Control}} \times 100$$

Benefit cost ratio

Gross return was calculated by multiplying total yield with the market price of the produce. Cost of cultivation and cost of treatment imposition was deducted from the gross returns, to find out net returns and cost benefit ratio by following formula

$$\text{B: C} = \frac{\text{Gross Returns}}{\text{Total Cost of Incurred}}$$

Where B: C = Benefit Cost Ratio

Results and Discussion

The results of studies undertaken during *Rabi*, 2014-15 on "Comparative efficacy of certain bio-pesticides against tomato fruit borer, *Helicoverpa armigera* (Hubner)] in trans yamuna region of Allahabad" are presented in the following heads.

First spray

Reduction of fruit borer (First spray)

The data on per cent reduction of fruit borer before spraying (Table 2) revealed that the results were statistically non significant. 3rd day after 1st spraying. The descending order of different treatment is given below. Some treatments were non significantly and some significantly superior over control.

T_4	T_5	T_6	T_1	T_2	T_3	T_0
72.22	**63.03**	**56.07**	**55.42**	**44.37**	**43.42**	**0.00**

The data on population reduction percent of fruit borer, (*Helicoverpa armigera)* on 3rd day after spraying showed that all the treatment was significantly superior over control. Maximum reduction was observed with spinosad (72.22%), followed by quinalphos (63.03%), HaNPV (56.07%), *Beauveria bassiana* (55.42%) *Verticillium lecanii* (44.37%), and *Metarhizium anisopliae* (44.37%), were most effective treatment.

Table.2 Comparative efficacy of certain bio-pesticides against tomato fruit borer [*Helicoverpa armigera* (Hubner)] on different days after 1st spray during Rabi season 2014-2015

	%reduction in *Helicoverpa armigera*					
	Treatment	**Before**	**3DAS**	**7DAS**	**14DAS**	**Mean**
T_1	*Verticillium lecanii*	4.95	55.42 **(48.11)***	58.95 **(50.15)***	46.27 **(42.86)***	53.54
T_2	*Beauveria bassiana*	5.4	44.37 **(41.76)***	45.55 **(42.44)***	44.85 **(42.04)***	44.92
T_3	*Metarhizium anisopliae*	4.8	43.42 **(41.22)***	44.56 **(41.87)***	35.17 **(36.37)***	41.05
T_4	Spinosad	5.05	72.22 **(58.20)***	73.85 **(59.25)***	70.77 **(57.27)***	72.28
T_5	Quinalphos	5.05	63.07 **(52.58)***	65.50 **(54.03)***	63.03 **(52.56)***	63.86
T_6	HaNPV	4.7	56.07 **(48.49)***	59.52 **(50.49)***	54.30 **(47.46)***	56.63
T_0	Untreated control Water spray	4.95	0.00 **(0.54)***	0.00 **(0.54)***	0.00 **(0.54)***	0.0
	Over all Mean		47.79	49.70	44.91	
	F- test		S	S	S	
	S. Ed. (±)		0.96	0.83	0.89	
	C. D. (P = 0.05)		2.03	1.76	1.87	4.60

Table.3 Comparative efficacy of certain bio-pesticides against tomato fruit borer [*Helicoverpa armigera* (Hubner)] on different days after 2nd spray during Rabi season 2014-2015

			%reduction in *Helicoverpa armigera*			
	Treatment	**Before**	**3DAS**	**7DAS**	**14DAS**	**Mean**
T_1	*Verticillium lecanii*	2.6	57.95 **(49.57)***	62.72 **(52.37)***	64.22 **(53.26)***	61.63
T_2	*Beauveria bassiana*	3.15	46.25 **(42.84)***	48.46 **(44.12)***	53.17 **(46.82)***	49.29
T_3	*Metarhizium anisopliae*	3.1	45.07 **(42.17)***	47.05 **(43.30)***	51.50 **(45.86)***	47.87
T_4	Spinosad	1.5	73.75 **(59.18)***	77.07 **(61.39)***	82.17 **(65.05)***	77.66
T_5	Quinalphos	1.75	65.65 **(54.12)***	66.92 **(54.89)***	73.72 **(59.17)***	68.76
T_6	HaNPV	2.05	58.55 **(49.92)***	62.45 **(52.21)***	67.55 **(55.27)***	62.85
T_0	Untreated control Water spray	5.9	0.0 **(0.54)***	0.0 **(0.54)***	0.0 **(0.54)***	
	Over all Mean		49.60	52.09	56.04	
	F- test		S	S	S	
	S. Ed. (±)		0.66	0.83	1.04	
	C. D. (P = 0.05)		1.39	1.74	2.20	3.20

Table.4 Comparative efficacy of certain bio-pesticides against tomato fruit borer [*Helicoverpa armigera* (Hubner)] during Rabi season in tomato. (Mean of 1st and 2nd spray) 2014-15

		%reduction in *Helicoverpa armigera*		
	Treatments	**Ist spray**	**IInd spray**	**Overall mean**
T_1	*Verticillium lecanii*	53.54 **(47.04)***	61.63 **(51.73)***	57.58 **(49.37)***
T_2	*Beauveria bassiana*	44.92 **(42.01)***	49.29 **(44.59)***	47.10 **(43.33)***
T_3	*Metarhizium anisopliae*	41.05 **(39.82)***	47.87 **(43.77)***	44.46 **(41.81)***
T_4	Spinosad	72.28 **(58.23)***	77.66 **(61.86)***	74.97 **(60.00)***
T_5	Quinalphos	63.86 **(53.05)***	68.76 **(56.05)***	66.31 **(54.52)***
T_6	HaNPV	56.63 **(48.81)***	62.85 **(52.46)***	59.74 **(50.62)***
T_0	Untreated control Water spray	0.0 **(0.54)***	0.0 **(0.54)***	0.0 **(0.54)***
	F- test	S	S	S
	S. Ed. (±)	1.82	1.2	0.90
	C. D. (P = 0.05)	4.60	3.02	2.29

Table.5 Economic of treated tomato crop of cultivation/ha

S.n.	Particular	Requirement	Rate/unit Rs.	Cost
(A)	**Land preparation**			
I.	Ploughing	3 hours	500 Rs/hours	1500
II.	Harrow	3 hours	500 Rs/hours	1500
III.	Layout of field & showing	15 labours	150 Rs/labour	2250
(B)	**Manures and fertilizer**			
I.	Urea	260 kg	12 Rs./Kg	3120
II.	SSP	150 kg	7.8 Rs./Kg	1170
III.	MOP	90 kg	19 Rs./Kg	1710
IV.	Labour	2 labours	150	300
(C)	**Seed sowing**	400-500 gm/ ha.	800 Rs./Kg	400
I.	Seed material	3 labours		
II.	Weeding		150Rs/labour	450
(D)	**Irrigation**			
I.	First time	4 hours	100 Rs./hours	400
II.	Second time	4 hours	100 Rs./hours	400
III.	Labour	2 Labours	100 Rs/labour	200
(F)	**Harvesting**	15 labours	150 Rs/labour	2250
I.	Labour	6 Labour	150 Rs/hours	900
II.	Transport charge	1 Truck	5000	5000
(G)	**Total cost of cultivation**			**21550**

Table.6 Cost of Insecticides/ha

Treatment	Use of chemical (2TimeSpray)	Cost of Insecticides	Total Cost of Insecticides (Rs.)	Use of 2 labours (Rs.)	Total labour cost (Rs.)	Total cost of Treatment
Control						
Verticilliumlecanii	5 kg/ ha	200 Rs /kg	1000	150	600	1600
Beauveriabassiana	5kg./ha	180Rs /kg.	900	150	600	1500
Metarhiziumanisopliae	5 kg /ha	220Rs /kg.	1100	150	600	1700
Spinosad	900 ml/ha	13000 Rs /lit.	9750	150	600	10350
Quinalphos	2 lit/ha	400Rs / lit.	800	150	600	1400
HaNPV	500 LE/ha	200 Rs/ LE	800	150	600	1400

Table.7 Economics of treatment

Treatment	Yield of q/ha	Cost of yield (Rs/q)	Total cost of yield (Rs.)	Common cost (Rs.)	Treatment cost (Rs.)	Total cost (Rs.)	C:B ratio
Control	110	2000	220000	21550	--	21550	1:10.20
Verticillium lecanii	165	2000	330000	21550	1600	23150	1:14.25
Beauveria bassiana	158	2000	316000	21550	1500	23050	1:13.70
Metarhizium anisopliae	150	2000	300000	21550	1700	23250	1:12.90
Spinosad	200	2000	400000	21550	10350	31900	1:12.53
Quinalphos	180	2000	360000	21550	1400	22950	1:15.68
HaNPV	172	2000	344000	21550	1400	22950	1:14.98

Treatments T_3, $T_2$and T_1, T_6 were par with each other. 7th day after 1st spraying. The descending order of different treatment is given below.

T_4	T_5	T_6	T_1	T_2	T_3	T_0
73.85	**65.50**	**59.52**	**58.95**	**45.55**	**44.56**	**0.00**

Some treatments were non significantly and some significantly superior over control. The data on population reduction percent of fruit borer (*Helicoverpa armigera)* on 7th day after spraying showed that all the treatment were significantly superior over control Maximum reduction was observed with spinosad (73.85%), followed by quinalphos (65.50%), HaNPV (59.52%), *Beauveria bassiana* (58.95%), *Verticillium lecanii* (45.55%), and *Metarhizium anisopliae* (44.46%), were most effective treatment. Treatments T_3, $T_2$and T_1, T_6 were par with each other.

14th day after 1st spraying

The descending order of different treatment is given below.

T_4	T_5	T_6	T_1	T_2	T_3	T_0
70.77	**63.03**	**54.30**	**46.27**	**44.85**	**35.17**	**0.00**

Treatments were significantly superior over Control. The data on population reduction percent reduction of *Helicoverpa armigera* over control on 14th day after spraying revealed that the treatment were superior to control. The data on population reduction percent of fruit borer (*Helicoverpa armigera*) on 14^{en} day after spraying showed that all the treatment were significantly superior over control Maximum reduction was observed with spinosad (70.77%), followed by quinalphos (63.03%), HaNPV (54.30%), *Beauveria bassiana* (46.27%), *Verticillium lecanii* (44.85%), and *Metarhizium anisopliae* (35.17%), were most effective treatment. Treatments $T_2$and T_1 were par with each other.

Mean of Ist spray. (3rd, 7th, and 14th DAS)

The descending order of different treatment is given below.

T_4	T_5	T_6	T_1	T_2	T_3	T_0
72.78	**63.86**	**56.63**	**53.54**	**44.92**	**41.05**	**0.00**

Treatments were significantly superior over Control. The data on population reduction percent reduction of (*Helicoverpa armigera)* over control on 14th day after spraying revealed that the treatment were superior to control. The data on population reduction percent of fruit borer (*Helicoverpa armigera)* on 1st spraying mean showed that all the treatment were significantly superior over control Maximum reduction was observed with spinosad (72.28%), followed by quinalphos (63.86%), HaNPV (56.63%), *Beauveria bassiana* (53.54%), *Verticillium lecanii* (44.92%), and *Metarhizium anisopliae* (41.05%), were most effective treatment. Treatments $T_{3,}$ T_2 and $T_{1,}$ T_6 were par with each other. Siumilar finding was observed by Gandhi *et al.*, (2013) evaluate the bio efficacy of spinosad 45 SC (0.1 ml/l), cypermethrin 10EC (0.5 ml/l), novaluran 10EC (1 ml/l), azardirachtin 5% and *Bacillus thringiensis* (1 ml/l) insecticides against ear head caterpillar *Helicoverpa armigera* in sorghum, spinosad 45 SC (0.1ml/1), novaluran 10 EC (1 ml/l) and azardirachtin 5% emerged as superior by recording72.0, 66.0 and 63.0% population reduction. Kale *et al.*, (2008) reported that the treatments, spinosad (0.01%) was most efficacious and recorded the lowest larval population and highest grain yield. Other effective microbial insecticides were HaNPV (250 LE ha-1) and Bt (750 ml ha-1), which stood only next to endosulfan (0.06%). *Metarhizium anisopliae* (2.5 kg ha-1) and *Beauveria bassiana* (2.5 kg ha-1) were less efficacious, but performed better than their combinations with either HaNPV or Bt and combination of HaNPV with Bt at reduced doses

Second spray

Reduction of fruit borer second (spray)

The data on per cent reduction of fruit borer before spraying revealed that the results were statistically non significant.

3rd day after IInd spraying

The descending order of different treatment is given below.

T_4	T_5	T_6	T_1	T_2	T_3	T_0
73.75	**65.55**	**58.55**	**57.95**	**46.25**	**45.07**	**0.00**

Some treatments were non significantly and some significantly superior over control. The data on population reduction percent of fruit borer (*Helicoverpa armigera)* on 3rd day after spraying showed that all the treatment were significantly superior over control Maximum reduction was observed with spinosad (73.75%), followed by quinalphos (65.65%), HaNPV (58.55%), *Beauveria bassiana* (57.95%), *Verticillium lecanii* (46.25%), and *Metarhizium anisopliae* (45.07%), were most effective treatment. Treatments T_3, $T_2$and T_1, T_6 were par with each other.

7th day after IInd spraying

The descending order of different treatment is given below.

T_4	T_5	T_6	T_1	T_2	T_3	T_0
77.07	**66.92**	**62.45**	**62.72**	**48.46**	**47.05**	**0.00**

Some treatments were non significantly and some significantly superior over control. The data on population reduction percent of fruit borer (*Helicoverpa armigera*) on 7th day after spraying showed that all the treatment were significantly superior over control Maximum reduction was observed with spinosad (77.07%), followed by quinalphos (66.92%), HaNPV (62.45%), *Beauveria bassiana* (62.72%) *Verticillium lecanii* (48.46%), and *Metarhizium anisopliae* (47.05%), were most effective treatment. Treatments T_3, $T_2$and T_1, T_6 were par with each other.

14th day after IInd spraying

The descending order of different treatment is given below.

T_4	T_5	T_6	T_1	T_2	T_3	T_0
82.17	**73.72**	**67.55**	**64.22**	**53.17**	**51.50**	**0.00**

Treatments were significantly superior over Control. The data on population reduction percent reduction of (*Helicoverpa armigera)* over control on 14th day after spraying revealed that the treatment were superior to control. The data on population reduction percent of fruit borer (*Helicoverpa armigera)* on 14en day after spraying showed that all the treatment were significantly superior over control Maximum reduction was observed with spinosad (82.17%), followed by quinalphos (73.72%), HaNPV (67.55%), *Beauveria bassiana* (64.22%) *Verticillium lecanii* (53.17%), and *Metarhizium anisopliae* (51.50%), were most effective treatment. Treatments $T_3$and T_2 were par with each other.

Mean of IIst spray. (3rd, 7th, and 14th DAS)

The descending order of different treatment is given below.

T_4	T_5	T_6	T_1	T_2	T_3	T_0
77.66	**68.76**	**62.85**	**61.63**	**49.29**	**47.87**	**0.00**

Treatments were significantly superior over Control. The data (Table 3) on population reduction percent reduction of *Helicoverpa armigera* over control on 14th day after spraying revealed that the treatment were superior to control.

The data on population reduction percent of fruit borer *Helicoverpa armigera* on 2nd spraying mean showed that all the treatment were significantly superior over control maximum reduction was observed with spinosad (77.66%), followed by quinalphos (68.76%), HaNPV (62.85%), *Beauveria bassiana* (61.63%) *Verticillium lecanii* (49.29%), and *Metarhizium anisopliae* (47.87%) were most effective treatment.

Treatments T_3, T_2 and T_1, T_6 were par with each other.

Randhawa *et al.,* (2009) reported that five insecticides, i.e. endosulfan 35 EC at 1250 ml endosulfan 35 EC at 2500 ml, spinosad 48 SC at 150 ml, indoxacarb 15 EC at 500 ml, cypermethrin 25 EC at 200 ml, chlorpyriphos 20 EC at 2500 ml per hectare, along with untreated control, were evaluated against gram caterpillar (*Helicoverpa armigera*) on seed crop of berseem. Spinosad 48 SC was found to be the most effective insecticide for the control of *H. armigera*, followed closely by indoxacarb15 EC. Phukon *et al.,* (2014) revealed the reduction in fruit damage was up to 92.20 per cent in cypermethrin treated plot followed by 91.12 per cent, 88.74 per cent and 87.01 per cent in the plots treated with Neem oil, *B. Bassiana* and *M. Anisopliae*, respectively due to *H. armigera* larvae over control. The highest increase in yield over control was noticed in cypermethrin treated plots (62.85%) followed by neem oil treated plots (41.83%).

The descending order of different treatment is given below.

T_4	**T_5**	**T_6**	**T_1**	**T_2**	**T_3**	**T_0**
72.78	**63.86**	**56.63**	**53.54**	**44.92**	**41.05**	**0.00**

Treatments were significantly superior over Control. The data on population reduction percent reduction of (*Helicoverpa armigera)* over control on 14th day after spraying revealed that the treatment were superior to control. The data on population reduction percent of fruit borer (*Helicoverpa armigera)* on 1st spraying mean showed that all the treatment were significantly superior over control Maximum reduction was observed with spinosad (72.28%), followed by quinalphos (63.86%), HaNPV (56.63%), *Beauveria bassiana* (53.54%) *Verticillium lecanii* (44.92%), and *Metarhizium anisopliae* (41.05%), were most effective treatment. Treatments T_3, T_2 and T_1, T_6 were par with each other.

Mean of IIst spray. (3rd, 7th, and 14th DAS)

The descending order of different treatment is given below.

T_4	**T_5**	**T_6**	**T_1**	**T_2**	**T_3**	**T_0**
77.66	**68.76**	**62.85**	**61.63**	**49.29**	**47.87**	**0.00**

Treatments were significantly superior over Control. The data on population reduction percent reduction of (*Helicoverpa armigera)* over control on 14th day after spraying revealed that the treatment were superior to control. The data on population reduction percent of fruit borer (*Helicoverpa armigera*) on 2nd spraying mean showed that all the treatment were significantly superior over control Maximum reduction was observed with spinosad (77.66%), followed by quinalphos (68.76%), HaNPV (62.85%), *Beauveria bassiana* (61.63%) *Verticillium lecanii* (49.29%), and *Metarhizium anisopliae* (47.87%), were most effective treatment. Treatments T_3, T_2 and T_1, T_6 were par with each other.

Over all mean of first and second spray

The descending order of different treatment is given below.

T_4	T_5	T_6	T_1	T_2	T_3	T_0
74.97	**66.31**	**59.74**	**57.58**	**47.10**	**44.46**	**0.00**

Treatments were significantly superior over Control. The data (Table 4) population reduction percent reduction of (*Helicoverpa armigera)* over control on 14th day after spraying revealed that the treatment were superior to control.

The data on population reduction percent of fruit borer (*Helicoverpa armigera*) on 1st and 2nd spraying mean showed that all the treatment were significantly superior over control Maximum reduction was observed with spinosad (74.97%), followed by quinalphos (66.31%), HaNPV (59.74%), *Beauveria bassiana* (57.58%), *Verticillium lecanii* (47.10%), and *Metarhizium anisopliae* (44.46%), were most effective treatment. Treatments T_1 and T_6 were par with each other. Similar founding was observed by

Singh *et al.*, (2009) reported that spinosad 45 SC proved to be the best treatment in reducing the incidence in shed fruiting bodies and damage on boll and loculi basis followed by novaluron @ 50 and 37.5 g a.i./ha. Although the incidence of American bollworm was less in spinosad but yield was comparatively higher in novaluron @ 50 and 37.5 g a.i/ha as against spinosad and chlorpyriphos. Lad *et al.*, (2009**)** reported that *Metarhizium anisopliae* @ 1x108 conidia ha-1, *Beaveria bassiana*1x108 conidia ha-1, *Metarhizium anisopliae* @ 1x106 conidia ha-1, *Beaveria bassiana* 1x106 conidia ha-1, were at par with each other, but significantly inferior to first three biological treatments. However, the microbials were significantly better than Neemark and NSE 5%.

Cost benefit ratio

The tables 5,6 and 7 with respect to cost benefit ratio (CB) as influenced by various treatments is presented in table 4.8 and which revealed that the higher amount of monetary return was obtained with quinalphos 25 EC (1:15.68) followed by HaNPV 250LE/ha (1:14.98), *Verticillium lecanii* (1:14.25), *Beauveria bassiana* (1:13.70), *Metarhizium anisopliae* (1:12.90) spinosad 45 SC (1:12.53), and Control (1:14.84). The similar finding was observed by the following researcher Naik *et al.*, (2013) reported that among the insecticides and biopesticides evaluated against *H. armigera*, the insecticide quinalphos (0.05) recorded the least leaf damage of 9.55% and it was at par with chlorpyriphos (0.05) (11.22%). Highest pod yield of 9.86 q/ha was recorded with chlorpyriphos (0.05) followed by quinalphos(0.05) 9.41 q/ha. The maximum cost:benefit ratio of 1:6.12 was obtained in quinalphos (0.05). Tayde and Simon (2010) revealed that Spinosad 45 SC @ 0.01% was found most effective and showed (09.84%) shoot infestation, per cent fruit infestation (06.87% on number basis and 07.35% on weight basis) and increasing yield of brinjal fruit (239.30q/ha). Whereas, carbaryl 50 WP @ 0.2% and endosulfan 35 EC @0.05% were also found effective in reducing per cent infestation shoot and fruit infestation and increasing yield. Amongst neem products NSKE 5% was found to be superior in terms of efficacy and yield. However, the increment cost benefit ratio (ICBR) showed that the application of quinalphos 25 EC @ 0.05% was economically most viable treatment (1:67.86) followed by endosulfan 35 EC @ 0.05% (1:66.19).

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How to cite this article:

Renu Choudhary, Ashwani Kumar, G.C. Jat, Vikram and Deshwal, H.L. 2017. Comparative Efficacy of Certain Bio-Pesticides against Tomato Fruit Borer, *Helicoverpa armigera* (Hub.). *Int.J.Curr.Microbiol.App.Sci.* 6(8): 1068-1081. doi: https://doi.org/10.20546/ijcmas.2017.608.133