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Comparison with botanicals and the bio-agents on Fruit borer, *Helicoverpa armigera* (Hubner) in Tomato

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Abstract
The present investigation was conducted to study "Comparison with botanicals and the bio-agents on Fruit borer, *Helicoverpa armigera* (Hubner) in Tomato" was carried out during the *Rabi* season of 2019-20 at the central field of the Department of Entomology, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. The study revealed that the overall efficacy of botanicals and bio-agents from the two sprays revealed that treatment Spinosad 45% SC was the best treatment which recorded a minimum (9.75%) mean fruit infestation and was significantly superior over all other treatments. It was followed by *Bacillus turingiensis*, which recorded (12.03%) fruit infestation. The following treatments in descending order of effectiveness were *Ha*-NPV, Neem seed kernel extract, *Beauveria bassiana*, Tobacco leaf extract and karanj oil which were recorded (12.29%), (14.26%), (14.71%), (15.16%) and (15.58%) fruit infestation, respectively. All the above treatments were found to be superior to the control, which recorded maximum fruit infestation (24.46%). In Spinosad, 45% SC (245q/ha), Fruit yields were high followed by *Bacillus turingiensis* (220q/ha).

Keywords: *Helicoverpa armigera*, botanicals, bio-agents, tomato, cost-benefit ratio

1. Introduction
Tomato (*Lycopersicon esculentum* Mill) is one of the important vegetable crops grown worldwide for fresh market and processing. It belongs to the family Solanaceae. He is said to be a native of Tropical America. It is grown around the year and growing belts of tomato are widely distributed throughout the world It can be used fresh in salad, curries or bi-products like chutney, pickle, soups, ketchup, sauce, powder, purees etc. (Patil *et al*., 2018) [8]. It is known as protective food because of its special nutritional value and comprehensive spread production. While it is botanically a fruit, it is considered a vegetable for culinary purposes.
Canned and dried tomatoes are economically crucial for processed products. It is economically attractive because of the relatively short duration crop and the area under cultivation is increasing day by day. Tomato is cultivated on 789 M ha in India with an annual production of 19759 Mt and an average productivity of 25 Mt ha^{-1} (Anonymous, 2017-18) [1]. In Uttar Pradesh it is cultivated on 21.24 M ha with an annual production of 841 Mt ha^{-1} (Anonymous, 2017-2018) [1]. Among the insect pests, tomato fruit borer, *Helicoverpa armigera* (Hub.), jassid, *Amrasca biguttula biguttula* (Ishida) and *Empoasca punjabensis* (Pruthi), tobacco caterpillar, *Spodoptera litura* (Fab.), thrips, *Thrips tabaci* (Linn.), aphids, *Aphis gossypii* (Glover), *Lipaphi serysimi* (Kalt.) and *Myzus persicae* (Sulzer), whitefly, *Bemisia tabaci* (Genn.) and epilachna beetle, *Epilachna dodecastigma* (Wiedemann) etc. occur regularly during the cropping season. But in India fruit borer is one of the most important pests of tomato. The damage caused by the fruit borer is one of the main constraints that limit tomato production and is a highly destructive pest causing serious damage and is responsible for significant yield loss of up to 55 percent. It also caused 40 to 50 percent damage to the tomato crop (Pareek and Bhargava, 2003) [6]. It has been estimated that the crops worth Rs.1000 crores are lost annually by this pest (Jayraj *et al*., 1994) [4]. This is a key pest as it attacks the cashable part of the plant *i.e.*, fruits and makes them unfit for human consumption causing considerable crop loss leading up to 55 percent.

2. Materials and Methods
The field experiment was conducted at the experimental farm of the Department of Entomology, Sam Higginbottom University of Agriculture, Technology and Sciences,

Prayagraj during *Rabi* season of 2019-2020 to study the efficacy of botanicals and the bio-agents on fruit borer, *Helicoverpa armigera* in Tomato. The seeds of the Tomato variety Arka alok was used to raise seedlings in portrays. The seedlings after one month of sowing at the 3-4 leaf stage, were transplanted in a plot size 2 X 2 m^2. The spacing of plant to plant and row to row 60 cm X 45 cm was maintained. The experiment was laid out in Randomized Block Design with Eight treatments were T_1Tobacco leaf extract (6 Kg/ha), T_2-Neem seed kernel extract (25 Kg/ha), T_3-karanj oil (5 Lit/ha), T_4-*Ha*-NPV (500 ml/ha), T_5-*Bacillus turingiensis* (1 Kg/ha), T_6-*Beauveria bassiana* (2.5 Kg/ha), T_7 -Spinosad 45% SC (125 ml/ha) and control. Treatment wise botanicals and the bio-agents were sprayed when the first symptom of infestation was observed at the time the of fruit formation stage and then 2nd spray was done at 15 days after the interval. The spray was done uniformly on the entire plant to ensure complete coverage with a Knapsack sprayer. Spraying was done in the evening to avoid bright sun, strong wind anto d save pollinating bees. The observations were recorded at randomly selected 5 plants in each treatment plot. It was investigated one day before spray and 7th and 14th day after spray. For assessing the tomato fruit borer incidence, the infested fruits and total fruits from 5 randomly selected plants were observed in each plot. The yield data in each treatment was recorded separately and subjected to statistical analysis to test the significance of mean yield variation in different treatments.

3. Results and Discussion

The results (Table 1, 2 and 3) after 1st spray revealed that revealed that all the treatments were significantly superior to control. Among all the treatments T_7–Spinosad 45% SC recorded lowest percent fruit infestation (10.94%) and proved significantly superior over rest of the treatments. Followed by T_5 - *Bacillus turingiensis* which is recorded (12.94%) fruit infestation was at par with T_4-*Ha*-NPV which is recorded (13.10%) fruit infestation. Followed by T_2-Neem seed kernel extract which is recorded (14.63%) fruit infestation was at par with T_6 - *Beauveria bassiana* which is recorded (15.00%), T_1-Tobacco leaf extract (15.44%). and T_3-karanj oil (15.86%) fruit infestation. Among all Treatments T_3-karanj oil was the least effective.

The data after 2nd spray revealed that all the treatments were significantly superior over control. Among all the treatments T_7 – Spinosad 45% SC recorded lowest percent fruit infestation (8.57%) and proved significantly superior over rest of the treatments. Followed by T_5 - *Bacillus turingiensis* which is recorded (11.12%) fruit infestation was at par with T_4-*Ha*-NPV which is recorded (11.48%) fruit infestation. Followed by T_2-Neem seed kernel extract which is recorded (14.02%) fruit infestation was at par with T_6 - *Beauveria bassiana* which is recorded (14.42%), T_1-Tobacco leaf extract (14.89%) fruit infestation. T_1-Tobacco leaf extract (14.89%) fruit infestation was at par with T_3- karanj oil (15.31%) fruit infestation. Among all Treatments T_3-karanj oil was the least effective.

The mean data of 1st & 2nd spray revealed that all the treatments were significantly superior over control. Among all the treatments T_7 – Spinosad 45% SC recorded lowest percent fruit infestation (9.75%) and proved significantly superior over rest of the treatments. T_5 - *Bacillus turingiensis* which is recorded (12.03%) fruit infestation and was at par with T_4-*Ha*-NPV which is recorded (12.29%) fruit infestation. Followed by T_2-Neem seed kernel extract which is recorded (14.32%) fruit infestation was at par with T_6 - *Beauveria bassiana* which is recorded (14.71%), T_1-Tobacco leaf extract (15.16%) and T_3-karanj oil (15.58%) fruit infestation. Among all Treatments T_3-karanj oil was the least effective.

The yields among the treatment were significant. The highest yield was recorded in T_7-Spinosad 45% SC (245q/ha), followed by T_5-*Bacillus turingiensis* (220q/ha), T_4-*Ha*-NPV (205q/ha), T_2-Neem seed kernel extract (195q/ha), T_6-*Beauveria bassiana* (180q/ha), T_1-Tobacco leaf extract (175q/ha), T_3-karanj oil (162.5q/ha), as compared to control T_0-Control (112.5q/ha).

The above findings are in accordance with the findings of Sathish *et al.* (2018) [12, 13] reported among biopesticides, spinosad 45 SC @ 0.2ml/lit. and *Bt. Var. kurstaki* @ 1.5gm/lit. with highest fruit yield of 155.65 q/ha and 148.25 q/ha respectively, were recorded. Ghosh *et al.* (2010) [2] found that Spinosad was effective against *H. armigera* on tomato at 73 to 84 gm a.i./ha than Quinalphos, Lambda cyhalothrin and Cypermethrin. Spinosad at 73 to 84 g a.i./ha were very safe to three important predators recorded in tomato field that is, *Menochilus sexmaculaus*., *Syrphus corollae* and *Chrysoperla carnea*. It is safe to nymphs and adults of the natural enemies. Singh *et al.* (2007) [14] found that among bio - pesticides, the maximum larval mortality after one week of spraying was achieved in halt i.e., 42.2% after first spraying and 42.8% after second spraying which was closely followed by *Ha* NPV. Both neem-based formulations were on par among each other but significantly superior over control. Rahman *et al.* (2014) [9, 14] resulted the lowest fruit infestation, both by number and weight, was observed in neem seed kernel extract (27.15%, 22.29%) treated plot which was statistically similar to tobacco leaf extract (27.71%, 23.31%) treated plot and cypermethrin (28.87%, 25.44%) treated fruits. While no significant difference was found among mahogany oil, mahogany seed extract and control treatments. Percent infestation reduction over control was the highest in neem seed kernel extract (30.08%) followed by tobacco leaf extract (28. 68%). The highest yield (18.14 t/ha) and the highest MBCR (2.99) were also obtained from neem seed kernel extract treated fruits. Ghugal *et al*. (2013) [3] found that spinosad 45 SC @ 73 g a.i./ha was the most effective in controlling pod borer and recorded significantly lowest pod damage (4.11%) and highest grain yield (2261.66 kg/ha) with CBR 1:7.37. Among biopesticides, *Beauveria bassiana* @ 1500 g/ha and NSKE 5% recorded 7.73 & 7.89 per cent pod damage and 2011.66 kg/ha & 2001.66 kg/ha grain yield with CBR 1:12.6 & 1:5.78 respectively.

Table 1: Efficacy of botanicals and the bio-agents on fruit borer, *Helicoverpa armigera* (Hubner) in tomato. (1st spray percent fruit infestation).

Treatments		% fruit Infestation			
		1DBS	7DAS	14DAS	Mean
T_1	Tobacco leaf Extract	15.99	14.96	15.93	15.44
		(23.57) *	(22.75) *	(23.52) *	(23.13) *
T_2	Neem seed kernel extract	16.78	14.27	15.00	14.63
		(24.18) *	(22.20) *	(22.78) *	(22.49) *
T_3	Karanj oil	16.90	15.12	16.61	15.86
		(24.27) *	(22.87) *	(24.05) *	(23.46) *
T_4	*Ha*NPV	14.59	12.84	13.36	13.10
		(22.45) *	(20.99) *	(21.43) *	(21.21) *
T_5	*Bacillus thuringiensis*	15.75	12.71	13.17	12.94
		(23.36) *	(20.87) *	(21.28) *	(21.07) *
T_6	*Beauveria bassiana*	16.16	14.40	15.61	15.00
		(23.68) *	(22.29) *	(23.26) *	(22.77) *
T_7	Spinosad 45% SC	15.11	10.88	11.01	10.94
		(22.85) *	(19.25) *	(19.37) *	(19.31) *
T_0	Control	15.91	20.94	23.33	22.13
		(23.50) *	(27.23) *	(28.88) *	(28.05) *
	F-test	NS	S	S	S
	S. Ed. (±)	0.97	0.65	0.59	0.62
	C. D. (P = 0.05)	2.08	1.40	1.28	1.34

*****Figures in parenthesis are Arc sin transformed values
DBS: Day before spray, DAS: Day after spray.

Table 2: Efficacy of botanicals and the bio-agents on fruit borer, *Helicoverpa armigera* (Hubner) in tomato. (2nd spray percent fruit infestation).

Treatments		% fruit Infestation		
		7DAS	14DAS	Mean
T_1	Tobacco leaf Extract	14.19	15.60	14.89
		(22.13) *	(23.25) *	(22.69) *
T_2	Neem seed kernel extract	13.70	14.34	14.02
		(21.72) *	(22.25) *	(21.98) *
T_3	Karanj oil	14.67	15.95	15.31
		(22.51) *	(23.53) *	(23.02) *
T_4	*Ha*-NPV	11.04	11.93	11.48
		(19.39) *	(20.20) *	(19.79) *
T_5	*Bacillus thuringiensis*	10.97	11.27	11.12
		(19.34) *	(19.61) *	(19.47) *
T_6	*Beauveria bassiana*	13.92	14.93	14.42
		(21.90) *	(22.73) *	(22.31) *
T_7	Spinosad 45% SC	8.55	8.60	8.57
		(17.00) *	(17.05) *	(17.02) *
T_0	Control	25.21	28.38	26.79
		(30.13) *	(32.18) *	(31.15) *
	F-test	S	S	S
	S. Ed. (±)	0.61	0.53	0.57
	C. D. (P = 0.05)	1.32	1.16	1.24

*****Figures in parenthesis are Arc sin transformed values
DAS: Days after spray

Table 3: Efficacy of botanicals and the bio-agents on fruit borer, *Helicoverpa armigera* (Hubner) in tomato. (1st spray & 2nd spray).

Treatments		% fruit Infestation		
		1st spray	2nd spray	Over all mean
T_1	Tobacco leaf Extract	15.44	14.89	15.16
		(23.13) *	(22.69) *	(22.91) *
T_2	Neem seed kernel extract	14.63	14.02	14.32
		(22.49) *	(21.98) *	(22.23) *
T_3	Karanj oil	15.86	15.31	15.58
		(23.46) *	(23.02) *	(23.24) *
T_4	*Ha*-NPV	13.10	11.48	12.29
		(21.21) *	(19.79) *	(20.50) *
T_5	*Bacillus thuringiensis*	12.94	11.12	12.03
		(21.07) *	(19.47) *	(20.27) *
T_6	*Beauveria bassiana*	15.00	14.42	14.71
		(22.77) *	(22.31) *	(22.54) *
T_7	Spinosad 45% SC	10.94	8.57	9.75
		(19.31) *	(17.02) *	(18.16) *

T_0	Control	22.13 (28.05) *	26.79 (31.15) *	24.46 (29.60) *
	F-test			S
	S. Ed. (±)	0.62	0.57	0.59
	C. D. (P = 0.05)	1.34	1.24	1.29

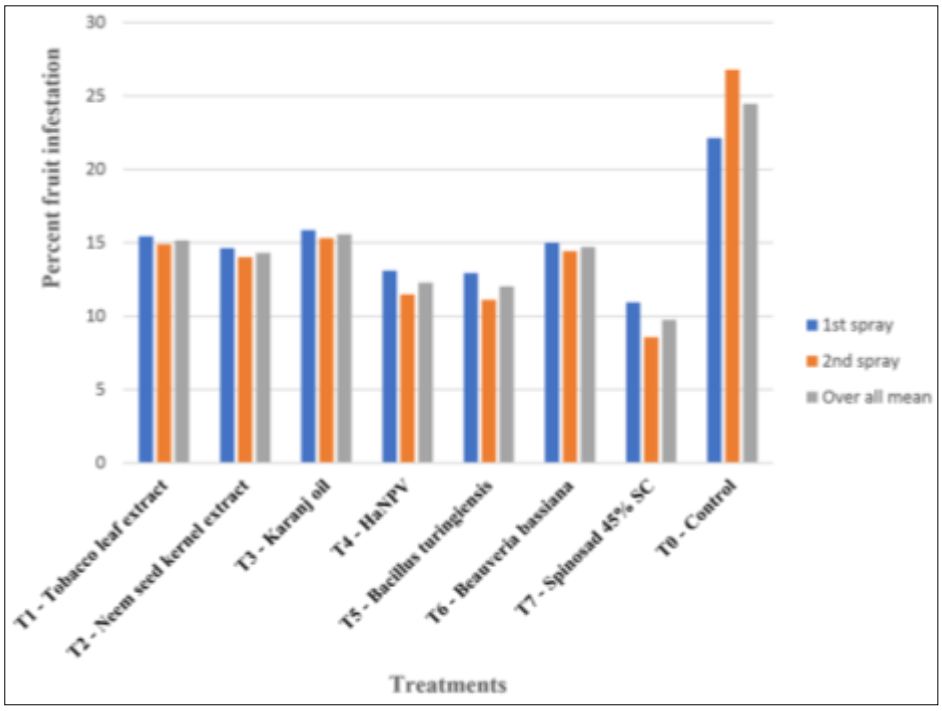

Fig 1: Graphical representation of percent fruit infestation (1st spray, 2nd spray & overall mean) of fruit borer (*Helicoverpa armigera*).

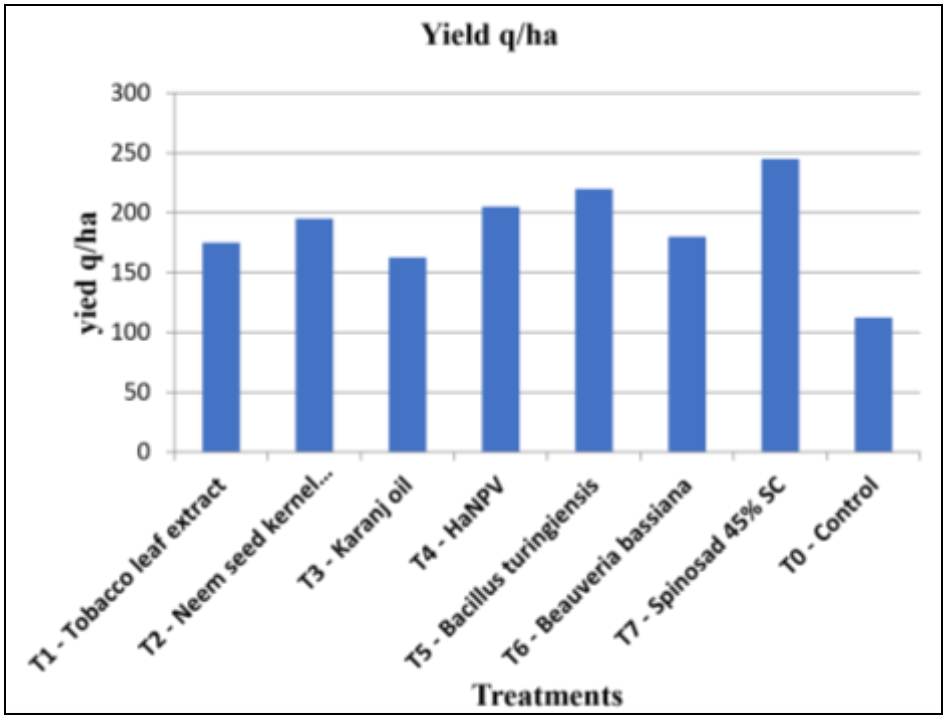

Fig 2: Effect of Treatments on yield.

4. Conclusion

The study concluded that Spinosad 45% SC found most effective and it shown the highest fruit yield also. While in Bio-agents, *B. thuringiensis* proved very effective followed by HaNPV and *Beauveraia bassiana*. But in Botanicals, Neem seed kernel extract proved very effective followed by Tobacco leaf extract and karanj oil least effective compare to rest of treatments. Botanicals are natural, eco-friendly pesticides are cheap, safer and affordable for small farmers compared to synthetic pesticides. Another advantage of Botanicals is that they are not very persistent. Indiscriminate use of chemical insecticides triggered the insect to develop resistance to insecticides. So, the bio-agents provide an alternative method to reduce the use of synthetic pesticides in integrated pest management in Sustainable agriculture.

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