Efficacy of biopesticides against leaf miner in tomato (*Solanum lycopersicum* L) var Solan Lalima under mid-hill conditions of Himachal Pradesh

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ABSTRACT

The present study was conducted at the Department of Seed Science and Technology of Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh to examine the effect of various biopesticides on leaf miner population in Solan Lalima variety of tomato (*Solanum lycopersicum* L) under the mid-hills of Himachal Pradesh during 2018-2019. Different combinations of biopesticides were employed in the study, including *Trichoderma viride*, neem cake, neem oil, cow urine, *Bacillus thuringiensis* and HaNPV, each used at different concentrations. The results of the study indicated that yield per ha, gross income per ha, net return per ha and B-C ratio were highest in the treatment comprising *T viride* 50 g + FYM 10 kg/plot + neem oil 5 ml/l (53,657.00 kg, Rs 1,073,140.00, Rs 710,790.00 and 1.96 respectively). Therefore, this treatment could be recommended for control of leaf miner in tomato var Solan Lalima in mid-hills of Himachal Pradesh.

Keywords: Leaf miner; tomato; biopesticides; yield; economics

INTRODUCTION

Tomato (*Solanum lycopersicum* L) is a valuable warm season vegetable crop that belongs to family Solanaceae. Originally from the Peru-Ecuador region, it has now become one of the most widely cultivated crops globally, occupying an area of 5.02 million hectares and producing 170.75 million tonnes annually (Anon 2017b). In Himachal Pradesh, tomato cultivation is widespread, covering an area of 11.064 thousand hectares with an annual production of 473.28 thousand tonnes and productivity of 44.78 tonnes per hectare (Anon 2017a). It is most important off-season crop in Himachal Pradesh.

Tomato is an important crop worldwide, providing nutrition and antioxidant properties to consumers. However, the use of synthetic pesticides has led to increased costs of cultivation and crop failures as well as health concerns due to residues on produce. According to the World Health Organization (WHO) approximately one to two million persons are affected every year because of pesticides (Palaniappan and Annadurai 2018). Biopesticides, such as neem-based biopesticides *Trichoderma*, *Phytopthora* and *Bacillus thuringiensis*, offer an effective and ecologically sound alternative for pest control.

These biopesticides are cheaper, safer and more affordable to small farmers, promoting sustainable development and quality food production. With the growing demand for health and environmental consciousness, biopesticides are a viable solution to improve the sustainability and profitability of tomato cultivation.

According to Illakwahhi and Srivastava (2019), foliar application of 2,500 ppm neem oil caused maximum mortality (61%) of leaf miner followed by 2,000 ppm (47%), 1,500 ppm (37%) and 1,000 ppm (28%) and least mortality (16%) was recorded in 500 ppm concentration. Barde and Shrivastava (2017) revealed that neem seed extract 10 per cent (10.93% leaf infestation) and neem oil 3 per cent (11.92% leaf infestation) treatments proved significantly superior to other treatments against leaf miner in tomato. Chavan

et al (2015) studied the effect of biopesticides against major pests of tomato and reported that spraying of 5 per cent neem seed kernel extract (NSKE) 2 kg per ha, neem oil 2.5 l per ha and azadirachtin 3,000 ppm 2.5 l per ha, 20 days after transplanting was most effective against leaf miner.

Haque et al (2012) concluded that in tomato, application of 50 per cent N fertilizer along with *Trichoderma*-enriched biofertilizers @ 5 g per plant augmented 203 per cent total yield over control along with maximum individual fruit weight (52 g) and highest fruit yield (1.67 kg) per plant. Wankhede et al (2007) conducted an experiment in tomato crop to check the efficacy of biopesticides against tomato leaf miner and concluded that 1 per cent neem oil gave the lowest leaf miner infestation (4.37%) at 14 days after second spray followed by 0.01 per cent spinosad and 5 per cent neem seed extract, which exhibited 4.60 and 5.07 per cent infestation respectively.

Krishnaraj et al (2018) reported that neem cake 100 kg/acre showed good results in both vegetative characters and also in the productivity of the crop. Oyinlola et al (2017) reported that the highest fruit yield of 14.54 and 19.70 tonnes per ha was obtained from 2 tonnes per ha neem seed cake + half fertilizer dose respectively in two years (2015-16) in tomato crop.

MATERIAL and METHODS

The experiment was laid down in 2018 to 2019 in the experimental farm of the Department of Seed Science and Technology, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh located at an altitude of 1,250 m amsl with latitude of 35.50^{o} N and longitude of 77.80^{o} E in the mid-hill zone of the state. Seedlings were transplanted at a spacing of 90 cm x 30 cm in plots having a size of 2.7 m x 1.2 m in a randomized block design comprising eleven treatments replicated thrice.

The experiment was initiated during the last week of May 2018. A total of three sprays of each treatment were administered at 30th, 45th and 60th day after seedling transplanting and observations were recorded after 3rd, 7th and 14th day of each spray. The different treatments used were: T_1: *Trichoderma viride* 50 g + FYM 10 kg/plot + neem oil 3 ml/l, T_2: *T viride* 50 g + FYM 10 kg/plot + *Bacillus thuringiensis* 2 g/l, T_3: *T viride* 50 g + FYM 10 kg/plot + *Ha*NPV (250LE) 1 ml/l, T_4: *T viride* 50 g + FYM 10 kg/plot + neem oil 5 ml/l, T_5: *T viride* 50 g + FYM 10 kg/plot + cow urine 50 ml/l, T_6: Neem cake 100 g + FYM 10 kg/plot + neem oil 3 ml/l, T_7: Neem cake 100 g + FYM 10 kg/plot + *B thuringiensis* 2 g/l, T_8: Neem cake 100 g + FYM 10 kg/plot + *Ha*NPV (250 LE) 1 ml/l, T_9: Neem cake 100 g + FYM 10 kg/plot + neem oil 5 ml/l, T_{10}: Neem cake 100 g + FYM 10 kg/plot + cow urine 50 ml/l and T_{11}: Control.

The observations were recorded on tomato plants for leaf miner population. The population of leaf miner (mines made by leaf miner) was recorded by counting six leaves ie 2 each from top, middle and bottom portion per canopy of five randomly tagged plants in each plot.

The number of healthy fruits from each picking of five randomly selected plants was counted and cumulative total after last picking was expressed as number of healthy fruits per plant. The fruit weight was calculated by weighing ten red ripe fruits of second harvest and their average was worked out. The total weight of all picked fruits during the season per plot gave the fruit yield per plot. The statistical analysis for randomized complete block design was done as per Gomez and Gomez (1984) using computer software OPSTAT.

RESULTS and DISCUSSION

The data given in Table 1 show that the treatments T_9 (Neem cake 100 g + FYM 10 kg/plot + neem oil 5 ml/l), T_6 (Neem cake 100 g + FYM 10 kg/plot + neem oil 3 ml/l), T_4 (*T viride* 50 g + FYM 10 kg/plot + neem oil 5 ml/l) and T_1 (*T viride* 50 g + FYM 10 kg/plot + neem oil 3 ml/l) recorded minimum leaf miner population of 2.51, 2.66, 2.90 and 3.12 per 6 leaves per plant respectively, which were at par, with 61.72, 59.41, 55.80 and 52.49 per cent less leaf miner population respectively than control.

The mean effect of time interval after spray revealed that 3 and 7 days after spray had lower leaf miner population (3.80 and 3.96/6 leaves/plant respectively), which were at par and the maximum population was recorded 14 days after spray (4.49).

Under the interaction effect, T_1, T_2 (*T viride* 50 g + FYM 10 kg/plot + *Bacillus thuringiensis* 2 g/

l), T_4, T_5, T_6 and T_9 after 3 days with 2.61, 3.32, 2.39, 2.43, 3.17 and 2.14 leaf miners per 6 leaves per plant respectively; T_1, T_2, T_4, T_6, T_7 (Neem cake 100 g + FYM 10 kg/plot + *B thuringiensis* 2 g/l) and T_9 after 7 days with 3.11, 3.04, 2.93, 2.76, 3.02 and 2.52 leaf miners per 6 leaves per plant respectively and T_6 and T_9 after 14 days of treatment with 2.80 and 2.87 leaf miners per 6 leaves per plant respectively resulted in lowest leaf miner population and all these treatments were at par with one another. These results are in conformity with the results of Illakwahhi and Srivastava (2019), Chavan et al (2015), Salem and Abdel-Moniem (2015) and Wankhede et al (2007).

The data given in Table 2 depict that fruit weigh per plantt was recorded maximum in treatments T_4 (79.43 g), T_1 (77.83 g) and T_9 (76.33 g) all being at par, which might be due to the action of *Trichoderma* and neem oil on leaf miner population. The minimum fruit weight per plant was recorded in T_{11} (Control) (69.33 g), T_8 [Neem cake 100 g + FYM 10 kg/plot + *Ha*NPV (250 LE) 1 ml/l], (71.19 g), T_3 [*T viride* 50 g + FYM 10 kg/plot + *Ha*NPV (250 LE) 1 ml/l] (72.00 g) and T_7 (72.03 g), which were at par.

Maximum fruit yield per plot was recorded in T_4 (221.73 kg) and T_1 (20.78 kg), which were at par and minimum in T_{11} (10.37 kg).

Data on economics of tomato cultivation using biopesticides depicted that yield per ha, gross income per ha, net return per ha and B-C ratio were highest in T_4 (53,657.00 kg, Rs 1,073,140.00, Rs 710,590.00 and 1.96 respectively) followed by T_1 (51,321.00 kg, Rs 1,026,420.00, Rs 655632.50 and 1.77 respectively) as compared to lowest in T_{11} (25,621.00 kg, Rs 512,420.00, Rs 241482.50 and 0.89 respectively) (Table 3).

CONCLUSION

Based on the results obtained, it is inferred that the treatment comprising *T viride* 50 g + FYM 10 kg/plot + neem oil 5 ml per l was the most effective that resulted in maximum yield per ha (53,657.00 kg), gross income per ha (Rs 1,073,140.00), net return per ha (Rs 710,590.00) and B-C ratio (1.96) as compared to other treatments. Thus this treatment could be recommended for leaf miner control in tomato in mid-hill conditions of Himachal Pradesh.

Table 1. Effect of different biopesticides on leaf miner population in tomato crop

Treatment	Leaf miner population (6 leaves/plant) days after spray				Reduction over control (%)
	3 (D_1)	7 (D_2)	14 (D_3)	Mean	
T_1	2.61 (1.90)	3.11 (2.03)	3.62 (2.15)	3.12 (2.03)	52.49
T_2	3.32 (2.08)	3.04 (2.01)	3.58 (2.14)	3.31 (2.08)	49.47
T_3	4.72 (2.39)	4.18 (2.27)	5.31 (2.51)	4.74 (2.39)	27.78
T_4	2.39 (1.84)	2.93 (1.98)	3.38 (2.09)	2.90 (1.97)	55.80
T_5	5.06 (2.46)	5.62 (2.57)	6.29 (2.70)	5.66 (2.58)	13.75
T_6	2.43 (1.85)	2.76 (1.94)	2.80 (1.95)	2.66 (1.91)	59.41
T_7	3.17 (2.04)	3.02 (2.01)	3.56 (2.13)	3.25 (2.06)	50.47
T_8	4.66 (2.38)	4.31 (2.30)	5.07 (2.46)	4.68 (2.38)	28.68
T_9	2.14 (1.77)	2.52 (1.88)	2.87 (1.96)	2.51 (1.87)	61.72
T_{10}	5.17 (2.48)	5.42 (2.53)	5.96 (2.63)	5.52 (2.55)	15.90
T_{11}	6.10 (2.66)	6.58 (2.75)	7.00 (2.83)	6.56 (2.75)	-
Mean	3.80 (2.17)	3.96 (2.21)	4.49 (2.32)		

Each value mean of 3 sprays; Figures in the parentheses represent square root transformation; T_1: *Trichoderma viride* 50 g + FYM 10 kg/plot + neem oil 3 ml/l, T_2: *T viride* 50 g + FYM 10 kg/plot + *Bacillus thuringiensis* 2 g/l, T_3: *T viride* 50 g + FYM 10 kg/plot + *Ha*NPV (250LE) 1 ml/l, T_4: *T viride* 50 g + FYM 10 kg/plot + neem oil 5 ml/l, T_5: *T viride* 50 g + FYM 10 kg/plot + cow urine 50 ml/l, T_6: Neem cake 100 g + FYM 10 kg/plot + neem oil 3 ml/l, T_7: Neem cake 100 g + FYM 10 kg/plot + *B thuringiensis* 2 g/l, T_8: Neem cake 100 g + FYM 10 kg/plot + *Ha*NPV (250 LE) 1 ml/l, T_9: Neem cake 100 g + FYM 10 kg/plot + neem oil 5 ml/l, T_{10}: Neem cake 100 g + FYM 10 kg/plot + cow urine @ 50 ml/l, T_{11}: Control

$CD_{0.05}$

Treatments (T):	0.18
Days (D):	0.10
Interaction (T × D):	0.31

Table 2. Effect of different biopesticides on fruit weight and fruit yield.

Treatment	Fruit weight/ plant (g)	Fruit yield (kg/plot)
T_1	77.83	20.78
T_2	73.87	16.25
T_3	72.00	17.11
T_4	79.43	21.73
T_5	74.77	15.49
T_6	75.22	17.09
T_7	72.03	15.90
T_8	71.19	16.74
T_9	76.33	18.26
T_{10}	74.00	14.57
T_{11}	69.33	10.37
$CD_{0.05}$	3.32	1.09

T_1: *Trichoderma viride* 50 g + FYM 10 kg/plot + neem oil 3 ml/l, T_2: *T viride* 50 g + FYM 10 kg/plot + *Bacillus thuringiensis* 2 g/l, T_3: *T viride* 50 g + FYM 10 kg/plot + *Ha*NPV (250LE) 1 ml/l, T_4: *T viride* 50 g + FYM 10 kg/plot + neem oil 5 ml/l, T_5: *T viride* 50 g + FYM 10 kg/plot + cow urine 50 ml/l, T_6: Neem cake 100 g + FYM 10 kg/plot + neem oil 3 ml/l, T_7: Neem cake 100 g + FYM 10 kg/plot + *B thuringiensis* 2 g/l, T_8: Neem cake 100 g + FYM 10 kg/plot + *Ha*NPV (250 LE) 1 ml/l, T_9: Neem cake 100 g + FYM 10 kg/plot + neem oil 5 ml/l, T_{10}: Neem cake 100 g + FYM 10 kg/plot + cow urine @ 50 ml/l, T_{11}: Control

Table 3. Economics of using different biopesticide treatments for tomato seed production

Treatment	Total cost of production/ha (Rs)	Yield (kg/ha)	Gross income / ha (Rs)	Net return/ ha (Rs)	B-C ratio
T_1	367,625.00	51,321.00	1,026,420.00	655,632.50	1.77
T_2	370,787.50	40,126.00	802,520.00	427,907.50	1.14
T_3	374,612.50	42,247.00	844,940.00	473,802.50	1.28
T_4	371,137.50	53,657.00	1,073,140.00	710,790.00	1.96
T_5	362,350.00	38,256.00	765,120.00	432,657.50	1.30
T_6	332,462.50	42,198.00	843,960.00	508,322.50	1.51
T_7	335,637.50	39,259.00	785,180.00	445,717.50	1.31
T_8	339,462.50	41,335.00	826,700.00	490,725.00	1.46
T_9	335,975.00	45,078.00	901,560.00	574,372.50	1.76
T_{10}	327,187.50	35,960.00	719,200.00	448,262.50	1.65
T_{11}	270,937.50	25,621.00	512,420.00	241,482.50	0.89

T_1: *Trichoderma viride* 50 g + FYM 10 kg/plot + neem oil 3 ml/l, T_2: *T viride* 50 g + FYM 10 kg/plot + *Bacillus thuringiensis* 2 g/l, T_3: *T viride* 50 g + FYM 10 kg/plot + *Ha*NPV (250LE) 1 ml/l, T_4: *T viride* 50 g + FYM 10 kg/plot + neem oil 5 ml/l, T_5: *T viride* 50 g + FYM 10 kg/plot + cow urine 50 ml/l, T_6: Neem cake 100 g + FYM 10 kg/plot + neem oil 3 ml/l, T_7: Neem cake 100 g + FYM 10 kg/plot + *B thuringiensis* 2 g/l, T_8: Neem cake 100 g + FYM 10 kg/plot + *Ha*NPV (250 LE) 1 ml/l, T_9: Neem cake 100 g + FYM 10 kg/plot + neem oil 5 ml/l, T_{10}: Neem cake 100 g + FYM 10 kg/plot + cow urine @ 50 ml/l, T_{11}: Control

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