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Efficacy of Insecticides against Major Insects of Tomato in Manipur

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted to evaluate the efficacy of some insecticides viz., Emamectin benzoate 5% SG (11 ga.i./ha), imidacloprid 17.8% SL (22.5 g a.i/ha), Neem oil (3 ml/l), *Beauveria bassiana* (0.2 ml/l), fipronil 5% SC (50 g a.i/ha) against major pests of tomato (*Lycopersicon esculentum* Mill.). There were six treatments arranged in randomized block design with four replications. Fruit borer, whiteflies, aphids and leaf miner were found to be the major insect pests of tomato. Among the insecticide used, imidacloprid 17.8% SL was found to be the most effective for management of sucking pest viz., Whiteflies, Aphids, Thrips, Mealybugs, Jassids while emamectin benzoate was found more effective on tomato fruit borer. *Beauveria bassiana* was found least effective against all the insect pests.

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1. INTRODUCTION

Tomato, *Lycopersicon esculentum* (Mill.) is cultivated widely both for fresh market and processing. It is said to be a native of tropical America. Tomato tops in the list of canned vegetables and are used to produce sauce, chutney, juice, ketchup, puree, paste and powder. It is a perennial in its native habitat, although often grown outdoors intemperate climates as an annual herb. In India, tomato crop is mainly grown in the states of Maharashtra, Andhra Pradesh, Orissa, West Bengal, Karnataka, Jharkhand, Gujarat, Tamil Nadu, Uttar Pradesh, Rajasthan *etc*. Being a major vegetable in India, tomato is cultivated in 789.15 thousand ha area in India with 19759.32 MT production and 25.03 tons per hectare productivity. Assam has the highest production of tomato in North East India which produces 396.24 MT with an area of 18.28 Ha. In Manipur, tomato is grown over anarea of 3.15 ha with a production of 33.72 MT [1].

Insect pest act as a limiting factor in harvesting high yields of healthy and quality of tomato fruits. However, this important crop is attacked by about 16 insects and other pest species which caused damage to tomato crop in India. The key insect pests of tomato include fruit borer (*Helicoverpa armigera*), cutworms (*Agrotis ipsilon*), aphids (*Myzus persicae*), thrips (*Ceratothripoides claratris*), white flies (*Bemisia tabaci*), leaf miners (*Liriomyza trifolii*), flea beetles (*Chalaenosoma metallicum*), leaf bug (*Nesidiocoris tenuis*), green bug (*Nezara biguttula*), mealy bug (*Pseudococcus cryptus*), spotted beetle, tomato hornworms, tobacco hornworms and Colorado potato beetles [2]. Among the various pests, the tomato fruit borer, *Helicoverpa armigera* Hub. (Lepidoptera: Noctuidae) is the most destructive due to its direct attack on fruits, high mobility, voracious feeding habit, high fecundity, multivoltine and overlapping generations. Several sucking pests cause appreciable damage to crop [3]. *Bemisia tabaci* alone can cause 10-90% damage depending upon the severity of the infestation and also transmits tomato yellow curl viruses [4]. The serpentine leaf miner, *Liriomyza trifolii* (Burgess) significantly reduced the yield and fruit quality by direct feeding [5].

Crop protection using chemicals is desirable and unavoidable part of integrated pest management [6]. The deployment of entomopathogenic fungi (EPF) for the control of crop pests is an important alternative to synthetic pesticides. *Beauveria bassiana* is known to be pathogenic to the South American tomato pinworm, *Tuta absoluta* (Meyrick) [7]. The lowest whitefly population (2.18 adults/leaf) was recorded in imidacloprid17.8 SC @ 0.005 % (2.8 ml/10 L of water) followed by 2.22 adults/leaf in dimethoate 30 EC @ 0.03 % (10 ml/10 L of water) and azadirachtin 3000 ppm at 3 ml/litre of water (5.69 adult/leaf) [8]. The idea of controlling insect pests by using various agro-techniques in combination with selective use of insecticides making compatible with other components of the management of tomato insect pests are gaining importance as the most effective measure. Hence, the study on the efficacy of insecticides against major insect pest of tomato was undertaken.

2. MATERIALS AND METHODS

A field experiment was conducted during February to June, 2021in a farm in Yurembam, Patsoi, Imphal West Manipur located at 24° 45' N latitude and 93° 56' E longitudes at an altitude of 790 m above Mean Sea Level (MSL) to study the efficacy of insecticides against major insect pest of tomato in Manipur. The climate was humid subtropical with mild and dry winter having an average rainfall ranging from 974-2646 mm annually. The mean temperature during summer was 17- 30°C and 4-25°C during winter with a relative humidity of 36-100. The soil is alluvial and acidic in nature. The experiment was laid out in Randomized Block Design (RBD) with 6 treatments each replicated thrice. Tomato variety Sultan was sown at spacing of 75 cm plant to plant and 45 cm row to row. All the 24 plots were given uniform intercultural operations during the entire growth period of study. Irrigation was given every day during the initial stage of the plant growth and afterward regularly at 3-5 days interval. 1st spray was given at 50% flowering stage and 2nd spraying at 15 days interval. Pre-treatment count was done one day before both first and second sprayings and post-treatment count was recorded at 3, 7, 10, and 14 days after spraying for both the sprayings to observe the efficacy of different insecticides.

3. RESULTS AND DISCUSSION

Efficacy of treated insecticides on the seven major insect pests observed on tomato is being discussed below.

Efficacy of insecticides against Aphids, *Aphis gossypii* The data obtained from the *Aphis gossypii* population are depicted in Table 1. Among the insecticides used, Imidacloprid 17.8% SL was found to be most effective against *Aphis gossypii* (70.67%). The findings are similar to Nderitu et al. [9] who recorded lowest aphid population in plot treated with imidacloprid (350 g L^{-1}) causing more than 95 per cent aphid population reduction and slightly higher yields. The findings are in close relation with Ghosal et al. [10] who reported that imidacloprid 17.8 SL @ 50 g a.i. ha^{-1} most effective against aphid showing least aphid infestation and 84.54 per cent reduction of population over control. In contrast to the present finding, Wade et al. [11] reported that that *Lecanicillium lecanii* were found to be most effective for aphid. The variation may be due to difference in climatic condition. Singh et al. [12] also found that neem and bakain were most effective treatments against aphids, *A. gossypii*.

Efficacy of insecticides against Whiteflies, *Bemisia tabaci* The highest per cent reduction (Table 2) of whitefly population was observed on 10 days post spray in both first and second sprays. Among the insecticides used, Imidacloprid 17.8% SL was found to be most effective (68.47%) against *Bemisia tabaci.* The per cent reduction of whitefly population (65.84% and 67.56% at first spray and second spray respectively) on 7 days post spray is supported by the studies done by Asif et al. [13] who reported that imidacloprid was highly effective with maximum reduction (63.24% at first spray and 66.77% at second spray) of whitefly population. Our findings are in agreement with Thorat et al. [14] who proved thatimidacloprid 17.8 SL was the most effective for suppressing the whitefly population in tomato crop under field condition. But Wade, et al. [11] found *Beauveria bassiana* to be most effective for whitefly which is contrary to the present findings.

Table 1. Effect of different pesticides against aphids, *Aphis gossypii* on tomato during February 2021 to June 2021

Treatments	First spray					Second spray					Mean
		Percent reduction					Percent reduction				
	Pre-treatment count	3 DAS	7 DAS	10 DAS	14 DAS	Pre-treatment count	3 DAS	7 DAS	10 DAS	14 DAS	
Emamectin benzoate 5% SG @ 11 g a.i./ha: (T_1)	2.50	52.65 (46.52)	60.12 (50.86)	67.74 (55.41)	64.75 (53.60)	1.70	52.78 (46.59)	60.97 (51.38)	68.33 (55.80)	65.00 (53.74)	61.54
Imidacloprid 17.8% SL@ 68g a.i. /ha:(T_2)	2.55	58.58 (49.95)	68.29 (55.76)	78.15 (62.20)	75.32 (60.24)	1.65	60.70 (51.20)	70.27 (57.08)	79.40 (63.17)	74.62 (59.87)	70.67
Neem oil @ 3ml//lt of water: (T_3)	2.43	48.33 (44.04)	56.44 (48.76)	62.69 (52.51)	58.52 (49.96)	1.40	48.21 (43.97)	56.70 (48.86)	62.65 (52.35)	60.86 (51.30)	56.80
Beauveria bassiana @ 0.2 ml/lt of water:(T_4)	2.85	38.86 (38.50)	46.98 (43.22)	54.17 (47.42)	50.46 (45.28)	1.85	37.55 (37.56)	45.69 (42.52)	56.19 (48.58)	52.23 (46.28)	47.77
Fipronil 5% SC @ 50 g/lt of water: (T_5)	2.70	50.76 (45.44)	57.42 (49.27)	63.87 (53.06)	60.23 (50.91)	2.05	51.14 (45.65)	58.84 (50.10)	65.47 (54.07)	63.20 (52.66)	58.87
Untreated control: (T_0)	2.10	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	3.10	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00
Sem±	0.15	1.55	1.97	1.94	1.89	0.16	1.65	1.37	1.47	1.46	-
CD (P=0.05)	NS	4.66	5.93	5.84	5.71	NS	4.97	4.13	4.43	4.40	-

Note: Figures in the table are mean values and those in parenthesis are angular transformed values.
NS: Non-significant at 5% level of significance

Table 2. Effect of different pesticides against whiteflies, *Bemisia tabaci* on tomato during February 2021 to June 2021

Treatments	First spray					Second spray					Mean
		Percent reduction					Percent reduction				
	Pre-treatment count	3 DAS	7 DAS	10 DAS	14 DAS	Pre-treatment count	3 DAS	7 DAS	10 DAS	14 DAS	
Emamectin benzoate 5% SG @ 11 g a.i./ha: (T_1)	2.80	52.20 46.26	58.53 49.94	65.80 54.26	60.20 50.90	1.80	55.59 48.21	61.49 51.94	68.65 56.32	65.83 54.48	61.04
Imidacloprid 17.8% SL@ 68g a.i. /ha: (T_2)	2.30	57.59 49.45	65.84 54.27	75.69 60.52	73.44 59.03	1.70	58.31 49.81	67.56 55.31	76.05 60.75	73.24 58.89	68.47
Neem oil @ 3ml//lt of water: (T_3)	2.55	48.58 44.14	54.67 47.69	60.46 51.10	57.42 49.32	1.85	48.21 43.97	55.89 49.77	62.58 52.30	58.75 50.19	55.82
Beauveria bassiana @ 0.2 ml/lt of water: (T_4)	2.70	36.21 36.99	39.33 38.82	46.48 42.98	40.55 39.54	2.00	37.34 37.66	40.10 39.21	48.05 43.78	42.37 40.52	41.30
Fipronil 5% SC @ 50 g/lt of water: (T_5)	2.65	50.65 45.37	56.57 48.78	62.97 52.53	60.40 51.01	1.80	50.42 45.24	56.25 48.62	64.17 53.27	60.83 51.27	57.78
Untreated control: (T_0)	2.60	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.75	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00
Sem±	0.26	1.80	1.35	1.33	1.53	0.23	1.11	1.49	1.95	1.34	-
CD (P=0.05)	NS	5.43	4.06	4.00	4.63	NS	3.34	4.49	5.88	4.03	-

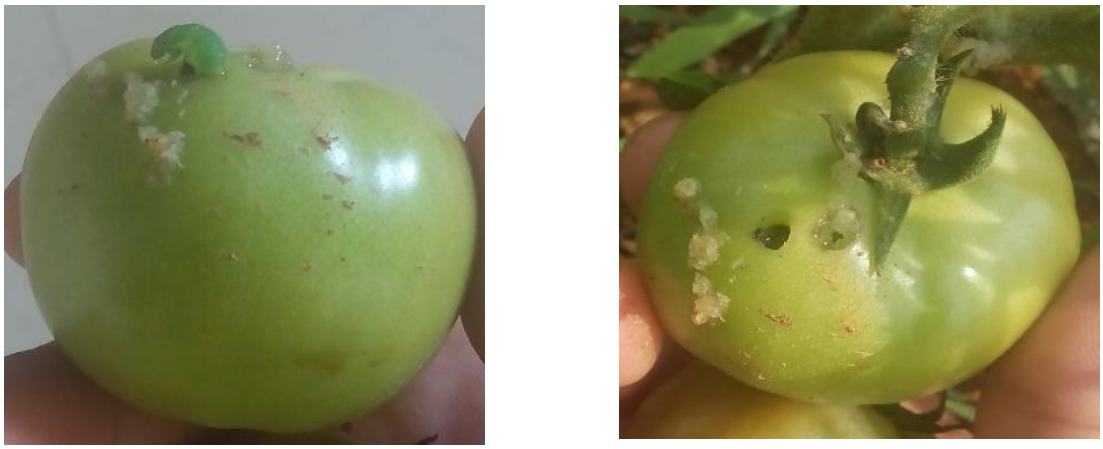
Note: Figures in the table are mean values and those in parenthesis are angular transformed values.
NS: Non-significant at 5% level of significance

Efficacy of insecticides against Thrips, *Scirthothrips dorsalis* among the insecticides used (Table 3), Imidacloprid 17.8% SL was found to be most effective (67.47%) against *Scirthothrips dorsalis.* The per cent reduction of thrips population (66.15% and at first spray and 66.47% at second spray) respectively on 7 days post spray is supported by the studies done by Asif et al. [13] who reported that imidacloprid was highly effective with maximum reduction (68.51% at first spray and 70.35% at second spray) of thrips population. Bambhaniya et al. [15] reported that imidacloprid 0.005 per cent gave very good results against aphid which is in agreement with the present findings. In contrast to this, Singh et al. [12] found that neem and bakain were most effective treatments against aphids, *A. gossypii* and thrips, *Scirtothrips dorsalis.*

Efficacy of insecticides against Mealy bugs, *Phenacoccus solenopsis* The highest per cent reduction of mealy bug's population (Table 4) was found on 10 days post spray in both first and second sprays. Among the insecticides used, Imidacloprid 17.8% SL was found to be most effective at first (74.92%) and second spray (76.36%) against *Phenacoccus solenopsis.* It was followed by Emamectin benzoate 5% SG, Fipronil 5% SC and Neem oil. The mean reduction of the pest by Neem oil and Fipronil 5 % were at par with each other. *Beauveria bassiana* was found to be least effective against this pest. These results were in conformity with El-Mageed et al. [16] who reported that Imidacloprid reduced *Phenacoccus solenopsis* population up to 77.82 per cent on cotton.

Efficacy of insecticides against Jassids, *Amrasca biguttula biguttula* among the insecticides used (Table 5), the mean reduction was found to be highest in Imidacloprid 17.8% SL treated plots (67.32%) against *Amrasca biguttula biguttula*. It was followed by Emamectin benzoate 5% SG, Fipronil 5% SC and Neem oil. However, Ghosaland Chatterjee [17] reported that highest percent reduction of jassid by

Imidacloprid 17.8% SL was 84.72 per cent. This discrepancy between the two results might be because of the different degree of effectiveness of the pesticides on two dissimilar crops. The per cent reduction of jassid population (65.66% and 66.49% at first spray and second spray respectively) on 7 days post spray is supported by the studies done by Asif et al. [13] who reported that imidacloprid was highly effective with maximum reduction (66.66% at first spray and 63.49% at second spray) of jassid population.



A B

Fig. 1A & B. Helicoverpa armigera infestation at fruiting stage

Table 3. Effect of different pesticides against thrips, *Scirthothrips dorsalis* on tomato during February 2021 to June 2021

Treatments	First spray					Second spray					Mean
		Percent reduction					Percent reduction				
	Pre-treatment count	3 DAS	7 DAS	10 DAS	14 DAS	Pre-treatment count	3 DAS	7 DAS	10 DAS	14 DAS	
Emamectin benzoate 5% SG @ 11 g a.i./ha: (T_1)	2.05	52.18 46.25	57.56 49.37	66.48 54.62	62.44 52.22	2.00	52.07 46.20	58.70 50.07	67.10 55.02	63.40 52.95	59.99
Imidacloprid 17.8% SL@ 68g a.i. /ha: (T_2)	2.35	56.79 48.93	66.15 54.43	75.32 60.24	70.02 56.85	2.10	55.81 48.35	66.47 54.65	76.18 60.85	72.98 58.72	67.47
Neem oil @ 3ml//lt of water: (T_3)	2.20	48.52 44.15	55.30 48.05	62.44 52.22	57.83 49.51	1.70	49.35 44.63	55.82 48.36	64.12 53.21	58.75 50.04	56.52
Beauveria bassiana @ 0.2 ml/lt of water: (T_4)	2.65	35.86 36.75	38.58 38.38	47.51 43.56	40.42 39.45	1.75	35.73 36.70	40.78 39.67	47.96 43.83	42.34 40.58	41.15
Fipronil 5% SC @ 50 g/lt of water: (T_5)	2.20	50.44 45.25	56.69 48.85	62.09 52.02	60.61 51.13	1.65	52.92 46.68	57.54 49.36	62.90 52.48	60.11 50.84	57.91
Untreated control: (T_0)	2.00	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.90	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00
Sem±	0.22	1.38	1.00	1.15	1.20	0.28	1.28	1.29	1.12	1.44	-
CD (P=0.05)	NS	4.16	3.01	3.47	3.60	NS	3.87	3.89	3.37	4.33	-

Note: Figures in the table are mean values and those in parenthesis are angular transformed values.
NS: Non-significant at 5% level of significance.

Table 4. Effect of different pesticides against mealy bug, *Phenacoccus solenopsis* on tomato during February 2021 to June 2021

Treatments	First spray					Second spray					Mean
		Percent reduction					Percent reduction				
	Pre-treatment count	3 DAS	7 DAS	10 DAS	14 DAS	Pre-treatment count	3 DAS	7 DAS	10 DAS	14 DAS	
Emamectin benzoate 5% SG @ 11 g a.i./ha: (T_1)	1.85	52.52 46.45	56.79 48.93	65.75 54.20	60.70 51.18	1.90	52.41 46.38	57.63 49.41	66.44 54.61	59.72 50.61	59.00
Imidacloprid 17.8% SL@ 68g a.i. /ha: (T_2)	1.65	55.49 48.15	65.24 53.88	74.92 60.03	70.62 57.20	1.60	55.52 48.17	67.11 55.02	76.36 60.98	72.63 58.46	67.24
Neem oil @ 3ml//lt of water: (T_3)	1.85	47.52 43.57	55.16 48.00	62.20 52.09	58.73 50.06	1.65	48.26 43.99	54.67 47.69	62.40 52.21	57.80 49.50	55.84
Beauveria bassiana @ 0.2 ml/lt of water: (T_4)	1.80	38.82 38.54	47.36 43.49	56.67 48.84	50.69 45.40	1.95	37.68 37.86	48.32 44.04	57.78 49.50	50.36 45.20	48.46
Fipronil 5% SC @ 50 g/lt of water: (T_5)	1.65	50.50 45.28	55.67 48.27	62.92 52.50	57.46 49.29	1.75	50.10 45.05	56.77 48.93	62.62 52.34	58.55 49.97	56.82
Untreated control: (T_0)	1.65	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.45	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00
Sem±	0.23	1.18	1.41	1.25	1.38	0.19	1.18	1.57	1.21	1.11	-
CD (P=0.05)	NS	3.55	4.26	3.75	4.17	NS	3.56	4.72	3.66	3.36	-

Note: Figures in the table are mean values and those in parenthesis are angular transformed values.
NS: Non-significant at 5% level of significance

Table 5. Effect of different pesticides againstjassids, *Amrasca biguttula biguttula* on tomato during February 2021 to June 2021

Treatments	First spray					Second spray					Mean
		Percent reduction					Percent reduction				
	Pre-treatment count	3 DAS	7 DAS	10 DAS	14 DAS	Pre-treatment count	3 DAS	7 DAS	10 DAS	14 DAS	
Emamectin benzoate 5% SG @ 11 g a.i./ha: (T_1)	1.23	52.50 46.44	57.71 49.45	65.83 54.26	61.88 51.89	1.30	52.64 46.51	58.06 49.14	67.50 55.25	62.92 52.51	59.88
Imidacloprid 17.8% SL@ 68g a.i. /ha: (T_2)	1.55	56.40 48.69	65.66 54.17	75.93 60.66	70.50 57.15	1.25	55.41 48.12	66.49 54.70	75.34 60.27	72.86 58.62	67.32
Neem oil @ 3ml//lt of water: (T_3)	1.90	47.47 43.54	56.70 48.85	60.71 51.21	54.91 47.82	1.40	47.92 43.80	54.43 47.54	60.42 51.04	56.25 48.60	54.85
Beauveria bassiana @ 0.2 ml/lt of water: (T_4)	1.60	42.65 40.77	47.17 43.38	53.07 46.76	50.24 45.14	1.20	44.87 42.05	48.44 44.10	55.65 48.25	52.68 46.54	49.35
Fipronil 5% SC @ 50 g/lt of water: (T_5)	1.25	50.89 45.51	57.46 49.29	62.17 52.05	60.80 51.24	1.40	52.64 46.51	58.54 49.93	64.69 53.57	60.63 51.16	58.48
Untreated control: (T_0)	1.60	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.00	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00
Sem±	0.31	1.25	1.34	1.23	1.10	0.17	1.19	1.29	1.24	1.22	-
CD (P=0.05)	NS	3.76	4.03	3.70	3.31	NS	3.58	3.88	3.75	3.68	-

Note: Figures in the table are mean values and those in parenthesis are angular transformed values
NS: Non-significant at 5% level of significance

Efficacy of insecticides against Leaf miners, *Liriomyza bryoniae* Among the insecticides used (Table 6) against leaf miner, *Liriomyza bryoniae,* Imidacloprid 17.8% SL was found to be most effective (65.17%) against *Liriomyza bryoniae.* The per cent reduction at second spray were; Imidacloprid 17.8% SL (65.24). Hence, the mean reduction of the pest population was highest for Imidacloprid 17.8% SL (58.64%) and the lowest was for *Beauveria bassiana* (43.49%). Our findings are in contrast with Abdelgaleil et al. [18] who reported that Imidacloprid was least effective with infestation reductions of 9.3 per cent against tomato leaf miner, *Tuta absoluta.* Sapkal et al. [19] also reported that chlorantraniliprole 18.5 % SC was found to be most effective against tomato leaf miner, *Tuta absoluta* (meyrick) and Tokhy et al. [20]. found that the Chlorantraniliprole insecticide alone and their mixture (Chlorantraniliprole + Fipronil and Chlorantraniliprole + Indoxacarb) were highly effective in relation to tomato leaf miner larva reduction which is also contrary to our present findings.

Efficacy of insecticides against Fruit borers, *Helicoverpa armigera* As the fruit borer was not present before the fruiting stage, there was no per cent reduction of the insect in the first spray. In second spray, highest per cent reduction was found on 10 days post spray. Among the insecticides (Table 7) used, emamectin benzoate 5% SG was found to be most effective (62.92%) against *Helicoverpa armigera.* This is in accordance with the findings of El-Fakhouret al. [21] who reported that under field conditions, emamectin benzoate was found to be highly effective in reducing the *H. armigera* larval population, pod damage and significantly increased grain yields by 25.8 per cent compared to the untreated plots. Das and Khatum [22] and Wade et al. [11]

Table 6. Effect of different pesticides against leaf miner, *Liriomyza bryoniae* on tomato during February 2021 to June 2021

Treatments	First spray					Second spray					Mean
		Percent reduction					Percent reduction				
	Pre-treatment count	3 DAS	7 DAS	10 DAS	14 DAS	Pre-treatment count	3 DAS	7 DAS	10 DAS	14 DAS	
Emamectin benzoate 5% SG @ 11 g a.i./ha: (T_1)	2.75	44.49 41.83	48.44 44.10	56.54 48.77	52.83 46.63	1.45	44.97 42.11	48.61 44.20	57.12 49.09	53.47 47.00	50.81
Imidacloprid 17.8% SL@ 68g a.i. /ha: (T_2)	2.45	50.30 45.17	58.23 49.75	65.17 53.83	62.39 52.19	1.65	50.49 45.28	57.18 49.15	65.24 53.88	60.11 50.84	58.6 4
Neem oil @ 3ml//lt of water: (T_3)	2.35	40.22 39.35	45.52 42.42	52.39 46.37	47.30 43.45	1.50	41.85 40.31	49.76 44.86	54.58 47.64	48.21 43.97	47.48
Beauveria bassiana @ 0.2 ml/lt of water: (T_4)	2.35	35.64 36.61	42.49 40.68	50.51 45.29	44.28 41.71	1.30	36.61 37.18	42.52 40.69	52.46 46.41	43.42 41.20	43.49
Fipronil 5% SC @ 50 g/lt of water: (T_5)	2.00	42.64 40.76	47.22 43.41	55.28 48.04	50.00 45.00	1.75	42.78 40.84	48.61 44.20	55.28 48.05	50.56 45.32	49.05
Untreated control: (T_0)	2.75	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.85	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00
Sem±	0.22	1.11	1.22	1.38	1.26	0.16	1.19	1.43	1.21	1.15	-
CD (P=0.05)	NS	3.35	3.69	4.16	3.81	NS	3.58	4.32	3.65	3.45	-

Note: Figures in the table are mean values and those in parenthesis are angular transformed values
NS: Non-significant at 5% level of significance

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Table 7. Effect of different pesticides against fruit borers, *Helicoverpa armigera* on tomato during February 2021 to June 2021

Treatments	First spray					Second spray					Mean
		Percent reduction					Percent reduction				
	Pre-treatment count	3 DAS	7 DAS	10 DAS	14 DAS	Pre-treatment count	3 DAS	7 DAS	10 DAS	14 DAS	
Emamectin benzoate 5% SG @ 11 g a.i./ha: (T_1)	0.00	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.25	50.00 45.00	55.65 48.25	62.92 52.52	60.24 50.98	57.20
Imidacloprid 17.8% SL@ 68g a.i. /ha: (T_2)	0.00	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.35	48.75 44.28	55.72 48.29	60.49 51.06	56.97 49.01	55.48
Neem oil @ 3ml//lt of water: (T_3)	0.00	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.45	44.44 41.77	50.69 45.40	55.56 48.23	52.43 46.39	50.78
Beauveria bassiana @ 0.2 ml/lt of water: (T_4)	0.00	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.50	40.97 39.77	44.10 41.61	48.26 44.00	42.01 40.37	43.84
Fipronil 5% SC @ 50 g/lt of water: (T_5)	0.00	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.50	46.53 43.00	52.78 46.60	58.68 50.01	55.21 48.00	53.30
Untreated control: (T_0)	0.00	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.65	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00
Sem±	-	-	-	-	-	0.16	1.34	1.21	1.46	1.72	-
CD (P=0.05)	-	-	-	-	-	NS	4.04	3.66	4.39	5.19	-

Note: Fig. in the Table are mean values and those in parenthesis are angular transformed values.
NS: Non-significant at 5% level of significance

also found that Suspend 5SG (Emamectin Benzoate) @ 1.0 was found to be the most effective against tomato fruit borer. But, in contrast to the present findings, Kumar et al. [23] observed that Indoxacarb 14.5SC @ 1.0 ml lit-1 was found to be very effective against *Helicoverpa armigera* followed by Fipronil 5SC @ 1.0 ml lit-1 in reducing the larval population and Kachave et al. [24] also observed the minimum mean larval population of *H. armigera* was observed in Flubendiamide 20WG @ 100 g/ha (0.54 larva/plant).

4. CONCLUSIONS

Tomato is attacked by several insect pests in all the stages from vegetative till harvesting which needs serious attention of researchers. Out of seven insect pests found, fruit borer, *Helicoverpa armigera* Hubner (Lepidoptera: Noctuidae), whitefly, *Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae), aphid, *Aphis gossypii* Glover (Homoptera: Aphididae) and leaf miner, *Liriomyza bryoniae* Kaltenbach (Diptera: Agromyzidae) were found to be major insect pests. Among the insecticides used, Imidacloprid 17.8% SL was most effective against aphid, whitefly, leaf miner, and thrips. Emamectin benzoate 5% SG was found to be most effective against *Helicoverpa armigera.* From this experiment, it is evident that new insecticides are effective in minimizing the population of different pests of tomato. It is suggested that further investigation should be carried out to study the reduced efficacy of certain insecticides so as to know the concrete results on their efficacy.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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