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PS Wade
Department of Agril. Entomology, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. Dist. Ratnagiri, Maharashtra, India

Dr. SM Wankhede
Jr. Entomologist, Regional Coconut Research Station, Bhatye, Maharashtra, India

SS Rahate
Department of Agril. Entomology, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. Dist. Ratnagiri, Maharashtra, India

Corresponding Author:
PS Wade
Department of Agril. Entomology, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. Dist. Ratnagiri, Maharashtra, India

Efficacy of different pesticides against major pests infesting tomato (*Solanum lycopersicum* L.)

PS Wade, SM Wankhede and SS Rahate

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Abstract
In order to examine the efficacy of different pesticides against major insects of tomato, a field study was determined at the Central Experimental Station, Wakawali, during *rabi*, 2018-2019. Four important pests were found infesting tomato including whitefly, aphid, leaf miner and fruit borer. The results revealed that *Beauveria bassiana* @ 5 ml lit^{-1} was the best treatment which was recorded minimum (3.28) mean whitefly population per three leaves followed by Azadirachtin 1% EC @ 0.002 per cent which recorded (3.32). For aphid, treatment *Lecanicillium lecanii* @ 5ml lit^{-1} was the best treatment which was recorded minimum (1.47) mean population per three leaves followed by *Beauveria bassiana* @ 5ml lit^{-1} which recorded (1.67) aphids per three leaves. Emamectin benzoate 05 SG @ 0.002 per cent was found most effective treatment for leaf miner and fruit borer which recorded lowest per cent leaf miner infestation (11.71%) and 13.10 per cent and 11.81 per cent on number and weight basis, respectively. Also Azadirachtin 1% EC @ 0.002 per cent was noticed effective against fruit borer damage which recorded 15.40 per cent on number and 13.86 per cent on weight basis.

Keywords: Tomato, pesticides, treatment, whitefly, aphid, leaf miner, fruit borer

Introduction

Tomato (*Lycopersicum esculentum* L.) is the world's largest cultivated vegetable crop occupying an outstanding place among the important vegetables of the world. Tomato is the third largest vegetable crop after potato and sweet potato in the world, but it tops the list of canned vegetables. It is an important condiment in most diets and a very cheap source of vitamins, like A, C, E, fibers and minerals (Olaniyi, 2010) [17]. Insect pest act as a limiting factor in harvesting high yields of healthy and quality tomato fruits. Because of its fleshy nature about sixteen insects and other pests species cause damage to the tomato crop in India resulting in use of large volume of pesticides which leave their toxic residues (Bhutani, 1977) [2]. Tomato consumption has been associated with decreased risk of breast cancer (Zhang *et al*., 2009) [26], head and neck cancers (Freedman *et al*., 2008) [6] and might be beneficial for reducing cardiovascular risk associated with type 2 diabetes (Shidfar *et al*., 2011) [23]. Tomato is cultivated in 789.15 thousand hectares area in India with 19759.32 metric tons production and 25.03 tons per hectare productivity. In Maharashtra, tomato is grown over an area of 45,500 hectares with a production of 1086.56 metric tons and productivity is 23.88 tons per hectare during 2017-18 (Anonymous, 2018). Productivity of tomato is low due to several reasons; the main being the damage caused by insect pests and diseases. Tomato is more prone to insect pests and diseases mainly due to its tenderness and softness as compared to other crops. It is devastated by an array of pests like jassids, aphids, tobacco caterpillar, leaf miner, flea beetles, spider mites and fruit borer (Katroju *et al*., 2014) [13]. The tomato aphid, are devastating insect pests of tomato in different districts of Punjab which are close to Sindh province (Aslam and Razaq, 2007) [1]. *Bemisia tabaci* alone can cause 10–90% damage depending upon the severity of the infestation and also transmits tomato yellow curl viruses (Rataul *et al*., 1989) [20]. Both adult and immature stages of this insect cause direct damage through sucking the plant sap (Brown *et al*., 1995) [3] and causes insurmountable losses to tomato plants (Gerling, 1986) [7]. Among these insect pests, the loss incurred *Liriomyza trifolii* (Burgess) has become most important in recent years (Lange and Bronson, 1981) [14]. The serpentine leaf miner was accidentally introduced to India along with chrysanthemum cuttings, whose infestation is increasing every year at an alarming rate (Medeiros *et al*., 2005) [15]. This pest significantly reduced the yield and fruit quality by direct feeding (Rai *et al*., 2013) [19]. *Helicoverpa armigera* Hubner is a polyphagous pest with host range of over 360 plant species including cultivated crops of economic importance (Duraimurugan and Regupathy, 2005) [5]. It alone causes the loss in tomato yield to the tune of 50 to 80 per cent (Tewari and

Krishnamoorthy, 1984) [25]. Tomato fruit borer damage can also be responsible for decreasing the seed viability compared to undamaged fruit (Karabhantanal *et al*., 2010) [12]. Larvae can be found only by opening the infested fruit (Shah *et al*., 2013) [21]. Present day pest management emphasizes on a holistic approach that cares for the plant, pest, beneficial organisms as well as the environment. Hence, the rationale should emphasize on the principle of "live and let live". It allows sustainability and stability to the entire crop ecosystem and eventually ensures good yields. Keeping this in view, the present investigation was undertaken to evaluate the efficacy of different pesticides against major pests infesting tomato.

Materials and methods

Field trial was conducted during the *rabi* season of 2018-19 at Vegetable Improvement Scheme, Central Experimental Station, Wakawali, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. The experiment was laid out in Randomized Block Design (RBD) with eight treatments *viz*., T_1 *Beauveria bassiana* @ 5 ml lit^{-1} of water, T_2 *Metarhizium anisopliae* @ 5 ml lit^{-1} of water, T_3 *Lecanicillium lecanii* @ 5 ml lit^{-1} of water, T_4 *Pongamia pinnata* 2% EC @ 2 ml lit^{-1} of water, T_5 *Bacillus thuringiensis* var. *kurstaki* @ 1.5 ml lit^{-1} of water, T_6 Azadirachtin 1% EC @ 3 ml lit^{-1} of water, T_7 Emamectin benzoate 5% SG @ 0.4 gm lit^{-1} of water and T_8 untreated control, replicated thrice in 4.80 x 1.20 m^2 plot size with a spacing of 60 x 60 cm. The tomato (cv. Sonali) was raised as per the recommended package of practices. The first spray was initiated when infestation noticed in the field and second and third sprays were given at an interval of 15 days. The observations were recorded on five randomly selected and tagged plants in each treatment, a day before application of insecticides as pre-treatment observations and post-treatment observations at 3rd, 7th, 10th and 14th days after each spray for whitefly, aphid and leaf miner infestation. Fruit borer damage was recorded one day before of each spray and subsequently post-treatment observations were recorded at each picking. Following different pesticides were tested for evaluation for the management of major pests infesting tomato.

Results and Discussion

The result of effectiveness of different pesticidal treatments against major pests of tomato showed that all the treatments were significantly superior over control in terms of reductions of pest populations.

Whitefly (*Bemisia tabaci* Genn.)

The average data of three sprays (table 1) on mean population of whitefly per three leaves per plant revealed that the treatment *Beauveria bassiana* @ 5ml lit^{-1} was the best treatment which was recorded minimum (3.28) whitefly population per three leaves and was at par with Azadirachtin 1% EC @ 0.002 per cent which recorded (3.32) and *Lecanicillium lecanii* @ 5ml lit^{-1} recorded (3.43) whiteflies per three leaves. The *Metarhizium anisopliae* @ 5ml lit^{-1} recorded (3.82) whiteflies per three leaves and was at par with treatment *Pongamia pinnata* 2 EC @ 0.1 per cent which recorded (4.10) whiteflies per three leaves. The other treatment like Emamectin benzoate 05 SG @ 0.002 per cent which recorded (4.22) and *Bacillus thuringiensis* @ 1.5ml lit^{-1} recorded (4.34) whiteflies per three leaves. All the above treatments were found to be superior over untreated control which recorded highest whitefly population (6.42 per three leaves). The present results corroborates with the findings of Javed *et al.* (2019) [10] studied two entomopathogenic fungi, *Beauveria bassiana* and *Verticillium lecanii* against whitefly and observed the mortality caused by *B. bassiana* was significantly higher than that of *V. lecanii*. Sharma *et al.* (2015) [22] showed that biopesticides *viz*. Bio Magic (92.67%), Racer (91.90%), Pacer (91.50%), Mealikil (90.84%) were highly effective following Bio Power (87.53%) and Biocide Manic (85.8%) in reducing the population of whitefly over control after third spray. *Metarhizium anisopliae* were found effective in reducing the pest population.

Aphid (*Aphis gossypii* Glover)

The results (table 1) regarding overall mean of three sprays against aphids infesting tomato revealed that the *Lecanicillium lecanii* @ 5ml lit^{-1} treatment was the best which was recorded minimum (1.47) mean population per three leaves and was at par with treatment *Beauveria bassiana* @ 5ml lit^{-1} which recorded (1.67) and Azadirachtin 1 EC @ 0.002 per cent which recorded (1.76) aphids per three leaves. The treatment *Metarhizium anisopliae* @ 5 ml lit^{-1} recorded (1.81) mean aphids population per three leaves and was at par with treatment *Pongamia pinnata* 2 EC @ 0.1 per cent which recorded (2.00), Emamectin benzoate 05 SG @ 0.002 per cent which recorded (2.06) and *Bacillus thuringiensis* @ 1.5ml lit^{-1} which recorded (2.10) aphids per three leaves. All the above treatments were found to be superior over untreated control which recorded highest pest population (3.46 per three leaves). The results of the present studies are in conformity with the findings of Janghel *et al.* (2015) [9] who evaluated different biopesticides for control of aphid, the most effective being *V. lecanii* which recorded 1.86 and 2.06 aphids/plant and 82.16 and 82.92 per cent reduction of aphid population. Chavan *et al*. (2008) [4] summarised that liquid formulation of *V. lecanii* showed significantly higher efficacy in controlling aphids irrespective of dosage and registered up to 96.70 per cent kill of the pest.

Leaf miner (*Liriomyza trifolii* Burgess)

The results regarding overall mean of three sprays against per cent leaf miner infestation showed that Emamectin benzoate 05 SG @ 0.002 per cent was found most effective treatment against serpentine leaf miner, *Liriomyza trifolii* Burgess, as it was recorded lowest per cent leaf miner infestation (11.71%) and was at par with Azadirachtin 1 EC @ 0.002 per cent which recorded (13.18%) infestation of leaf miner followed by *Metarhizium anisopliae* @ 5ml lit^{-1} (22.87%), *Beauveria bassiana* @ 5ml lit^{-1} (25.56%), *Bacillus thuringiensis* @ 1.5ml lit^{-1} (25.73%), *Pongamia pinnata* 2 EC @ 0.1 per cent which recorded (27.02%). *Lecanicillium lecanii* @ 5ml lit^{-1} was found to be the least effective treatment; as it was recorded maximum leaf miner infestation (28.07%). All the treatments registered significantly lower leaf infestation than untreated control (35.80%) (table 1). These findings are in agreement with the findings of Gosalwad *et al.* (2015) [8] who revealed that emamectin benzoate 5 SG @ 9.5 g a.i. ha^{-1} showed maximum efficacy against leaf miner. Tarate *et al.* (2016) [24] revealed that the insecticide application at 25, 45 and 65 days after transplanting showed that efficacy of emamectin benzoate 5 SG @ 9.5 g a.i ha^{-1} was most effective against tomato leaf miner, *Liriomyza trifolii* Burgess.

Fruit borer (*Helicoverpa armigera* Hubner)

The data (table 1) on mean per cent infestation of fruit borer of six pickings revealed that all the treatments were found significantly effective on number and weight basis as compared to untreated control (37.94% and 35.26%, respectively). Among the different treatments, effect on fruit borer infestation on number and weight basis were lowest in Emamectin benzoate 05 SG @ 0.002 per cent treated plot (13.10% number and 11.81% on weight basis) which was at par with Azadirachtin 1 EC @ 0.002 per cent treated plot (15.40% number and 13.86% on weight basis) which was way more superior than the rest of the treatments followed by *Bacillus thuringiensis* @ 1.5ml lit^{-1} (17.74% number and 15.86% on weight basis), *Beauveria bassiana* @ 5ml lit^{-1} (22.67% number and 20.75% on weight basis), *Metarhizium anisopliae* @ 5ml lit^{-1} (25.36% number and 23.18% on weight basis), *Lecanicillium lecanii* @ 5ml lit^{-1} (29.67% number and 27.18% on weight basis) and *Pongamia pinnata* 2 EC @ 0.1 per cent (30.27% number and 27.85% on weight basis). The present results corroborates with the findings of Murugaraj *et al*. (2006) [16] reported that emamectin benzoate was highly effective with 91.46 per cent reduction in fruit infestation. Patil *et al.* (2007) [18] who evaluated bio efficacy and economics of insecticides for management of *H. armigera* in chick pea and reported that the treatment with proclaim 05 SG was found to be more effective in reducing the pod damage (3.0%) followed by spinosad 45 SC (3.3%).

Yield obtained from different insecticidal treatment plots

The data on effect of different treatments on the yield of tomato revealed that the maximum tomato yield (32.65 t ha^{-1}) was recorded in Emamectin benzoate 05 SG @ 0.002 per cent in treated plot which was superior over rest of the treatments and was at par with Azadirachtin 1 EC @ 0.002 per cent (31.66 t ha^{-1}), *Bacillus thuringiensis* @ 1.5ml lit^{-1} (30.75 t ha^{-1}), *Beauveria bassiana* @ 5ml lit^{-1} (30.36 t ha^{-1}) and *Metarhizium anisopliae* @ 5ml lit^{-1} (29.35 t ha^{-1}). The next treatment followed were *Lecanicillium lecanii* @ 5ml lit^{-1} (25.93 t ha^{-1}) and *Pongamia pinnata* 2 EC @ 0.1 per cent (25.87 t ha^{-1}). The minimum tomato yield (16.20 t ha^{-1}) was recorded in untreated control (table 2). The present results are in conformity with the findings of Kamal *et al.* (2019) [11] who conducted efficacy of different management practices to control tomato fruit borer (TFB) under field condition and observed that the maximum marketable yield (33.95 t ha^{-1}) was achieved in the emamectin benzoate treated plot with the highest (1.46) benefit cost ratio. Murugaraj *et al*. (2006) [16] observed that emamectin benzoate 05 SG @ 11 g a.i. ha^{-1} was highly effective in reducing the larval population and fruit damage as well in increasing the yield of tomato.

Table 1: Efficacy of different pesticides against major pests of tomato after three sprays during *rabi* 2018-2019

Treatment	Whitefly population (3 leaves / plant)		Aphid population (3 leaves / plant)		Infestation of leaf miner (%)		Infestation of fruit borer (%)			
							Pre count		Post count	
	Pre count	Post count	Pre count	Post count	Pre count	Post count	No. basis	Wt. basis	No. basis	Wt. basis
Beauveria bassiana	5.31 (2.51)	3.28 (2.06)	3.78 (2.19)	1.67 (1.62)	31.59 [34.20]	25.56 [30.28]	33.54 [35.38]	31.14 [33.91]	22.67 [28.41]	20.75 [27.07]
Metarhizium anisopliae	5.64 (2.58)	3.82 (2.18)	3.41 (2.10)	1.81 (1.67)	32.50 [34.75]	22.87 [28.51]	32.30 [34.63]	29.39 [32.82]	25.36 [30.21]	23.18 [28.82]
Lecanicillium lecanii	5.27 (2.50)	3.43 (2.09)	3.73 (2.17)	1.47 (1.57)	31.63 [34.22]	28.07 [31.92]	33.65 [35.44]	31.89 [34.36]	29.67 [32.98]	27.18 [31.40]
Pongamia pinnata 2% EC	5.22 (2.49)	4.10 (2.24)	3.66 (2.15)	2.00 (1.72)	32.36 [34.67]	27.02 [31.25]	32.82 [34.93]	30.64 [33.58]	30.27 [33.36]	27.85 [31.84]
Bacillus thuringiensis	5.82 (2.61)	4.34 (2.29)	3.57 (2.13)	2.10 (1.75)	31.45 [34.11]	25.73 [30.45]	34.02 [35.68]	31.35 [34.04]	17.74 [24.69]	15.86 [23.25]
Azadirachtin 1% EC	5.24 (2.48)	3.32 (2.07)	3.73 (2.17)	1.76 (1.65)	31.48 [34.13]	13.18 [21.23]	33.62 [35.43]	31.29 [34.00]	15.40 [22.83]	13.86 [21.47]
Emamectin benzoate 5% SG	5.65 (2.57)	4.22 (2.26)	3.69 (2.16)	2.06 (1.74)	32.33 [34.65]	11.71 [19.89]	32.70 [34.87]	29.94 [33.16]	13.10 [21.02]	11.81 [19.91]
Untreated control	6.24 (2.69)	6.42 (2.73)	3.64 (2.15)	3.46 (2.10)	32.36 [34.67]	35.80 [36.74]	34.72 [36.08]	32.26 [34.59]	37.94 [38.00]	35.26 [36.40]
SE (m±)	0.07	0.02	0.09	0.03	0.35	0.46	0.88	0.93	0.82	0.80
CD at 05%	0.20	0.07	0.29	0.09	1.07	1.38	2.67	2.81	2.48	2.42

*Figures in parenthesis ( ) are square root transformation values. Figures in parenthesis [ ] are Arc sine transformed values

Table 2: Effect of different pesticidal treatments on the yield of tomato

Tr. No.	Treatment details	Dose lit^{-1} of water	Yield (t ha^{-1})
T_1	*Beauveria bassiana*	5 ml	30.36
T_2	*Metarhizium anisopliae*	5 ml	29.35
T_3	*Lecanicillium lecanii*	5 ml	25.93
T_4	*Pongamia pinnata* 2% EC	2 ml	25.87
T_5	*Bacillus thuringiensis* var. *kurstaki*	1.5 ml	30.75
T_6	Azadirachtin 1% EC	3 ml	31.66
T_7	Emamectin benzoate 5% SG	0.4 gm	32.65
T_8	Untreated control	-	21.76
SE (m±)			0.70
CD at 5%			2.13

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