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Research Article

DEVELOPMENT AND EVALUATION OF IPM MODULES AGAINST FRUIT BORER (*Helicoverpa armigera*) INFESTING TOMATO CROP

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ABSTRACT

Field studies on the "Development and evaluation of different management schedules against fruit borer, *Helicoverpa armigera* infesting tomato crop" were carried at farmer's field, village Surajgarh, Jhajjar, Haryana. The observations on infestation of fruit borer in tomato fruits at the time of each picking, %reduction of the fruit borer infestation, total marketable yield in different schedules over control and benefit cost ratio were calculated. The maximum larval reduction over control was observed in S6 i.e. spray of fenvalerate 20 EC @ 188 ml/ha (79.91%) followed by spray of nimbecidine 300 ppm @ 2.5 l/ha (79.04). On number basis, highest fruit damage reduction over control was observed in S6 (50.23%) followed by S5 (43.83%) and lowest (21.72%) in S4 i.e. African yellow marigold + yellow sticky trap + *Trichogramma chilonis* Ishi @ 50000 parasitised eggs/ha (2 releases at 4 days interval). On weight basis, %fruit damage reduction over control was maximum in S6 (57.47%) followed by S5 (53.10%) and minimum in S4 (25.06%). The highest benefit cost ratio (22.81) was recorded in S6 due to lowest cost of plant protection (Rs.3628.34/ha) and highest increased yield over control (72 q/ha). Although schedule S4 was next to S6 in term of total cost of plant protection but showed lowest benefit cost ratio (3.46) due to minimum increased yield over control (20 q/ha) among all the management schedules. Benefit cost ratio in remaining schedules were 8.97, 5.40, 3.71 and 3.58 in S5, S1, S2 and S3, respectively.

Keywords: Fenvalerate, *Helicoverpa armigera*, Management schedules, Nimbecidine, Tomato.

INTRODUCTION

Tomato (*Lycopersicon esculentum* M.) is an important vegetable crop grown all over the world. It is also an important source of lycopene, ascorbic acid and β-carotene, which are potent antioxidants. However, it is attacked by number of insects pest and tomato fruit borer, *Helicoverpa armigera* (Hubner) has been a major constraint causing extensive damage to the extent of about 50-70% (Reddy and Tangtrakulwanish, 2013; Abbas *et al.*, 2015). *H. armigera* is voracious feeder in habit, having high mobility, multivoltine and overlapping generations makes it as pest of high magnitude that cause direct attack on fruiting structures of tomato. It causes losses upto the tune of 18.2 to 80.0% to the crop depending on different agro climatic conditions (Lal *et al.*, 2001) across the country. However, sometimes there has been complete destruction of tomato crop by this pest (Fery and Cuthbert, 1974). Many a time's farmers apply insecticidal sprays even when the insect-pest population is far below economic threshold level (ETL). The farmers therefore, follow plant protection schedule based on plant growth and time of pest appearance. With the introduction of new molecules, farmers use a variety of chemical insecticidal sprays in a haphazard manner for management of insect-pests of tomato. Inspite of regular spraying of insecticides, its incidence in farmers' fields varies from 10 to 20% and at times, this pest causes yield loss up to 40% (Tiwari and Krishnamoorthy, 1984). To overcome this pest, insecticides play a significant role in its effective crop management program globally. To reduce the ill effects of conventional chemical insecticides, there is great need to evaluate different management schedules based on combination of bio-rational and eco-friendly pesticides, alone and in combination. But reports on integration of all such components and their efficacy against target insect pests of tomato are lacking. Keeping this in consideration, the present investigation was,

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therefore, using different management schedules on tomato fruit borer, *H. armigera* infesting tomato crop.

MATERIALS AND METHODS

Studies were conducted for development and evaluation of different management schedules against fruit borer, *H. armigera* infesting tomato crop during rabi season at farmer's field of an extensive tomato (var. Abhinav) growing village Surajgarh, Jhajjar, Haryana. Jhajjar is situated in southern part of Haryana and lies between 28^o 62' north latitudes and 76^o 65' east longitudes and 220 meters above mean sea level (MSL). The plot size was kept 6 x 3 m^2 keeping row to row and plant to plant distances of 60 cm and 45 cm, respectively. A complete simple randomized block design (RBD) with seven treatments (IPM modules) including untreated control each replicated thrice (Table 1).

Table 1. Management schedules evaluated against tomato fruit borer, *H. armigera* infesting tomato crop.

Schedule	Management practice/spray				
	1st management practice/spray	2nd management practice/spray	3rd management practice/spray	4th management practice/spray	5th management practice/spray
S_1	Spray of Nimbecidine 300 ppm @ 2.5 l/ha	Mixed Spray of Nimbecidine 300 ppm @ 1.25 l/ha +Novaluron 10 EC @ 188 ml/ha	Spray of *B.t.k.*@ 1.0 kg/ha	Spray of Spinosad 45 SC @ 188 ml/ha	Spray of Novaluron 10 EC @ 375 ml/ha
S_2	Spray of Nimbecidine 300 ppm @ 2.5 l/ha	Mixed Spray of Nimbecidine 300 ppm @ 1.25 l/ha+Novaluron 10 EC @ 188 ml/ha)	Spray of *B.t.k.*@ 1.0 kg/ha	Spray of Novaluron 10 EC @ 375 ml/ha	Spray of Novaluron 10 EC @ 375 ml/ha
S_3	*Trichogramma chilonis* Ishi @ 50000 parasitised eggs/ha (2 releases at 4 days interval)	Spray of Nimbecidine 300 ppm @ 2.5 l/ha	Spray of Spinosad 45 SC @ 188 ml/ha	Spray of Nimbecidine 300 ppm @ 2.5 l/ha	Spray of Novaluron 10 EC @ 375 ml/ha
S_4	African yellow marigold+ Yellow sticky trap+ *Trichogramma chilonis* Ishi @ 50000 parasitised eggs/ha (2 releases at 4 days interval)	Spray of Nimbecidine 300 ppm @ 2.5 l/ha	Spray of *B.t.k.*@ 1.0 kg/ha	Spray of Nimbecidine 300 ppm @ 2.5 l/ha	Spray of *B.t.k.*@ 1.0 kg/ha
S_5	Spray of Nimbecidine 300 ppm @ 2.5 l/ha	Spray of Malathion 50 EC @ 1.0 l/ha	Spray of *B.t.k.*@ 1.0 kg/ha	Spray of Decamethrin 2.8 EC @ 500 ml/ha	Spray of Spinosad 45 SC @ 188 ml/ha
S_6	Spray of Fenvalerate 20 EC @ 188 ml/ha	Spray of Malathion 50 EC @ 1.0 l/ha	Spray of Decamethrin 2.8 EC @ 500 ml/ha	Spray of Malathion 50 EC @ 1.0 l/ha	Spray of Cypermethrin 25 EC @ 150 ml/ha
S_7	Untreated (control)	Untreated (control)	Untreated (control)	Untreated (control)	Untreated (control)

One row of african yellow marigold was alternated after five rows of tomato at the time of transplanting. For this purpose, the nursery of marigold was raised one month in advance of tomato so that there was synchronization of flowering on them in the field. One yellow sticky trap per replications was installed after establishment of plants. Observations on larval population of *H. armigera* were recorded per 3 leaves on 5 randomly selected plants in each schedule including untreated (control), one day before each spray and at 3, 5 and 7 days after completion of the schedule using drop sheet method. The observation on infestation of fruit borer in tomato fruits were recorded at the time of each picking. For this purpose, damaged and healthy fruits were separately counted and weighed at every picking in all the schedules including control. %reduction of the fruit borer infestation was calculated in different schedules over control. Total marketable yield and benefit cost ratio of all the schedules were calculated.

Percentage of fruit damage was worked out with the help of following formula given by Abott, 1925.

$$\text{Percentage of fruit damage (number basis)} = \frac{\text{Number of damaged fruits}}{\text{Total number of fruits (damaged+healthy)}} \times 100$$

$$\text{Percentage of fruit damage (weight basis)} = \frac{\text{weight of damaged fruits}}{\text{Total weight of fruits (damaged+healthy)}} \times 100$$

Statistical analysis

The obtained data were statistically analysed using angular transformation and $\sqrt{n+1}$ square root transformation whenever needed.

RESULTS AND DISCUSSION

The data presented in Table 2 indicate that 3 days after completion of all the management schedules, population of *H. armigera* was lowest in S6 i.e. spray of fenvalerate 20 EC @ 188 ml/ha (0.79 larvae/plant) which was statistically at par with S1, S2 and S5. Significantly higher population (2.00 larvae plant^{-1}) was observed in S4. The results clearly indicated that at 5, 7 and 10 days after completion of schedules lowest larval population i.e. 0.60, 0.50 and 0.46 larvae/plant were observed in S6 while the highest population i.e. 1.20, 0.96 and 0.79 larvae/plant were observed in S4 among all the management schedules, respectively. Where, S6 was at par with S5 and S4 was at par with S3. However, all the management schedules were significantly better than S7 at 3, 5, 7 and 10 days after completion of all the schedules. The perusal of data presented in Table 3 indicate that fruit damage (number basis) due to *H. armigera* on first picking varied between 18.67 % in S6 i.e. spray of fenvalerate 20 EC @ 188 ml/ha and 25.10 % in S4 among various management schedules as compared to 32.27 % in control. In second picking, it ranged from 17.10 to 24.43 % in all the management schedules as compared to 33.20 % in control. In third picking, it was 15.10 to 24.10 % in various management schedules as compared to 36.30 % in control.

On fourth picking, the fruit damage number basis was recorded minimum (25.15%) in S6 i.e. spray of fenvalerate 20 EC @ 188 ml/ha and maximum (36.07 %) in S4 schedule as compared to 48.20 % in control. In fifth picking, the fruit damage ranged from 21.10 to 35.10 in various management schedules as against 44.20 % in control, whereas, in sixth picking, it was 18.15 to 31.10 % among different management schedules and 32.75 % in control. In seventh picking the fruit damage ranged from 15.76 to 26.15 in various management schedules as against 29.00 % in control. During the last picking, the fruit damage ranged from 9.06 to 20.10 % in various management schedules as compared to 25.50 % in control. The pooled mean of fruit damage on number basis among various management schedules showed that significantly lowest fruit damage (17.51%) was observed in S6 (spray of fenvalerate 20 EC @ 188 ml/ha) which was closely followed by S5 (19.76%) while it was significantly highest in S4 (27.54%) which was statistically at par with S3 (27.43%). The schedules S1 and S2 were statistically at par but proved significantly better than S3 and S4. It is evident from the data that all the management schedules proved better than control where 35.18 % fruit damage was recorded.

Table 2. Population of *H. armigera* larvae after completion of management schedules on tomato.

Schedule (S)	No. of larvae/plant (average of 5 plants)			
	3 DACS*	5 DACS*	7 DACS*	10 DACS*
S1	0.92 (1.34)^{a}	0.70 (1.30)^{b}	0.65 (1.28)^{b}	0.62 (1.27)^{b}
S2	0.98 (1.34)^{a}	0.71 (1.31)^{b}	0.65 (1.28)^{b}	0.66 (1.29)^{b}
S3	1.90 (1.58)^{b}	1.10 (1.45)^{c}	0.90 (1.38)^{c}	0.76 (1.33)^{c}
S4	2.00 (1.64)^{c}	1.20 (1.48)^{c}	0.96 (1.40)^{c}	0.79 (1.34)^{c}
S5	0.95 (1.34)^{a}	0.60 (1.26)^{a}	0.55 (1.24)^{a}	0.48 (1.22)^{a}
S6	0..79 (1.34)^{a}	0.60 (1.26)^{a}	0.50 (1.22)^{a}	0.46 (1.21)^{a}
S7	3.70 (2.12)d	2.73 (1.93)^{d}	2.52 (1.88)^{d}	2.29 (1.81)^{d}
SE (m)	0.01	0.01	0.006	0.005
C.D (p=0.05)	0.04	0.03	0.02	0.02

* DACS = Days after completion of schedule

Table 3. Effect of various pest management schedules on fruit damage (number basis) due to fruit borer, *H. armigera* on tomato.

Schedule (S)	Fruit damage (%) on various picking (number basis)								Pooled mean
	1st	2nd	3rd	4th	5th	6th	7th	8th	
S1	21.75	19.10	18.20	32.10	30.10	27.10	24.10	13.10	23.19
	(27.78)^{b}	(25.89)^{a}	(25.89)^{a}	(34.48)^{b}	(33.25)^{b}	(31.34)^{b}	(29.38)^{b}	(21.20)^{c}	(28.77)^{c}
S2	21.60	19.35	18.10	33.30	31.16	28.15	25.07	14.15	23.86
	(27.67)^{b}	(26.07)b	(26.07)a	(35.22)^{b}	(33.91)^{b}	(32.02)^{b}	(30.02)^{c}	(22.08)^{c}	(29.22)^{c}
S3	24.60	23.10	22.15	38.10	35.10	31.10	26.15	19.10	27.43
	(29.71)^{c}	(28.70)^{c}	(28.70)^{b}	(38.09)^{c}	(36.31)^{c}	(33.87)^{c}	(30.73)^{c}	(25.89)^{d}	(31.56)^{d}
S4	25.10	24.43	24.10	36.07	34.20	30.20	26.10	20.10	27.54
	(30.05)^{c}	(29.60)^{c}	(29.60)^{b}	(36.88)^{c}	(35.76)^{c}	(33.31)^{c}	(30.70)^{c}	(26.61)^{d}	(31.63)$^{d`}$
S5`	20.07	18.78	17.86	27.10	24.15	19.10	18.86	12.12	19.76
	(26.60)^{a}	(25.67)^{a}	(25.66)^{a}	(31.34)^{a}	(29.40)^{a}	(25.89)^{a}	(25.72)^{a}	(20.36)^{b}	(26.37)^{b}
S6	18.67	17.10	15.10	25.15	21.10	18.15	15.76	9.06	17.51
	(25.58)^{a}	(24.40)^{a}	(24.40)	(30.07)^{a}	(27.31)^{a}	(25.19)^{a}	(23.37)^{a}	(17.50)^{a}	(24.72)^{a}
S7	32.27	33.20	36.30	48.20	44.20	32.75	29.00	25.50	35.18
	(34.59)^{d}	(35.16)^{d}	(35.16)^{c}	(43.95)^{d}	(41.64)^{d}	(34.88)^{d}	(32.55)^{d}	(30.29)^{e}	(36.35)^{e}
SE (m)	0.38	0.28	0.27	0.74	0.66	0.58	0.66	0.42	0.28
C.D (p=0.05)	1.18	0.86	0.86	2.33	2.07	1.83	2.07	1.32	0.89

Figures in parentheses are square root transformation ($\sqrt{n+1}$) values
Figure with same letter are non significant

Table 4. Effect of various pest management schedules on fruit damage (weight basis) due to fruit borer *H. armigera* on tomato

Schedule (S)	Fruit damage (%) on various picking (weight basis)								Pooled mean
	1st	2nd	3rd	4th	5th	6th	7th	8th	
S1	16.40	14.20	12.10	27.20	24.22	21.13	17.10	9.21	17.76
	(23.87)^{b}	(22.12)^{b}	(20.34)^{b}	(31.42)b	(29.38)^{c}	(26.64)^{b}	(24.39)^{b}	(17.93)^{b}	(24.78)^{b}
S2	16.60	14.70	12.80	28.20	25.92	22.68	18.08	10.16	18.71
	(24.03)^{b}	(22.53)^{b}	(20.94)^{b}	(32.06)^{b}	(30.51)^{c}	(27.73)^{b}	(25.13)^{b}	(18.84)^{b}	(25.49)^{b}
S3	19.70	15.80	13.20	36.20	32.10	28.10	24.50	15.20	23.10
	(26.33)^{c}	(23.41)^{b}	(21.29)^{b}	(36.97)^{c}	(34.49)^{d}	(31.99)^{c}	(29.65)^{c}	(22.92)^{c}	(28.71)^{c}
S4	20.10	16.70	13.60	35.20	32.40	29.25	25.10	17.10	23.68
	(26.62)^{c}	(24.11)^{b}	(21.62)^{b}	(36.37)^{c}	(34.68)^{d}	(32.72)^{c}	(30.04)^{c}	(24.40)^{d}	(29.10)^{c}
S5	15.80	12.10	10.10	23.10	19.82	16.25	13.20	8.20	14.82
	(23.41)^{b}	(20.34)^{a}	(18.52)^{a}	(28.70)^{a}	(26.42)^{b}	(23.76)^{a}	(21.29)^{a}	(16.63)^{a}	(22.63)^{a}
S6	14.60	11.20	9.60	20.25	17.00	15.10	12.10	7.70	13.44
	(22.45)^{a}	(19.54)^{a}	(18.04)^{a}	(26.72)^{a}	(24.34)^{a}	(22.85)^{a}	(20.34)^{a}	(16.10)^{a}	(21.50)^{a}
S7	24.80	29.66	33.25	40.36	37.50	35.20	31.85	20.20	31.60
	(29.85)^{d}	(32.97)^{c}	(35.19)^{c}	(39.41)^{d}	(37.73)^{e}	(36.36)^{d}	(34.32)^{d}	(26.69)^{e}	(34.18)^{d}
SE (m) ±	0.29	0.35	0.35	0.60	0.42	0.53	0.57	0.46	0.20
C.D P=0.05	0.91	1.09	1.09	1.88	1.33	1.66	1.79	1.43	1.63

Figures in parentheses are square root transformation ($\sqrt{n+1}$) values
Figure with same letter are non significant

Table 5. Overall reduction in larval population and fruit damage due to *H. armigera* and increased marketable yield of tomato under different management schedules.

Schedule (S)	Reduction (%) over control			Yield (q/ha)	% increased yield over control
	Larval population (%)	Fruit damage (%)			
		Number basis	Weight basis		
S1	72.93	34.08	43.80	275	20.61
S2	71.18	32.18	40.79	260	14.03
S3	66.81	22.03	26.90	256	12.28
S4	65.50	21.72	25.06	248	8.77
S5`	79.04	43.83	53.10	285	25.00
S6	79.91	50.23	57.47	300	31.58
S7				228	
SE (m)				6.38	
C.D (p=0.05)				19.89	

It is evident from the data presented in Table 4 that the fruit damage (weight basis) due to fruit borer on tomato fruits at first picking in various treatment schedules varied from 14.60 % in S6 (spray of fenvalerate 20 EC @ 188 ml/ha) to 20.10 % in S4 as against 24.80 % in control. Among the remaining schedules, significantly higher fruit damage than S6 was observed in S5, S1 and S2 which were statistically at par. The fruit damage in S3 was at par with S4; however, all the management schedules were significantly better than control. During second and third pickings, the management schedules viz., S6 and S5 were significantly better than other schedules and control. On fourth picking there was increase in fruit damage in all the management schedules ranging from 20.25 to 36.20 % as against significantly highest i.e. 40.36 % in control. However, the schedules viz., S6 and S5 were statistically at par and significantly better than the remaining schedules. In fifth picking, significantly lowest fruit damage (17.00%) was observed in S6 and highest (32.40%) in S4 which was statistically at par with S3. However, all the management schedules were better than control where 37.50 % fruit damage was observed. In sixth and seventh pickings, the lowest fruit damage was recorded in S6 which was at par with S5 and the highest in S4 which was at par with S3. However, all the management schedules were significantly better than control. In the last picking, lowest fruit damage (7.70%) was recorded in S6 which was at par with S5 but significantly better than remaining treatments (9.21 to 17.10%) and control (20.20%). The overall information coming out from pooled mean of all the eight pickings indicated that the fruit damage on weight basis in various management schedules was significantly lowest (13.44%) in S6 which was at par with S5 (14.82%) while it was significantly highest in S4 (23.68%) which was statistically at par with S3 (23.10%). The schedules S1 and S2 were statistically at par but proved significantly better than S3 and S4. It is evident from the data that all the management schedules proved better than control where 31.60 % fruit damage was recorded. The data presented on marketable yield of tomato revealed the same order of the efficacy of various management schedules as explained in case of percent reduction in larval population and fruit damage over control. Among various management schedules, the highest and lowest yields i.e. 300 and 248 q/ha was recorded in S6 and S4, respectively as compared to control (228 q ha^{-1}). Spray of fenvalerate 20 EC @ 188 ml/ha increased yield to the extent of 31.58 % over untreated check over control among different management schedules (Table 5).

After complection of all schedules, their efficacy was studied in detail by recording observations on larval population of *H. armigera* after 3, 5, 7 and 10 days of last spray. At each observation, chemical insecticide schedule i.e. S6 (fenvalerate 20 EC @ 188 ml/ha followed by malathion 50 EC @ 1.0 l/ha, decamethrin 2.8 EC @ 500 ml/ha, malathion 50 EC @ 1.0 l/ha and cypermethrin 25 EC @ 150 ml/ha) was found most effective with lowest larval population and was at par with S5 (nimbecidine 300 ppm @ 2.5 l/ha followed by malathion 50 EC @ 1.0 l/ha, *B.t.k.*@ 1.0 kg/ha, decamethrin 2.8 EC @ 500 ml/ha and spinosad 45 SC @ 188 ml/ha) while bio-intensive schedule i. e. S4 (african yellow marigold + yellow sticky trap + *T. chilonis* @ 50000 parasitised eggs/ha (two releases at 4 days interval) followed by nimbecidine 300 ppm @ 2.5 l/ha, *B.t.k.* @ 1.0 kg/ha, nimbecidine 300 ppm @ 2.5 l/ha and *Bt* formulation (delfin) @ 1.0 kg/ha) was found least effective having highest larval population.

The efficacy of various management schedules was further studied by recording observations on fruit damage (during 8 pickings) on both number and weight basis. It is evident from pooled mean data that fruit damage on number basis was lowest (17.51%) in chemical insecticide schedule fenvalerate 20 EC @ 188 ml/ha followed by malathion 50 EC @ 1.0 l/ha, decamethrin 2.8 EC @ 500 ml/ha, malathion 50 EC @ 1.0 l/ha and cypermethrin 25 EC @ 150 ml/ha) and highest (27.54%) in S4 (african yellow marigold + yellow sticky trap + *T. chilonis* @ 50000 parasitised eggs/ha (two releases at 4 days interval) followed by nimbecidine 300 ppm @ 2.5 l/ha, *B.t.k.*@ 1.0 kg/ha, nimbecidine 300 ppm @ 2.5 l/ha and *B.t.k.*@ 1.0

kg/ha). On number basis, S6 was closely followed by S5 (nimbecidine 300 ppm @ 2.5 l/ha followed by malathion 50 EC @ 1.0 l/ha, *B.t.k.* @ 1.0 kg/ha, decamethrin 2.8 EC @ 500 ml/ha and spinosad 45 SC @ 188 ml/ha) where as fruit damage on weight basis was statistically similar in both the schedules.

The bio-intensive schedule S4 and S3 (*T. chilonis* @ 50000 parasitised eggs/ha (two releases at 4 days interval) followed by nimbecidine 300 ppm @ 2.5 l/ha, spinosad 45 SC @ 188 ml/ha, nimbecidine 300 ppm @ 2.5 l/ha and novaluron 10 EC @ 375 ml/ha) were again found least effective showing highest fruit damage both on number and weight basis. S1 (nimbecidine 300 ppm @ 2.5 l/ha followed by nimbecidine 300 ppm @ 1.25 l/ha + novaluron 10 EC @ 188 ml/ha**,** *B.t.k.* @ 1.0 kg/ha, spinosad 45 SC @ 188 ml/ha and novaluron 10 EC @ 375 ml/ha) and S2 (nimbecidine 300 ppm @ 2.5 l/ha followed by nimbecidine 300 ppm @ 1.25 l/ha + novaluron 10 EC @ 188ml/ha, *B.t.k.*@ 1.0 kg/ha**,** novaluron 10 EC @ 375 ml/ha and novaluron 10 EC @ 375 ml/ha) were found equaly effective, superior than S3 and S4 but inferior to S5 and S6. The data on over all réduction over control in larval population and fruit damage clearly indicated the order of efficacy of different mangement schedules in decending order as S6, S5, S1, S2, S3 and S4. this was further supported by data on marketable yield in same order of efficacy. However, all the management schedules yielding better 248 to 300 q/ha than control (228 q/ha). Hasan *et al.* (2016) found that the indoxacarb treated treatments @ 60 and 70 g a.i./ha, yielded the highest yield of marketable fruits 29.16 and 29.50 tons/ha, respectively as compared to untreated control (16.66 tons/ha). Marigold planted as one row on either side or parallel to 10 to 15 rows of tomato resulted maximum reduction of eggs population and larval population of *H. armigera* in tomato (Srinivasan *et al.*, 1994).

The IPM module consisting of trap crop (15 rows of tomato: 1 row marigold) + *T. pretiosum* @ 45,000/ha + NSKE 5% + HaNPV @ 250 LE/ha + endosulfan 35 EC @ 1250 ml/ha found significantly superior in reducing the larval population of *H. armigera* (Karabhantanal and Awaknavar, 2005). It was indicated that emamectin benzoate @ 10.0 and 8.75 g a.i./ha was more effective against the *H. armigera* followed by spinosad 2.5 SC (12.5 g a.i.) in reducing the larval population and fruit damage (Khanna *et al.*, 2005). Similarly, it was reported emamectin benzoate @ 0.11 g a.i./ha as most effective in reducing the larval population of *H. armigera* in tomato (Murugaraj *et al.*, 2006).

Rathod *et al.* (2014) found *Bt* @ 1.0 kg/ha to be the most effective treatment which gave highest mortality of *H. armigera* and was at par with *B. bassiana* @ 2.0 kg/ha. In case of insecticides, rynaxy-pyr 0.006 % proved to be the most effective treatment against *H. armigera* and was found statistically at par with indoxacarb 0.008 %). One of experiment indicated that flubendiamide 0.004 % recorded minimum larval population (0.43 larva/plant) and 10.09 % fruit damage on weight basis followed by chlorantraniliprole 0.0055 % (0.58 larva/plant and 10.62 % fruit damage) and spinosad 0.0068 % (0.68 larva/plant and 11.34 % fruit damage) which were identical (Ambule *et al.*, 2015). Chavan *et al.* 2015 recorded the minimum larval incidence of *H. armigera* (0.95 and 0.36 larva/m row length) in rynaxypyr 20 SC at 3 and 7 days after spraying followed by flubendiamide 48 SC (1.47 and 0.78 larvae/m row length) and emamectin benzoate 5 SG (1.55 and 0.89 larvae/m row length).

CONCLUSION

Integrated pest management modules evaluated in present study were showed significantly judicious over untreated control. The experimental trials conducted on tomato crop showed the potential of implementing integrated pest management to set up the productivity significantly by reducing the losses due to *H. armigera*. These modules should be demonstrated on farmers' field for assessing the performance of improved technology, after that developed module should be disseminated among the farmers.

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