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FIELD EFFICACY OF SOME SYSTEMIC INSECTICIDES AND MICROBIAL PESTICIDES (MODULES) AGAINST APHID, *APHIS GOSSYPII* GLOVER AND FRUIT BORER, *HELICOVERPA ARMIGERA* (HUBNER) ON TOMATO IN PUNJAB

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ABSTRACT

An experiment was conducted to evaluate the field efficacy of some systemic insecticides and microbial pesticides modules against cotton aphid, *Aphis gossypii* Glover and tomato fruit borer, *Helicoverpa armigera* (Hubner) on tomato (*Lycopersicon esculenum* Mill.) at the Vegetable Research Farm, Punjab Agricultural University, Ludhiana, during 2006-08. The need based sprays of different modules i.e., Imidacloprid (Confidor) 17.8 SL@ 0.3 ml/L in module M_1, Thiomethoxam (Actara) 25 WG@ 0.4 g/L in module M_2, *Verticillium lecanii* (Ecocill) @ 2.5 kg/ha + Econeem (AzEC) 1% @500 ml/ha in module $M_{3,}$ Profenophos (Carina) 50EC@2ml/L in module M_4, Acephate (Asataf) 75 SP @ 1.0 g/L in module M_5 against M_6 standard check Malathion 50 EC@ 1L/ha and control (M_7) at 10 days interval for aphid, while Spinosad 45% SC @ 0.5 ml/L in module M_1 and Profenophos (Carina) 50 EC @ 1.5L/ha in module M_5 at 15 days interval ,and *Bt* (Delfin WG) @ 500 g/ha in module M_2 and *Beauveria bassiana* (Larvocel) @ 4g/L in module M_3, Nucleo Polyhedro Virus (NPV) @ 350 LE/ha in module M_4 at 10 days interval were evaluated for fruit borer and compared with the standard check (M_6) i.e., Profenophos (Carina) 50 EC @ 1.5 L/ha and the untreated control (M_7) at 10 days interval. The pooled data of 3 years revealed that thiamethoxam (Actara) 25 WG and imidacloprid 17.8 SL significantly reduced aphid population (109.99-123.08 aphids/15 leaves) as against other modules (141.85-208.31 aphids/15 leaves), standard check Malathion 50 EC (175.82 aphids/15 leaves) and control (247.75 aphids/15 leaves). Whereas, spinosad 45% SC in module M_1 significantly resulted in lower fruit borer infestation (9.68%) than other modules (M_2-M_5) with 13.73-29.00% fruit infestation, standard check M_6 (13.87%) and control M_7 (32.66%). Highest marketable fruit yield and economic returns were obtained in module M_1 viz. imidacloprid 17.8 SL + Spinosad 45%SC (259.06q/ha and ₹136717) over the other modules (86.97-184.41 and ₹ 14535-88094 q/ha, respectively), the standard check module: Malathion 50 EC and Profenophos 50 EC (149.12 q/ha and ₹62140) and control module M_7 (57.02 q/ha).

Keywords:
Systemic microbial pesticides, *Aphis gossypii*, *Helicoverpa armigera*, Tomato

INTRODUCTION

India is the third largest producer of tomato in the world after USA and China having an area of 0.63 million hectares with production of 1.24 million tonnes during 2009-10 (NHB, 2010). Similarly it ranks 8th among all vegetables in Punjab with an area of 6.26 thousand hectares and production of 154.45 thousand tonnes in 2010-11 (Anonyms, 2012). This crop is attacked by a large number of insect-pests, out of which cotton aphid, *A. gossypii*r and fruit borer, *H. armigera* cause considerable losses (20 to 60 per cent) to this crop. Several reports (Ghosh *et al*., 2010) have confirmed the *H. armigera* as the main limiting factor in the tomato cultivation. The indiscriminate use of synthetic chemical pesticides to control this pest resulted in development of resistance (Armes *et al.,* 1994) and harmful pesticide residues in fruits. Tewari (2009) has reported 22-38 per cent quantitative losses due to *H. armigera* attack on tomato. *H. armigera* causes damage to the developing fruits and results in yield loss ranging from 20 to 60 percent (Lal and Lal, 1996). Under Punjab conditions, incidence of aphid occurs during end January - March with the warming up of season. They suck plant sap and lowers plant vigour and yield. The main objective of present studies is to determine the field efficacy of different systemic insecticides and microbial pesticides in different modules against *H. armigera* and *A. gossypii* infesting tomato.

MATERIALS AND METHODS

The experiments were conducted at Vegetable Research Farm, Punjab Agricultural University, Ludhiana in three consecutive years during 2006, 2007 and 2008 on tomato. The trails were laid out in randomized block design, replicated thrice and the plot size was kept 10.5 m^2 with the 35 × 30 cm spacing. Different systemic insecticides and microbial pesticides (Table 1 and 2) were evaluated against aphid and fruit borer on tomato. Tomato variety Punjab Upma was transplanted in the field on

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December 4, December 10 and February 18 respectively during 2006, 2007 and 2008. The spray schedules against aphid were initiated on March 17, February 1 and February 20 respectively in year 2006, 2007 and 2008. The sprays for borer control were started on March 20, March 22 and April 16 during 2006, 2007 and 2008 respectively. Need based sprays were given for aphid and fruit borer control in all the modules except control treatment. Details of different modules under study are given below.

Treatments for aphid control

Two sprays in each module viz., imidacloprid (Confidor) 17.8 SL@ 0.3 ml/L in M_1, thiomethoxam (Actara) 25 WG @ 0.4 g/L in M_2, *Verticillium lecanii* (Ecocill) @ 2.5 kg/ha + *Azadirachta indica* (Econeem) 1% EC @ 500 ml//ha M_3, profenophos (Carina) 50 EC @ 2ml/L in M_4, acephate (Asataf) 75 SP @ 1g/L in M_5 were given at 10 days interval and compared with Standard check Malathion 50 EC @ 1L/ha in M_6 and untreated control (M_7) as in Table 1.

Treatments for fruit borer control

Need based 2-4 sprays of spinosad (Tracer) 45% SC @ 0.5 ml/L in M1, profenophos (Carina) 50 EC @ 1.5L/ha in M5 and M6 (Standard check) were applied at 15 days interval (Table2), whereas 3-5 sprays of *Bacillus thuriengensis* (Delfin WG) @ 500 g/ha in M2, *Beauveria bassiana* (Larvocel) @ 4 g/L in M3, Nucleopolyhedron virus (NPV) @ 350 LE/ha in M4 were applied on fruit borer appearance at 10 days interval against untreated control (M7).The aphid population was counted from the three compound leaves (one each from top, middle and bottom canopy) of randomly selected 5 plants of each plot after 7 and 10 days of 1st and 2nd spray in all the three consecutive years. At each harvest during 2006 to 2008, borer infested and healthy fruits of tomato were counted on number basis from each plot and the cumulative per cent fruit damage was calculated from cumulative totals of all the pickings of each plot. The weight of healthy fruits in each plot was also recorded at each picking. Later on marketable fruit yield (q/ha) basis and the economics of aphid and borer control on tomato was worked out.

RESULTS AND DISCUSSION

Present studies revealed that there were significant differences with respect to aphid and borer control among different modules during 2006-08 and are discussed as under:

Aphid Population

Significant low aphid population counts/15 leaves were registered in different modules over the control from 2006 to 2008 (Table 1). In 2006, on 7th days after first spray, although all modules treatments gave significantly better control of aphids with aphid counts/ 15 leaves ranging from 395.70 to 566.30 except *V. lecanii + A. indica* (835.30) and were found superior to standard check Malathion 50 EC (643.95) and control (711.70). But on 10th days after first spray, differences among all modules treatments w. r. t. aphid counts/ 15 leaves were found non-significant (661.65-879.00). On 7th day of second spray, significantly low aphid counts/15 leaves (96.65-116.65) were recorded in treatments of imidacloprid, thiomethoxam and acephate as compared to other modules treatments (126.80-159.00) and standard check Malathion (240.65) and control (300.35). On 10th day of second spray, again significantly low aphid counts/15 leaves were recorded in imidacloprid and thiomethoxam treatments (35.65-53.30) as against other modules treatments (62.35-111.70), standard check (80.00) and control (121.65). The pooled data of year 2006 (Table1) also indicated the same trend with significantly lowest counts in these two treatments of imidacloprid and thiomethoxam (307.07-333.72 aphids/15 leaves) than the other modules treatments (337.22-466.50), standard check (434.39) and control (503.17).

During 2007, overall incidence of aphids was low on the crop. On 7th day of first spray, significantly low aphid counts/15 leaves (0.00-2.00) were registered in the module treatments imidacloprid and thiomethoxam in contrast to other modules treatments (22.00-150.67), standard check (34.67) and control (76.33), while differences among different modules treatments w. r. t. aphid population were non-significant (0.00-1.33) on 10th day of first spray. The low aphid population was because of rains during this period. After 7th day of second spray, the aphid counts/15 leaves were found significantly lower (16.33-61.00) in all the modules treatment including control and standard checks except modules in treatments of *V. lecanii + A. indica* (154.00). On 10th day after second spray, again the differences among different modules treatments were non-significant (27.00-54.67 aphids/15 leaves). However, the pooled data of 2 sprays showed significant differences among different treatments. Significantly lower aphid counts/15 leaves (11.17-23.91) were recorded(Table1). in imidacloprid and thiomethoxam treatments than other modules treatments (28.08-71.50) and standard check (30.91) and control (46.83).During 2008, on 7th day after first spray, significantly lower aphids/15 leaves (13.00-21.33) were recorded in treatments imidacloprid and thiomethoxam as against other module treatments (73.33-235), standard check (101) and control (541.33). On 10th day after first spray, the same trend was observed with significantly lower aphid counts/15 leaves (19.67-30.33) in treatments of imidacloprid and thiomethoxam in contrast to other module treatments (46.33-170.33), standard check (105.33) and control (159.00).

Table 1 Effect of different treatments in different modules on *Aphis gossypii* population during 2006 – 08

Module	Treatment for aphid control	No. of aphids/15 leaves															
		2006					2007					2008				Pooled mean	Overall mean of 3 years
		1st Spray		2nd Spray		Pooled Mean	1st Spray		2nd Spray		Pooled Mean	1st Spray		2nd Spray			
		7 DAS	10DAS	7 DAS	10 DAS		7 DAS	10DAS	7 DAS	10 DAS		7 DAS	10 DAS	7DAS	10DAS		
M_1	Imidacloprid (Confidor) 200SL@0.3ml/L	408.65^{a} (20.23)	793.95	96.65^{a} (9.78)	35.65^{a} (5.63)	333.72^{a} (15.96)	2.00^{ab} (1.62)	0.67	48.00^{a} (6.70)	45.00	23.91^{ab} (4.08)	21.33^{a} (4.67)	19.67^{a} (4.46)	4.00^{a} (2.21)	1.33	11.58^{a} (3.20)	123.08^{a} (8.91)
M_2	Thiomethoxam (Actara) 25 WG @ 0.4g/L	396.70^{a} (19.75)	661.65	116.65^{a} (10.76)	53.30^{ab} (6.98)	307. 07^{a} (15.79)	0.00^{a} (1.00)	1.33	16.33^{a} (4.00)	27.00	11.17^{a} (2.92)	13.00^{a} (3.35)	30.33^{ab} (5.55)	1.00^{a} (1.38)	2.67	11.75^{a} (3..05)	109.99^{a} (8.14)
M_3	*Verticillium lecanii* (Ecocill) @ 2.5kg/ ha + *A. indica* (Econeem) 1% EC @ 500 ml / ha	835.30^{d} (28.91)	760.00	159.00^{b} (12.59)	111.70^{cd} (9.99)	466.50^{c} (19.73)	76.33^{cd} (8.79)	1.00	154.00^{b} (11.87)	54.67	71.50^{d} (7.33)	235.00^{d} (15.34)	91.00^{c} (9.57)	18.33^{b} (4.34)	3.33	86.92^{c} (7.82)	208.31^{d} (13.09)
M_4	Profenophos(Carina) 50EC @2ml/L	395.70^{a} (19.68)	764.05	126.80^{ab} (11.24)	62.35^{ab} (7.47)	337.22^{ab} (16.50)	150.67^{d} (11.85)	0.67	36.00^{a} (5.83)	44.00	57.83^{d} (6.40)	73.33^{b} (8.50)	46.33^{b} (6.87)	2.00^{a} (1.72)	0.33	30.50^{b} (4.56)	141.85^{b} (10.41)
M_5	Acephate (Asataf) 75 SP @ 1g/L	566.30^{b} (23.78)	734.00	109.00^{a} (10.47)	64.30^{abc} (7.76)	368.40^{b} (17.27)	22.00^{ab} (3.67)	0.00	47.66^{a} (6.95)	42.67	28.08^{b} (4.54)	90.00^{bc} (9.50)	170.33^{e} (13.04)	30.33^{c} (5.59)	0.00	72.67^{c} (7.28)	156.38^{bc} (11.47)
M_6	Malathion 50 EC@ 1L /ha	643.95^{bc} (25.38)	772.95	240.65^{c} (15.43)	80.00^{bcd} (8.79)	434.39^{c} (19.35)	34.67^{bc} (5.34)	0.33	60.67^{a} (7.60)	28.00	30.91^{bc} (4.85)	101.00^{a} (10.67)	105.33^{cd} (10.26)	42.33^{c} (6.58)	0.00	62.17^{c} (7.94)	175.82^{cd} (11.47)
M_7	Control	711.70^{cd} (26.63)	879.00	300.35^{d} (17.30)	121.65^{d} (11.07)	503.17^{d} (21.17)	76.33^{cd} (83.22)	0.00	61.00^{ab} (7.67)	50.00	46.83^{cd} (6.07)	541.33^{c} (23.25)	159.00^{e} (12.55)	70.00^{d} (8.42)	2.67	193.25^{d} (13.00)	247.75^{e} (14.38)
	CD (P=0.05)	(2.72)	NS	(1.79)	(2.30)	(1.06)	4.30	NS	(4.20)	NS	(1.47)	(1.41)	(2.40)	(0.78)	NS	0.75	(0.90)

*Figure given in parentheses are square root transformed values.

On 7th day of second spray, again significantly lower aphid counts/ 15 leaves (1.00-4.00) were observed in treatments imidacloprid, thiomethoxam and profenophos as compared to other treatments (18.33-30.33) than standard check (42.33) and control (70.00). The differences among different module treatments w.r.t. aphids were found non-significant (0.00-2.67) on 10th day after second spray. The pooled data of 2008 revealed that significantly lower aphids counts/15 leaves (11.58-11.75) were recorded in treatments imidacloprid and thiomethoxam than other module treatments (30.50-86.92), standard check (62.17) and control (193.25).The pooled data of three years (2006-08) has also indicated the same trend. Significantly lower aphid counts/15 leaves were recorded in imidacloprid and thiomethoxam modules treatments (109.99-123.08) in comparison to other modules treatments (141.85-208.31), standard check (175.82) and control (247.75).

Per cent fruit damage by fruit borer

During 2006, spinosad treatments in a module M_1 resulted in significantly lower fruit infestation (13.98 per cent) followed by profenophos in a module (M_5) and module M_6 (standard check) with 24.70 - 25.32% fruit infestation, respectively (table 2) as against other modules (34.24-46.66%) and control (40.78%). During 2007, significantly lower fruit infestation (8.45%) in treatment spinosad in module (M_1) was recorded which was found on a par with profenophos (M_5) and standard check (10.82-12.13%), but superior to other modules (31.65-38.35%) and control (43.92%). In 2008, again significantly lower fruit infestation (6.62%) was recorded in treatment spinosad in module (M_1) followed by profenophos (M_5) and standard check (4.79-5.06%) than other modules (8.70-11.61%) and control (13.26%).The pooled data of 3 years revealed that significantly lowest fruit infestation (9.68) was registered in treatment of spinosad in module(M_1) followed by profenophos treatment in module (M_5) and standard check module M_6 (13.73-13.87%) as against other treatments (27.03-29.00%) and control (32.66%).

Marketable fruit yield

Significantly and consistently highest marketable fruit yield ranging from 90.28 to 394.05 q/ha in all the three years (table 3) was registered in module M_1 (imidacloprid + spinosad) followed by module M_5 (acephate + profenophos) ranging from 73.57 to 221.03 q/ha, respectively. The pooled data of 3 years also indicated that significantly highest yield was obtained in module M_1 (259.06q/ha) followed by module M_5 (184.41q/ha) as against other modules (86.97-137.21 q/ha) standard check (149.12q/ha) and control (57.02q/ha).

Economics of control of aphid and fruit borer

The crop transplanted on February 18, 2008 had poor performance being frost year. Therefore based upon 2 year's data (2006 and 2007), economics of control of aphid and fruit borer control was worked out (Table 3). Although the highest cost benefit ratio of 1: 24.03 was obtained for module M_5 (acephate + profenophos), but the highest returns (₹. 1, 36,717.00) were achieved from module M_1 (imidacloprid + spinosad) followed by module M_5 (₹ 88, 094.00) in comparison to other modules (₹. 14,535.00-48,150.00), standard check (₹ 62,410.00) over the control. From the perusal of above data it is evident that Module M_1 (need based sprays of imidacloprid 17.8 SL @ 0.5m L^{-1} at 10 days interval for aphid control and spinosad 45 SC @ 0.5 mL^{-1} at 15 days interval for tomato fruit borer control) resulted in the highest marketable fruit yield and economic returns.Present findings are also supported by the work of Ravi *et al* (2008) and Anon. (2010) who reported that spinosad 45 SC (@ 75 g a.i./ha and profenophos 50 EC @

1.5l/ha gave effective control of *H. armigera*. Ghosh *et al* (2010) also reported spinosad 45% SC @ 73 and 84 g a.i./ha to be very effective to give 100% reduction of fruit borer with 33.8 -34.6 q/ha increase of fruit yield on tomato, respectively after 3 and 7 days. They also reported that spinosad is safe to nymphs and adults of three important predators in tomato field i.e., *Menochilus sexmaculatus.*, *Syrphus corollae* and *Chrysoperla carnea*. Low toxicity of spinosad to mammals and birds with a wide margin of safety to many beneficial insects has been reported by Thompson and Hutchins (1999).However, the following reports were in contradiction to the present investigation. Parveen (2000) reported the microbials formulations viz., *Ha*NPV, *Btk* effective in reducing the *H. armigera* population and fruit damage on tomato. Ravi *et al* (2008) also reported *Ha*NPV @ 1.5x1012 OB/ha), *Bt* var. *kurstaki* Berliner (Delfin® 25 WG @1 kg/ha) and neem (neemazol 1.2 EC @ 1000ml/ha) effective against fruit borer on tomato. But Sharma *et* al (2008) reported that bio pesticides alone were not as effective but the combination of *Ha*NPV (250LE) + *Btk* (500 g/ha) + *T. chilonis* (50,000 parasitoids/ha) resulted in significantly higher reduction of larval population of *H. armigera*.

Table 2 Effect of different treatments in different modules on fruit damage by *Helicoverpa armigera* and marketable fruit yield during 2006 - 08

Module	Treatment for tomato fruit borer control	Fruit damage by *Helicoverpa armigera**			Overall mean	Marketable fruit yield (q/ha)			Overall mean
		2006	2007	2008		2006	2007	2008	
M_1	Spinosad (Tracer) 45%SC@ 0.5ml /L	13.98^{a} (21.81)	8.45^{a} (16.86)	6.62^{a} (14.75)	9.68^{a} (17.81)	394.05^{a}	292.86^{a}	90.28^{a}	259.06^{a}
M_2	*Bt* (DelfinWG) @ 500g /ha	37.55^{de} (37.77)	31.94^{b} (34.24)	11.61^{de} (19.85)	27.03^{c} (30.62)	200.69^{bc}	143.16^{c}	67.78^{cde}	137.21^{c}
M_3	*Beauveria bassiana* (Larvocel) @4g/L	34.24^{bcd} (35.67)	38.35^{bc} (38.13)	10.42^{cd} (18.81)	27.67^{c} (30.87)	102.32^{e}	99.71^{d}	58.89^{d}	86.97^{d}
M_4	NPV @350LE/ha	46.66^{e} (43.03)	31.65^{b} (34.08)	8.70^{c} (17.14)	29.00^{cd} (31.42)	96.76^{e}	93.78^{de}	80.84^{ab}	90.34^{d}
M_5	Profenophos (Carina) 50 EC@1.5L/ha	25.32^{bc} (30.13)	10.82^{a} (19.02)	5.06^{b} (12.87)	13.73^{b} (20.67)	221.03^{b}	258.62^{a}	73.57^{bc}	184.41^{b}
M_6	Profenophos (Carina) 50 EC @1.5L/ha (Standard Check)	24.70^{b} (29.55)	12.13^{a} (20.20)	4.79^{a} (12.30)	13.87^{b} (20.68)	176.64^{cd}	200.99^{b}	69.75^{cd}	149.12^{c}
M_7	Control	40.78^{e} (39.56)	43.92^{c} (41.49)	13.26^{e} (21.31)	32.66^{d} (34.12)	55.26^{f}	57.33^{e}	58.47^{e}	57.02^{e}
	CD (P=0.05)	(6.75)	(4.67)	(2.24)	(2.80)	(30.64)	(36.57)	(10.77)	(23.36)

Table 3. Economics of aphid and fruit borer control in tomato

Module	Module detail	Marketable fruit yield (q/ha)	Increase in marketable fruit yield over control (q/ha)	Gross Income (₹)	Cost of inputs (₹)	Net benefit (₹)	B:C ratio
M_1	Imidacloprid (Confidor) 17.8SL@0.3ml/L+Spinosad (Tracer) 45%SC@ 0.5ml /L	343.46	287.16	143580.00	6863.00	136717.00	1:19.92
M_2	Thiomethoxam (Actara) 25 WG@0.4g/L+ *Bt*(Delfin WG) @ 500g /ha	171.92	115.62	57810.00	9660.00	48150.00	1:4.98
M_3	*Verticillium lecanii* (Ecocill) @ 2.5kg / ha+ (Econeem) *A. indica* 1% EC @ 500 ml / ha + *Beauvarica bassiana* (Larvocel) @4g/L	101.02	44.72	22360.00	4981.00	17379.00	1:3.49
M_4	Profenophos(Carina)50EC @2ml/L + NPV@350LE /ha	95.27	38.97	19485.00	4950.00	14535.00	1:2.94
M_5	Acephate (Asataf) 75 SP @ 1g/L+ Profenophos (Carina) 50 EC@1.5L/ha	239.82	183.52	91760.00	3660.00	88094.00	1:24.03
M_6	Malathion 50 EC@1L/ha +Profenophos (Carina) 50 EC @1.5L/ha	188.82	126.52	66260.00	3850.00	62410.00	14:16.20
M_7	Control	56.30	-	-	-	-	-

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