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Effect of organic amendments, botanicals and biopesticides against tomato fruit borer, *Helicoverpa armigera* (Hub.) and its parasitoid, *Trichogramma chilonis* Ishii

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Abstract : Studies were carried out to evaluate the biological activity of organic amendments against the fruit borer, *Helicoverpa armigera* and safety of botanicals and biopesticides against egg parasitoid, *Trichogramma chilonis* Ishii and biochemical effects of *Pseudomonas florescens* on tomato under pot culture conditions. The feeding and infestation of the larvae of *H. armigera* were significantly low in FYM + *Azospirillum* + SSB + *Phosphobacteria* + Neem cake and followed by FYM + *Azospirillum* + SSB + *Phosphobacteria* + mahua cake applied plants. *Trichogramma* parasitization on *H. armigera* eggs was adversely affected by Neem oil 3% on treated plants followed by NSKE + Spinosad. Under laboratory condition among the microbial pesticide tested Spinosad (75 g a.i./ha), *HaNPV* + Spinosad + *Bt* (1.5 xl0^{12} POBs/ha +75 g a.i./ha +15000 IU/mg (2 lit/ha), Spinosad + *Bt* (75 g a.i./ha +15000 IU/mg (2 lit/ha) showed superiority in exhibiting higher insecticidal toxicity (100 per cent mortality on 72 h) to all instars of *H. armigera* larvae. Biochemical parameters like phenol content, peroxidase and phenyl alanine ammonialyase (PAL) activity recorded higher levels in *Pseudomonas florescens* seed treatment @ 30 g/kg of seed and foliar spray @ 1 g/litre treated tomato plants. These biochemical components were negatively correlated to *H. armigera* infestation in tomato.

Key words: Organic amendments, botanicals, biopesticides, H. armiger, T. chilonis

Introduction

Tomato, *Lycopersicon esculentum* Mill (Family: Solanaceae) is one of the most important "protective foods" because of its superior nutritional values. Tomato is the world's largely consumed vegetable crop after potato and sweet potato and it tops the list of canned vegetables also. Of the several biotic limiting factors of tomato production, tomato fruit borer, *Helicoverpa armigera* (Hub.) is a serious pest in the flowering and fruiting stages causing severe damage up to 50 per cent in tomato. The control strategies applied by using the synthetic insecticides let to the development of cross and multiple resistances in *H. armigera*. Hence, attempts are made and search is till on way to find better alternatives to synthetic insecticides. Of several options, organic amendments, botanical pesticides and biopesticides are the best alternatives to manage the pests below the economic threshold level (ETL) and provide security to mankind from the residues of pesticides. In the use of botanical pesticides, the major limiting factor is their faster photo-degradability of biologically active compounds under field conditions. Hence, studies are undertaken to stabilize the neem compounds with other botanicals and increase the efficacy with biopesticides namely *Ha*NPV, *Bacillus*

Table 1. Effect of organic amendments on *H. armigera* infestation in pot cultured tomato

Treatments	Concentration	Per cent damage*	
		30 DAT*	45 DAT**
Compost + SSB + *Azospirillum*+ Phosphobacteria + Neem cake	12.5 t ha^{-1} +2 kg ha^{-1} + 2 kg ha^{-1} + 2 kg ha^{-1}+ 300 kg ha^{-1}	3.51 (10.79)[f]	3.00 (9.97)[f]
Compost +SSB +*Azospirillum* + Phosphobacteria + Mahua cake	12.5 t ha^{-1} +2 kg ha^{-1} + 2 kg ha^{-1} + 2 kg ha^{-1}+ 400 kg ha^{-1}	2.04 (8.21)[d]	2.46 (9.02)[e]
FYM + SSB + *Azospirillum* + Phosphobacteria + Mahua cake	12.5 t ha^{-1} +2 kg ha^{-1} + 2 kg ha^{-1} + 2 kg ha^{-1} + 400 kg ha^{-1}	1.80 (7.71)[c]	1.26 (6.44)[b]
FYM + SSB + *Azospirillum* + Phosphobacteria + Castor cake	12.5 t ha^{-1} +2 kg ha^{-1} + 2 kg ha^{-1} + 2 kg ha^{-1} + 400 kg ha^{-1}	2.55 (9.18)[e]	2.07 (8.27)[d]
FYM + SSB + *Azospirillum* + Phosphobacteria + Neem cake	12.5 t ha^{-1} +2 kg ha^{-1} + 2 kg ha^{-1} + 2 kg ha^{-1} + 300 kg ha^{-1}	1.08 (5.96)[a]	1.05 (5.88)[a]
FYM + SSB + *Azospirillum* + Phosphobacteri + Pungam cake	12.5 t ha^{-1} +2 kg ha^{-1} + 2 kg ha^{-1} + 2 kg ha^{-1} + 400 kg ha^{-1}	1.35 (6.67)[b]	1.77 (7.64)[c]
Compost + NPK	12.5 t ha^{-1} ^ 150:100:50 kg ha^{-1}	5.80 (13.93)*	5.26 (13.25)*
FYM + NPK	12.5 t ha^{-1}+150:100:50 kg ha^{-1}	4.86 (12.73)[h]	4.20 (11.82)[h]
Compost	12.5 t ha^{-1}	5.10 (13.05)'	4.66 (12.46)[i]
FYM	12.5 t ha^{-1}	4.26 (11.91)[g]	3.54 (10.84)[g]
NPK	150:100:50 kg ha^{-1}	7.53 (15.92)[k]	8.43 (16.87)'
Untreated check	-	7.62 (16.02)[k]	8.16 (16.59)[k]

*Mean of three replications.
**DAT - Days after transplanting.
Values in parentheses are *arc sine* transformed.
Means followed by same letter(s) are not significantly different (p= 0.05) by DMRT.

thuringiensis (Bt), spinosad and *Pseudomonas florescens* application in pot culture experiment to ascertain their use in eco-friendly pest management strategy and their safety to egg papsitoid, *Trichogramma chilonis* Ishii.

Materials and methods

The materials used and methods followed in the pot culture experiment in the use of neem seed kernel extract with other botanicals, biopesticides *viz.*, *Ha*NPV, *Bacillus thuringiensis*, *Saccaropolyspora spinosa*, *Pseudomonas florescens* and organic amendments for the management of tomato fruit borer are described below.

Organic manures and biofertilizers

The organic manures *viz.*, compost, farm yard manure (FYM) and cakes of neem, castor, mahua and pungam were obtained from the Central Farm Unit of Agricultural College and Research Institute, Madurai. The biofertilizers *viz.*, Silicate Solubilizing Bacteria (SSB), *Azospirillum*, and *Phosphobacterium* were obtained from the Department of Agricultural Microbiology, Agricultural College and Research Institute, Madurai.

Plant materials

Three plant species *viz.*, neem *(Azadirachta indica* A.Juss), pungam *(Pongamia glabra* Vent.) and sweet-flag *(Acorus calamus* Linn.) had been chosen for this study and the extracts were prepared, formulated and used for evaluation. Seeds of neem and pungam were collected from farm premises of Agricultural College and Research Institute, Madurai. The rhizomes of sweet-flag were obtained from local market. The extracts of seed kernels and rhizomes were prepared using ethanol as solvent and formulations were made in mixtures in the following procedure. Seed kernels/rhizomes were ground to fine powder in an electric grinder. One hundred gram of seed kernel/rhizome powder was stirred with 500 ml of ethanol for 3 hours using a magnetic stirrer and filtered through Whatman No. 1 filter paper. The marc was restirred with 500 ml of ethanol in a distillation unit at 50 ^{o}C under reduced pressure. The extract was formulated to 60 EC using an suitable organic solvent and an emulsifier at 30 % and 10 %, respectively (patent applied). The mixtures were prepared @ Neem + Sweet-flag + Pungam (NSP) 60 EC in 1:1:1 (v/ v) and Neem + Sweet-flag (NS) 60 EC in 2:1 (v/ v) from the extracts and formulated.

Biopesticides

H. armigera Nucleo Polyhedro Virus (HaNPV) was obtained from the Biocontrol unit of the Department of Agricultural Entomology, AC & RI, Madurai. It was used in 1.5 x 10^{12} POBs/ha to evaluate the efficacy against *H. armigera*. Commercial formulation of *Bacillus thuringiensis* var *galleriae:* Spicturin® was used @ 15000 IU/mg (2 lit/ha) to test the efficacy against *H. armigera*. Commercial formulation of spinosad: Success® was supplied by M/S E. I. D Parry Agro Chemicals Ltd, Chennai. Spinosad used @ 75 g a.i./ha to test against *H. armigera.* A talc based *Pseudomonas florescens (Pf* 1) was obtained from the Department of Plant Pathology, Tamil Nadu Agricultural University (TNAU), Coimbatore. It was used at different concentrations for seed treatment and foliar spray to evaluate its efficacy against *H. armigera* in both laboratory, pot culture and field experiments.

Mass culturing of H.armigera

Nucleus culture of *H. armigera* was obtained from the Biocontrol Laboratory, TNAU, Coimbatore for breeding and egg laying. The larvae were reared individually in multicavity trays (25 x 10 x 3 cm) using modified semi-synthetic diet developed by

Table 2. Influence of botanicals and biopesticides on parasitization by *Trichogramma* on *H. armigera* eggs

Treatment	Concentration	Average No.of eggs laid in 24h/9 females#	No.of parasitized eggs#	* Per cent parasitism
NSP	0.12%	21.6 (4.64)^{cd}	19.0 (4.4 l)^{e}	90.2 (71.75)^{a}
NSP	0.18%	20.0 (4.51)^{cd}	16.3 (4.09)^{f}	82.35 (65.15)^{d}
NS	0.12%	26.0 (5.10)^{e}	24.0 (4.89)^{d}	90.0 (71.43)^{a}
Neem oil	3%	15.0 (3.87)^{a}	11.0 (3.27)^{h}	77.32 (58.56)^{e}
NSKE + *Bt*	5% +15000 IU / mg (2 lit/ha)	40.0 (6.36)^{g}	35.0 (5.94)^{b}	87.4 (69.2 l)^{b}
NSKE + *Ha*NPV	5%+1.5x 10^{12} POBs/ha	32.0 (5.66)^{f}	29.0 (5.39)^{c}	90.7 (72.24)^{a}
NSKE + Spinosad	5% + 75 g a.i. / ha	17.0 (4.17)^{b}	15.0 (3.87)^{8}	86.2 (68.19)^{bc}
Endosulfan	0.07%	32.0 (5.69)^{f}	28.0 (5.36)^{c}	88.9 (70.54)^{b}
Untreated check	-	44.0 (7.03)^{h}	44.0 (6.64)^{a}	90.1 (71.62)^{a}

* Values in parentheses are *arc sine* transformed.

\# Values in parentheses are square root transformed.
Mean of three replications.

Means followed by the same letter(s) are not significantly different (p= 0.05) by DMRT.

Shorey and Hale (1965) under 25 ±1° C and 75-80 per cent relative humidity (Sathiah *et al.,* 1998). The pupae from parental colony were kept in a 30 x 30 cm adult emergence cage for eclosion. Adults are stout bodied moth typical noctuid appearance, 14-18 mm long and color variable but male usually greenish-grey and females orange brown. Ten pairs of healthy adults were transferred to oviposition cage. A solution containing 10 per cent sucrose fortified with vitamins was provided in the cage as food for adults. The oviposition cage consisted of a mud pot, which was kept in a round plastic tray containing wet sand. The mouth of the mud pot was covered by black cloth, which served as the oviposition substrate. Oviposition substrate and adult food were replaced and replenished daily. The bits of muslin cloth containing yellowish-white eggs were collected and labeled properly and were kept inside plastic bucket (20 cm dia.). To eliminate the microbial contaminants, 24 h old egg clothes were submerged in a 10 % formaldehyde solution for 10 minutes. Clothes were shade dried after washing in tap water for 20 minutes to remove the excess of formaldehyde. Newly hatched larvae were transferred to diet trays and third instar larvae were released into multi cavity trays till larvae attained pupal stage. Pupae (mahogany brown, 14-18 mm long and two tapering parallel spines at posterior tip) were washed in sodium hypochloride 0.25 % solution and kept in adult emergence cage. The adults emerged from this cage

Table 3. Biochemical changes in tomato due to seed treatment of *Pseudomonas florescens*

Dose of *Pf* 1 (g/kg of seed)	5 DAST			10 DAST			20 DAST			30 DAST		
	Phenol	Peroxidase	PAL	Phenol	Peroxidase	PAL	Phenol	Peroxidase	PAL	Phenol	Peroxidase	PAL
10	285.3	0.018	417.3	294.0	0.018	426.3	320.5	0.024	438.0	308.1	0.0201	430.5
15	440.1	0.021	516.0	474.3	0.024	525.0	496.2	0.0282	537.0	474.3	0.024	524.1
20	588.6	0.027	622.2	619.5	0.0321	630.3	644.4	0.0351	645.0	624.6	0.0261	624.0
25	634.5	0.033	698.1	648.3	0.0345	714.0	664.1	0.0381	724.2	664.5	0.0321	720.3
30	744.0	0.045	748.5	753.0	0.0441	756.6	756.0	0.048	786.3	752.1	0.0442	780.6
Untreated check	216.0	0.012	388.2	225.0	0.0135	402.0	228.0	0.0141	414.0	224.4	0.012	411.03

1 Mean of three replications.
1 Phenol (µg/g).
1 Peroxidase (n.mol/min/g).
1 PAL - Phenyl alanine ammonialyase (n.mol/min/g).
1 DAST - Days after seed treatment.

were utilized for further maintenance of culture.

Pot culture experiments

Organic amendments

The pot culture trial was conducted in a CRBD with PKM 1 tomato variety and plants were maintained carefully. The details of the treatments are given in the respective results table. All the potted plants were kept inside the screen house. On 20 days after the treatment (DAT), 20 pairs of freshly emerged *H. armigera* adults were released as free choice for them. On 30 DAT and 45 DAT infestation of *H. armigera* was assessed and expressed as per cent damage.

Parasitization by Trichogramma chilonis

The potted and caged tomato plants were sprayed with test concentrations of of the botanical and biopesticides as given in the respective table under results. Freshly emerged *H. armigera* adults were released at the rate of one pair per plant for oviposition. Third day after releasing of adults, *Trichogramma chilonis* card (Tricho^{R} cards) was stapled to plants for parasitization of eggs. Fourth day after release, percentage of parasitization was recorded.

Percentage parasitization =

$$\frac{\text{No.of eggs parasitized by } T.chilonis}{\text{Total no.of eggs per plant}} \times 100$$

Seed treatment of Pseudomonas florescens (Pf1)

Tomato seeds (variety PKM 1) were treated with *Pseudomonas florescens (Pfl)* @ 10, 15, 20, 25, and 30 g / kg of seeds. Each treatment was replicated

three times. Treated seeds were sown in pots. Seedlings were transplanted into individual pots 30 days after sowing. Leaf samples were collected 5, 10, 20, and 30 days after transplanting for biochemical analyses *viz.*, phenol, peroxidase, and phenylalanine ammonia lyase (PAL) contents were estimated as suggested by Malick and Singh (1980) and Sadasivam and Manickam (1996).

Foliar spray of Pseudomonas florescens (Pfl) against H.armigera

Healthy potted 45-days-old tomato plants were sprayed with the *Pseudomonas florescens (Pfl*) with help of a hand atomizer @ 1.0, 2.5, 5.0, 7.5 and 10 g/litre concentrations. Each treatment was replicated thrice. Leaf samples were collected individually from pre-spraying and 5^{th}, 10^{th}, 20^{th}, and 30^{th} days after spraying (DAS). The leaf samples were collected and subjected to biochemical analyses *viz.*, phenol, peroxidase, and phenylalanine ammonia lyase (PAL) contents were estimated as suggested by Malick and Singh (1980) and Sadasivam and Manickam (1996).

Results

Effect of organic amendments on H. armigera infestation

On 30 DAT, per cent damage by *H. armigera* on pot cultured tomato plants was low in FYM +SSB + *Azospirillum* + *Phosphobacteria* + neem cake applied plants (1.08%), and followed by in FYM +SSB + *Azospirillum* + *Phosphobacteria* + pungam cake applied plants (1.35%) compared to untreated check (7.62%). At 45DAT, application of FYM +SSB + *Azospirillum* + *Phosphobacteria* + neem cake recorded the lowest level of 1.05 per cent followed by FYM +SSB + *Azospirillum* + *Phosphobacteria* + mahua cake (1.26%), which was significantly on par with in FYM +SSB + *Azospirillum* + *Phosphobacteria* + pungam cake applied plants (Table 1).

Trichogramma parasitization on eggs of H. armigera

The lowest number of eggs was laid in Neem oil 3% (15.00) and followed by NSKE + Spinosad (17.00) (Table 2). Lowest percentage of parasitism by *Trichogramma* on eggs of *Helicoverpa* was recorded in Neem oil 3% (77.32%) followed by NSKE + Spinosad (86.20%) compared to untreated check (90 %).

Biochemical changes in tomato plants due to seed treatment of Pseudomonas florescens

On 5 DAST, phenol content (744.0 µg/g), peroxidase (0.045 n.mol/min/g) and PAL (748.5 n.mol/min/g) in *Pfl* (30g/kg of seed) compared to untreated check 216.0 µg/g, 0.012 n.mol/min/g and 388.2 n.mol/min/g of phenol, peroxidase and PAL, respectively (Table 3). On 10 DAST phenol, peroxidase and PAL activities considerably increased in all treatments. Phenol content ranged from 225 to 753 µg/g, peroxidase 0.0135 to 0.0441 n.mol/min/g and PAL 402.0 to 756.6 n.mol/min/g. On 20DAST, *Pfl* (30g/kg of seed) showed the highest amount of phenol, peroxidase and PAL contents of 756.0 µg/g, 0.048 n.mol/min/g, 786.3 n.mol/min/g respectively compared to untreated check phenol (228.0 µg/g), peroxidase (0.014 n.mol/min/g)and PAL (414.0 n.mol/min/g). On 30 DAST phenol, peroxidae and PAL activity were significantly reduced in all treatments. Highest amount of phenol (752.1 µg/g), peroxidase (0.044 n.mol/min/g) and PAL (780.6 n.mol/min/g) compared to untreated check.

Biochemical changes in tomato plants due to foliar spray of Pseudomonas florescens

Table 4 shows that the phenol content was in the range of 250.2 to 258.6 µg/g, peroxidase ranged between 0.015 to 0.018 n.mol/min/g and PAL ranged from 437.1 to 445.5 n.mol/min/g before spraying. On 5DAS, sudden increase of phenol, peroxidase and PAL was recorded with corresponding values of 636 µg/g, 0.048 n.mol/min/g and 1516 n.mol/min/g respectively in *Pfl* (10 g/ lit of water). Followed by 7.5 g/lit of water 518.1 µg/g, 0.045 n.mol/min/g, and 1016.2 n.mol/min/g of phenol, peroxidase and PAL respectively. On 10DAS, phenol content ranged from 253.5 to 648.03 µg/g, peroxidase (0.0183 to 0.052 n.mol/min/g) and PAL (436.2 to 1538.4 n.mol/min/g). On 20DAS, phenol content was 702.6 µg/g, peroxidase (0.0582 n.mol/min/g) and PAL (1596.3 n.mol/min/ g) in *Pfl* (10 g/lit of water) compared to untreated check where phenol content peroxidase and PAL values were 255.0 µg/g, 0.024 n.mol/ min/g and 438.0 n.mol/min/g respectively. On 30DAS, phenol, peroxidase and PAL content were significantly reduced in all treatments compared to 5, 10, 20 DAS. Higher range of phenol (696 µg/g), peroxidase (0.0552 n.mol/min/g) and PAL (1590.3 n.mol/min/ g) were estimated compared to untreated check 255.0 µg/g, 0.024 n.mol/min/g, and 432.3 n.mol/min/g of phenol, peroxidase and PAL respectively.

Discussion

Effect of organic amendments on H. armigera infestation in pot cultured tomato

In the present investigation, it was found that FYM + SSB + *Azospirillum* + *Phosphobacteria* + Neem cake applied plants recorded lower percentage of *H. armigera* infestation on 30 DAT and 45 DAT. The effect noticed might either be due to lack of nutrients or due to the presence of toxic substances in FYM + SSB + *Azospirillum* + *Phosphobacteria* + Neem cake treated plants. The biochemical factors such as physiological inhibitors and nutritional deficiencies might be associated with resistance of plants to insects. *Rhizobium* and *Phosphobacteria* had significant effect in reducing larval feeding (Ramakrishnan *et al.,* 1987). The organic sources *viz.,* FYM, compost, neem cake, pungam, mahua, castor cakes were significantly superior and recorded lower fruit borer infestation than mineral fertilizer (NPK) (Chaudary and Kashyap, 1987) on cotton boll worms; Rao *et al.* (1998) on chilli pod borer. Dayakar *et al.* (1995) recorded the lowest pod borer population on pigeon pea when FYM was effective in bringing down the population of fruit borer on bhendi. Also neem cake application in soil inhibited the development and population buildup of rice stem borers after transplantation. Mallik and Lai (1989) reported that deoiled neem cake application @ 5kg/plot reduced the incidence of fruit borer *E. vitella* on bhendi. Gour (1984) reasoned that the higher polyphenol content in organic manure treated plants would have resulted possibly in the low pest build up. Present results are in line with the above findings.

Influence of botanical mixtures and biopesticides on parasitization by Trichogramma on H. armigera eggs

The safety aspects of botanicals and biopesticides to non-target organisms had been already studied by several workers (Raguraman and Singh, 1997; Rosaish, 2001). HaNPV was not found pathogenic to *T. chilonis* (Balasubramanian *et al.,* 2001). Spicturin® and Delfin® were safe to *T. chilonis* and *T. australicum* in terms of adult emergence

Table 4. Biochemical changes in tomato due to foliar spray *of Pseudomonas florescens*

Dose of *Pfl* (g/litre of water)	Pre spraying			5 DAS			10 DAS			20 DAS		
	Phenol	Peroxidase	PAL	Phenol	Peroxidase	PAL	Phenol	Peroxidase	PAL	Phenol	Peroxidase	PAL
1.0	255.3	0.015	437.1	340.5	0.018	528.5	352.0	0.0195	554.7	365.1	0.027	567.0
2.5	258.6	0.018	439.2	396.3	0.024	612.0	404.1	0.0291	618.3	448.5	0.042	684.3
5.0	256.2	0.0172	440.2	428.6	0.033	828.1	432.0	0.033	828.6	458.4	0.045	848.7
7.5	257.2	0.018	435.0	518.1	0.045	1016.2	528.1	0.045	1024.5	546.0	0.048	1046.4
10.0	258.0	0.0184	445.5	636.0	0.048	1516.2	648.03	0.052	1538.4	702.6	0.0582	1596.3
Untreated check	250.2	0.018	144.66	252.0	0.018	435.0	253.5	0.0183	436.2	255.0	0.024	438.0

- Mean of three replications.
- Phenol (µg/g).
- Peroxidase (n.mol/min/g).
- PAL - Phenyl alanine ammonialyase (n.mol/min/g).
- DAS -Days after spray.

(88-90%) and per cent parasitization (88-90%) from treated cards (Loganthan *et al.,* 1999). Subbulakshmi (2001) reported that Spinosad at 0.05, 0.10 and 0.15 per cent was safer to *T. chilonis* recording more than 50 per cent parasitization. In the present study, among the mixtures of botanicals and biopesticides evaluated neem oil 3% recorded 77.32 per cent of parasitism compared to check (90%). The present findings are in conformity with findings of Raguraman and Singh (1999) who reported the contact toxicity of neem oil 4% to the adults *T. chilonis*, which resulted up to fifty per cent mortality and reduced the percentage of parasitization.

Induced systemic resistance through foliar spray and seed treatment of Pseudomonas florescens against H. armigera

P. florescens influences the growth and development of insects at all stages of their growth. *P. maltophi* affects the growth of larval stage of *H. zea,* leading to reduced adult emergence, (Bong and Sikorowski, 1991). In the present study, among the various doses of *Pseudomonas florescens* used as foliar spray and seed treatment the doses of 10 g/lit of water and 30 g/kg of seed recorded higher amount of biochemical compounds like phenol, peroxidase, and PAL which increased gradually upto 20 days after spraying. After 20th day decreasing trend of these compounds was observed. The

present findings are comparable with findings of Thangavelu *et al.* (2003).

Conclusion

It is concluded that the Nature holds the key for many problems of insect pest management. Organic amendments to tomato, in general, improved the plant capacity to naturally resist the attack by *H. armigera*, the pest which had developed many fold resistance to commonly recommended synthetic insecticides. In addition to organic amendments in the soil, other naturally occurring insecticidal principles of plant origin insecticides especially neem with pungam and sweet-flag extracts or its formulation and in combination with *Bt*, *Ha*NPV, and spinosad should give desired control of *H. armigera* at field level. However, a marginal safety period is suggested while using the botanicals along with release of *Trichogramma* parasitoid to avoid even minor ill effects.

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