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Biorational Effects of Organic Manures, Botanicals and Biopesticides against Tomato Fruit Borer, *Helicoverpa armigera* and Its Egg Parasitoid, *Trichogamma chilonis*

K. Sathish, S. Raguraman* and N. Ganapathy
*Department of Agricultural Entomology
Tamil Nadu Agricultural University
Coimbatore - 641 003

Studies were carried out to evaluate biological activity of organic manures against tomato fruit borer, *Helicoverpa armigera* (Hub.) 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 farm yard manure (FYM) + *Azospirillum* + silicate solubilising bacteria (SSB) + *Phosphobacteria* + neem cake applied plants 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 neem seed kernel extract (NSKE 5%) + spinosad 75 g a.i./ha. Under laboratory condition among the microbial pesticide tested Spinosad (75 g a.i./ha), *Ha*NPV + Spinosad + *Bt* (1.5 x10^{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 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 its foliar spray @ 1 g/litre in treated tomato plants.

Key words: Organic manures, botanicals, biopesticides, *H. armigera, T. chilonis*

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 too. 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. Control strategies applied by using synthetic insecticides led to the development of cross and multiple resistances in *H. armigera*. Of several options, organic manures, botanical pesticides and biopesticides are the best alternatives to manage pests below 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 were undertaken to stabilize the neem compounds with other botanicals namely pungam and sweet-flag biopesticides namely *Ha*NPV, *Bacillus thuringiensis* (*Bt)*, spinosad and *Pseudomonas florescens* application in pot culture experiment to ascertain their use in eco-friendly pest management and their safety to egg parasitoid, *Trichogramma chilonis* Ishii.

Materials and Methods

Organic Manures and Biofertilizers

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, Tamil Nadu. The biofertilizers *viz*., Silicate solubilizing bacteria (SSB), *Azospirillum*, and *Phospho*

*Corresponding author email: raguraman99@gmail.com

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

Treatment	Dose	Fruit damage (%)* 30 DAT**	Fruit damage (%)* 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* + Phosphobacteria + 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)^{j}	5.26 (13.25)^{j}
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)^{i}	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)^{l}
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.

bacteria were obtained from the Department of Agricultural Microbiology, Agricultural College and Research Institute, Madurai.

Plant Materials

Neem (*Azadirachta indica* A.Juss), pungam (*Pongamia glabra* Vent.) and sweet-flag (*Acorus calamus* Linn.) 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. Rhizomes of sweet-flag were obtained from local market. Extracts of seed kernels and rhizomes were prepared using ethanol as solvent and formulations were made in mixtures by 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° C under reduced pressure. The extract was formulated to 60 EC using a 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.

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

Treatment	Concentration	Average No. of eggs laid in 24h/10 females#	No. of parasitized eggs#	*Per cent parasitism
NSP	0.12%	21.6 (4.64)cd	19.0 (4.41)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 (69.21)b
NSKE + *Ha*NPV	5% +1.5 x 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)g	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.

Biopesticides

H. armigera Nucleo Polyhedro Virus (*Ha*NPV) was obtained from the Biocontrol Unit of the Department of Agricultural Entomology, AC & RI, Madurai. It was used at 1.5 x 10^{12} POBs/ha. Commercial formulation of *Bacillus thuringiensis* var *galleriae* (Spicturin®) was used @ 15000 IU/ mg (2 lit/ha). Commercial formulation of spinosad (Success®) supplied by M/S E. I. D Parry Agro Chemicals Ltd, Chennai was used @ 75 g a.i./ha. 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. Larvae were reared individually in multicavity trays (25 x 10 x 3 cm) using modified semi-synthetic diet developed by Shorey and Hale (1965) under 25 ±1° C and 75-80 per cent relative humidity (Sathiah *et al.,* 1998). Pupae from parental colony were kept in a 30 x 30 cm adult emergence cage. Adults are stout bodied moth typical noctuid appearance, 14-18 mm long and males are 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. Oviposition cage consisted of a mudpot kept in a round plastic tray containing wet sand.

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

Dose of *Pf* 1(g/kg of seed)	35 DAT*			40 DAT			50 DAT			60 DAT		
	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

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

The mouth of the mud pot was covered with 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 kept inside plastic bucket (20 cm dia.). To eliminate microbial contaminants, 24 h old egg clothes were submerged in 10 % formaldehyde solution for 10 minutes. Clothes were shade dried after washing in tap water for 20 minutes to remove excess 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 were washed in sodium hypochloride 0.25 % solution and kept in adult emergence cage. Adults emerged from this cage were utilized for further maintenance of culture.

Pot Culture Experiments

Organic Manures

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 Table 1. 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 releasedinside screen house as free choice test. 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 botanicals and biopesticides as given in the respective Tables. 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 by discolouration of eggs.

$$\text{Parasitization (\%)} = \frac{\text{No. of eggs parasitized by T.}\textit{chilonis}}{\text{Total no.of eggs per plant}} \times 100$$

Seed Treatment of Pseudomonas florescens (Pf 1)

Tomato seeds (variety PKM 1) were treated with *Pf 1* @ 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. 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 Pf 1 against H. armigera

Healthy potted 45-days-old tomato plants were sprayed with *Pf* 1 using a hand atomizer @ 1.0, 2.5, 5.0, 7.5 and 10 g/litre**.** Each treatment was replicated thrice. Leaf samples were collected individually from pre-spraying and 5th, 10th, 20th, and 30th days after spraying (DAS). Leaf samples were subjected to biochemical analyses. 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 Manures on H. armigera

On 30DAT, 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 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 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) followed by NSKE 5% + 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 Pf 1

On 5 days after seed treatment (DAST), phenol content (744.0 µg/g), peroxidase (0.045 n.mol/min/g) and PAL (748.5 n.mol/min/g) in *Pf* 1 (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 20 DAST, *Pf* 1 (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 with phenol (228.0 µg/g), peroxidase (0.014 n.mol/min/g)and PAL (414.0 n.mol/min/g). On 30 DAST phenol, peroxidase 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 Pf 1

Table 4 shows that the phenol content was in the range of 250.2 µg/g to 258.6 /g, peroxidase content ranged from 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 5 DAS, 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 *Pf*1 (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 *Pf* 1 (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 30-DAS, 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

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 may either be due to lack of nutrients or due to the presence of toxic substances. Biochemical factors such as physiological inhibitors and nutritional deficiencies may be associated with resistance of plants to insects. *Rhizobium* and *Phosphobacteria* had significant effect in reducing larval feeding of *H. armigera* on pigeon pea pods (Ramakrishnan *et al.,* 1987). Organic sources *viz*., FYM, compost, neem cake, pungam, mahua, castor cakes were significantly superior and recorded lower infestation than mineral fertilizers (NPK) on cotton boll worms(Chaudary and Kashyap, 1987) and chilli pod borer (Rao *et al.* 1998). Dayakar *et al.* (1995) recorded the lowest pod borer population on pigeon pea when FYM was applied. Mallik and Lal (1989) reported that deoiled neem cake application @ 5kg/plot reduced the incidence of fruit borer *E. vitella* on bhendi. Gour (1984) reasoned that higher polyphenol content in organic manure treated plants would have resulted possibly in low pest build up. Present results are in line with the above findings.

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

Dose of *Pf* 1 (gL^{-1})	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 spraying

The safety aspects of botanicals and biopesticides to non-target organisms had been already studied by several workers (Raguraman and Singh, 1997; Rosaiah, 2001). *Ha*NPV was not pathogenic to *T. chilonis* (Balasubramanian *et al.,* 2001). Spicturin® and Delfin® were safe to *T. chilonis* and *T. australicum* in terms of adult emergence (88-90%) and per cent parasitization (88-90%) from treated cards. 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 adults *T. chilonis*, which resulted up to fifty per cent mortality and reduced the percentage of parasitization.

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).

It is concluded that the Nature holds the key for many problems of insect pest management. Organic manures 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 manures 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 can offer desired control of *H. armigera* at field level. However, a marginal safety period is suggested while using botanicals along with release of *Trichogramma* parasitoid to avoid even minor ill effects.

Reference

Balasubramanian, G., Sundarababu, P.C. and Manjula, T.R. 2001. Efficacy of *Bacillus thuringiensis* var *galleriae* formulation (Spicturin®) against *Helicoverpa armigera* (Hub) on chickpea (*Cicer arietinum* L.). *Madras Agric. J.,* **88:** 336-338.

Bong, C.F.G. and Sikorowski, P.P. 1991. Effects of cytoplamic polyhedrosis virus and bacterial contamination on growth and development of the corn earworm, *Helicoverpa zea*. *J. Invert. Pathol*. **57**: 406-412.

Chaudary, O.P. and Kashyap, R.K. 1987. Field fertilization *vis-a-vis* incidence of insect pest complex and marketable yield in egg plant, *Solanum melangena*. *Italino di Entomologica,* **3:** 413-420.

Dayakar, S., Rao, P.A. and. Rao, K.T. 1995. Effect of organic and inorganic sources of N and P and certain insecticides on the buildup of podborer on pigeonpea. *Andhra Agric. J.,* **42:** 14-17.

Gour, A.C. 1984. Responseof rice to organic matter. In *The Indian Experience in Organic Matter and Rice*. IRRI, Los Banos, Laguna, Philippines, p. 503-504.

Mallik, S.N. and Lal, I.B. 1989. Efficacy of neem oil cake and fertilizer mixture against okra fruit borer*. Pestology,* **13:** 6-7.

Mallick, C.P. and Singh, M.B. 1980. *Plant Enzymology and Histo-Enzymology*. Kalyani Publishers. New Delhi, p. 286.

Raguraman, S. and Singh, R.P. 1997. Biopotentials of *Azadirachta indica* A. Juss. and *Cederus deodara* oils on *Callosobruchus chinensis*. *Intl. J. Pharmacognosy,* **35**: 344-348.

Raguraman, S. and Singh, R.P. 1999. Biological effect of neem (*Azadirachta indica*) seed oil on an egg parasitoid, *Trichogramma chilonis*. *J. Econ. Entomol.,* **2**: 1274-1283.

Ramakrishnan, C., Radhakrishnan, T. and Ramadoss, G. 1987. Effect of nitrogen, *Rhizobium* inoculation and phosphorus level on damage of pigeonpea pods by *Heliothis armigera***.** *Intl. Pigeonpea Newsl.,* **6:** 62.280.

Rao, N.M., Rao, G.M. and Rao, K.T. 1998. Efficacy of neem products and their combinations against chilli podborers. *Andhra Agric. J.,* **45**: 179-181.

Rosaiah, B. 2001. Performance of different botanicals against the pest complex of bhendi. *Pestology,* **25**: 17-19.

Sathiah, N., Kennedy, J.S. and Rabindra, R.J. 1998. Mass production of the gram podborer, *Helicoverpa armigera* (Hubner). In *Emerging Trends in Microbial Control of Crop Pests,* R.J. Rabindra, G. Santharam, N. Sathiah and J.S. Kennedy, (eds.) IARI Publishers, New Delhi, p. 245-285.

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Sadasivam, S. and Manickam, A.1996. *Biochemical Methods.* New Age International Limited, New Delhi and Tamil Nadu Agric. Univ., Coimbatore, p. 246.

Subbulakshmi, K. 2001. Bioefficacy of acetamiprid and spinosad on target pests and safety to non-target organisms in cotton eco-systems. M. Sc. Thesis, Tamil Nadu Agricultural University, Coimbatore.

Thangavelu, R. Palaniswamy, A., Doraiswamy, S and Velazhahan, R. 2003. The effect of *Pseudomonas fluorescens* and *Fusarium oxysporum* f.sp. *cubense* on induction of defense enzymes and phenolics in banana. *Biologia Plantarum*, **46**: 107-112.