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Evaluation of insecticides against *Agrotis segetum* (Denis and Schiffermuller) and *Spoladea recurvalis* (Fabricius) on fenugreek, *Trigoniella foenumgraecum* L

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Abstract
A field experiment was laid out in a randomized block design at the College of Horticulture, University of Horticultural Sciences, Bagalkot, during 2013-14 to study the bio efficacy of different insecticides against *Agrotis segetum* (Denis and Schiffermuller) and *Spoladea* (=*Hymenia*) *recurvalis* (Fabricius) on fenugreek. The experiment consisted of ten treatments, among all the treatments the green labeled or newer molecules *viz.,* emamectin benzoate 5 SG @ 0.25 g/l, indoxacarb 15.8 EC @ 0.25 ml/l and fipronil 5 SC @ 1 ml/l were found very effective in minimizing the larval population and superior in reducing foliage damage throughout the period of experiment and also fetched higher yields 14.14, 14.42 and 14.58 t/ha. The highest incremental cost benefit ratio (30.89) was obtained from the treatment malathion 50 EC @ 2 ml/l.

Keywords: Fenugreek, emamectin benzoate, fipronil, indoxacarb

1. Introduction
Fenugreek (*Trigoniella foenumgraecum* L.) is a self pollinated small seeded annual legume Family: Fabaceae) that is grown as a leafy vegetable, spice and forage crop, also called by the names like *Methi, Menthalu,* Greek hay *etc.* The genus name *Trigonella* means 'tri-angled' may be because of triangular shape of its flowers, whereas the species name *foenum graecum means* Greek hay [14]. The fenugreek leaves are quite rich in iron, protein, minerals and Vitamin A and C which supply dietary fibres. Seeds contain little amount of starch (1.6%), sugar (0.4%), ash (3.2%), protein (3.6%) and oil (6%) but a large amount of dietary fibres (45%). Seeds also contain in small quantities (< 2%) coumarin, diosgenin, saponins and other steroids [5]. These compounds and other constituents give fenugreek products an undesirable taste for some uses. One of the limiting factors in increasing the productivity of leafy vegetables is the damage caused by a wide range of insect pests, in general and defoliators in particular with higher level of losses suffered. Added to this, there is limited research that has been put into enhancing production of leafy vegetables [12]. Fenugreek is reported to be infested by five insects namely alfa alfa weevil, *Hypera postica* Gyllenhal, leaf miner *Liriomyza* sp.[9], (aphid, *Aphis craccivora* Koach [18], blister beetle *Epicauta* sp. [7], cutworm, *Agrotis nigrum* Linn. [1] and a snail, *Cryptozona semirugata* Beck [3]. It is evident from literature that much work has not been done to record the insect pests and their natural enemies in fenugreek ecosystem. Hence the present research was initiated.

2. Materials and Methods
The field experiment was carried out in the Vegetable Science block of Udyanagiri campus of College of Horticulture, UHS, Bagalkot, Karnataka, during summer season of 2014, to evaluate the efficacy of different insecticides, bio-pesticides and botanicals against defoliators on fenugreek. The Local variety of fenugreek was used for this experiment. The package of practices for crop management was followed as prescribed by UHS, Bagalkot [2]. The experiment was laid out in Randomized Block Design consisting of eleven treatments replicated thrice with plot size of 2m X 2m. First spray was given on 25th day after sowing of seeds and second spray on 35th day after sowing by using knapsack sprayer based on damage level. Pre-treatment count of larvae was made prior to the spray. The post treatment counts were made at one, three, five and seven days after each spray.

Observations were made on number of larvae per plant and also the percentage of damage. For recording larval population, ten plants were selected randomly in each treatment and average per plant was worked out. Similarly, percentage of foliage damage was also recorded before and after spray. Data obtained from various studies were subjected to either arc sine or square root transformation as the case may be before suitable statistical analysis using WASP statistical software. Data pertaining to management trial were analyzed by using one way ANOVA and treatment means were separated by using DMRT.

3. Results and Discussion

The larval population was uniform throughout the experimental field as indicated by the ANOVA (F-test) which was not significant. The larval population ranged from 1.10 to 1.63 per plant before spray. The percent foliage damage ranged from 5.67 to 7.00 and there was no significant difference between the treatments (Table 1 & 2).

3.1 First spray

Initially, the extent of mining and number of mines due to *Liriomyza* sp. was taken. The observations recorded one day before and one day after first spray did not indicate any significant differences in the number of mines and percent foliage damage due to serpentine leaf miner (Table 2).

At three days after first spray, indoxacarb 15.8% EC @ 0.25 ml/l of water was found to be superior over all other treatments by recording the 0.33 larvae (*A. segetum* and *S. recurvalis*) per plant and it was at par with fipronil 5% SC @ 1.0 ml/l and emamectin benzoate 5% SG @ 0.25 g/l (0.40 and 0.43 larvae/plant, respectively). *Beauveria bassiana* and azadirachtin (0.63 larvae/plant) were significantly superior over untreated control with maximum number of larval population (1.03 larvae/plant) (Table 1).

Least percent foliage damage was recorded in the treatment indoxacarb 15.8% EC @ 0.25 l of water (4.33%) and it was statistically superior over all other treatments. Next best treatments in the rank were fipronil 5% SC @ 1 ml/ l (6.67%) and emamectin benzoate 5% SG @ 0.25 g/l, malathion 50% EC @ 2 ml/l of water and deltamethrin 2.8% EC @ 0.5 ml/l (7.00, 8.33 & 8.33% damage/plant). Whereas, dilchlorvas 76% EC @ 0.5 ml/ l (11.33%) was on par with untreated control recording 13.00 percent foliage damage (Table 2).

At five days after first spray, significantly less larval population was recorded in indoxacarb 15.8% EC @ 0.25 ml/l (0.57 larvae/plant) than other treatments. Next best treatment in the rank was fipronil 5% SC @ 1 ml/l recorded 0.73 larvae per plant and this treatment was at par with dichlorvas 76% EC @ 0.50 ml/l, emamectin benzoate 5% SG @ 0.25 g/l, deltamethrin 2.8% EC @ 0.5 ml/l and *Bacillus thuringensis* 2 g/l of water (0.90, 1.10, 1.10 and 1.07 larvae/plant, respectively). Maximum number of larval population was recorded in untreated control (1.50 larvae/plant).

With respect to the percent foliage damage, indoxacarb 15.8% EC @ 0.25 ml/l recorded least 7.67 percent foliage damage and it was at par with malathion 50% EC @ 2.00 ml/l of water and *Beauveria bassiana* at 2.0 g/l (11.00%). Whereas, NSKE 5% @ 50 g/l recorded 14.33 percent foliage damage per plant and it was on par with dichlorvas 76% EC @ 2 ml/l and deltamethrin 2.8% EC @ 0.5 ml/l (12.33 and 13.67% damage/plant, respectively).

Again, at seven days after first spray, indoxacarb 15.8 EC @ 0.25 ml/l was found to be superior treatment recording 0.63 larvae per plant and it was at par with deltamethrin 2.8% EC @ 0.5 ml/l, azadirachtin 1500 ppm @ 3 ml/l, NSKE 5% @ 50 g/l, emamectin benzoate 5% SG @ 0.25 g/l and fipronil 5% SC @ 1 ml/l (0.83, 0.90, 0.90, 0.93, 0.97 and 1.07 larvae per plant, respectively). Biopesticides, *Bacillus thuringensis* @ 2.0 g/l of water and *Beauveria bassiana* @ 2.0 g/l recorded maximum number of larvae (1.23 and 1.17 larvae/plant, respectively).

Very interestingly, at seven days after first spray, botanical azadirachtin 1500 ppm at 3 ml/l was found to be superior over all other treatments with 7.00 percent foliage damage on par with indoxacarb 15.8 EC @ 0.25 ml/l, fipronil 5% SC @ 1 ml/l, *Beauveria bassiana* @ 2.0 g/l, deltamethrin 2.8 EC @ 0.5 ml/l and malathion 50 EC @ 0.5 ml/l (8.33, 8.67, 11.00, 11.33% foliage damage, respectively). Whereas, maximum percent foliage damage was noticed in dichlorvas 76 EC @ 0.50 ml/l (12.33%) at par with emamectin benzoate 5% SG @ 0.25 g/l, *Bacillus thurigensis* 2 g/l and NSKE 5% @ 50 g/l (12.00 and 11.33% foliage damage, respectively).

3.2 Second spray

On the first day after second spray, indoxacarb 15.8% EC @ 0.25 ml/l of water was superior by recording 0.40 larvae per plant, followed by fipronil 5% SC @ 1.0 ml/l, azadirachtin 1500 ppm @ 3.00 ml/l (0.57 larvae/plant). These treatments were at par with dichlorvas 76% EC @ 0.5 ml/l, *Bacillus thuringiensis* @ 2 g/l, *Beauveria bassiana* @ 2 g/l, emamectin benzoate @ 5% SG @ 0.25 g/l, deltamethrin 2.8 EC 0.50 ml/l and malathion 50 EC @ 2 ml/l (0.67, 0.70, 0.73, 0.73, 0.73, 0.80 number/plant, respectively). Maximum larval population was recorded in untreated control (1.33 larvae/plant) which was on par with NSKE 5% @ 50 g/l (0.97 larvae/plant) (Table 1). Indoxacarb 15.8% EC @ 0.25 ml/l recorded 4.33 percent of foliage damage per plant and it was at par with azadirachtin 1500 ppm @ 3 ml/l, fipronil 5% SC @ 1 ml/l, emamectin benzoate 5% SG @ 0.25 g/l and *Beauveria bassiana* @ 2 g/l (7.00, 7.33, 7.33 and 7.67% damage/plant, respectively). Whereas, highest percent foliage damage was recorded in both the treatments *Bacillus thuringensis* @ 2 g/l and malathion 50% EC@ 2 ml/l (10.67% foliage damage) and these treatments were on par with NSKE 5% @ 50 g/l and dichlorvas 76% EC @ 0.5 ml/l (9.67 and 9.33% foliage damage, respectively) (Table 2).

Again at three days after spray, indoxacarb 15.8 EC @ 0.25 ml/l recorded 0.43 larvae per plant and it was significantly superior over other treatments. Next best treatments in the rank were fipronil 5% SC @ 1 ml/l recorded (0.60 larvae/plant) and malathion 50% EC @ 2 ml/l, dichlorvas 76% EC @ 0.5 ml/l, azadirachtin 1500 ppm @ 3 ml/l and deltamethrin 2.8% EC @ 0.5 ml/l (0.70, 0.73, 0.80, 0.80 and 0.87 larvae/plant, respectively). Emamectin benzoate 5% SG @ 0.25 g/l and *Beauveria bassiana* @ 2 g/l recorded maximum of 0.90 larvae per plant and were on par with NSKE 5% @ 50 g/l of water (0.87 larvae/plant). Least percent of foliage damage of 5.67 was recorded in the treatment indoxacarb 15.8% EC @ 0.25 ml/l, followed by fipronil 5% SC @ 1 ml/l of water (8.00%) malathion 50% EC @ 2 ml/l of water, azadirachtin 1500 ppm @ 2 ml/l and *Beauveria bassiana* @ 2 g/l (9.00, 9.33 and 9.67% foliage damage, respectively). Significantly maximum percent foliage damage was recorded in *Bacillus thuringensis* @ 2.00 g/l (12.67%) and it was on par with emamectin benzoate 5% SG @ 0.25 g/l (12.33%).

At five days after second spray, among the different insecticides evaluated against defoliators on fenugreek, emamectin benzoate 5% SG @ 0.25 g/l was found to be superior over all other treatments by recording 0.63 larvae per plant. This treatment was at par with indoxacarb 15.8% EC @ 0.25 ml/l, azadirachtin 1500 ppm @ 3 ml/l, *Bacillus thuringensis* @ 2 g/l, dichlorvas 76 EC @ 2 ml/l and deltamethrin 2.8% EC @ 0.5 ml/l (0.73, 0.73, 0.83, 0.90 and 1.03 larvae/plant, respectively). Other than untreated control, maximum of 1.20 larvae per plant was recorded in the treatment NSKE 5% @ 50 g/l of water and it was on par with *Beauveria bassiana* @ 2 g/l of water (1.17larvae/plant). Plants treated with indoxacarb 15.8% EC @ 0.25 ml/l recorded 8.33 percent foliage damage and this treatment was significantly superior over all other treatments but at par with fipronil 5% SC @ 1 ml/l, emamectin benzoate 5% SG @ 0.25 ml/l, malathion 50 EC @ 2 ml/l and *Beauveria bassiana* 2 g/l with 12.33 percent foliage damage. Whereas, untreated control was recorded 23.33 percent foliage damage.

At seven days after second spray, again indoxacarb 15.8% EC @ 0.25 ml/l was found to be significantly superior over all other treatments by recording 0.77 larvae per plant and it was at par with emamectin benzoate @ 5% SG @ 0.25 g/l, *Bacillus thuringensis* @ 2 g/l and deltamethrin 2.8% EC (0.87, 0.90 and 0.93 larvae/plant, respectively), NSKE 5% @ 50 g/l of water and malathion 50 EC @ 2 ml/l recorded maximum number of 1.23 larvae per plant at par with untreated control (1.50 larvae/plant).

With respect to the percent foliage damage, least damage was recorded in plants treated with indoxacarb 15.8% EC @ 0.25 ml/l (10.67%) and it was at par with fipronil 5% SC @ 1 ml/l of water. Emamectin benzoate 5% SG @ 0.25 g/l, dichlorvas 76% EC @ 0.5 ml/l, *Bacillus thuringensis* @ 2 g/l, *Beauveria bassiana* 2 g/l and malathion 50% EC @ 2 ml/l (12.67, 12.67, 13.00, 13.00, 14.00 and 14.00% foliage damage/plant, respectively). Maximum percent damage was recorded in untreated control (17.33%).

Again in the present investigation, at seven days after second spray, azadirachtin 1500 ppm @ 3 ml/l and *Bacillus thuringiensis* @ 2 g/l and *Beauveria bassiania* 2 g/l, were found to be the superior treatments in reducing the larval population of defoliators significantly on fenugreek over untreated control and but these treatments were on par with new molecules of insecticides. Earlier also, Dipel (*Bacillus thuringiensis*) is reported to be effective in controlling pests of fenugreek [16].

Studies were conducted on palak and amaranthus, wherein the effectiveness of indoxacarb, fipronil and emamectin benzoate was proved. [10] [11]. Emamectin benzoate (5% SG at 0.25 g/l**)** acts as chloride channel activator by binding gamma amino butyric acid (GABA) receptor and glutamate-gated chloride channels disrupting nerve signals within arthropods [8]. The stronger binding of GABA increases the cells permeability to chloride ions within the cell due to the hypotonic concentration gradient [17]. Neurotransmission is thereby reduced by subsequent hyperpolarisation and the elimination of signal transduction. While, fipronil (5% SC@1 ml/l) is a broad-spectrum insecticide that disrupts the insect central nervous system by blocking both GABA-gated chloride channels and glutamate-gated chloride (GluCl) channels. This causes hyperexcitation of treated insects' nerves and muscles. [15]. Main mode of action of Indoxacarb (15.8% EC at 0.25 ml) is via blocking of nerve sodium channels [6]. It remains active even after digestion so it can be passed along to other insects through faeces and bait sharing. The primary route of entry is through ingestion of treated foliage, with some additional absorption through the pest cuticle [13, 4].

3.3 Effect of different treatments on foliage yield of fenugreek

Significantly higher foliage yield was obtained in fenugreek from the treatments indoxacarb 15.8% EC@ 0.25 ml/l, fipronil 5% SC @ 1 ml/l and emamectin benzoate 5% SG @ 0.25 g/l (14.14, 14.42 and 14.58 t/ha, respectively). The next best treatments were malathion 50 EC at 2.00 ml/l (11.96 t/ha), dichlorvas 76 EC at 0.50 ml/l (10.44 t/ha), *Beauveria bassiana* at 2 g/l (9.58 t/ha), *Bacillus thuringiensis* at 2.00 g/l of water (9.57 t/ha), azadirachtin 1500 ppm 3 ml/l of water (9.20 t/ha). Lowest foliage yield of 8.81 t/ha was obtained from the treatment deltamethrin 2.8%EC @ 0.5 ml/l which was on par with untreated control (7.57t/ha) (Table 3).

3.4 Economics of management of defoliators on fenugreek

The data on cost of economics of various treatments used in the management of defoliators are presented in the Table 3. Fipronil 5% SC @ 1 ml/l, indoxacarb 15.8 EC at 0.25 ml/ and emamectin benzoate 5% SG at 0.25 g/l recorded maximum additional yield (7.85, 7.01 and 6.83 t/ha, respectively). Other treatments *viz.*, malathion 50% EC at 2.00 ml/l (4.39 t/ha), dichlorvas 76% EC at 0.50 ml/l (2.87 t/ha), *Beauveria bassiana* at 2 g/l (2.01 t/ha), *Bacillus thuringiensis* at 2.00 g/l (2.00 t/ha), NSKE 50 g/l (1.66 t/ha), azadirachtin (1.63 t/ha) and deltamethrin (1.24 t/ha) recorded maximum additional yield over untreated control (Table 3).

The higher gross returns were obtained from the treatment of fipronil (5% SC @ 1 ml / l) indoxacarb (15.8% EC @ 0.25 ml/l) and emamectin benzoate 5% SG @ 0.25 g/l (Rs. 145800, 144200 and 141400 /ha, respectively). Other treatments like malathion 50% EC@ 2 ml/l fetched gross returns of Rs. 119600, dichlorvas Rs. 104400 EC at 0.5 ml/l *Beauveria bassiania* Rs. 95800 *Bacillus thuringiensis* 2.0 g/l Rs. 95700, NSKE 5 percent at 50 g/l Rs. 92300 azadirachtin Rs. 92000 and deltamethrin 2.8 EC at 0.5 ml/l Rs. 88100..

Table 1: Bio-efficacy of different synthetic insecticides, botanicals and bio-pesticides against defoliators* on fenugreek during 2013-14

SI. No.	Treatments	Dosage/ Concn. (g/ml/l)	Day before spray	**Mean number of mines or larvae per plant at different days after spray							
				First spray				Second spray			
				1 DAS ***	3 DAS	5 DAS	7 DAS	1 DAS	3 DAS	5 DAS	7 DAS
T_1	Neem Seed Kernal Extract 5%	50 g/l	1.33 (1.15)	5.40 (2.29)	0.60 (0.78) ^{bc}	1.30 (1.12) ^{ab}	0.93 (0.97) ^{bc}	0.97 (0.97) ^{ab}	0.87 (0.94) ^{b}	1.2 (1.08) ^{b}	1.23 (1.10) ^{ab}
T_2	Azadirachtin (1500 ppm)	3.0 ml/l	1.63 (1.27)	6.10 (2.45)	0.63 (0.79) ^{b}	1.17 (1.09) ^{ab}	0.90 (0.95) ^{bc}	0.57 (0.75) ^{cd}	0.80 (0.89) ^{bc}	0.73 (0.85) ^{bcd}	1.67 (1.07) ^{abc}
T_3	*Bacillus thuringiensis*	2.0 g/ l	1.33 (1.13)	6.80 (2.58)	0.63 (0.79) ^{b}	1.07 (1.02) ^{abc}	1.23 (1.10) ^{b}	0.70 (0.83) ^{bcd}	0.87 (0.92) ^{bc}	0.9 (0.95) ^{bcd}	0.90 (0.95) ^{bcd}
T_4	*Beauveria bassiana*	2.0 g/l	1.33 (1.16)	6.20 (2.49)	0.63 (0.79) ^{b}	1.13 (1.06) ^{ab}	1.17 (1.04) ^{b}	0.73 (0.84) ^{bcd}	0.90 (0.94) ^{b}	1.17 (1.07) ^{b}	1.67 (1.07) ^{abc}
T_5	Deltamethrin 2.8% EC	0.50 ml/l	1.40 (1.19)	5.03 (2.21)	0.57 (0.75) ^{bcd}	1.13 (1.06) ^{ab}	0.83 (0.91) ^{bc}	0.73 (0.85) ^{bc}	0.80 (0.89) ^{bc}	1.03 (1.00) ^{bcd}	0.93 (0.96) ^{bcd}
T_6	Emamectin benzoate 5% SG	0.25 g/l	1.33 (1.24)	6.20 (2.47)	0.43 (0.66) ^{cde}	1.10 (1.02) ^{abc}	0.93 (0.97) ^{bc}	0.73 (0.85) ^{bcd}	0.93 (0.96) ^{b}	0.63 (0.78) ^{d}	0.87 (0.93) ^{cd}
T_7	Indoxacarb 15.8% EC	0.25 ml/l	1.50 (1.22)	5.83 (2.41)	0.33 (0.58) ^{e}	0.57 (0.75) ^{d}	0.63 (0.79) ^{c}	0.40 (0.62) ^{d}	0.43 (0.66) ^{d}	0.73 (0.89) ^{bcd}	0.77 (0.87) ^{d}
T_8	Fipronil 5% SC	1.0 ml/l	1.40 (1.18)	5.80(2.41)	0.40 (0.63) ^{de}	0.73 (0.85) ^{cd}	1.07 (0.99) ^{bc}	0.57 (0.75) ^{cd}	0.60 (0.76) ^{cd}	0.87 (0.82) ^{bc}	1.00 (0.99) ^{ab}
T_9	Dichlorovas 76% EC	0.50 ml/l	1.10 (1.05)	6.27 (2.49)	0.57 (0.75) ^{bcd}	0.90 (0.95) ^{bcd}	0.97 (0.98) ^{bc}	0.67 (0.80) ^{bcd}	0.73 (0.85) ^{bc}	0.83 (0.91) ^{bcd}	1.00 (0.99) ^{ab}
T_{10}	Malathion 50% EC	2.0 ml/l	1.43 (1.24)	4.60 (2.14)	0.67 (0.80) ^{d}	1.10 (1.04) ^{abc}	0.97 (0.98) ^{bc}	0.80 (0.88) ^{bc}	0.70 (0.84) ^{bc}	1.13 (1.05) ^{bc}	1.23 (1.10) ^{ab}
T_{11}	Untreated control	-	1.10 (1.00)	7.73 (2.78)	1.03 (1.012) ^{a}	1.50 (1.22) ^{a}	1.57 (1.37) ^{a}	1.23 (1.10) ^{a}	1.30 (1.13) ^{a}	2.33 (1.52) ^{a}	1.50 (1.22) ^{a}
S. Em±			-	-	0.046	0.070	0.063	0.076	0.054	0.077	0.051
CD= (0.05)			NS	NS	0.139	0.205	0.233	0.229	0.169	0.237	0.163

* *Agrotis segetum* and *Spodalea recurvalis* **DAS: Days after spray ***Mean of three replications NS: Non significant Figures in parenthesis indicate square root transformed values $(\sqrt{(x+0.5)})$ Means followed by the same alphabet (s) are not significantly different (P=0.05)

Table 2: Effect of different synthetic insecticides, botanicals and bio- pesticides on foliage damage by defoliators* on fenugreek during 2013-14

SI. No.	Treatments	Dosage/ Concn. (g/ml/l)	Day before spray	**Mean percent of foliage damage at different days after spray							
				First spray				Second spray			
				1 DAS***	3 DAS	5 DAS	7 DAS	1 DAS	3 DAS	5 DAS	7 DAS
T_1	Neem Seed Kernal Extract 5%	50 g/l	5.67 (13.76)	9.67 (18.10)	9.17 (17.62) ^{bcd}	14.33 (22.05) ^{ab}	11.33 (19.60) ^{b}	9.67 (18.10) ^{ab}	11.00 (19.33) ^{abc}	14.33 (22.11) ^{b}	14.67 (22.50) ^{b}
T_2	Azadirachtin (1500 ppm)	3.0 ml/l	5.00 (12.88)	13.00 (21.07)	9.67 (18.07) ^{bc}	12.00 (20.12) ^{b}	7.00 (15.28) ^{c}	7.00 (15.24) ^{bc}	9.33 (17.75) ^{bc}	15.00 (20.31) ^{b}	15.33 (23.00) ^{b}
T_3	*Bacillus thuringiensis*	2.0 g/ l	7.00 (15.240	12.67 20.56)	10.00 (18.39) ^{bc}	12.00 (20.19) ^{b}	12.00 (20.24) ^{b}	10.67 (18.95) ^{ab}	12.67 (20.83) ^{ab}	15.00 (19.62) ^{b}	13.00 (21.13) ^{bc}
T_4	*Beauveria bassiana*	2.0 g/l	6.73 (14.85)	16.00 (23.56)	8.00 (16.27) ^{cde}	11.00 (19.27) ^{bc}	8.67 (17.07) ^{bc}	7.67 (16.02) ^{bc}	9.67 (18.06) ^{bc}	12.33 (20.56) ^{bc}	14.00 (21.91) ^{bc}
T_5	Deltamethrin 2.8% EC	0.50 ml/l	6.67 (14.90)	11.67 (19.89)	8.33 (16.75) ^{cde}	12.33 (20.54) ^{ab}	11.00 (19.21) ^{bc}	8.67 (17.01) ^{ab}	11.7 (19.95) ^{abc}	16.33 (22.96) ^{b}	15.67 (23.27) ^{b}
T_6	Emamectin benzoate 5% SG	0.25 g/l	6.00 (14.14)	12.33 (20.47)	7.00 (15.35) ^{de}	11.67 (19.93) ^{b}	11.67 (19.93) ^{b}	7.33 (15.57) ^{bc}	12.33 (20.39) ^{ab}	12.33 (21.02) ^{bc}	12.67 (20.83) ^{bc}
T_7	Indoxacarb 15.8% EC	0.25 ml/l	6.67 (14.85)	12.00 (20.22)	4.33 (11.90) ^{f}	7.67 (15.93) ^{c}	8.33 (16.77) ^{bc}	4.33 (11.99) ^{c}	5.67 (13.69) ^{d}	8.33 (15.65) ^{c}	10.67 (18.92) ^{c}
T_8	Fipronil 5% SC	1.0 ml/l	5.67 (13.76)	11.67 (19.72)	6.67 (14.90) ^{e}	11.33 (19.56) ^{b}	8.33 (16.47) ^{bc}	7.33 (15.41) ^{bc}	8.00 (16.37) ^{cd}	12.33 (18.02) ^{bc}	12.67 (20.70) ^{bc}
T_9	Dichlorovas 76% EC	0.50 ml/l	6.33 (14.43)	14.33 (22.22)	11.33 (19.56) ^{ab}	13.67 (21.65) ^{a}	12.33 (20.51) ^{ab}	9.33 (17.75) ^{ab}	11.67 (19.90) ^{abc}	13.67 (19.83) ^{bc}	13.00 (21.10) ^{bc}
T_{10}	Malathion 50% EC	2.0 ml/l	5.67 (13.69)	12.00 (19.80)	8.33 (16.65) ^{cde}	11.00 (19.15) ^{bc}	11.33 (19.56) ^{bc}	10.67 (18.77) ^{ab}	9.00 (17.18) ^{bcd}	12.33 (20.56) ^{bc}	14.00 (21.87) ^{bc}
T_{11}	Untreated control	-	6.33 (14.54)	15.00 (22.59)	13.00 (21.13) ^{a}	16.00 (23.58) ^{a}	17.67 (24.788^{a}	12.67 (20.630^{a}	15.33 (23.03) ^{a}	23.33 (24.17) ^{a}	17.33 (27.01) ^{a}
S. Em±			-	-	0.919	1.148	1.453	1.492	1.364	1.494	1.106
CD= (0.05)			NS	NS	2.712	3.380	4.286	4.402	4.025	4.484	3.318

*_Agrotis segetum_ and _Spodalea recurvalis_ **DAS: Days after spray
***Mean of three replications NS: Non significant
Figures in parenthesis indicate arcsine transformed values
Means followed by the same alphabet (s) are not significantly different (P=0.05)

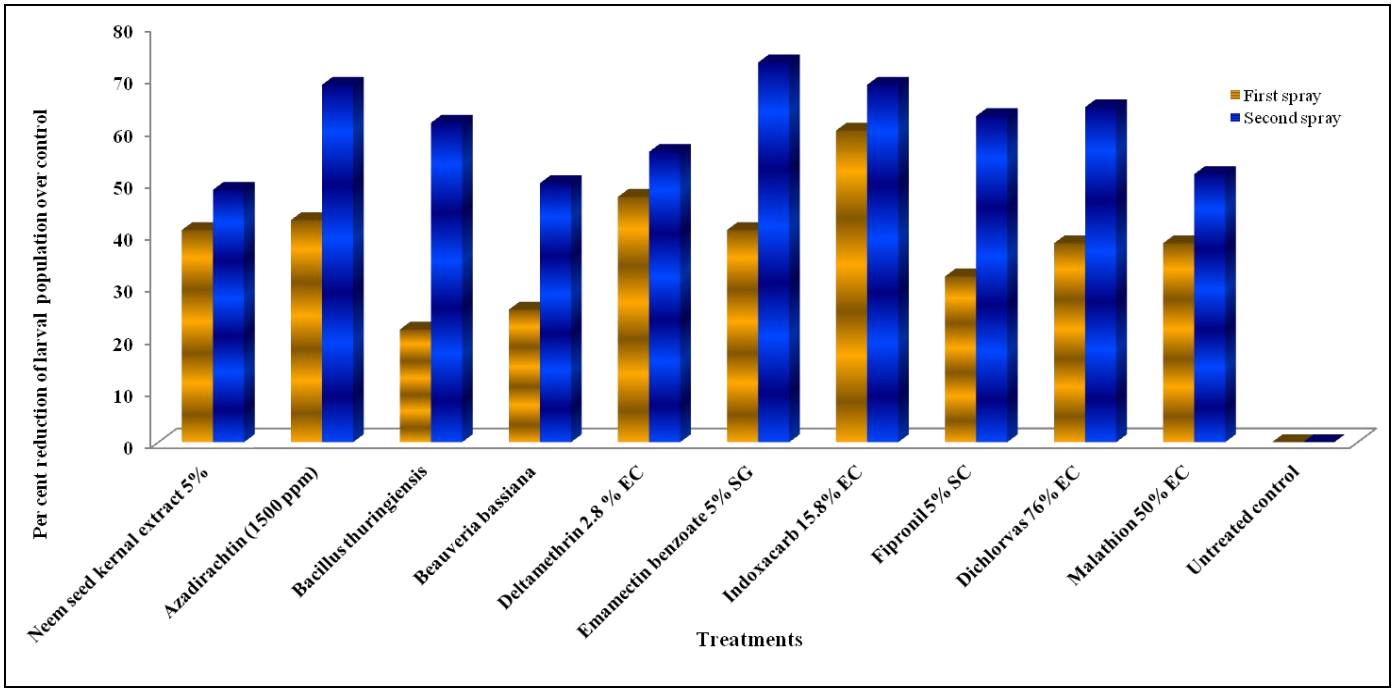

Fig 1: Bio efficacy of different synthetic insecticides, botanicals and bio-pesticides against *Agrotis segetum* and *Spoladea recurvalis*

Table 3: Economics of management of defoliators on fenugreek

Treatments	Dosage/ Concn. (g/ml/l)	Yield (t/ha)	Gross returns (Rs./ha)	Incremental yield over control (t/ha)	Incremental Benefit over control (Rs./ha)	*Cost of plant protection	Additional Net profit	IBCR
Neem Seed Kernal Extract 5%	50 g/l	9.23^{de}	92300	1.66	16600	1400	13400	9.57
Azadriachtin (1500 ppm)	3.0 ml/l	9.20^{cd}	92000	1.63	16300	3200	13100	4.09
Bacillus thuringiensis	2.0 g/ l	9.57^{cd}	95700	2.00	20000	2656	17344	6.53
Beauveria bassiana	2.0 g/l	9.58^{cd}	95800	2.01	20100	1000	19100	19.10
Deltamethrin 2.8% EC	0.50 ml/l	8.81^{cde}	88100	1.24	21400	750	20650	27.53
Emamectin benzoate 5% SG	0.25 g/l	14.14^{a}	141400	6.83	68300	3800	64500	16.97
Indoxacarb 15.8% EC	0.25 ml/l	14.42^{a}	144200	7.85	78500	1956	76550	39.25
Fipronil 5% SC	1.0 ml/l	14.58^{a}	145800	7.01	70100	2776	67324	24.52
Dichlorovas 76% EC	0.50 ml/l	10.44^{bc}	104400	2.87	28700	900	27800	30.89
Malathion 50% EC	2.0 ml/l	11.96^{b}	119600	4.39	43900	1360	42540	31.27
Untreated control	-	7.57^{e}	75700	-	-	-	-	-
SEm± CD at 5%		0.092 0.278						

IBCR= Incremental Benefit Cost Ratio) *Cost of treatment + Cost of application) * Market price of Fenugreek leaves was Rs. 10/kg.
Neem Seed Kernel Extract 10 Kg: Rs. 400 Azadirachtin 1500 ppm 1L: Rs. 500 *Bacillus thuringiensis* 500g: Rs. 307 *Beauveria bassiana* 500g: Rs. 100
Deltamethrin 2.8% EC 1L: Rs. 554 Malathion 50% EC 1l: Rs. 290 Emamectin benzoate 5% SG 500g: Rs. 3600Indoxacarb 15.8% EC 200 ml: Rs. 828
Fipronil 5% SC 250 ml: Rs. 250 Dichlorovas 76% EC 250 ml: Rs.175.

4. Conclusion

In fenugreek fipronil 5% SC, emamectin benzoate 5% SG and indoxacarb 15.8% EC were significantly superior throughout the period of investigation in their bio-efficacy against defoliators and in reducing the percent foliage damage under field conditions. However, the studies related to residues and waiting period/ safety for consumption of fenugreek need to be done.

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