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Evaluation of new insecticides and bio pesticides against defoliators on *Palak*

■ Y.K. KOTIKAL* AND K.N. MANJULA

Department of Entomology, University of Horticultural Sciences, BAGALKOT (KARNATAKA) INDIA

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***Corresponding author:**
Email : dsw@uhsbagalkot.edu.in

ABSTRACT

The investigation was undertaken at the College of Horticulture, UHS, Bagalkot, during 2013-2014 to study the bio efficacy of different insecticides against *Agrotis segetum* (Denis and Schiffermuller) and *Spoladea* (=*Hymenia*) *recurvalis* (Fabricius) on *Palak*. The results indicated that the newer molecules *viz.*, emamectin benzoate 5 per cent SG @ 0.25g/lit indoxacarb 15.8 per cent EC @ 0.25 ml/lit and fipronil 5 per cent SC @ 1ml/lit were found very effective in minimizing the larval population and were superior in reducing the foliage damage and also fetched higher yields of 15.00, 15.11 and 15.33 t/ha, respectively throughout period of experiment. The highest ICBR (50.21) was obtained from the treatment indoxacarb 15.8 per cent EC @ 0.25 ml/lit.

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INTRODUCTION

Palak is one of the most common leafy vegetables of tropical and subtropical region. It is botanically called as *Beta vulgaris* var. *bengalensis* Hort. of the family Chinopodiaceae. Leaves of this crop might have been used in Bengal and hence named as var. *bengalensis*. It is a rich and cheap source of Vitamin A as compared to spinach and carrot. It contains high quantity of ascorbic acid and iron. A 100 g of leaves supply, as much as essential amino acids as 100 g of any non- vegetarian foods like meat and fish (Nath and Subramanyan, 1972). Its succulent leaves and stems form a nutritious dish after cooking. It has some medicinal properties also. The herbaceous parts of *Palak* are mildly laxative besides other medicinal values. However, one of the greatest limiting factors in increasing the productivity of leafy vegetables is the damage caused by wide range of insect pests in general and defoliators in particular with higher level of losses suffered (Akinlosotu, 1977). Added to this, there is a limited research effort that has been put in to enhance production of leafy vegetables (Ouma, 2004). As in other crops, *Palak* is also infested by various insects belonging to orders Coleoptera, Hemiptera, Lepidoptera and Orthoptera. However, the two defoliators, *Agrotis segetum* (Denis and Schiffermuller) and *Spoladea* (*=Hymenia) recurvalis* (Fabricius) are causing major loss. Hence, the study was taken to evaluate selected insecticides against these pests.

MATERIAL AND METHODS

The field experiment was carried out in the Vegetable Science block of Udyanagiri campus of College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, during summer season of 2014, to evaluate the efficacy of different insecticides, bio-pesticides and botanicals against defoliators on *Palak*. The Local variety of *Palak* was used for this experiment. The package of practices for crop management was followed as prescribed by University of Horticultural Sciences, Bagalkot (Anonymous, 2013). 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.

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

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

Sr. No.	Treatments	Dosage/ Concn. (g/ml/lit)	Day before spray	**Mean number of 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/lit	0.63 (0.79)	0.80 $(1.13)^{bc}$	1.70 $(1.27)^{ab}$	2.06 $(1.42)^{b}$	1.93 $(1.39)^{a}$	1.03 $(1.00)^{bc}$	1.5 $(1.22)^{bc}$	1.07 $(1.03)^{bc}$	1.57 $(1.23)^{b}$
T_2	Azadirachtin (1500 ppm)	3.0 ml/lit	0.67 (0.82)	0.73 $(1.09)^{bc}$	0.53 $(0.73)^{cdef}$	1.63 $(1.26)^{bc}$	1.20 $(1.05)^{bc}$	1.00 $(0.98)^{bcd}$	1.37 $(1.19)^{bc}$	1.00 $(0.987)^{bc}$	0.97 $(0.974^{bc}$
T_3	*Bacillus thuringiensis*	2.0 g/ lit	0.57 (0.75)	1.06 $(1.10)^{bc}$	1.13 $(1.06)^{bc}$	1.43 $(1.20)^{bcd}$	1.57 $(1.23)^{abc}$	0.80 $(0.89)^{bcd}$	1.90 $(1.31)^{b}$	1.17 $(1.08)^{bc}$	1.03 $(1.02)^{bc}$
T_4	*Beauveria bassiana*	2.0 g/lit	0.57 (0.75)	0.67 $(1.06)^{bc}$	0.87 $(0.92)^{cd}$	1.43 $(1.18)^{bcd}$	1.13 $(1.06)^{bc}$	1.10 $(1.03)^{ab}$	1.10 $(1.05)^{bcd}$	1.03 $(1.01)^{bc}$	1.07 $(0.139)^{bc}$
T_5	Deltamethrin 2.8 % EC	0.50 ml/lit	0.63 (0.79)	0.56 $(1.15)^{bc}$	0.87 $(0.92)^{cd}$	1.60 $(1.25)^{bc}$	1.40 $(1.18)^{abc}$	0.67 $(0.80)^{bcd}$	1.00 $(0.99)^{bcd}$	1.83 $(1.33)^{ab}$	0.90 $(0.95)^{bc}$
T_6	Emamectin benzoate 5 % SG	0.25 g/lit	0.60 (0.78)	0.37 $(0.92)^{cde}$	0.37 $(0.61)^{def}$	0.93 $(0.94)^{de}$	1.00 $(0.99)^{bc}$	1.40 $(0.69)^{cde}$	0.67 $(0.81)^{d}$	0.80 $(0.89)^{c}$	1.10 $(1.03)^{bc}$
T_7	Indoxacarb 15.8 % EC	0.25 ml/lit	0.57 (0.75)	0.10 $(0.78)^{de}$	0.23 $(0.53)^{ef}$	0.93 $(0.97)^{de}$	0.93 $(0.97)^{bc}$	0.20 $(0.43)^{e}$	0.63 $(0.79)^{d}$	0.83 $(0.86)^{c}$	0.73 $(0.85)^{b}$
T_8	Fipronil 5% SC	1.0 ml/lit	0.70 (0.85)	0.03 $(0.73)^{e}$	0.21 $(0.45)^{f}$	0.70 $(0.84)^{e}$	0.87 $(0.92)^{c}$	0.57 $(0.74)^{de}$	0.73 $(0.85)^{cd}$	0.73 $(0.85)^{c}$	0.93 $(0.97)^{bc}$
T_9	Dichlorovas 76 % EC	0.50 ml/lit	0.53 (0.73)	0.47 $(0.98)^{cd}$	0.43 $(0.66)^{def}$	1.97 $(1.38)^{b}$	1.70 $(1.28)^{ab}$	0.57 $(0.71)^{bcde}$	1.13 $(1.06)^{bcd}$	1.83 $(1.31)^{ab}$	1.47 $(1.20)^{bc}$
T_{10}	Malathion 50 % EC	2.0 ml/lit	0.60 (0.78)	1.03 $(1.22)^{b}$	0.63 $(0.84)^{cde}$	1.13 $(1.04)^{cde}$	1.03 $(1.02)^{bc}$	0.47 $(0.67)^{de}$	1.13 $(1.06)^{bcd}$	1.07 $(1.03)^{bc}$	1.43 $(1.13)^{bc}$
T_{11}	Untreated control	-	0.63 (0.79)	2.50 $(1.72)^{a}$	2.27 $(1.59)^{a}$	4.97 $(2.23)^{a}$	2.03 $(1.41)^{a}$	1.87 $(1.30)^{a}$	2.77 $(1.66)^{a}$	2.57 $(1.60)^{a}$	3.10 $(1.72)^{a}$
	S.E. ±		-	0.683	0.108	0.111	0.112	0.104	0.121	0.129	0.115
	C.D.(P=0.05)		NS	0.219	0.335	0.296	0.323	0.327	0.359	0.396	0.341

* *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)

0.93 to 1.27 per plant before spray. The per cent foliage damage ranged from 8.00 to 10.33 and there was no significant difference between the treatments (Table 1).

First spray:

Significantly least larval population was noticed in all the treatments compared to untreated control (2.87 larvae/plant) on the first day after first spray. Fipronil 5 per cent SC @ ml/lit of water was significantly superior over all other by recording 0.03 larvae per plant which was at par with indoxacarb 15.8 per cent EC @ 0.25 ml/ lit of water and emamectin benzoate 5 per cent SG @ 0.25 g/lit of water (0.10 and 0.37 larvae per plant, respectively). Maximum larval population was recorded in NSKE 5 per cent @ 50 g/lit of water plants treated plants (1.70 larvae per plant) (Table 1). Foliage damage of 2.67 per cent of was noticed in the case of *Palak* treated with fipronil 5 per cent SC @ 1.00 ml/lit of water and it was at par with indoxacarb 15.8 EC @ 0.25 ml/lit of water (3.00 %) followed by emamectin benzoate 5 per cent SG @ 0.25 g/lit of water (4.67 %). Maximum foliage damage (11.33%) was in *Beauveria bassiana* @ 2g/lit of water and it was at par with the malathion 50 per cent EC @ 2 ml/lit of water and deltamethrin 2.8 per cent EC @ 0.5 ml/lit of water (9.33 and 8.33 % foliage damage, respectively) (Table 2). At three days after first spray, once again fipronil 5 per cent SC @ 1ml/lit of water was significantly superior over all other treatments by recording minimum number of larval population (0.21 larvae per plant) followed by indoxacarb 15.8 per cent EC @ 0.25 ml/lit of water (0.23 larvae/plant) and it was at par with emamectin benzoate 5 SG @ 0.25 g/lit of water, dichlorvas 76 EC @ 0.5 ml/lit of water and azadirachtin 1500 ppm @ 3ml/lit of water (0.37, 0.43 and 0.53 larvae per plant). Whereas, maximum larval population was recorded in the case of plants treated

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

Sr. No.	Treatments	Dosage/ Concn. (g/ml/lit)	Day before spray	**Mean per cent 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/lit	7.50 (15.82)	8.00 (16.30)^{bc}	11.33 (19.66)^{bcd}	19.00 (25.81)^{b}	21.67 (27.68)^{ab}	23.33 (28.34)^{ab}	13.00 (21.10)^{de}	15.00 (22.73)^{cd}	21.33 (27.46)^{b}
T_2	Azadirachtin (1500 ppm)	3.0 ml/lit	9.67 (18.00)	7.33 (15.49)^{bc}	9.33 (17.70)^{de}	21.67 (27.73)^{b}	16.33 (23.79)^{bcd}	15.33 (22.74)^{bcd}	14.67 (24.84)^{bc}	14.67 (21.94)^{cd}	20.00 (26.53)^{bc}
T_3	*Bacillus thuringiensis*	2.0 g/ lit	10.69 (19.05)	7.33 (15.56)^{bc}	10.67 (19.05)^{bcd}	20.33 (27.68)^{b}	14.00 (21.87)^{de}	19.00 (25.78)^{abc}	12.00 (21.98)^{cd}	17.67 (23.57)^{bcd}	17.70 (24.76)^{bcd}
T_4	*Beauveria bassiana*	2.0 g/lit	833 (16.67)	11.33 (18.96)^{b}	14.67 (22.37)^{b}	23.67 (25.03)^{b}	20.00 (26.51)^{abc}	13.00 (21.02)^{cd}	11.33 (22.98)^{bcd}	13.67 (24.84)^{bc}	18.33 (25.27)^{bcd}
T_5	Deltamethrin 2.8% EC	0.50 ml/lit	8.33 (17.26)	8.33 (16.65)^{b}	14.33 (22.13)^{bc}	18.67 (25.46)^{b}	19.00 (25.69)^{abcd}	15.67 (19.36)^{cde}	16.33 (25.55)^{b}	18.67 (26.98)^{ab}	20.00 (24.06)^{bcd}
T_6	Emamectin benzoate 5% SG	0.25 g/lit	11.00 (19.25)	4.67 (12.46)^{cd}	6.00 (14.05)^{ef}	12.33 (20.47)^{c}	14.67 (22.49)^{cde}	8.33 (17.00)^{de}	14.33 (21.41)^{de}	13.00 (21.02)^{de}	14.67 (22.51)^{cd}
T_7	Indoxacarb 15.8% EC	0.25 ml/lit	8.00 (16.41)	3.00 (9.72)^{d}	4.00 (11.29)^{f}	9.33 (17.71)^{c}	10.00 (18.35)^{e}	4.67 (12.28)^{e}	7.33 (15.28)^{f}	9.00 (17.25)^{e}	13.30 (21.42)^{d}
T_8	Fipronil 5% SC	1.0 ml/lit	9.00 (17.41)	2.67 (9.27)^{d}	3.67 (10.76)^{f}	12.33 (20.51)^{c}	14.33 (22.22)^{cde}	8.00 (16.24)^{de}	12.67 (18.68)^{e}	13.67 (21.65)^{cd}	13.33 (21.37)^{cd}
T_9	Dichlorovas 76% EC	0.50 ml/lit	6.67 (16.59)	6.67 (14.92)^{bc}	10.67 (19.05)^{bcd}	20.33 (26.62)^{b}	16.67 (23.96)^{bcd}	8.00 (16.27)^{de}	15.00 (23.18)^{bcd}	16.33 (23.83)^{bcd}	15.67 (25.81)^{bc}
T_{10}	Malathion 50% EC	2.0 ml/lit	9.33 (17.75)	9.33 (17.37)^{b}	9.67 (18.10)^{cde}	18.67 (25.56)^{b}	15.67 (23.25)^{cd}	11.00 (19.56)^{cd}	13.67 (21.03)^{de}	19.67 (24.34)^{bcd}	18.00 (27.35)^{bcd}
T_{11}	Untreated controls	-	9.33 (17.75)	20.00 (26.56)^{a}	21.67 (27.67)^{a}	30.67 (33.55)^{a}	23.33 (28.78)^{a}	27.00 (31.27)^{a}	25.00 (31.94)^{a}	25.00 (29.94)^{a}	29.00 (32.53)^{a}
	S.E.±		-	1.391	1.382	1.450	1.473	2.414	1.061	1.289	1.289
	C.D. (P=0.05)		NS	4.106	4.084	4.286	4.349	7.128	3.136	3.806	3.806

* *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)

with NSKE 5 per cent @ 50g/lit of water (1.70 larvae/ plant) and it was at par with untreated control. Fipronil 5 per cent SC @ 0.25 ml/lit of water recorded least percentage of damage (3.67%) and it was at par with indoxacarb 15.8 per cent EC @ 0.25 ml/lit of water (4.00 %) followed by emamectin benzoate 5 per cent SG @ 0.25g/lit of water (6.00 %). All other treatments *viz*., *Beauveria bassiana* @ 2g/lit of water, deltamethrin 2.8 per cent EC @ 0.5 ml/lit of water, NSKE 5% @ 50g/lit of water, *Bacillus thuringensis* @ 2g/lit of water, dichlorvas 76 EC @ 0.5 ml/lit of water and azadirachtin 1500 ppm @ 3ml/lit of water with 14.67 14.33, 11.33, 10.67, 10.67 and 9.33 per cent foliage damage, respectively, were at par with each other. Similarly at five days after first spray, once again fipronil 5% SC @ 1ml/lit of water was found to be significantly superior over all other treatments recording 0.70 larvae per plant and it was at par with emamectin benzoate 5% SG @ 0.25 g/lit of water and indoxacarb 15.8% EC @ 0.25 ml/lit of water (0.93 larvae per plant). Whereas maximum larval population was recorded in the treatment NSKE 5% @ 50 g/lit of water (1.70 larvae/plant) and it was at par with dichlorvas 76% EC @ 0.5 ml/lit of water (Fig. 1).

Similar trend was noticed in per cent foliage damage inflicted. Fipronil 5% SC @ 1ml/lit of water was found to be statistically superior over all other treatments and at par with indoxacarb 15.8% EC @ 0.25 ml/lit of water and emamectin benzoate 5% SG @ 0.25 g/lit of water (12.33%). *Beauveria bassiania* @ 2g/lit of water recorded 23.33 per cent foliage damage and it was at par with azadirachtin 1500 ppm @ 3ml/lit of water, dichlorvas 76% EC @ 0.5 ml/of water, NSKE 5% @ 50 g/ lit of water, deltamethrin 2.8% EC @ 0.5 ml/lit of water and malathion 50% EC @ 2ml/lit of water (21.67, 20.33, 20.33, 19.00, 18.67 and 18.67 per cent foliage damage, respectively). At seven days after first spray, minimum number of larval population was observed in plots treated with fipronil 5% SC @ 1ml/lit of water (0.87 larvae/plant) and this treatment was significantly superior over all other treatments, but at par with indoxacarb 15.8% EC @ 0.25 ml/lit of water and emamectin benzoate 5% SG @ 0.25 g/ lit of water (0.93 and 1.00 larvae/plant, respectively). Whereas, maximum number of larval population was observed in the treatment NSKE 5% @ 50 g/lit of water (1.93 larvae/plant) and it was at par with untreated control. Least per cent foliage damage was recorded in plants treated with indoxacarb 15.8% EC @ 1.25 ml/lit of water, which was found to be significantly superior over all other treatments, (10.00 % foliage/plant). Next best treatment in the rank was *Bacillus thuringiensis* @ 2 g/lit of water (14.00%) and it was at par with fipronil 5% SC @ 1ml/ lit of water and emamectin benzoate 5% SG @ 0.25 g/lit of water (14.33 and 14.67 % foliage damage, respectively). NSKE 5% @ 50 g/lit of water was at par

Table 3 : Economics of management of defoliators on *Palak*

Treatments	Dosage/ concn. (g/ml/lit)	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	ICBR
Neem seed kernal extract 5%	50 g/l	9.22^{ef}	92200	1.29	12900	1400	11500	8.20
Azadriachtin (1500 ppm)	3.0 ml/l	10.00^{de}	100000	2.07	20700	3200	17500	5.47
Bacillus thuringiensis	2.0 g/ l	10.00^{de}	100000	2.07	20700	2656	18044	6.79
Beauveria bassiana	2.0 g/l	10.89^{cd}	108900	2.96	29600	1000	28600	28.60
Deltamethrin 2.8 % EC	0.50 ml/l	11.33^{cd}	113300	3.40	34000	750	33250	44.33
Emamectin benzoate 5 % SG	0.25 g/l	15.00^{a}	150000	7.07	70700	3800	66900	17.60
Indoxacarb 15.8 % EC	0.25 ml/l	15.11^{a}	151100	7.18	71800	1956	69844	35.70
Fipronil 5% SC	1.0 ml/l	15.33^{a}	153300	7.40	74000	2776	71224	25.65
Dichlorovas 76 % EC	0.50 ml/l	13.00^{b}	130000	5.07	50700	900	49710	50.21
Malathion 50 % EC	2.0 ml/l	12.33^{bc}	123300	4.40	44000	1360	42640	31.52
Untreated control	-	7.93^{f}	79300	-	-	-	-	-
S.E.±		0.085						
C.D. (P=0.05)		0.257						

IBCR= Incremental benefit cost ratio) *Cost of treatment + Cost of application) * Market price of *Palak* 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. 3600
Indoxacarb 15.8 % EC 200 ml: Rs. 828 Fipronil 5% SC 250 ml: Rs. 250 Dichlorovas 76% EC 250 ml: Rs. 175.

with untreated control (23.33 %) (Fig. 2).

Second spray:

On the first day after second spray, indoxacarb 15.8% EC @ 0.25 ml/lit of water recorded minimum larval population (0.20 larvae/plant) and this treatment was significantly superior over all other treatments, but at par with emamectin benzoate 5% SG @ 0.25 g/lit of water, malathion 50% EC @ 2ml/lit of water, fipronil 5% SC @ 1 ml/lit of water and dichlorvas 76% EC @ 0.5 ml/lit of water (0.40, 0.47, 0.57 and 0.59 larvae/plant, respectively). The treatment *Beauveria bassiania* @ 2 g/lit of water was at par with untreated control (1.87 larvae/plant). Significantly least per cent foliage damage was noticed in *Palak* treated with indoxacarb 15.8% EC @ 0.25 ml/lit of water (4.67 %) and it was at par with fipronil 5% SC @ 0.25 ml/lit of water dichlorvas 76% EC @ 2ml/lit and emamectin benzoate 5% SG 0.25 g/lit of water (8.00, 8.00 and 8.33%, respectively). Botanical pesticide NSKE 5% @ 50 g/lit of water recorded 14.63 per cent foliage damage and this treatment was at par with untreated control (27.00 %). At three days after second spray, significantly less (0.63/ plant) larval population was recorded in the case of plants treated with indoxacarb 15.8% EC @ 0.25 ml/lit of water (0.63 larvae/plant). Next best treatments were emamectin benzoate 5% SG @ 0.25 g/lit of water and fipronil 5% SC @ 1 ml/lit of water (0.67 and 0.73 larvae/ plant, respectively). Other than untreated control (2.77 larvae/plant) maximum number of larval population was recorded to extent of 1.90 larvae per plant in the plots treated with *Bacillus thuringiensis* @ 2 g/lit of water. With respect to per cent of foliage damage, indoxacarb 15.8% EC @ 0.25 ml/lit of water recorded least (7.33%) which was significantly superior over all other treatments followed by fipronil 5 % SC @ 0.25 ml/lit of water (12.67%), malathion 50 EC @ 2ml/lit of water and emamectin benzoate 5% SG @ 0.25 g/lit of water (13.67 and 14.33 % foliage damage, respectively). Whereas, maximum per cent damage was noticed in the treatment deltamethrin 2.8% EC @ 0.5 ml/lit of water (16.33 and it was at par with untreated control (25.00%). At five days after second spray, fipronil 5% SC @ 1.00 ml/lit of water was found to be superior over all other treatments by recording 0.73 larvae per plant and this treatment was at par with indoxacarb 15.8% EC @ 0.25 ml/lit of water and emamectin benzoate 5% SG @ 0.25 g/lit of water (0.80 and 0.83 larvae/plant, respectively). Whereas, maximum number of larval population was recorded in the treatments of deltamethrin 2.8% EC @ 0.5 ml/lit of water and dichlorvas 76% EC @ 0.5 ml/lit of water (1.83 larvae/plant) and these treatments were at par with untreated control (2.57 larvae/ plant). Indoxacarb 15.8% EC @ 0.25 ml/lit of water recorded minimum 9.00 per cent of foliage damage and it was significantly superior over all other treatments but at par

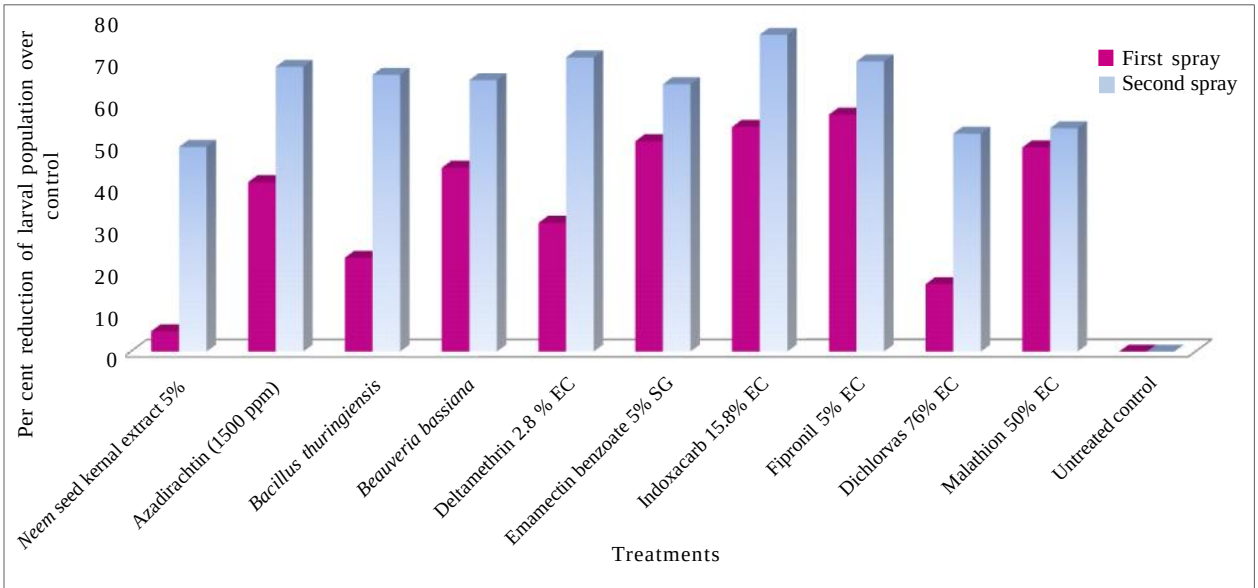

Fig. 1 : Bio-efficacy of different synthetic insecticides, botanicals and bio-pesticides against *Agrotis segetum* and *Spoladea recurvalis* on *Palak*

with emamectin benzoate 5% SG @ 0.25 g/lit of water (13.00%) followed by fipronil 5% SC @ 1.00 ml/lit of water (13.67 %) and these treatments were at par with botanical pesticides azadirachtin 1500 ppm @ 3ml/lit of water and NSKE 5% @ 50 g/lit of water (14.67 and 15.00 %, respectively). Maximum foliage damage was noticed in untreated control (30.67%). At seven days after second spray, again indoxacarb 15.8% EC @ 0.25 ml/lit of water was found to be superior treatment by recording minimum number of larvae per plant and it was at par with deltamethrin 2.8% EC @ 0.5 ml/lit of water, fipronil 5% SC @ 1 ml/lit of water, azadirachtin 1500 ppm @ 3 ml/lit of water *Beauveria bassiana* @ 2g/lit of water, *Bacillus thuringiensis*, @ 2g/lit of water, ememectin benzoate 5% SG @ 0.25g/lit of water, malathion 50 EC @ 2 ml/lit of water and dichlorvas 76% EC @ 0.5 ml/lit of water (0.90, 0.93, 0.97, 1.03, 1.07, 1.10, 1.43 and 1.47 larvae/plant, respectively). Untreated control recorded on an average 3.10 larvae per plant. Indoxacarb 15.8% EC @ 0.25 ml/lit of water was found to be significantly superior over all other treatments by recording 13.30 per cent foliage damage and this treatment was at par with fipronil 5% SC @ 1 ml/lit of water (13.33 %) followed by emamectin benzoate 5% SG @ 0.25 g/lit of water which recorded 14.67 per cent foliage damage and it was at par with dichlorvas 76% EC @ 0.5 ml/lit of water (15.67 %). NSKE 5 % @ 50 g/lit of water treated plants recorded 21.33 per cent foliage damage and untreated control recorded 29.00 per cent damage (Fig. 2).

The new insecticides emamectin benzoate 5 % SG, indoxacarb 15.8 % EC and fipronil 5 % SC, botanical azadirachtin 1500 ppm and biopesticide *Beauveia bassiania* which are tested for the first time found to be the superior treatments in reducing the larval population and foliage damage on *Palak* by the insect defoliators. However, Srinivasiihr (2013), indicated that malathion @ 1ml/lit was effective in controlling leaf eating caterpillar and aphid but with the waiting period of 15 days for harvesting.

Yield and economics :

The yield of *Palak* ranged from 7.93 to 15.33 tonnes per hectare. Plots treated with the fipronil 5 % SC @ 1 ml/lit of water, indoxacarb 15.8 EC at 0.25 ml/lit of water and emamectin benzoate 5 % SG @ 0.25 g/lit of water were found to be significantly superior over all other treatments by recording maximum leaf yield of 15.33, 15.10 and 15.00 t/ha, respectively. The next best treatments were dichlorvas 76 EC at 0.5 ml/lit of water (13.0 t/ha) and malathion 50 EC 2ml/lit of water (12.33 t/ha). Treatments deltamethrin 2.8% EC @ 0.5 ml/lit of water (11.33 t/ha), *Beauveria bassiana* 2.0 g/lit of water (10.89 t/ha), *Bacillus thuringiensis* 2.0 g/lit of water

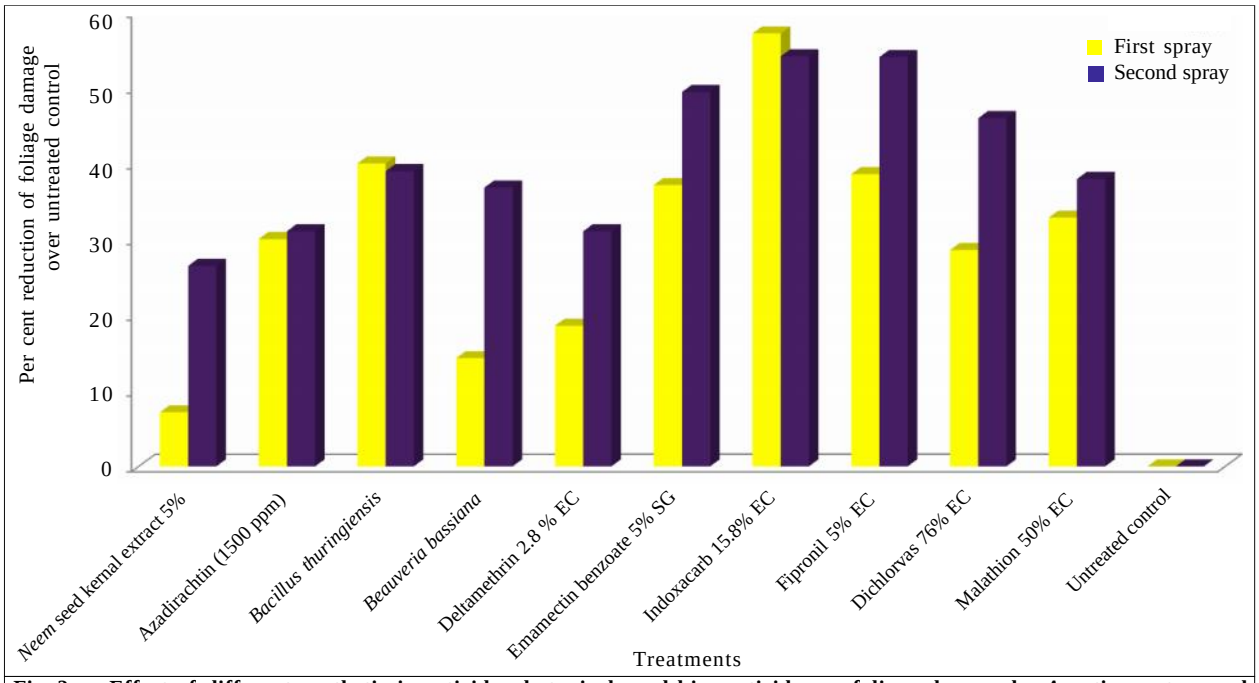

Fig. 2 : Effect of different synthetic insecticides, botanicals and bio-pesticides on foliage damage by *Agrotis segetum* and *Spoladea recurvalis* on *Palak*

(10.00 t/ha) and azadirachtin 1500 ppm 3ml/lit of water (10.00 t/ha) were at par with each other. Lowest yield was obtained from the treatment *Neem* seed kernel extract at 5 per cent at 50 g/lit of water (9.22 t/ha) at par with untreated control (7.93 t/ha) (Table 3). The data of cost economics on various treatments were used in the management of defoliators in *Palak* are presented in the Table 3. *Palak* treated with fipronil 5% SC @ 1ml/lit of water, indoxacarb 15.8% EC at 0.25 ml/lit of water and emamectin benzoate 5 SG at 0.25 g/lit of water fetched maximum additional yield (12.67, 12.44 and 11.67 t/ha, respectively). The treatments dichlorvas 76 % EC @ 0.5 ml/lit of water (5.07 t/ha) and malathion 50 EC @ 2 ml/lit of water (4.40 t/ha) were found to be the next best treatments followed by deltamethrin 2.8% EC at 0.5 ml/lit of water (3.40 t/ha). Azadirachtin 1500 ppm 3 ml/lit of water and *Beauveria bassiana* 2.0 g/lit of water treated plots recorded 2.07 tonnes per hectare. Lowest additional yield was obtained from the treatment NSKE at 5 per cent at 50 g/lit of water (1.29 t/ha) (Table 3). The higher gross returns were obtained from the treatment fipronil 5% SC @ 1 ml/lit of water, indoxacarb 15.8 EC @ 0.25 ml/lit of water and emamectin benzoate 5% SG @ 0.25 g/lit of water, (Rs.153300, 15110 and 15000 /ha, respectively). Other treatments like malathion 50 EC 2 ml/lit of water fetched gross returns of Rs. 130000, dichlorovas 123300 EC @ 0.5 ml/lit of water, deltamethrin 2.8 EC @ 0.5 ml/lit of water Rs. 113300, *Beauveria bassiania* Rs. 10890 *Bacillus thuringiensis* 2.0 g/lit of water Rs. 10000, azadirachtin Rs. 10000 and NSKE 5 per cent at 50 g/lit of water Rs. 92200. Net returns were highest in the case of plots treated with fipronil 5% SC at 1ml/lit of water, indoxacarb 15.8 EC at 0.25 ml/ of water and emamectin benzoate 5 SG at 0.25 g/lit of water (Rs. 74000, 71800 and 70700/ha, respectively). Dichlorvas 76 % EC @ 0.50 ml/lit of water (Rs. 50700 /ha) and malathion (Rs. 44000/ha) were found to be the next best treatments. Deltamethrin with Rs. 34000/ha, azadirachtin 1500 ppm @ 3 ml/lit of water with Rs. 29600 *Beauveria bassiana* and *Bacillus thuringiensis* both Rs. 20700 /ha, NSKE with 12900 Rs. were the better options. However, highest IBCR of 50.21 was obtained from the treatment dichlorvas 76 % EC @ 0.50 ml/lit of water followed by deltamethrin 2.8% EC @ 0.5 ml/lit of water (44.33) indoxacarb (35.70) and malathion 50% EC @ 2ml/lit of water (31.52). Even though higher benefits were obtained from the treatments, emamectin benzoate 5% SG at 0.25 g/lit of water and indoxacarb 15.8 EC at 0.25 ml/lit of water and fipronil 5% SC at 1 ml/lit of water, ICBR was low due to higher cost of insecticides. Similar work related to the present investigation was also carried out by Chandra *et al*. (2010) on urd bean, Dange *et al*. (2011) and Anuja and Jayalakshmi (2011) in *Palak*.

Conclusion :

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

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