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Field Efficacy of Some Insecticides and Biopesticides Against *Leucinodes orbonalis* Guenee on Brinjal

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Abstract

The efficacy of synthetic insecticides and biopesticides viz. acetamiprid, acephate, avermectin, cartap-hydrochloride, ethofenprox, fenvalerate, imidacloprid, lambda-cyhalothrin, neem seed kernel extract and thiamethoxam was determined both in terms of shoot and fruit infestation by *L. orbonalis* on brinjal during 2003 and 2004. During 2003, acetamiprid and cartap hydrochloride recorded least shoot infestation (1.22%), which was statistically at par to thiamethoxam, imidacloprid, neem seed kernel extract (1.30, 1.66, 1.86%, respectively). Based on mean shoot infestation during 2004, it was found that cartap hydrochloride treatment revealed no shoot infestation. On fruits, acetamiprid registered mean minimum fruit infestation (10.89%) being at par to thiamethoxam (11.61%) during 2003 ; whereas cartap hydrochloride (10.27%), acetamiprid (10.33%) and imidacloprid (10.33%) were at par during 2004. Acetamiprid resulted in maximum profit (Rs 24,146/ha) followed by cartap hydrochloride (Rs 18,471/ha).

Key words : Field efficacy, Insecticides, Biopesticides, Brinjal.

Brinjal (*Solanum melongena* L.), a versatile vegetable, is one of the most popular and economically important vegetables among small-scale farmers and low-income consumers of south Asia. It is grown in almost all states of India with an area of 5.10 lakh hectares under cultivation and production of 88.0 lakh tonnes (1). In Himachal Pradesh, the crop is grown in an area of 772 hectares with production of 14,267 metric tonnes (2). The crop is attacked by a large number of insect-pests (3), among them shoot and fruit borer, *Leucinodes orbonalis* Guenee (Lepidoptera : Pyralidae) is the key pest throughout Asia (4—6). The pest has a country wide distribution and has been categorized as the most destructive and serious pest causing huge losses in brinjal crop (7). The pest has been reported to inflict losses to the tune of 20.7—60.0% in Tamil Nadu (8), 70% in Andhra Pradesh (9), 80% in Gujarat (10) and 41% in Himachal Pradesh (11). The growers resort to indiscriminate use of insecticide applications in a quest to get healthy fruits for fetching premium price in the market. But sole reliance on chemicals has resulted in development of resistance in *L. orbonalis* to different insecticides (12), pest resurgence (13), harmful pesticide residues (14), destruction of beneficial insects (15) and environmental hazards. In Himachal Pradesh, the pest has developed resistance to fenvalerate, acephate, carbaryl and endosulphan (16). Keeping in view the development of insecticide resistance to the recommended insecticides, some new insecticides and biopesticides were evaluated so that they can be incorporated in sound IPM techniques.

Methods

Field efficacy of ten insecticidal treatments comprising synthetic insecticides viz. acephate, acetamiprid, ethofenprox, fenvalerate, imidacloprid, lambda-cyhalothrin and thiamethoxam, and biopesticides viz. avermectin, cartap-hydrochloride and neem seed kernel extract was determined during 2003 and 2004. Brinjal variety, Arka Nidhi was raised in plots of 3×2 m^2 as per recommended package of practices (17), except insect-pest management. The insecticides were applied with the help of knapsack sprayer up to runoff at fortnightly intervals starting from the initiation of shoot damage. The inci-

Table 1. Field efficacy of different insecticides against *Leucinodes orbonalis* in shoots. * Figures in parentheses are the values pertaining to the year 2004. ** Figures in parentheses are the square root transformed values ; 1 DBS = one day before spray. CD (P = 0.05) 2003 : Treatments = 0.58, Spray application = NS. 2004 : Treatments = 0.34, Spray application = 0.21.

Treatments	Dose (g a.i./ha)	1DBS*	Shoot infestation (%) after spray application ** Spray I 2003	Spray I 2004	Spray II 2003	Spray II 2004	Spray III 2003	Spray III 2004	Mean 2003	Mean 2004
Acephate	315	12.22 (5.00)	4.39 (2.16)	6.62 (2.42)	1.66 (1.48)	0.26 (1.10)	1.28 (1.44)	0.24 (1.09)	2.44 (1.70)	2.37 (1.54)
Acetamiprid	18	18.25 (1.94)	3.30 (1.84)	1.86 (1.58)	0.37 (1.13)	0.89 (1.31)	0.00 (1.00)	0.00 (1.00)	1.22 (1.32)	0.92 (1.30)
Avermectin	5.7	9.26 (0.95)	8.86 (2.90)	4.84 (2.12)	7.10 (2.60)	0.48 (1.16)	1.52 (1.50)	1.89 (1.59)	2.83 (2.33)	2.40 (1.62)
Cartap hydrochloride	300	5.56 (2.96)	0.75 (1.27)	0.00 (1.00)	1.83 (1.54)	0.00 (1.00)	1.09 (1.33)	0.00 (1.00)	1.22 (1.38)	0.00 (1.00)
Ethofenprox	60	15.48 (0.83)	5.75 (2.35)	2.79 (1.76)	0.37 (1.13)	0.70 (1.21)	5.44 (2.22)	1.57 (1.43)	3.85 (1.90)	1.69 (1.47)
Fenvalerate	60	6.30 (4.04)	4.99 (2.11)	4.00 (1.86)	7.80 (2.54)	0.61 (1.19)	2.20 (1.66)	1.58 (1.46)	5.00 (2.10)	2.06 (1.50)
Imidacloprid	64	18.26 (1.67)	3.73 (2.04)	0.99 (1.33)	0.42 (1.17)	0.88 (1.30)	0.83 (1.24)	1.67 (1.39)	1.66 (1.48)	1.18 (1.38)
Lambda-cyhalothrin	24	9.34 (1.11)	8.42 (2.83)	4.08 (2.06)	6.78 (2.71)	0.56 (1.18)	3.49 (2.03)	3.77 (1.95)	6.23 (2.52)	2.80 (1.36)
Neem seed-kernel extract	10%	6.48 (1.82)	3.20 (1.81)	2.14 (1.63)	2.38 (1.60)	0.56 (1.18)	0.00 (1.00)	1.00 (1.27)	1.86 (1.47)	1.27 (1.39)
Thiamethoxam	60	6.48 (0.00)	3.11 (1.79)	2.93 (1.84)	0.00 (1.00)	0.30 (1.11)	0.79 (1.23)	0.00 (1.00)	1.30 (1.34)	1.08 (1.32)
Untreated check		5.56 (4.49)	14.52 (3.86)	11.20 (3.40)	15.62 (4.03)	4.06 (2.22)	7.50 (2.89)	6.30 (2.67)	12.55 (3.59)	7.19 (2.70)
Mean		10.29 (2.26)	5.55 (2.27)	3.77 (1.91)	4.03 (1.90)	0.84 (1.27)	2.20 (1.59)	1.64 (1.44)		

dence of *L. orbonalis* on shoots and fruits was recorded on five randomly selected plants at weekly intervals. The efficacy of synthetic insecticides and biopesticides was determined both in terms of shoot and fruit infestation by *L. orbonalis.* Total yield of marketable fruits of brinjal was recorded and cost benefit ratio of different treatments was worked out. Data collected from different experiments were subjected to analysis of variance for drawing inference using standard statistical procedures.

Results and Discussion

Efficacy of Insecticides on the Basis of Shoot Infestation

The perusal of data on shoot infestation in various treatments during 2003 (Table 1) reveals that 1 day before spray, the shoot infestation varied from 5.56 to 18.25%. The shoot infestation was significantly higher during the first spray application and declined during the later applications. After first spray, cartap hydrochloride recorded least shoot infestation (0.75 and 0.00%), however, it was at par to NSKE, thiamethoxam and acetamiprid during 2003. During 2004, cartap hydrochloride recorded no shoot infestation which was followed by imidacloprid (0.99%) and acetamiprid (1.86%). After second spray, no shoot infestation was observed in thiamethoxam though at par with acetamiprid (0.37%), ethofenprox (0.37%) and imidacloprid (0.42%) during 2003. Though cartap hydrochloride recorded no shoot infestation during 2004 but was at par to all the treatments except untreated check (4.06%). No shoot infestation was recorded in acetamiprid and neem seed kernel extract after third spray in both the years. Lambdacyhalothrin (3.49%) and ethofenprox (5.44%) were least effective during 2003. Similarly, acetamiprid, thiamethoxam and cartap hydrochloride recorded no shoot infestation during 2004, being at par with

Table 2. Field efficacy of different insecticides against *Leucinodes orbonalis* in fruits. *Figures in parentheses pertain to the year 2004 ; **Figures in parentheses are the angular transformed values ; 1DBS = one day before spray. CD ($P = 0.05$) 2003 : Treatments = 5.98 ; Spray application = 3.21 ; 2004 : Treatments = 5.56 ; Spray application = 3.35.

Treatments	Dose (g a.i./ha)	1DBS*	Fruit infestation (%) after spray application** Spray I 2003	Spray I 2004	Spray II 2003	Spray II 2004	Spray III 2003	Spray III 2004	Mean 2003	Mean 2004
Acephate	315	0.00	20.30	34.33	42.89	20.86	34.11	40.53	32.43	31.91
		(13.33)	(22.43)	(37.21)	(40.70)	(25.45)	(35.53)	(39.47)	(32.89)	(34.04)
Acetamiprid	18	0.00	11.71	17.77	9.60	7.68	11.36	5.53	10.89	10.33
		(8.00)	(12.22)	(23.65)	(16.41)	(15.18)	(16.57)	(10.05)	(15.07)	(16.29)
Avermectin	5.7	0.00	18.36	47.61	51.70	15.43	47.39	30.08	39.15	29.71
		(0.00)	(19.21)	(43.71)	(46.04)	(20.78)	(43.42)	(32.62)	(36.22)	(32.37)
Cartap-hydrochloride	300	0.00	16.43	9.25	30.01	12.42	24.64	11.14	23.69	10.27
		(5.00)	(19.44)	(15.61)	(32.98)	(20.18)	(29.30)	(18.86)	(27.24)	(18.22)
Ethofenprox	60	0.00	26.60	19.36	58.82	19.34	46.42	51.43	43.95	30.04
		(6.67)	(29.28)	(23.69)	(50.23)	(25.49)	(42.07)	(45.83)	(40.53)	(31.67)
Fenvalerate	60	0.00	23.07	36.30	51.66	24.89	49.72	57.38	41.48	39.52
		(2.22)	(22.01)	(36.32)	(45.89)	(28.63)	(44.74)	(49.36)	(37.54)	(38.10)
Imidacloprid	64	0.00	16.03	13.51	20.62	5.60	26.38	11.83	21.01	10.31
		(3.33)	(17.86)	(19.25)	(26.12)	(12.09)	(30.80)	(17.81)	(24.93)	(16.38)
Lambda-cyhalothrin	24	0.00	28.05	17.04	50.90	22.74	48.31	43.56	42.42	27.78
		(2.22)	(29.23)	(21.62)	(45.51)	(27.52)	(44.00)	(41.08)	(39.58)	(30.07)
Neem seed-kernel extract	10%	0.00	18.05	26.36	39.11	12.89	30.84	14.80	29.33	18.02
		(8.89)	(20.63)	(30.33)	(38.61)	(20.61)	(33.25)	(22.56)	(30.83)	(24.50)
Thiamethoxam	60	0.00	2.81	37.86	17.82	15.81	14.19	14.20	11.61	22.66
		(12.78)	(6.37)	(37.49)	(24.26)	(22.39)	(21.36)	(21.74)	(17.33)	(27.21)
Untreated check		0.00	31.96	51.78	60.57	29.69	58.29	60.62	50.27	47.36
		(6.67)	(33.18)	(46.34)	(51.30)	(31.78)	(50.03)	(52.10)	(44.84)	(43.41)
Mean		0.00	19.40	28.29	39.43	17.03	35.61	31.01		
		(6.28)	(21.08)	(30.48)	(38.00)	(22.74)	(35.55)	(31.95)		

acephate (0.24%) and NSKE (1.27%). Fenvalerate, ethofenprox, avermectin and lambda cyhalothrin proved less effective in checking shoot infestation during 2004. In untreated check, shoot infestation was 7.50 and 6.30% during 2003 and 2004, respectively. On the basis of two years data minimum shoot infestation was found in acetamiprid and cartap hydrochloride treatments followed by thiamethoxam, imidacoprid and neem seed kernel extract.

Efficacy of Insecticides on the Basis of Fruit Infestation

Table 2 reveals that during 2003, no fruit infestation was observed 1 day before insecticide application (though shoot infestation was evident during the period). The first spray application provided significantly lower fruit infestation (19.40%), being 39.43 and 35.61% during second and third spray, respectively which were at par to each other. Lowest fruit infestation was observed in thiamethoxam (2.81%) followed by acetamiprid (11.71%) during 2003 but it was lowest in cartap hydrochloride (9.25%) and imidacloprid (13.51%) during 2004. In untreated check the fruit infestation was 51.78%. After second spray application during 2003, acetamiprid (9.60%) provided the least fruit infestation. However, during 2004 imidacloprid was found to be superior to acetamiprid though they were at par. Cartap hydrochloride and NSKE were the next best treatments. Acetamiprid (11.36%) and thiamethoxam (14.19%) proved to be seperior after third spray in 2003 whereas acetamiprid (5.53%) provided significantly less fruit infestation during 2004 followed by cartap hydrochloride (11.14%). In control, the fruit infestation was 58.29 and 60.62% during 2003 and 2004, respectively.

Based on fruit infestation, the order of relative efficacy of insecticides during 2003 was acetamiprid ≈ thiamethoxam > imidacloprid ≈ cartap hydrochloride ≈ neem seed kernel extract ≈ acephate≈ avermectin ≈ fenvalerate > lambda-cyhalothrin≈

Table 3. Economics of different insecticides against *Leucinodes orbonalis* in brinjal. Mean yield in untreated check = 69.63 q/ha ; Sale price of produce = Rs 500/q ; Labor charges at Rs 70/day. Cost of insecticides : acephate at Rs 325/500 g, acetamiprid at Rs 2600/500 g, avermectin at Rs 4,500/500 ml, cartap hydrochloride at Rs 375/500 g, ethofenprox at Rs 300/500 ml, fenvalerate at Rs 48.50/500 g, imidacloprid at Rs 1,780/500 ml, lambda cyhalothrin at Rs 295/500 ml, neem seed kernel at Rs 25/500 g and thiamethoxam at Rs 2,000/500 g.

Treatments	Dose (g a.i. / ha)	Yield (q/ha)	In-crease in yield (q/ha)	Cost of pro-duce (Rs)	Cost of pro-tec-tion (Rs)	Net profit (Rs)	Cost benefit ratio (C : B)
Acephate	315	90.00	20.37	10187	1239	8948	7.22
Acetamiprid	18	121.57	51.94	25970	1824	24146	13.24
Avermectin	5.7	78.50	8.87	4435	8520	– 4085	– 0.48
Cartap hydrochloride	300	110.11	40.48	20241	1770	18471	10.44
Ethofenprox	60	76.96	7.33	3664	1500	2164	1.44
Fenvalerate	60	76.99	7.36	3678	507	3171	6.25
Imidacloprid	64	96.24	26.61	13303	4265	9038	2.12
Lambda cyhalothrin	24	89.85	20.22	10109	1270	8839	6.96
Neem seed kernel extract	10%	97.46	27.83	13914	9420	4494	0.48
Thiamethoxam	60	110.64	41.01	20504	3300	17204	5.21

ethofenprox. During 2004, the order of relative efficacy of insecticides was cartap-hydrochloride ≈ imidacloprid ≈ acetamiprid > neem seed kernel extract ≈ thiamethoxam > lambda-cyhalothrin ≈ ethofenprox ≈ avermectin ≈ acephate > fenvalerate. Based upon two years data, acetamiprid resulted in minimum fruit infestation followed by cartap hydrochloride, imidacloprid and NSKE.

The present observations on the effectiveness of cartap hydrochloride are in conformity with those of Naitam and Mali (18) and Muthukumar and Kalyansundram (19), who also recorded cartap hydrochloride to be effective in reducing fruit infestation by *L. orbonalis.* Naqvi (20) also observed that a module consisting of three sprays of acetamiprid to be effective against *L. orbonalis* in hyper-arid region of Rajasthan, which substantially support the present findings.

Mathirajan et al. (21) observed fenvalerate to be least effective against *L. orbonalis* amongst the three insecticides (lambda cyhalothrin, imidacloprid and fenvalerate) tested. Muthukumar and Kalyansundram (19) and Duara et al. (22) also observed fenvalerate to be relatively less effective as compared to other tested insecticides. Low effectiveness of fenvalerate compared to other insecticides against *L. orbonalis* has also been observed by Umapathy and Baskaran (23). The present results are contrary to those of Brar et al. (24), Misra (25) and Mehta et al. (26) who reported fenvalerate to be effective against *L. orbonalis.* The low efficacy of fenvalerate against *L. orbonalis* might be due to the reason that the insecticide is recommended to manage the pest (17) and as many as 5—6 sprays of this insecticide are given which might have resulted in the development of insecticide resistance in this insect. Resistance to fenvalerate has been reported in Himachal Pradesh (16), which supports the lower effectiveness of fenvalerate in the present study.

Economics of Different Insecticides Against L. orbonalis in Brinjal

Table 3 reveals that mean maximum fruit yield of both the years was recorded in acetamiprid (121.57 q/ha) followed by cartap hydrochloride (110.11 q/ha) and thiamethoxam (110.64 q/ha). Freshly prepared neem seed kernel extract and imidacloprid treatment registered 97.46 and 96.24 q/ha fruit yield, respectively. This was followed by ethofenprox, fenvalerate and avermectin treatments (76.96, 76.99 and 78.50 q/ha, respectively). Yield was minimum in untreated check (69.63 q/ha). Increase in yield over untreated check was maximum in acetamiprid (51.94 q/ha) followed by thiamethoxam and cartap hydrochloride (41.01 and 40.48 q/ha, respectively). How-

ever, the treatments, neem seed kernel extract and imidacloprid registered 27.83 and 26.61 q/ha increase in yield over control while it was low (7.33 to 8.87 q/ha) for avermectin, ethofenprox and fenvalerate. Net profit in all the insecticide treatments was positive, except in avermectin, which provided negative returns (-Rs 4,085/ha). Acetamiprid resulted in maximum profit (Rs 24,146/ha) followed by cartap hydrochloride (Rs 1,8471/ha). Net profit of Rs 4,494 per hectare was recorded in neem seed kernel extract treatment. However, the profit was minimum in ethofenprox (Rs 2,164/ha).

Cost benefit ratio was found to be maximum in acetamiprid (1 : 13.24) followed by cartap hydrochloride (1 : 10.44), however it was minimum (-0.48) in avermectin. Neem seed kernel extract recorded benefit of Rs 0.48 per rupee invested for protection. Despite of better efficacy, imidacloprid and thiamethoxam resulted in the cost benefit ratio of 1 : 2.12 and 1 : 5.21, respectively.

Naqvi (20) observed that three sprays of acetamiprid in brinjal resulted in substantial increase in yield (234.33 q/ha) over control and gave a return of Rs 15.66 per rupee invested. The increase in marketable fruit yield by cartap hydrochloride is also corroborated by similar observations of Muthukumar and Kalyansundram (19).

Thiamethoxam also reflected increase in yield over control (41.01 q/ha, 58.90%) and benefit of Rs 5.21 per rupee invested in the present studies. Muthukumar and Kalyansundram (19) reported that thiamethoxam provided moderate increase in fruit yield of brinjal (17.53 t/ha) as against 12.17 t/ha in control.

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