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Efficacy of different insecticides against leaf and capsule borer, *Antigastra catalaunalis* (Dup.) infesting sesame, *Sesamum indicum* (Linn.)

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Abstract
Investigations on "Efficacy of Different insecticides Against Leaf and Capsule Borer, *Antigastra catalaunalis* (Dup.) Infesting Sesame, *Sesamum indicum* (Linn.)." were conducted at Agronomy farm and Department of Entomology, S.K.N. College of Agriculture, Jobner during *Kharif*, 2015 and 2016. *A. catalaunalis* were recorded as major insect pests of sesame during both the years of study. Total nine treatments including untreated control were tested against *A. catalaunalis* for their efficacy. The insecticides *viz.*, spinosad and indoxacarb followed by acephate and standard check (carbaryl) were found most effective, whereas, the entomopathogenic fungus, *B. bassiana* and NSKE were found least effective against the pest. The highest seed yield of 8.22, 8.16, 7.85 and 7.59 q ha^{-1} was recorded in the plots treated with spinosad, indoxacarb, acephate and carbaryl, respectively. The highest B: C ratio was recorded in acephate (11.61), followed by vertimec (11.37) and carbaryl (9.43).

Keywords: Sesame, *Antigastra catalaunalis* (Dup.), insecticides, biopesticides

Introduction

Sesame, *Sesamum indicum* (Linn.) (Family: Pedaliaceae) is the oldest oilseed crop of world cultivated throughout the India. East Africa and India are considered to be the native home of sesame (Bedigian, 1985 and Nayar and Mehra, 1970) [6, 17]. Its seeds contain 52- 57 percent oil and 25 percent protein (Smith *et al.,* 2000) [22]. The important sesame growing countries are India, China, Sudan, Burma and Mexico. In India, the cultivation is mainly confined to Uttar Pradesh, Rajasthan, Madhya Pradesh, Andhra Pradesh, Odisha, Gujarat, Tamil Nadu and Karnataka. In India, production of sesame was estimated to be 8.11 lakh tonnes during 2014-15 (Anonymous, 2015a) [4]. The total area under cultivation of sesame in Rajasthan was about 3.30 lakh hectares with annual production to the tune of 9.49 thousand tonnes and average productivity of 288 kg (Anonymous, 2015b) [5]. Its cultivation gained impetus because of high quality edible oil, rich source of carbohydrate, protein, calcium and phosphorus (Seegeler, 1983) and, therefore, considered to be the 'queen of oil seeds'. The pests attack tolls a heavy loss (25- 90%) in seed yield (Ahuja and Kalyan, 2002) [2]. Among 67 insect pests damaging sesame crop, the leaf insect pests, *viz.,* leaf and capsule borer, *Antigastra catalaunalis* (Dup.); jassid, *Orosius albicinctus* Distant; whitefly, *Bemisia tabaci* (Genn.) and mirid bug, *Nesidiocoris tenuis* (Reuter) are considered to be key pests (Ahirwar *et al.*, 2009) [1]. The *A. catalaunalis* is an important pest because this attacks the crop in all the growth stages after about two weeks of emergence (Suliman *et al*., 2004) [24]. The attack is more severe during dry seasons and after initiation of flowering. It feeds on tender foliage by webbing the top leaves, bores into the pods and shoots (Narayanan and Nadarajan, 2005) [16]. This insect pest causes 10-70 percent infestation of leaves, 34-62 percent of flower buds/ flowers and 10-44 percent infestation of pods resulting in upto 72 percent loss in yield (Ahirwar *et al.,* 2010a) [2]. The chemical control has been suggested by many workers to combat with the insect pests of sesame crop (Goel and Kumar, 1991; Kumar *et al*., 1994; Selvanarayanan and Baskaran, 1996; Brar *et al.,* 1999; Tripathi *et al*., 2007; Kumar and Ali, 2010; Suliman *et al.,* 2013) [9, 24] but due to one or other reasons, could not become panacea in protection of the crop. The use of insecticides have undoubtedly resulted in the maximum production of food grain for the world food supply, but the proliferation of insecticides and their unilateral utilization have posed many grave problems such as development of resistance in insect pests to insecticides, resurgence of insect pests, outbreak of secondary insect pests, insecticidal residues etc. Development of insecticide resistance in insect pests is now one of the major problems in pest management. It causes unexpected crop losses to the growers. Presently, various bioinsecticides with different mode of action are available, that necessitate evaluation against *A. catalaunalis* a major insect pest of sesame.

Materials and methods

The experiment was laid out in simple randomized block design with nine treatments including control, each replicated thrice. The seeds of sesame (variety RT-125) were sown in the field on 12th July in *Kharif*, 2015 and 16 in the plots measuring 2.5 x 1.5 m^2 keeping 30 cm and 10 cm row to row and plant to plant distance, respectively. The insecticides were applied when sufficient population of sesame leaf and capsule borer built up on the plants. First spray was done on 16th August using a knap sack sprayer and second application was made three weeks after first application. The re-build up of population was observed at this stage. The spray solution used for spraying the crop was 500 and 600 l ha^{-1} in first and second spray, respectively.

Result and discussion

First spray

The data presented in (Table 1) indicated that one day after application of insecticides, the maximum reduction of 75.70 percent in leaf and capsule borer population was observed in spinosad followed by indoxacarb (73.55%), carbaryl (70.20%) and acephate (70.00%) that formed a non significant and most effective group of insecticides. The next effective treatments were vertimec, *Btk*, NSKE and *Beauveria bassiana* with 67.85, 66.65, 65.50 and 65.50 percent reduction, respectively; these treatments were at par each other. The minimum reduction of 65.50 percent was recorded in NSKE followed by *B. bassiana* (65.50%).

After three days of application of the treatments, the spinosad 0.01 percent and indoxacarb 0.01 percent, *viz*., 79.65 and 76.36 percent reduction which were found at par with each other. The indoxacarb 0.01 percent was found at par with carbaryl (72.55) and acephate (72.47) Choudhary and Singh (1986) [8] and Hubbaishan (1989) pointed out the best spray schedule comprising carbaryl which supports the present finding. *Beauveria bassiana* 1 g/ l and NSKE 5.0 percent showed lowest reduction, *viz*., 68.83% and 68.08% percent, respectively which were found at par with each other. The remaining treatments ranked in the middle order. Selvanarayan and Baskaran (1996) registered effectiveness of Btk which corroborates with the present finding. After seven days of application of treatments, the spinosad 0.01 percent and indoxacarb 0.01 percent revealed maximum reduction in caterpillar population, *viz*., 73.80 percent and 71.16 percent and stood significantly superior over rest of the treatments, this treatment was followed by carbaryl 0.1 percent (67.60 %) and acephate 0.05 percent (66.57%). The *Beauveria bassiana* 1 g/ l and NSKE 5.0 percent revealed caterpillar reduction of 57.43 percent and 59.80 percent reduction, respectively which was statistically inferior to the other treatments. The remaining treatments ranked in the middle order. After fifteen days of application of insecticides, the spinosad 0.01 percent and indoxacarb 0.01 percent revealed maximum reduction in caterpillar population, *viz*., 61.56 percent and 58.10 percent and stood significantly superior over rest of the treatments. This treatment was followed by carbaryl 0.1 percent (55.52 %) and acephate 0.05 percent (54.95%).which formed a non-significant group. The *Beauveria bassiana* 1 g/ l stood at the lowest order of efficacy (35.63% reduction). The other treatments resulted in the middle order of efficacy. The order of efficacy in the first application of insecticides was spinosad 0.01 percent> indoxacarb 0.01 percent> Acephate 0.05 percent> carbaryl 50 WP> vertimec 1.9 mg a.i. l^{-1}> *Btk* 1 ml/ l> NSKE 5.0 percent> *Beauveria bassiana* 1 g/ l.

Second spray

All the insecticidal treatments proved significantly superior over untreated control in reducing the leaf and capsule borer population after one day of application. The maximum reduction of 75.60, 73.78, 70.20 and 70.02 percent was recorded in spinosad, indoxacarb, carbaryl and acephate, respectively and stood at par with each other. The next effective treatments were vertimec, *Btk,* NSKE and *Beauveria bassiana* which resulted in 67.90, 66.78, 65.78 and 65.00 percent reduction, respectively.

Three days after application of the treatments, the maximum reduction in leaf and capsule borer population recorded was 80.06, 79.08, 75.12 and 75.10 percent in spinosad, indoxacarb, carbaryl and acephate respectively which stood at par with each other. The next effective treatments were vertimec, *Btk* and NSKE *Beauveria bassiana* which registered 71.20, 69.85, 70.40 and 69.28 reduction in leaf and capsule borer population, respectively and were at par each other. The least effective treatments were NSKE (70.40) and *Beauveria bassiana* (69.28%) both were at par, significantly inferior to rest of the treatments but significantly superior over control.

Seven days after application, all the treatments were found significantly superior over untreated control after seven days of spray. The treatment of spinosad, indoxacarb, carbaryl,and acephate proved highly effective in reducing the leaf and capsule borer population 76.53, 74.06, 68.62 and 68.17 percent reduction, respectively and at par in their efficacy. The minimum reduction of 64.70, 63.74, 61.60 and 57.93 percent was recorded in vertimec, *Btk,* NSKE and *B. bassiana*, respectively which were statistically at par witch each other. These findings are in close conformity with that of Nath *et al.* (2002) Kumar and Ali (2010) which supports the present findings.

Fifteen days after application of insecticides, the maximum reduction in leaf and capsule borer population was recorded in spinosad (70.10%), indoxacarb (65.28%), carbaryl (60.95%) and acephate (60.35%). These treatments had non significant difference between them. The minimum reduction of 53.65, 50.13, 45.14 and 42.48 percent was recorded in *B. bassiana,* NSKE, *Btk* and vertimec, respectively, which were statistically at par with each other in their efficacy. The order of effectiveness of these treatments after fifteen days of application in descending order was spinosad, indoxacarb, acephate, carbaryl, vertimec, *Btk,* NSKE and *B. bassiana*.

Choudhary and Singh (1986) [8], Mahto, (1985), Hubaishan (1989), Singh and Grewal (1989), Goel and Kumar (1991) [9], Singh *et al.* (1991), Rohilla and Singh (1992), Kumar *et al*. (1994), Selvanarayanan and Baskaran (1996), Brar *et al.* (1999), Nath *et al.* (2002), Tripathi *et al*. (2007), Ahirwar *et al.* (2010b) [2], Kumar and Ali (2010), Kumar *et al*., 2011), Suliman *et al.* (2013) [24] and Wazire and Patel (2015) worked on the chemical control of insect pests of sesame emphasizing the efficacy of different insecticides against *A. catalaunalis*.

Damage indices

The leaf damage revealed in different treatments was in the range of 2.85-5.03 percent (Table-2). It was minimum in spinosad (2.85%) which was significantly superior over rest of the treatments. This was followed by indoxacarb (3.18%) and acephate (3.90%). as high as 27.26 percent leaf damage was observed in the control plots. All the treatments resulted in low leaf damage as compared to control. The highest leaf damage was recorded in *Beauveria bassiana* (5.03%) and NSKE (4.73%), these treatments were found significantly inferior over the other treatments. The remaining treatments resulted in the middle order.

The capsule damage in different treatments was in the range of 2.92-4.85 percent, the minimum being in the spinosad (2.92) which was significantly superior over rest of the treatments. This was followed by indoxacarb (3.08%) and acephate (3.43%). The overall efficacy of tested insecticides and biopesticides based on leaf and capsule damage was found to be: spinosad 0.01 percent > indoxacarb 0.01 percent > acephate 0.05 percent > carbaryl 0.1 percent > vertimec 9.5 mg ai l^{-1} > *Btk* 1 ml> NSKE 5.0 percent *B. bassiana* 1g/ l.

Seed Yield

The data registered on yield of sesame showed that it was maximum in the spinosad (8.22 q ha^{-1}) followed by indoxacarb (8.16 q ha^{-1}), acephate (7.85 q ha^{-1}) and carbaryl (7.59), these treatments were comparable with each other as well as best in enhancing the yield of sesame (Table 3). The treatment of *B. bassiana* proved least effective (5.44 q ha^{-1}) followed by NSKE *Btk*, and vertimec which registered seed yield of 6.10, 6.59 and 7.13 q ha^{-1} respectively which were significantly superior as compared to untreated control (3.74 q ha^{-1}). The results are in partial agreement with the finding of Mishra (2003) who reported that acephate+ cypermethrin was found quite effective in reducing the capsule damage done by *A. catalaunalis* ultimately increasing the seed yield.

Economics of treatments

The data presented in (Table 3) indicated that maximum net return (Rs 21,925.72 ha^{-1}) was obtained in the plots treated with spinosad followed by indoxacarb (Rs 17,913.5 ha^{-1}) and acephate (Rs 21,765.67ha^{-1}). The minimum net return of Rs 8,195 was obtained in the *B. bassiana* followed by 11,491 in NSKE treated plots. The plots treated with acephate gave maximum benefit cost ratio of 11.61 followed by vertimec (11.33) and carbaryl (9.43). Wazire and Patel (2015) indicated that maximum net return was obtained in the plots treated with spinosad and acephate and the highest cost benefit ratio was obtained with acephate which supports the present finding to some extent.

Table 1: Bioefficacy of different insecticides against sesame leaf and capsule borer, *Antigastra catalaunalis* (Dup.) on sesame

S. No.	Treatments	Conc. (%)/ Dosage	Mean percent reduction									
			First spray					Second spray				
			One	Three	Seven	Fifteen	Mean	One	Three	Seven	Fifteen	Mean
1.	Acepate 75 SP	0.05	70.00*	72.47	66.57	54.95	66.25	70.02	75.10	68.17	60.35	68.42
			(56.79)**	(58.36)	(55.29)	(47.86)	(54.49)	(56.81)	(60.07)	(55.69)	(51.01)	(55.82)
2.	Spinosad 45 SC	0.01	75.70	79.65	73.80	61.56	72.68	75.60	80.06	76.53	70.10	75.57
			(60.47)	(63.19)	(59.21)	(51.68)	(58.49)	(60.40)	(63.47)	(61.02)	(56.85)	(60.38)
3.	Vertimec 1.9 EC	9.5 mg ai	67.85	70.59	63.68	48.19	62.58	67.90	71.20	64.70	53.65	64.36
			(55.46)	(57.16)	(52.94)	(43.96)	(52.28)	(55.49)	(57.54)	(53.55)	(47.09)	(53.35)
4.	Indoxacarb 14.5 SC	0.01	73.55	76.36	71.16	58.10	69.79	73.78	79.08	74.06	65.28	73.05
			(59.05)	(60.91)	(57.52)	(49.66)	(56.66)	(59.20)	(62.78)	(59.38)	(53.90)	(58.72)
5.	Btk (*Bacillus thuringienus*) 8L	1 ml l^{-1}	66.65	69.58	63.08	42.58	60.47	66.78	69.85	63.74	50.13	62.62
			(54.73)	(56.53)	(52.58)	(40.73)	(51.04)	(54.80)	(56.70)	(52.98)	(45.07)	(52.31)
6.	*Beauveria bassiana* 1.15 WP	1 g l^{-1}	65.50	68.83	57.43	35.63	56.84	65.00	69.28	57.93	42.48	58.67
			(54.03)	(56.06)	(49.27)	(36.65)	(48.93)	(53.73)	(56.34)	(49.56)	(40.67)	(49.99)
7.	NSKE	5.0	65.50	68.08	59.80	40.03	58.35	65.78	70.40	61.60	45.14	60.73
			(54.03)	(55.60)	(50.65)	(39.25)	(49.81)	(54.20)	(57.04)	(51.70)	(42.21)	(51.19)
8.	Check, (Carbaryl) 50 WP	0.1	70.20	72.55	67.60	55.52	66.47	70.20	75.12	68.62	60.95	68.73
			(56.92)	(58.42)	(55.31)	(48.21)	(54.63)	(56.92)	(60.09)	(55.94)	(51.33)	(56.00)
9.	Control	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	S.Em. ±		1.26	1.20	1.13	1.04	1.05	1.32	1.36	1.30	1.06	1.07
	CD (p= 0.05)		3.77	3.59	3.38	3.13	3.14	3.94	4.07	3.89	3.19	3.21

* Mean of three replications

**Figures in parentheses are angular transformed values

Table 2: Bioefficacy of different insecticides against sesame leaf and capsule borer, *Antigastra catalaunalis* (Dup.) on sesame

Sr. No.	Treatments	Conc.(%)/ Dosage	Leaf damage (%)			Capsule damage (%)		
			2015	2016	Pooled	2015	2016	Pooled
1.	Acepate 75 SP	0.05	3.85*	3.95	3.90	3.75	3.75	3.75
			(11.32)**	(11.46)	(11.39)	(11.17)	(11.17)	(11.17)
2.	Spinosad 45 SC	0.01	2.75	2.95	2.85	2.89	2.95	2.92
			(9.55)	(9.89)	(9.72)	(9.79)	(9.89)	(9.84)
3.	Vertimec 1.9 EC	9.5 mg ai	4.00	4.05	4.03	3.90	3.85	3.88
			(11.54)	(11.61)	(11.57)	(11.39)	(11.32)	(11.35)
4.	Indoxacarb 14.5 SC	0.01	3.35	3.00	3.18	3.05	3.10	3.08
			(10.55)	(9.97)	(10.26)	(10.06)	(10.14)	(10.10)
5.	Btk (*Bacillus thuringienus*) 8L	1 ml l^{-1}	4.35	4.45	4.40	4.25	4.05	4.15
			(12.04)	(12.18)	(12.11)	(11.90)	(11.61)	(11.75)
6.	*Beauveria bassiana* 1.15 WP	1 g l^{-1}	5.00	5.05	5.03	4.95	4.75	4.85
			(12.92)	(12.99)	(12.95)	(12.86)	(12.59)	(12.72)
7.	NSKE	5.0	4.50	4.95	4.73	4.55	4.35	4.45
			(12.25)	(12.86)	(12.55)	(12.32)	(12.04)	(12.18)
8.	Check, (Carbaryl) 50 WP	0.1	3.75	3.85	3.80	3.35	3.50	3.43
			(11.17)	(11.32)	(11.24)	(10.55)	(10.78)	(10.67)
9.	Control	-	25.67	28.85	27.26	38.44	40.05	39.24
			(30.44)	(32.48)	(31.47)	(38.31)	(39.26)	(38.78)
	S.Em. ±		0.32	0.29	0.24	0.34	0.30	0.25
	CD (p= 0.05)		0.97	0.86	0.72	1.01	0.89	0.74

* Mean of three replications

** Figures in parentheses are angular transformed values

Table 3: Comparative economics of insecticidal treatments against *Antigastra catalaunalis* (Dup.) on sesame

S. No.	Treatments	Conc. (%) / doses	Yield (q ha^{-1})	Increase in yield over untreated check (q ha^{-1})	Return of increased yield (Rs ha^{-1})*	Total cost of expenditure (Rs)**	Net profit (Rs ha^{-1})	B : C ratio
1.	Acephate 75 SP	0.05	7.85	4.11	23640	1874.33	21765.67	11.61
2.	Spinosad 45 SC	0.01	8.22	4.48	25792.5	3866.8	21925.7	5.66
3.	Vertimec 1.9 EC	9.5 mg	7.13	3.39	19487.5	1574	17913.5	11.37
4.	Indoxacarb 14.5 SC	0.01	8.16	4.42	25452.5	3783.5	21669	5.72
5.	Btk (*Bacilus thuringiensis Var. krustaki*)	1 ml l^{-1}	6.59	2.85	16402.5	2344	14058.5	5.99
6.	*Beauveria bassiana* 1.15 WP	1 g/ l^{-1}	5.44	1.70	9807.5	1612.5	8195	5.08
7.	NSKE	5.0	6.10	2.36	13587.5	2096.5	11491	5.47
8.	Check (Carbaryl)	0.1	7.59	3.85	22157.5	2124	19533.5	9.43
9.	Control	-	3.74	-	-	-	-	-

* Cost of sesamum seed at current season was Rs 57.5/- per kg.

** It includes cost of insecticides and labour charges.

Conclusion
The most effective insecticides/ biopesticides were found to be the spinosad 0.01 percent and indoxacarb 0.01 percent (79.65 and 76.36 percent reduction, respectively) which were found at par with each other. These were followed by indoxacarb 0.01 percent and acephate. The plots treated with acephate gave maximum benefit cost ratio of 11.61 followed by vertimec (11.33) and carbaryl (9.43).

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