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RELATIVE EFFICACY OF BIO-PESTICIDES AGAINST MAJOR INSECT-PESTS OF CABBAGE

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ABSTRACT

The relative efficacy of biopesticides was evaluated in field trials carried out at Horticulture Farm, Rajasthan College of Agriculture, Udaipur during *rabi,* 2012-13. Among different treatments tested**,** *Verticillium lecani* @ 1x10^8 CFU/g caused maximum reduction of 74.18 per cent in population of aphid and was significantly superior over other treatments followed by Spinosad 45 SC @ 200 ml/ha and *Metarhizium anisopliae* @ 1x10^8 CFU/g with 55.67 and 42.12 per cent mean reduction. Spinosad 45 SC @ 200 ml/ha caused maximum reduction in population of diamond back moth (75.67%) and flea beetle (80.30%) that was significantly superior over other treatments followed by *Bacillus thuringiensis* var. *kurstaki* @ 1 kg/ha (71.25% and 70.34%) and *Metarhizium anisopliae* @ 1x10^8 CFU/g (60.20% and 59.12%). Spinosad 45 SC @ 200 ml/ha also caused maximum reduction of tobacco caterpillar (85.33%) and was significantly superior over other treatments followed by SlNPV @ 250 LE (1.5X10^{12} POB/ha) (83.15%) and *B. t*. var. *kurstaki* @ 1 kg/ha (75.20%).

Key words: Entmopathogens, botanicals, major insect pests, cabbage

INTRODUCTION

Cruciferous vegetables have an important place among *rabi* crops grown in India. Cabbage, *Brassica oleracea* var. *capitata* (Linn.), is a popular vegetable that is grown in all the states of India and has appreciable nutritional and economic value. Cabbage is used as salad, boiled vegetable, in curries and pickles; it is rich in minerals and vitamins A, B and C. The total area under cabbage cultivation in India is 372.36 thousand hectares with an annual production of 8534.23 thousand tonnes (NHB data base 2012-13). Insect pests are a serious menace in the profitable cultivation of cabbage. The more important insect pests that infest cabbage are the tobacco caterpillar (*Spodoptera litura* Fab.), diamond back moth (*Plutella xylostella* L.), cabbage semilooper (*Trichoplusia ni* Hubner), painted bug (*Bagrada hilaris* Burmeister), cabbage butterfly (*Pieris brassicae* L.), flea beetle (*Phyllotreta cruciferae* Goeze), aphids (*Lipaphis erysimi* Kalt.) and the mustard saw fly (*Athalia lugens proxima* Klug.) (Ayyar, 1963; Lall, 1964). Among these, *S. litura* (F.) (Lepidoptera: Noctuidae), is a major pest of cabbage. The caterpillars voraciously feed on the leaves and in nurseries entire seedbeds get defoliated within a week. The pest causes damage to an extent of 80-100 per cent in the nurseries under favourable conditions (Chari *et al.*, 1994) and 10-25 per cent to the field crop (Rao and Sitaramaiah, 2001). The indiscriminate use of insecticides has led to problems like insecticide resistance, pest resurgence and environmental pollution besides upsetting the natural balance. Researchers later recognized the harmful effects of pesticides and tried to bring eco-friendly approaches to reduce pesticide load in environment by using bio-agent and bio-pesticides. Hence, there is an urgent need for the development of environment friendly methods such as utilization of insect pathogens, antagonist or competitor populations of a third organism and botanicals to suppress the pest population.

MATERIALS AND METHODS

A few biopesticides (Table 1) were evaluated for their efficacy in a field trial at the Horticulture Farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur during *rabi*, 2012-2013.

The seeds of cabbage variety, 'Golden Acre' were sown in well prepared nursery beds in the first week of December, 2012. The seedlings were transplanted in the experimental field after four weeks.

The cabbage seedlings were transplanted with a row to row and plant to plant space of 45 cm and 45 cm, respectively. The experiment was laid out in Randomized block design with three replications. Observation on population of insect pests *viz.*, aphid, (*Lipaphis erysimi* Kalt.), diamond back moth, (*P. xylostella* Linn.), tobacco caterpillar, (*S. litura* Fab.) and flea beetle, (*P. cruciferae*

Goeze) were recorded 24 h before and 3, 7 and 15 days after each spray.

Statistical analysis

Efficacy of different treatments in controlling the insect pests was analyzed by analysis of variance. The population data was corrected using the correction factor given by Henderson and Tilton (1952) as under:

$$\text{Per cent reduction in population} = 100\left[1 - \frac{T_a \times C_b}{T_b \times C_a}\right]$$

Where,

T_a = Number of insects after treatment

T_b = Number of insects before treatment

C_a = Number of insects in untreated check after treatment

C_b = Number of insects in untreated check before treatment.

The reduction percentage figures were transformed into arc sine values and subjected to analysis of variance.

Table 1. Treatment details

S. No.	Treatments	Doses (ha)
1.	Spinosad 45 SC	200 ml/ha
2.	*Verticillium lecani*	$1x10^8$ CFUs/g
3.	*Metarhizium anisopliae*	$1x10^8$ CFUs/g
4.	SlNPV	250 LE/ha
5.	Bt.K	1kg/ha
6.	NSKE (Azadirachtin 1%)	5 ml/lit.
7.	Control	–

Where

B.t.k. = *Bacillus thuringiensis var*. kurstaki

CFUs = Colony forming units

POBs = Polyhedral occulated bodies

RESULTS AND DISCUSSION

All the treatments were significantly superior over control (Tables 2 to 7). Among the different treatments *V. lecani* @ $1x10^8$ CFU/g caused maximum reduction (74.18%) in the population of aphid being significantly superior over other treatments followed by Spinosad 45 SC @ 200 ml/ha and *M. anisopliae* @ $1x10^8$ CFU/g with 55.67 and 42.12 per cent mean reduction (Table 2). Similarly, Spinosad 45 SC @ 200 ml/ha caused maximum reduction of (75.67%) in larval population of diamond back moth and was significantly superior over other treatments followed by *B. t*. var. *kurstaki* @ 1 kg/ha (71.25%) and *M. anisopliae* @ $1x10^8$ CFU/g (60.20%) (Table 3). Spinosad 45 SC @ 200 ml/ha caused maximum reduction in population of tobacco caterpillar (85.33%) and was significantly superior over other treatments followed by SlNPV @ 250 LE ($1.5X10^{12}$ POB/ha) (83.15%) and *B. t*. var. *kurstaki* @ 1 kg/ha (75.20%) (Table 4). Spinosad 45 SC @ 200 ml/ha also caused maximum reduction (80.30%) in population of flea beetle and was significantly superior over other treatments followed by *B. t*. var. *kurstaki* @ 1 kg/ha (70.34%) and *M. anisopliae* @ $1x10^8$ CFU/g (59.12%) (Table 5).

Mote *et al.* (2003) reported that *V. lecanii* at 0.3 per cent caused appreciable mortality of aphid population, 28.83, 61.67 and 93.44 per cent at 3, 7 and 14 days after

Table 2. Relative efficacy of bio-pesticides against aphid on cabbage during *Rabi*, 2012-2013

S. No.	Treatments	Quantity/ doses (ha)		Mean reduction (%) in aphid population					
				I Spray			II Spray		
			PTP	3 DAS	7 DAS	15 DAS	3 DAS	7 DAS	15 DAS
1.	Spinosad 45 SC	200 ml/ha	14.56	41.16 (43.33)	44.24 (48.67)	38.23 (38.31)	45.19 (50.33)	48.26 (55.67)	39.31 (40.13)
2.	*Verticillium lecani*	$1x10^8$ CFUs/g	15.61	46.19 (52.07)	52.37 (62.67)	55.04 (67.1)	56.94 (70.14)	58.21 (72.12)	59.56 (74.18)
3.	*Metarhizium anisopliae*	$1x10^8$ CFUs/g	16.88	35.44 (33.65)	38.84 (39.34)	39.94 (41.23)	34.04 (31.35)	39.49 (40.45)	40.46 (42.12)
4.	SlNPV	250LE ($1.5x10^{12}$ POBs/ha)	16.45	0.00	0.00	0.00	0.00	0.00	0.00
5.	Bt.K	1 kg/ha	15.85	0.00	0.00	0.00	0.00	0.00	0.00
6.	NSKE (Azadirachtin1%)	5 ml/lit.	15.95	40.01 (41.34)	39.62 (40.67)	33.90 (31.12)	41.04 (43.12)	39.92 (41.19)	34.55 (32.17)
7.	Control	_	16.48	NA	NA	NA	NA	NA	NA
	S. Em. ±	_		0.900	0.943	0.865	1.064	1.047	0.976
	CD at 5%	_		2.837	2.971	2.727	3.352	3.300	3.075

* Figures in the parenthesis are retransformed per cent values; DAS- Days after spray, PTP- Pre treatment population

Table 3. Relative efficacy of bio-pesticides against diamond back moth on cabbage during *Rabi*, 2012-2013

S. No.	Treatments	Quantity/ doses (ha)	PTP	Mean reduction (%) in diamond back moth population					
				I Spray			II Spray		
				3 DAS	7 DAS	15 DAS	3 DAS	7 DAS	15 DAS
1.	Spinosad 45 SC	200 ml/ha	4.77	52.01 (62.11)	59.46 (74.15)	39.81 (40.99)	55.01 (67.11)	60.45 (75.67)	42.64 (45.89)
2.	*Verticillium lecani*	1x10^8 CFUs/gram	5.61	39.42 (40.33)	40.45 (42.11)	39.89 (41.15)	42.21 (45.14)	43.39 (47.2)	44.51 (49.15)
3.	*Metarhizium anisopliae*	1x10^8 CFUs/gram	6.81	45.40 (50.7)	47.71 (54.7)	48.97 (56.89)	46.21 (52.1)	49.10 (57.11)	50.91 (60.2)
4.	SlNPV	250LE (1.5x10^{12} POBs/ha)	6.45	0.00	0.00	0.00	0.00	0.00	0.00
5.	Bt.K	1 kg/ha	5.85	50.85 (60.12)	56.40 (69.34)	52.61 (63.1)	52.67 (63.21)	57.60 (71.25)	54.42 (66.12)
6.	NSKE (Azadirachtin1%)	5 ml/lit.	5.95	41.04 (43.11)	37.92 (37.78)	34.03 (31.32)	42.11 (44.96)	38.70 (39.1)	34.53 (32.14)
7.	Control	_	6.48	NA	NA	NA	NA	NA	NA
	S. Em. ±	_		0.689	0.965	0.816	0.694	0.790	0.820
	CD at 5%	_		2.170	3.041	2.571	2.186	2.489	2.584

* Figures in the parenthesis are retransformed per cent values; DAS- Days after spray, PTP- Pre treatment population

Table 4. Relative efficacy of bio-pesticides against *S. litura* on cabbage during *Rabi*, 2012-2013

S. No.	Treatments	Quantity/ doses (ha)	PTP	Mean reduction (%) in *S. litura* population					
				I Spray			II Spray		
				3 DAS	7 DAS	15 DAS	3 DAS	7 DAS	15 DAS
1.	Spinosad 45 SC	200 ml/ha	5.54	56.89 (70.14)	65.95 (83.32)	40.28 (42.12)	59.49 (74.20)	67.55 (85.33)	41.70 (44.20)
2.	*Verticillium lecani*	1x10^8 CFUs/g	6.61	39.87 (41.10)	40.31 (42.16)	41.61 (44.10)	41.64 (44.16)	42.81 (46.19)	44.57 (49.25)
3.	*Metarhizium anisopliae*	1x10^8 CFUs/g	6.45	45.70 (51.21)	48.05 (55.30)	50.01 (58.67)	46.21 (52.10)	49.10 (57.11)	50.90 (60.19)
4.	SlNPV	250LE (1.5x10^{12} POBs/ha)	6.67	50.01 (58.62)	54.45 (66.15)	59.63 (74.34)	61.58 (77.21)	63.66 (80.14)	65.95 (83.15)
5.	Bt.K	1 kg/ha	7.02	52.75 (63.35)	59.98 (74.90)	56.61 (69.67)	54.49 (66.23)	60.18 (75.2)	57.57 (71.20)
6.	NSKE (Azadirachtin1%)	5 ml/lit.	6.95	41.90 (44.60)	38.24 (38.31)	33.36 (30.25)	42.11 (45.2)	39.39 (40.27)	33.98 (31.25)
7.	Control	_	7.07	NA	NA	NA	NA	NA	NA
	S. Em. ±	_		1.135	1.437	1.282	1.435	1.479	1.498
	CD at 5%	_		3.756	4.527	4.039	4.521	4.661	4.719

* Figures in the parenthesis are retransformed per cent values; DAS- Days after spray, PTP- Pre treatment population

treatment, respectively. Downward (2004) found that Spinosad was highly effective against diamondback moth and several other important lepidopteran pests; whereas, Paliwal and Oommen (2005) reported spinosad most effective against tobacco caterpillar, *S. litura* in cauliflower. Amongst its various doses tested, 60 g a.i./ha^{-1} gave maximum population reduction of *S. litura* (88.03 %) after seven days of first spraying. Topagi *et al.* (2010) reported that Spinosad 45 SC (0.015%) was very effective against *S. litura* with 51 per cent mean reduction in larval population over untreated check. The cumulative population reduction for aphids and larvae of diamond back moth after two applications of biopesticides has been given in Table (6) and that for tobacco caterpillar and flea beetles in Table (7).

Table 5. Relative efficacy of bio-pesticides against flea beetle on cabbage during *Rabi*, 2012-2013

S. No.	Treatments	Quantity/ doses (ha)	PTP	Mean reduction (%) in flea beetle population					
				I Spray			II Spray		
				3 DAS	7 DAS	15 DAS	3 DAS	7 DAS	15 DAS
1.	Spinosad 45 SC	200 ml/ha	7.05	56.58 (69.65)	62.23 (78.25)	40.18 (42.11)	57.86 (71.67)	63.69 (80.30)	42.81 (46.19)
2.	*Verticillium lecani*	$1x10^8$ CFUs/g	8.61	39.31 (40.15)	40.50 (42.19)	42.24 (45.2)	42.23 (45.18)	43.35 (47.13)	44.51 (49.14)
3.	*Metarhizium anisopliae*	$1x10^8$ CFUs/g	9.04	44.24 (48.67)	46.32 (52.30)	49.02 (56.96)	45.00 (50.00)	47.41 (54.18)	50.28 (59.12)
4.	SlNPV	250LE ($1.5x10^{12}$ POBs/ha)	8.43	0.00	0.00	0.00	0.00	0.00	0.00
5.	Bt.K	1 kg/ha	8.85	46.26 (52.20)	54.50 (66.25)	52.07 (62.19)	48.56 (56.19)	57.03 (70.34)	54.52 (66.28)
6.	NSKE (Azadirachtin1%)	5 ml/lit.	9.08	39.17 (39.90)	39.89 (41.13)	34.59 (32.24)	39.30 (40.12)	40.55 (42.27)	34.65 (32.34)
7.	Control	_	9.07	NA	NA	NA	NA	NA	NA
	S. Em. ±	_		0.929	0.924	0.835	0.983	0.980	0.882
	CD at 5%	_		2.926	2.911	2.630	3.098	3.089	2.778

* Figures in the parenthesis are retransformed per cent values; DAS- Days after spray, PTP- Pre treatment population

Table 6. Cumulative reduction in population of aphid and larval population of diamond back moth in cabbage crop after two applications of bio-pesticide treatments during *Rabi*, 2012-13

S. No.	Treatments	Population reduction (%) of Aphid			Mean	Larval population reduction (%) of Diamond back moth			Mean
		3 DAS	7 DAS	15 DAS		3 DAS	7 DAS	15 DAS	
1.	Spinosad 45 SC	46.83	52.17	39.22	46.07	64.61	74.91	43.44	60.98
2.	*Verticillium lecani*	61.10	67.39	70.64	66.37	42.73	44.65	45.15	44.17
3.	*Metarhizium anisopliae*	32.50	39.89	41.67	38.02	51.40	55.90	58.54	55.28
4.	SlNPV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5.	Bt.K	0.00	0.00	0.00	0.00	61.66	70.29	64.21	65.38
6.	NSKE (Azadirachtin1%)	42.23	40.93	31.64	38.26	44.03	38.44	31.73	38.06

DAS= Days after spray

Table 7. Cumulative reduction in larval population of *Spodoptera litura* and population of flea beetles in cabbage crop after two applications of bio-pesticide treatments during *Rabi*, 2012-13

S. No.	Treatments	Larval population reduction (%) of *Spodoptera litera*			Mean	Population reduction (%) of Flea beetles			Mean
		3 DAS	7 DAS	15 DAS		3 DAS	7 DAS	15 DAS	
1.	Spinosad 45 SC	72.17	84.32	43.16	66.55	70.66	79.27	44.15	64.69
2.	*Verticillium lecani*	42.63	44.17	46.67	44.49	42.66	44.66	47.17	44.83
3.	*Metarhizium anisopliae*	51.65	56.20	59.43	55.76	49.33	53.24	58.04	53.53
4.	SlNPV	67.91	73.14	78.74	73.26	0.00	0.00	0.00	0.00
5.	Bt.K	64.79	75.05	70.43	70.09	54.19	68.29	64.23	62.23
6.	NSKE (Azadirachtin1%)	44.90	39.29	30.75	38.31	40.01	41.70	32.29	38.00

DAS= Days after spray

Table 8. Cost benefit ratio of different treatments against major insect-pests of cabbage during *Rabi*, 2012-13

S. No.	Treatments	No. of sprays	Average yield (q/ha)	Gross return (Rs.)	Increased yield over control (q/ha)	Value of increased yield over control (Rs./ha)	Management Cost (labour + Bio-pesticides) (Rs./ha)	Net profit (Rs./ha)	C:B ratio
1.	Spinosad 45 SC @ 200ml/ha	2	289.25	433875	146.67	220005	6721	213284	1:2.000
2.	*Verticillium lecani* @ 1x10^8 CFUs/g	2	232.56	348840	89.98	134970	1388	133582	1:1.620
3.	*Metarhizium anisopliae* @1x10^{8}CFUs/g	2	205.68	308520	63.10	94650	1388	93262	1:1.433
4.	SlNPV @ 250 LE/ha	2	265.81	398715	123.23	184845	1788	183057	1:1.848
5.	Bt.K @ 1 kg/ha	2	244.64	366960	102.06	153090	1888	151202	1:1.700
6.	NSKE (Azadirachtin1%) @ 5 ml/lit	2	182.35	273525	39.77	59550	3468	56082	1:1.258
7.	Control	0	142.58	213870	-	-	-	-	-

(1) Present price of bio-pesticides: Spinosad @ Rs. = 15335/lit. SlNPV @ Rs. = 2400/lit.

(2) Labour charge: @ Rs. 147 *Verticillium lecani* @ Rs. =400/kg Bt.K @ Rs. = 650/kg

Two labour / spray *Metarhizium anisopliae* @ Rs. = 400/kg NSKE (Azadirachtin1%) @ Rs. = 640/lit.

(3) Sale price of cabbage @ Rs. = 15/kg

The maximum net profit of Rs. 213284, and the highest cost benefit ratio of 1:2.00, were recorded for Spinosad 45 SC @ 200ml/ha. It was followed by SlNPV @ 250 LE/ha, *B. t*. var. *kurstaki* @ 1 kg/ha, *V. lecani* @ $1x10^8$ CFU/gram and *M. anisopliae* @ $1x10^8$ CFU/gram with the net profit and C: B ratio of Rs.183057, 151202, 133582, 93262, and 1:1.620, 1:1.433, 1:1.848, 1:1.700, respectively. The minimum net profit and cost benefit ratio of Rs. 56082 and 1:1.258 were recorded for NSKE (Azadirachtin 1%) @ 5 ml/lit (Table 8). The present findings are is in conformity with the earlier results of SlNPV @ 250 LE/ha that gave an average yield of 232.81 q/ha and cost benefit ratio 1:1.524, respectively (Wadhwani and Prasad, 2005).

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