Int.J.Curr.Microbiol.App.Sci (2020) *9*(12): 804-813

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 9 Number 12 (2020)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2020.912.096

Evaluation of Some Insecticides against Insect Pests of Cauliflower (*Brassica oleracea* var. *botrytis* L.)

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Keywords

Insecticides, Cauliflower, *Brevicoryne brassicae*, *Pieris canidia*, Benefit cost ratio

Article Info

Accepted:
07 November 2020
Available Online:
10 December 2020

A B S T R A C T

A field experiment was conducted to evaluate eight insecticides viz., Emamectin benzoate 5% SG @ 0.3 g/lit, Spinosad 45% SC @ 0.5 ml/lit, Thiacloprid 21.7% SC @ 0.3 ml/lit, Indoxacarb 14.5% SC @ 0.75 ml/lit, Imidacloprid17.8% SL @ 0.3 ml/lit, Thiamethoxam 30% FS @ 0.3 ml/lit, Chlorantraniliprole 18.5% SC @ 0.3 ml/lit and Cartap Hydrochloride 50 SP @ 1.5 ml/lit against cabbage aphid, *Brevicoryne brassicae* and cabbage butterfly, *Pieris canidia* on cauliflower. The result indicated that imidacloprid 17.8% SL recorded the highest (84.57 to 85.88%) reduction of aphid population followed by thiamethoxam 30% FS and thiacloprid 21.7% SC. The bio pesticide Spinoasd 45% SC recorded the highest (82.70 to 89.94%) reduction of cabbage butterfly population followed by emamectin benzoate 5% SG (80.15 to 83.28%). The benefit cost ratio was the highest in thiacloprid 21.7% SC (18.33:1) followed by thiamethoxam 30% FS (15.24:1) and Imidacloprid 17.8% SL (12.55:1).

Introduction

Cauliflower, *Brassica oleracea* var. *botrytis* (L.) belongs to the family Cruciferae is one of the important winter vegetable crops in India. It is a cool weather crop that is closely related to broccoli and cabbage.

Cauliflower can be grown in a wide range of soil with good fertility and good water regime. Fairly deep, loamy, rich in organic matter and well drained soil is preferable for growing cauliflower. The optimum p^H for cauliflower is 6.0-6.5. The optimum temperatures for curd formation are 15 to 22˚C, with an average maximum of 25˚C and average minimum of 8˚C.

Insect pest problem is one of the major constraints for achieving higher production in horticultural crops. During cultivation cauliflower attracts many insect pests which act as a limiting factor in the profitable cultivation of this crop (Abrol and Gupta, 2010). The major insect pests of this crop are cabbage butterfly (*Pieris brassicae)* and aphids (*Lipaphis erysimi)* which cause about 5 to 100% damage (Sachin and Gangwar,

1990). Diamond back moth, *Plutella xylostella* (Lepidoptera: Plutellidae) is also a serious pest of Cole crops and has a great economic importance worldwide (You and Wei, 2007). The damage is caused by its larvae which skeletonises the foliage part of the host plant and renders it unfit for consumption. It infests the plants at all growing stages causing defoliation, leaf curling and stunting of the plant. Cabbage butterfly, *Pieris* spp. (Linn.) is one of the most serious pests of the cruciferous crops causing about 20 to 100 per cent damage (Sachan and Gangwar, 1990).

As a quick solution, insecticides are the key tool in enhancing the agricultural production (Mehmood *et al.*, 2001). However, the excessive and haphazard use has not only caused environmental pollution but also led to the development of resistance, pest resurgence and adversely affected beneficial organisms. With increasing concerns of excessive use of chemical fertilizers and pesticides in agriculture, the non-synthetic pest control approaches seem to be novel alternatives of chemical insecticides and have high potential which may play an important role in future IPM programmes.

Despite having some effects on human health and environment, use of chemical pesticides is indispensable in order to bring down pests population by striking the weakest point of insect pests. Keeping in view of this, the present investigation was taken to evaluate the efficacy of some synthetic insecticides and bio-pesticides against insect pests of cauliflower.

Materials and Methods

Field experiment was carried out at School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema Campus during *Rabi* season of 2016-2017 to evaluate the efficacy of some synthetic insecticides and bio-pesticides against the major insect pests of cauliflower. A susceptible variety SF kartika was sown and raised as per recommended package of practices except insect pest management practices. The experiment was laid out in a Randomized Block Design (RBD) with 9 treatments including untreated control, each replicated thrice. The insecticide treatments were Emamectin benzoate 5% SG @ 0.3 g/lit, Spinosad 45% SC @ 0.5 ml/lit, Thiacloprid 21.7% SC @ 0.3 ml/lit, Indoxacarb 14.5% SC @ 0.75 ml/lit, Imidacloprid 17.8% SL @ 0.3 ml/lit, Thiamethoxam 30% FS @ 0.3 ml/lit, Chlorantraniliprole 18.5% SC @ 0.3 ml/lit and Cartap Hydrochloride 50 SP @ 1.5 ml/lit. Two sprays were given at 15 days interval using 625 litres of spray volume per hectare when the population exceeded beyond the prescribed economic threshold level (ETL).

The observations on the efficacy of the synthetic insecticides and bio-pesticides were recorded as pre-treatment and post-treatment count. Pre-treatment count was done one day before both first and second sprayings and post-treatment count was recorded at 3, 7 and 14 days after the respective sprayings to observe the efficacy of the insecticides. The pre treatment and post-treatment observation on aphids population was recorded from 5 randomly selected plants per plot. The aphid population was recorded by counting the number of adults as well as nymphs from three leaves i.e., top, middle and bottom leaves per plant. The larvae of cabbage butterfly were counted by inspecting 5 randomly selected plants from each plot. To assess the efficacy of each treatment, the per cent reduction of pest population was calculated from the following formula:

$$Per\ cent\ reduction = \frac{\text{Pre treatment count - post treatment count}}{\text{Pre treatment count}} \times 100$$

Data obtained were subjected to statistical analysis of variance after suitable transformations. Economics of different insecticide treatments were calculated according to prevailing market price of inputs and outputs. The benefit cost ratio (BCR) was calculated as:

$$\text{BCR} = \frac{\text{Net return (Profit due to treatments)}}{\text{Cost of treatments}}$$

Results and Discussion

During the period of investigation, two insects *viz*., Cabbage aphid, *Brevicoryne brassicae* (Hemiptera: Aphididae) and Cabbage butterfly, *Pieris canidia* (Linnaeus) (Lepidoptera: Pieridae) were recorded as major insect pests as they were found in large number and damaged the crop. Eight insecticides including two bio pesticides were evaluated against the two major insect pests of cauliflower during winter season of 2016-2017. The results thus obtained are presented and discussed under the following headings.

Efficacy of insecticides against cabbage aphid, *Brevicoryne brassicae*

The data pertaining to aphid population on one day before spraying and the per cent reduction of population at 3, 7 and 14 days after spraying on two different spray schedules are presented in Table 1.

After first spraying

The initial mean number of population of cabbage aphid, *Brevicoryne brassicae* on one day before spraying ranged from 10.14 to 15.95 per leaf. After three days of treatment imposition, the highest per cent reduction of 92.12 in population of *Brevicoryne brassicae* was observed in the plots treated with imidacloprid 17.8% SL. It was followed by thiacloprid (86.24%) and thiamethoxam (84.30%) which were at par with each other. The lowest reduction was found in chlorantraniliprole 18.5% SC (74.76%) which was found to be at par with emamectin benzoate 5% SG. The other treatments like indoxacarb 14.5% SC, cartap hydrochloride 50 SP and spinosad 45% SC were also found to be at par with each other during this period.

The observation recorded after seven days of spraying, the highest reduction of cabbage aphid was found in the plots treated with imidacloprid (83.83%) followed by thiacloprid (79.05%) and thiamethoxam (78.41%). The lowest reduction was found in chlorantraniliprole 18.5% SC (66.65%) during this period. The reduction of aphid population in the remaining treatments varied from 68.89 to 75.34%.

After 14 days of spraying, the highest reduction of cabbage aphid was found in the plots treated with imidacloprid 17.8% SL (77.77%) followed by thiamethoxam 30% FS (72.26%), thiacloprid 21.7% SC (70.40%) and indoxacarb 14.5% SC (67.43%). Thiacloprid 21.7% SC and thiamethoxam 30% FS were found to be at par with each other. The lowest reduction was found in the plot treated with chlorantraniliprole 18.5% SC (58.36%) which was also found to be at with emamectin benzoate 5% SG and spinosad 45% SC. However, the effect of all the treatments on the aphid population was significantly superior to the untreated control.

From the present findings, it is evident that all the treatments could significantly reduce the aphid population. The mean data indicated that imidacloprid 17.8% SL was the best insecticide which could reduce the aphid population up to 84.57% followed by thiacloprid 21.7% SC (78.56%). Chlorantraniliprole 18.5% SC was the least effective insecticide; however, it exhibited a mean of 66.59% reduction of aphid population.

After second spraying

The initial mean number of population of cabbage aphid, *Brevicoryne brassicae* on one day before spraying ranged from 4.09 to 12.90 per leaf. After three days of treatment, the highest per cent reduction of 95.08 in population of *Brevicoryne brassicae* was observed in the plots treated with imidacloprid 17.8% SL. It was followed by thiamethoxam 30% FS (88.29%), thiacloprid 21.7% SC (87.08%) and cartap hydrochloride 50 SP (85.63%) which were statistically found to be at par with each other. The lowest reduction was found in the plots treated with chlorantraniliprole 18.5% SC (71.76%) which was at par with emamectin benzoate 5% SG. Similarly, cartap hydrochloride 50 SP and indoxacarb 14.5% SC were also found to be at par with each other.

After seven days of spraying, the highest reduction was found in the plot treated with imidacloprid 17.8% SL (89.29%) followed by thiacloprid 21.7% SC (79.31%) and thiamethoxam 30% FS (78.24%). The latter two were found to be at par with each other. The lowest reduction was found in emamectin benzoate 5% SG (61.81%) followed by spinosad 45% SC (63.62%) which was at par with chlorantraniliprole 18.5% SC (65.83%) during this period. Similarly, cartap hydrochloride 50 SP and indoxacarb 14.5% SC were also found to be at par with each other.

After 14 days of spraying, the highest reduction in aphid population was found in the plot treated with imidacloprid 17.8% SL (73.26%) followed by thiamethoxam 30% FS (70.87%) which were found to be at par with each other. The lowest reduction was observed in spinosad 45% SC (52.15%). The reduction of aphid population in the remaining treatments varied from 54.40 to 67.21%.

From the present findings, it is evident that all the treatments had significantly reduced the aphid population. The mean data on different days of observation after spraying indicated that imidacloprid 17.8% SL proved to be significantly superior in reducing the aphid population with 85.88% followed by thiamethoxam 30% FS (79.13%). Emamectin benzoate 5% SG was the least effective insecticide, however, it exhibited a mean of 63.56% reduction of aphid population. The present findings are in accordance with the findings of earlier workers (Muthukumar *et al.,* 2007). They reported that imidacloprid was the most effective insecticide against aphid and recorded higher mean per cent reduction over the control than thiamethoxam and cartap hydrochloride. The performance of imidacloprid to reduce the population of aphid is good because of its systemic property.

Efficacy of insecticides against cabbage butterfly, *Pieris canidia* L.

The data pertaining to cabbage caterpillar population on one day before spraying and the per cent reduction of caterpillar at 3, 7 and 14 days after spraying on two different spray schedules are presented in Table 2.

After first spraying

The initial mean number of larval population of cabbage butterfly, *Pieris canidia* L. on one day before spraying ranged from 1.73 to 2.90 per plant. The observation recorded three days after spraying showed the highest reduction in plots treated with spinosad 45% SC (96.17%) followed by emamectin benzoate 5% SG (87.97%) and cartap hydrochloride 50 SP (82.67%). The lowest reduction of *Pieris canidia* was observed in the plots treated with indoxacab 14.5% SC (57.66%). The reduction of caterpillar population in the remaining treatments varied from 67.77 to 79.62%.

Table.1 Efficacy of different insecticides in reducing the population of Cabbage aphid, *Brevicoryne brassicae* during November, 2016 to January, 2017

Treatments	Dose (ml or g/lit)	First Spray				Second Spray					Mean
		1 DBS (Number per leaf)	Per cent reduction			Mean	1 DBS (Number per leaf)	Per cent reduction			
			3 DAS	7 DAS	14 DAS			3 DAS	7 DAS	14 DAS	
Thiacloprid	0.30	12.55 (3.61)	86.24 (68.25)	79.05 (62.79)	70.40 (57.06)	78.56	4.99 (0.23)	87.08 (69.02)	79.31 (62.97)	67.21 (55.12)	77.87
Imidacloprid	0.30	15.20 (3.96)	92.12 (73.71)	83.83 (66.34)	77.77 (61.87)	84.57	4.09 (2.14)	95.08 (77.34)	89.29 (70.91)	73.26 (58.93)	85.88
Cartap hydrochloride	1.50	12.65 (3.63)	79.28 (62.93)	72.13 (58.16)	64.36 (53.35)	71.92	9.63 (3.18)	85.63 (67.75)	69.89 (56.75)	58.98 (50.18)	71.50
Spinosad	0.50	10.84 (3.37)	77.94 (62.05)	70.23 (56.98)	61.16 (51.46)	69.78	7.22 (2.77)	76.61 (61.11)	63.62 (52.93)	52.15 (46.23)	64.13
Indoxacarb	0.75	10.14 (3.26)	81.04 (64.20)	75.34 (60.35)	67.43 (55.22)	74.60	9.32 (3.13)	83.84 (66.32)	68.41 (55.81)	57.24 (49.16)	69.83
Emamectin benzoate	0.30	13.76 (3.77)	76.81 (61.31)	68.89 (56.10)	60.23 (50.90)	68.64	12.90 (3.66)	74.46 (59.64)	61.81 (51.83)	54.40 (47.53)	63.56
Chlorantraniliprole	0.30	15.95 (4.05)	74.76 (59.85)	66.65 (54.74)	58.36 (49.82)	66.59	12.24 (3.57)	71.67 (57.91)	65.83 (54.26)	56.33 (48.64)	64.61
Thiamethoxam	0.30	12.76 (3.64)	84.30 (66.66)	78.41 (62.47)	72.26 (58.25)	78.32	5.84 (2.52)	88.29 (69.99)	78.24 (62.21)	70.87 (57.35)	79.13
Control	--------	10.20 (3.27)	0 (0.00)	0 (0.00)	0 (0.00)	0	10.29 (3.28)	0 (0.00)	0 (0.00)	0 (0.00)	0
SEm±		0.24	1.06	1.55	0.92		0.37	1.03	1.07	1.14	
CD (p=0.05)		NS	3.19	4.66	2.77		NS	3.09	3.20	3.43	

DBS- Days before spraying, DAS – Days after spraying, Figures in parenthesis are $\sqrt{(X + 0.5)}$ values for number of aphid/leaf on 1 DBS and angular transformed values for per cent reduction of aphid

Table.2 Efficacy of different insecticides in reducing the population of Cabbage butterfly, *Pieris canidia* during November, 2016 to January, 2017

Treatments	Dose (ml or g/lit)	First Spray				Second Spray					Mean
		1 DBS (Number per plant)	Per cent reduction			Mean	1 DBS (Number per plant)	Per cent reduction			
			3 DAS	7 DAS	14 DAS			3 DAS	7 DAS	14 DAS	
Thiacloprid	0.30	2.09 (1.61)	79.62 (63.23)	74.46 (59.74)	60.11 (50.90)	71.40	1.43 (1.61)	78.05 (62.51)	70.75 (57.40)	62.80 (52.72)	70.53
Imidacloprid	0.30	1.73 (1.42)	67.77 (55.44)	60.32 (51.05)	52.19 (46.27)	60.09	1.43 (1.42)	84.89 (67.22)	77.86 (61.96)	68.28 (55.75)	77.01
Cartap hydrochloride	1.50	2.39 (1.64)	82.67 (65.73)	83.59 (66.16)	73.36 (59.06)	79.87	1.32 (1.64)	73.84 (60.82)	80.70 (64.09)	72.58 (58.51)	75.71
Spinosad	0.50	1.99 (1.52)	96.17 (78.83)	92.74 (74.48)	80.91 (64.14)	89.94	1.30 (1.54)	86.85 (68.94)	83.85 (66.31)	77.39 (61.64)	82.70
Indoxacarb	0.75	1.90 (1.62)	57.66 (49.43)	53.37 (47.03)	50.50 (45.31)	53.84	2.04 (1.62)	83.74 (66.720	72.41 (58.33)	62.47 (52.25)	72.87
Emamectin benzoate	0.30	2.90 (1.54)	87.97 (69.83)	82.42 (65.24)	79.44 (63.10)	83.28	1.66 (1.54)	88.03 (70.29)	82.06 (65.34)	70.36 (57.20)	80.15
Chlorantraniliprole	0.30	1.95 (1.31)	77.02 (61.52)	71.51 (57.86)	67.27 (55.18)	71.93	1.56 (1.31)	69.90 (57.20)	61.26 (51.55)	56.13 (48.55)	62.43
Thiamethoxam	0.30	2.14 (1.61)	71.83 (58.05)	67.79 (55.56)	65.24 (53.97)	68.29	1.89 (1.61)	68.89 (56.43)	60.30 (51.14)	53.21 (46.96)	60.8
Control	--------	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)		1.13 (2.14)	0 (0.00)	0 (0.00)	0 (0.00)	0
SEm±		0.20	2.06	2.79	2.78		0.17	4.70	2.26	3.03	
CD (p=0.05)		NS	6.17	8.36	8.34		NS	14.10	6.78	9.09	

DBS- Days before spraying, DAS – Days after spraying, Figures in parenthesis are $\sqrt{(X+0.5)}$ values for number of *Pieris canidia* per plant on 1 DBS and angular transformed values for per cent reduction of *Pieris canidia*

Table.3 Economics of different insecticide treatments against major insect pests of cauliflower during October, 2016 to January, 2017

Treatments	Dose (ml or g/ha)	No. of spray	Gross yield (q/ha)	Additional yield over control (q/ha)	Value of additional yield (Rs./ha)	Cost of insecticide treatments (Rs.)	Profit due to treatments (Rs.)	Benefit Cost Ratio
Emamectin benzoate 5% SG	308.64	2	33.92	20.04	40080	5474.05	34605.95	6.32:1
Spinosad 45% SC	514.40	2	41.97	28.09	56180	18683.84	37496.16	2.00:1
Thiacloprid 21.7% SC	308.64	2	41.49	27.61	55220	2856.78	52363.22	18.33:1
Indoxacarb 14.5% SC	771.60	2	32.58	18.70	37400	6520.768	30879.23	4.73:1
Imidacloprid 17.8% SL	308.64	2	34.16	20.28	40560	2992.58	37567.42	12.55:1
Thiamethoxam 30% FS	308.64	2	43.62	29.74	59480	3663.36	55816.64	15.24:1
Chlorantraniliprole 18.5% SC	308.64	2	33.02	19.14	38280	10144.80	28135.20	2.77:1
Cartap Hydrochloride 50 SP	1543.21	2	32.82	18.94	37880	5631.00	32249.00	5.73:1
Control	–	–	13.88		–	–	–	–

Cost of insecticides- Emmamectin benzoate- Rs. 660/100g; Spinosad- Rs.1680/100ml; Thiacloprid- Rs. 236/100ml; Indoxacarb- Rs. 332/100ml; Imidacloprid- Rs. 258/100ml; Thiamethoxam- Rs. 220/60ml; Chlorantraniliprole- Rs. 850/60ml; Cartap Hydrocloride- Rs. 1371/1kg
Labour charge @ Rs. 300/day (2 men/day/ha/spray) 3. Rental charge of sprayer @ Rs. 50/day 4. Cost of cauliflower @ Rs. 2000/q

After seven days of spraying, the highest reduction of cabbage butterfly was found in the plots treated with spinosad 45% SC (92.74%) followed by cartap hydrochloride 50 SP (83.59%) and emamectin benzoate 5% SG (82.42%) which were statistically at par with each other. The lowest reduction was found in indoxacab 14.5% SC (53.37%) during this period. The reduction of caterpillar population in the remaining treatments varied from 60.32 to 74.46%.

After 14 days of spraying, the highest reduction of cabbage butterfly was found in the plots treated with spinosad 45% SC (80.91%) followed by emamectin benzoate 5% SG (79.44%) and cartap hydrochloride 50 SP (73.36%) which were found to be at par with each other. The other treatments like thiacloprid 21.7% SC (60.11%), thiamethoxam 30% FS (65.24%) and chlorantraniliprole 18.5% SC (67.27%) were also found to be at par with each other. The lowest reduction was found in indoxacarb 14.5% SC (50.50%) followed by imidacloprid 17.8% SL (52.19%). However, all the insecticides were significantly superior over the control in reducing the population of cabbage butterfly.

From the present findings, it is evident that all the treatments could significantly reduce the cabbage butterfly population. The mean data on different days of observation after first spraying indicated that spinosad 45% SC was the best insecticide which could reduce the caterpillar population up to 89.94% followed by emamectin benzoate 5% SG (83.28%). Indoxacarb 14.5% SC was the least effective insecticide; however, it exhibited a mean of 53.84% reduction of the pest population.

After second spraying

The initial mean number of larval population of cabbage butterfly, *Pieris canidia* L. on one day before spraying ranged from 1.13 to 2.04 per plant. The observation recorded three days after spraying showed the highest per cent reduction in plots treated with emamectin benzoate 5% SG (88.03) followed by spinosad 45% SC (86.85), imidacloprid 17.8% SL (84.89) and indoxacarb 14.5% SC (83.74) which were found to be statistically at par with each other. The lowest per cent reduction was observed in the plots treated with thiamethoxam 30% FS (68.89) which was found to be at par with treatments like chlorantraniliprole 18.5% SC (69.90), cartap hydrochloride 50 SP (73.84) and thiacloprid 21.7% SC (78.05). After seven days of spraying the highest reduction of cabbage butterfly was found in the plots treated with spinosad 45% SC (83.85%) followed by emamectin benzoate 5% SG (82.06%), cartap hydrochloride 50 SP (80.70%) and imidacloprid 17.8% SL (77.86%) which were found to be statistically at par with each other. The lowest reduction was found in the treatment thiamethoxam 30% FS (60.30%) followed by chlorantraniliprole 18.5% SC (61.26%) which were at par with each other.

The observation recorded after 14 days of spraying showed the highest reduction of cabbage butterfly in the plots treated with spinosad 45% SC (77.39%) followed by cartap hydrochloride 50 SP (72.58%) and emamectin benzoate 5% SG (70.36%) which were found to be at par with each other. The other treatments like thiacloprid 21.7% SC (62.80%), indoxacarb 14.5% SC (62.47%) and imidacloprid 17.8% SL (68.28%) were also found to be statistically at par with each other. The lowest reduction was found in the treatment with thiamethoxam 30% FS (53.21%) followed by chlorantraniliprole 18.5% SC (56.13%) which were also at par with each other. However, all the insecticides were significantly superior over the control in reducing the population of cabbage butterfly.

The mean data on different days of observation after second spraying revealed that spinosad 45% SC was the best insecticide with 82.70% reduction in cabbage butterfly population followed by emamectin benzoate 5% SG (80.15%). The present finding of both after first and second spraying is in almost conformity with the findings of Rangad *et al.*, (2010) who reported that spinosad was found to give maximum control among the bio pesticides.

Economics of different insecticide treatments against major insect pests of cauliflower

It is evident from the data presented in Table 3 that the highest cost of insecticide treatments was incurred by spinosad 45% SC (Rs. 18683.84) followed by chlorantraniliprole 18.5% SC (Rs. 10114.8), indoxacarb 14.5% (Rs. 6520.77), cartap hydrochloride 50 SP (Rs. 5631), emamectin benzoate 5% SG (Rs. 5474.05), thiamethoxam 30% FS (Rs. 3663.36) and imidacloprid 17.8% (Rs. 2992.58), while the lowest cost was incurred by thiacloprid 21.7% SC (Rs. 2856.78).

The highest additional yield was obtained in thiamethoxam 30% FS (29.74 qt/ha) followed by spinosad 45% SC (28.09 qt/ha), thiacloprid 21.7% SC (27.61 qt/ha), imidacloprid 17.8% SC (20.28 qt/ha), emamectin benzoate 5% SG (20.04 qt/ha), chlornatraniliprole 18.5% SC (19.14 qt/ha) and cartap hydrochloride 50 SP (18.94 qt/ha). The lowest additional yield among the treatments was obtained from indoxacarb 14.5% SC (18.70 qt/ha).

The maximum profit due to treatments was obtained by the treatment thiamethoxam 30% FS (Rs. 55816.64) followed by thiacloprid 21.7% SC (Rs. 52363.22), imidacloprid 17.8% SC (Rs. 37567.42), spinosad 45% SC (Rs. 37496.16), emamectin benzoate 5% SG (Rs. 34605.95), cartap hydrochloride 50 SP (Rs. 32249.00) and indoxacarb 14.5% SG (Rs. 30879.23). The lowest profit was obtained by chlorantraniliprole 18.5% SC (Rs. 28135.20).

The maximum benefit cost ratio was in the treatment thiacloprid 21.7% SC (18.33:1) followed by thiamethoxam 30% FS (15.24:1) and imidacloprid 17.8% SL (12.55:1). The lowest was in the treatment spinosad 45% SC (2.00:1). The benefit cost ratio in the other treatments varied from 2.77:1 to 6.32:1. The present finding is closely in accordance with the findings of Bhati and Sharma (2014) who reported that thiamethoxam gave the highest BCR. Mishra and Yadav (2011) also reported that imidacloprid gave the highest Benefit Cost Ratio among the treatments.

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How to cite this article:

Pankaj Neog. 2020. Evaluation of Some Insecticides against Insect Pests of Cauliflower (*Brassica oleracea* var. *botrytis* L.). *Int.J.Curr.Microbiol.App.Sci.* 9(12): 804-813.
doi: https://doi.org/10.20546/ijcmas.2020.912.096