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Efficacy of Bio-pesticides and Newer Insecticides against Major Insect Pests of Cauliflower

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field trail Comprising of nine insecticides conducted at farmer's field in endemic area of pests on cauliflower in Siwan district of Bihar during 2018-19. Data revealed that Indoxacarb 14.5 SC @1.0 ml/L of water was found to be most effective insecticides on major pests of cauliflower *i.e.* leaf webber (41.06% reduction), tobacco caterpillar (48.91% reduction), Diamond Back Moth (64.40% reduction) and aphid (69.96% reduction) over farmer's practices (chlorpyriphas 20 EC @ 1.5 ml/L of water) *i.e.* 24.67% 27.86%, 32.47% and 34.81% reduction of leaf webber, tobacco caterpillar, Diamond Back Moth and aphid, respectively. Similarly, significantly highest yield (144.26 q/ha) produced cauliflower in treatment of Indoxacarb 14.5 SC. However, Cost-benefit analysis revealed that highest cost-benefit ratio of 1:11.15 in treatment of Cartap hydrochloride 50 SP @ 1.0gm/L of water followed by Thiodicarb 75 WP @ 1.0g/L (1:9.39), Indoxacarb 14.5 SC @ 1.0 ml/L (1: 7.96), Emamectin benzoate 5 WSG @ 0.25 gm/L (1:7.22), Novaluran 10 EC @ 1.0 ml/L (1:6.48), Spinosad 45 SC @0.33 ml/L (1:6.34), Avemectin 1.9 EC @ 0.5 ml/L (1:5.57), Azadirachtin 0.15% @ 4 ml/L (1:4.10) and farmer's practices (1:3.10), respectively.

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1. INTRODUCTION

Cauliflower, *Brassica oleracea* L.var. botrytis is the most popular winter vegetable grown in India. It consumed as vegetable in curries, soups, pickles and low fat content with rich source of dietary fibbers, vitamins and minerals. The chief constraint in the production of cauliflower is the damage caused by the pest complex right from germination to till harvesting stage with enormous yield loss. The economics losses in the crop production every year caused by insect pest is a threat to global agriculture. Sometimes the yield loss by insect pests reaches as high as 60-70 per cent [1]. In India, 37 insect pest species have been reported to feed on the crop [2]. Among all, the crops is ravaged by aphid, *Brevicorne brassicae* Linn., *leaf webber, Crocidolomia binotalis* Zell., tobacco caterpillar, *Spodoptera litura* Fab, and diamond back moth, *Plutella xylostella* Linn., and chemical insecticides are widely used by the growers to control these pests. Several insecticides have been recommended through ages to avert pest damage. But, almost all of them are obsolete due to development of insect resistance to insecticides and there is possibility of presence residue in the edible parts of cauliflower. The other issues like resurgence and secondary pest's outbreak. Keeping the facts in view, the present investigation is undertaken with bio-rational and newer insecticides in order to formulate on effective and economic packages of control measures for the management of these pests on cauliflower crop and it's also compared with the local check insecticide (Farmer's practice).

2. MATERIALS AND METHODS

The field experiment was carried out at village of Chiroli in Siwan district of Bihar. The cauliflower crop (cv. Pusa Kataki) was transplanted in first week of November 2018. The following treatments were evaluated : T_1 –Indoxacarb 14.5 SC @ 1.0 ml/L, T_2 – Emamectin benzoate 5 WSG @ 0.25 gm/L, T_3 – Thiodicarb 75 WP @ 1.0gm/L, T_4 – Novaluran 10 EC @ 1.00 ml/L, T_5 – Azadirachtin 0.15% @ 4.00 ml/L, T_6 – Avermectin 1.9 EC @ 0.50 ml/L, T_7 – Spinosad 45 SC @ 0.33 ml/L, T_8 – Cartap hydrochloride 50 SP @ 1.00 gm/L, T_9 – Chlorpyriphos 20 EC @ 1.00 ml/L at weekly interval (Farmer's Practice), T_{10} – Untreated check.

Two sprays were given at 15 days interval (Except farmer's practice) in the evening time by knapsack sprayer. Observations were recorded on the population of major pests on 10 randomly selected plants with treatment wise at one day before spraying (DBS) and at 5 and 10 days after each spraying (DAS). The Yield of marketable flower heads was recorded treatment-wise and converted per hectare basis before subjected to statistical analysis *i.e* Randomized Block Design.

3. RESULTS AND DISCUSSION

Efficacy of newer insecticides for the management of major insect pest of cauliflower during the crop season 2018-19.The treatments were statistically significant over untreated control in reducing the pest's incidence during early stages of the crop. Among the different sets of treatments, T_1, comprising spray of Indoxacarb 14.5 SC @ 1 ml/L. proved to be the most effective with significantly lower per cent of leaf webber damage 8.15 and 6.94 after first spray and second spray, respectively. The other effective treatments in respect to leaf webber damage wereT_3 and T_8 the latter being at par with T_7, having leaf webber damage varying from 8.38 to 8.87 per cent and 7.31 to 7.52 per cent after first and second spray, respectively (Table 1) The higher percentage of leaf webber damage (9.49 - 9.89) was recorded with T_9 (Farmer's practice) in comparison, the mean per cent of leaf webber damage of 11.85 and 13.76 were recorded in untreated control. Overall the lowest mean per cent of leaf webber damage (7.55) was recorded in T_1 which was significantly at par with T_3 (7.85) and T_8 (8.20). However, T_5 recorded mean highest percent of leaf webber damage (9.42) which is at par with farmers practice as T_9 (9.65) and were least effective against leaf webber. The percentage reduction of leaf webber damage over untreated control was varying from 24.67 to 41.06 (Table 1) Similar findings were also reported by Sharma and Misra, [3] and Mandal et al. [4] on cabbage.

Statistically significant highest reduction in percentage head damage due to *S. lutra* was also recorded with T_1 (48.91%) over untreated control (Table 2). The results being comparable with T_3 (47.02%) and T_8 (45.05%). Although, the other treatments, the per cent reduction in head damage to *S. lutra* was varied from 27.86% to

Table 1. Efficacy of insecticides against leaf webber on cauliflower during 2018-19

Treatment	Dose g/ml/L	Leaf webber damaged plant (%)								Over all mean	% reduction over control
		Frist Spray				Second Spray					
		1 DBS	5 DAS	10 DAS	Mean	1 DBS	5 DAS	10 DAS	Mean		
T_1 – Indoxacarb 14.5 SC	1.0 ml	9.42 (17.83)	8.26 (16.74)	8.04 (16.43)	8.15 (16.64)	7.62 (16.00)	7.31 (15.68)	6.56 (14.89)	6.94 (15.23)	7.55 (16.00)	41.06
T_2 – Emamectin benzoate 5WSG	0.25 gm	9.62 (18.05)	9.35 (17.85)	9.12 (17.56)	9.24 (17.66)	8.73 (17.16)	8.24 (16.64)	8.02 (16.43)	8.13 (16.54)	8.69 (17.16)	32.17
T_3 – Thiodicarb 75 WP	1.0 gm	9.83 (18.24)	8.51 (17.05)	8.24 (16.64)	8.38 (16.85)	8.04 (16.43)	7.52 (15.89)	7.10 (15.45)	7.31 (15.68)	7.85 (16.32)	38.72
T_4 - Novaluron 10 EC	1.0 ml	9.74 (18.15)	9.83 (18.24)	9.61 (18.05)	9.72 (18.15)	8.26 (17.36)	8.39 (16.85)	8.28 (16.74)	8.34 (16.74)	9.03 (17.46)	29.51
T_5 -Azadirachtin 0.15%	4 ml	10.25 (18.72)	10.02 (18.44)	9.59 (17.95)	9.81 (18.24)	8.72 (17.16)	9.41 (17.85)	8.65 (17.16)	9.03 (17.46)	9.42 (17.85)	26.46
T_6 – Avermectin 1.9 EC	0.5 ml	9.46 (18.05)	9.81 (18.24)	9.54 (17.85)	9.68 (18.05)	8.91 (17.36)	8.33 (16.74)	8.10 (16.54)	8.22 (16.64)	8.95 (17.36)	30.13
T_7 – Spinosad 45 SC	0.33 ml	9.51 (17.94)	9.12 (17.56)	9.00 (17.46)	9.06 (17.56)	8.37 (16.85)	8.00 (16.43)	7.86 (16.32)	7.93 (16.32)	8.50 (16.95)	33.65
T_8 – Cartap hydrochloride 50 SP	1.0 gm	9.36 (17.85)	9.31 (17.76)	8.43 (16.85)	8.87 (17.36)	8.63 (17.05)	7.84 (16.22)	7.20 (15.56)	7.52 (15.89)	8.20 (16.64)	35.98
T_9 – Chlorpyriphos 20 EC (Former's Practice)	1.50 ml	10.72 (19.09)	10.42 (18.81)	9.36 (17.76)	9.89 (18.34)	9.86 (18.34)	9.47 (17.95)	9.32 (17.76)	9.49 (17.85)	9.65 (18.15)	24.67
T_{10}- Untreated Check	-	9.68 (18.15)	10.87 (19.28)	12.82 (20.96)	11.85 (20.18)	12.53 (20.70)	14.17 (22.14)	13.34 (21.39)	13.76 (21.81)	12.81 (20.96)	-
SEm (±)	-	N.S.	0.121	0.540	0.446	0.362	0.421	0.437	0.638	0.375	-
CD (P= 0.05)	-	-	0.364	1.621	1.342	1.086	1.264	1.315	1.276	1.124	-

Average mean of there replications; Figure in parentheses are Arc sine transformed values.
DBS = Days before spraying: DAS = Days after spraying: NS = Non significant

Table 2. Efficacy of insecticides against tobacco caterpiller on cauliflower during 2018-19

Treatment	Dose g/ml/L	Tobacco caterpillar damaged (%)								Over all mean	% reduction over control
		First Spray				Second Spray					
		1 DBS	5 DAS	10 DAS	Mean	1 DBS	5 DAS	10 DAS	Mean		
T_1 – Indoxacarb 14.5 SC	1.0 ml	11.62 (19.91)	8.12 (16.54)	8.00 (16.43)	8.06 (16.54)	7.34 (15.68)	6.73 (15.00)	6.25 (14.54)	6.49 (14.77)	7.28 (15.68)	48.91
T_2 – Emamectin benzoate 5WSG	0.25 gm	12.41 (20.62)	9.91 (18.44)	9.39 (14.85)	9.65 (18.15)	8.52 (16.95)	8.21 (16.64)	7.93 (16.32)	8.07 (16.43)	8.86 (17.36)	37.82
T_3 – Thiodicarb 75 WP	1.0 gm	12.53 (20.70)	8.61 (17.05)	8.04 (17.46)	8.33 (16.74)	7.46 (15.89)	7.00 (15.34)	6.52 (14.77)	6.76 (15.12)	7.55 (16.00)	47.02
T_4 - Novaluron 10 EC	1.0 ml	12.34 (19.64)	10.45 (18.91)	10.11 (18.53)	10.28 (18.72)	9.05 (17.46)	8.92 (17.36)	8.46 (16.95)	8.69 (17.16)	9.49 (17.95)	33.40
T_5 -Azadirachtin 0.15%	4 ml	11.85 (20.18)	10.91 (19.28)	10.53 (18.91)	10.72 (19.09)	9.48 (17.95)	9.16 (17.66)	8.72 (17.16)	8.94 (17.36)	9.83 (18.24)	31.02
T_6 – Avermectin 1.9 EC	0.5 ml	12.40 (20.62)	10.00 (18.44)	9.62 (18.05)	9.81 (18.24)	8.67 (17.16)	8.34 (16.74)	8.00 (16.43)	8.17 (16.64)	8.99 (17.46)	36.91
T_7 – Spinosad 45 SC	0.33 ml	12.36 (20.53)	9.82 (18.24)	9.33 (17.76)	9.58 (18.05)	8.20 (16.64)	7.63 (16.00)	7.13 (15.45)	7.38 (15.89)	8.48 (16.95)	40.49
T_8 – Cartap hydrochloride 50 SP	1.0 gm	11.62 (19.91)	9.16 (17.66)	8.54 (16.95)	8.85 (17.46)	7.80 (16.22)	7.36 (15.79)	6.24 (14.42)	6.80 (15.12)	7.83 (16.22)	45.05
T_9 – Chlorpyriphos 20 EC (Former's Practice)	1.50 ml	12.00 (20.27)	11.51 (19.82)	10.76 (19.19)	11.14 (19.46)	10.32 (18.72)	9.74 (18.15)	9.10 (17.56)	9.42 (17.85)	10.28 (18.72)	27.86
T_{10}- Untreated Check	-	12.51 (20.70)	12.46 (20.62)	12.87 (21.05)	12.67 (22.88)	12.93 (21.05)	14.38 (22.30)	17.26 (24.58)	15.82 (23.42)	14.25 (22.22)	-
SEm (±)	-	N.S.	0.245	0.376	0.475	0.621	0.450	0.643	0.574	0.512	-
CD (P= 0.05)	-	-	0.734	1.125	1.428	1.865	1.352	1.927	1.723	1.536	-

Average mean of there replications; Figure in parentheses are Arc sine transformed values.
DBS = Days before spraying: DAS = Days after spraying: NS = Non significant

Table 3. Efficacy of insecticides against diamond back moth on cauliflower during 2018-19

Treatment	Dose g/ml/L	Mean number of diamond back moth larvae / plant								Over all mean	% reduction over control
		First Spray				Second Spray					
		1 DBS	5 DAS	10 DAS	Mean	1 DBS	5 DAS	10 DAS	Mean		
T_1 – Indoxacarb 14.5 SC	1.0 ml	6.70 (2.68)	3.91 (2.10)	3.17 (1.92)	3.54 (2.01)	3.02 (1.88)	2.31 (1.68)	1.06 (1.25)	1.69 (1.48)	2.62 (1.77)	64.40
T_2 – Emamectin benzoate 5WSG	0.25 gm	6.62 (2.67)	4.72 (2.28)	3.98 (2.12)	4.35 (2.20)	3.90 (2.10)	3.00 (1.87)	2.41 (1.71)	2.71 (1.79)	3.53 (2.00)	52.04
T_3 – Thiodicarb 75 WP	1.0 gm	6.14 (2.58)	4.56 (2.25)	3.42 (1.97)	3.98 (2.12)	3.13 (1.91)	2.16 (1.63)	1.72 (1.49)	1.94 (1.56)	2.96 (1.86)	59.78
T_4 - Novaluron 10 EC	1.0 ml	6.25 (2.60)	5.12 (2.37)	4.31 (2.19)	4.72 (2.28)	4.00 (2.12)	3.24 (1.93)	2.83 (1.82)	3.04 (1.88)	3.88 (2.09)	47.28
T_5 -Azadirachtin 0.15%	4 ml	6.16 (2.58)	5.05 (2.36)	4.63 (2.26)	4.84 (2.31)	4.21 (2.17)	3.35 (2.01)	3.00 (1.87)	3.18 (1.92)	4.01 (2.12)	45.52
T_6 – Avermectin 1.9 EC	0.5 ml	6.73 (2.69)	5.21 (2.39)	3.90 (2.10)	4.56 (2.25)	3.46 (1.99)	3.11 (1.90)	2.45 (1.72)	2.78 (1.81)	3.67 (2.04)	50.14
T_7 – Spinosad 45 SC	0.33 ml	5.91 (2.53)	4.62 (2.26)	3.80 (2.07)	4.21 (2.17)	3.31 (1.95)	2.85 (1.83)	2.16 (1.63)	2.51 (1.73)	3.36 (1.96)	54.35
T_8 – Cartap hydrochloride 50 SP	1.0 gm	6.54 (2.65)	4.43 (2.22)	3.92 (2.10)	4.18 (2.16)	2.84 (1.83)	2.52 (1.74)	2.23 (1.65)	2.38 (1.70)	3.28 (1.94)	55.43
T_9 – Chlorpyriphos 20 EC (Former's Practice)	1.50 ml	6.61 (2.67)	6.12 (2.57)	5.31 (2.41)	5.72 (2.49)	5.00 (2.35)	4.35 (2.20)	4.10 (2.14)	4.23 (2.17)	4.97 (2.34)	32.47
T_{10}- Untreated Check	-	6.53 (2.65)	6.94 (2.73)	6.79 (2.70)	6.87 (2.71)	7.56 (2.84)	7.74 (2.87)	7.93 (2.90)	7.84 (2.89)	7.36 (2.80)	-
SEm (±)	-	N.S.	0.043	0.058	0.064	0.072	0.092	0.156	0.127	0.046	-
CD (P= 0.05)	-	-	0.131	0.174	0.192	0.216	0.275	0.468	0.381	0.142	-

Average mean of there replications; Figure in parentheses are $\sqrt{X + 0.5}$ *transformed values.*
DBS = Days before spraying: DAS = Days after spraying: NS = Non significant

Table 4. Efficacy of insecticides against aphids on cauliflower during 2018-19

Treatment	Dose g/ml/L	Mean number of aphid population / leaf								Over all mean	% reduction over control
		First Spray				Second Spray					
		1 DBS	5 DAS	10 DAS	Mean	1 DBS	5 DAS	10 DAS	Mean		
T_1 – Indoxacarb 14.5 SC	1.0 ml	135.82 (11.68)	75.16 (8.70)	52.34 (7.27)	63.75 (8.02)	53.21 (7.33)	42.38 (6.55)	31.52 (5.75)	36.95 (6.12)	50.35 (7.13)	69.96
T_2 – Emamectin benzoate 5WSG	0.25 gm	133.24 (11.56)	108.42 (10.44)	80.17 (8.98)	94.30 (9.74)	82.00 (9.08)	74.32 (8.65)	65.30 (8.11)	69.81 (8.39)	82.06 (9.09)	48.95
T_3 – Thiodicarb 75 WP	1.0 gm	116.12 (10.80)	84.61 (9.23)	64.43 (8.06)	74.52 (8.66)	63.72 (18.01)	53.41 (7.34)	44.08 (6.68)	48.74 (7.02)	61.63 (7.88)	36.77
T_4 - Novaluron 10 EC	1.0 ml	144.26 (12.03)	120.25 (10.99)	99.65 (10.00)	109.95 (10.51)	97.20 (9.88)	86.82 (9.34)	79.21 (8.93)	83.02 (9.14)	96.49 (9.85)	42.45
T_5 -Azadirachtin 0.15%	4 ml	150.41 (12.28)	126.84 (11.28)	103.47 (10.20)	115.16 (10.75)	102.32 (10.14)	92.50 (9.64)	83.00 (9.14)	87.75 (9.39)	101.46 (10.10)	39.47
T_6 – Avermectin 1.9 EC	0.5 ml	123.52 (11.14)	112.36 (10.62)	94.32 (9.74)	103.34 (10.19)	93.10 (9.67)	79.86 (8.96)	70.42 (8.42)	75.14 (8.70)	89.24 (9.47)	46.76
T_7 – Spinosad 45 SC	0.33 ml	118.34 (10.90)	102.17 (10.13)	78.90 (8.91)	90.57 (9.54)	75.23 (8.70)	68.00 (8.28)	63.41 (7.99)	66.71 (8.20)	78.63 (8.90)	28.19
T_8 – Cartap hydrochloride 50 SP	1.0 gm	140.65 (11.88)	98.42 (9.95)	72.26 (8.53)	83.34 (9.26)	71.10 (8.46)	63.12 (7.97)	47.96 (6.96)	55.54 (7.49)	79.44 (8.42)	57.98
T_9 – Chlorpyriphos 20 EC (Former's Practice)	1.50 ml	145.34 (12.08)	134.86 (11.63)	112.48 (10.63)	123.67 (11.14)	110.44 (10.53)	98.27 (9.94)	91.45 (9.59)	94.86 (9.77)	109.27 (10.48)	34.81
T_{10}- Untreated Check	-	126.87 (11.29)	145.24 (12.07)	158.52 (12.61)	151.88 (12.34)	162.93 (12.78)	174.45 (13.23)	192.24 (13.88)	183.35 (13.56)	167.62 (12.97)	-
SEm (±)	-	N.S.	0.138	0.543	0.412	0.451	0.574	0.715	0.805	0.641	-
CD (P= 0.05)	-	-	0.415	1.628	1.236	1.352	1.721	2.143	2.416	1.924	-

Average mean of there replications; Figure in parentheses are $\sqrt{X + 0.5}$ transformed values.
DBS = Days before spraying: DAS = Days after spraying: NS = Non significant

Table 5. Economics of insecticides against the pests on cauliflower during 2018-19

Treatments	Dost g/ml/l	Yield (q/ha)	Increased Yield over control	Value of additional yield over control (Rs./ha)	Cost of treatment (Rs/ha)	Incremental benefit (Rs/ha)	CB ratio
T_1 – Indoxacarb 14.5 SC	1.0 ml	144.26	48.42	50841.00	5672.00	45169.00	1:7.96
T_2 – Emamectin benzoate 5WSG	0.25 gm	123.75	27.91	29306.00	3565.00	25741.00	1:7.22
T_3 – Thiodicarb 75 WP	1.0 gm	140.63	44.84	47082.00	4536.00	42456.00	1:9.37
T_4 - Novaluron 10 EC	1.0 ml	120.42	24.58	25809.00	3452.00	22357.00	1:6.48
T_5 -Azadirachtin 0.15%	4 ml	118.56	22.72	23856.00	4680.00	19176.00	1:4.10
T_6 – Avermectin 1.9 EC	0.5 ml	121.34	25.50	26775.00	4078.00	22697.00	1:5.57
T_7 – Spinosad 45 SC	0.33 ml	128.15	32.31	33926.00	4625.00	29301.00	1:6.34
T_8 – Cartap hydrochloride 50 SP	1.0 gm	134.70	38.86	40803.00	3358.00	37445.00	1:11.15
T_9 – Chlorpyriphos 20 EC (Former's Practice)	1.50 ml	110.26	14.42	15141.00	3690.00	11451.00	1:3.10
T_{10}- Untreated Check	-	95.84	-	-	-	-	-
SEm (±)	-	3.154	-	-	-	-	-
CD (P= 0.05)	-	9.462	-	-	-	-	-

Average mean of there replications; Market price of cauliflower @ Rs. 1050/quintal

40.49% which is inconformity with the findings of Sharma and Misra [5] and Monobrullah et al. [6]. Rao et al. [7] reported Indoxacarb @ 0.0145% and Thiodicarb @ 0.075% to be most effective in reducing larval population of *S. lutra* on fenugreek, while Prasad et al. [8] and Stanley et al. [9] reported Emamectin benzoate to be the best treatment with the highest relative toxicity. Similar results were also recorded by Parthiban et al. [10] and Yadav et al. (2015) on reducing the larval population of *S. lutra.*

The results of Diamond Back Moth (Table 3) observed that T_3 comprising spray of Indoxacarb 14.5 SC @ 1.0 ml/L of water was recorded 3.54 and 1.69 larvae/plant after first and second spray, respectively, proved to be most effective and which was followed by T_3 with mean number of 3.98 and 1.94 larvae/plant and it was at par with T_8 (4.18 and 2.38 larvae/plant) during first and second spray, respectively. The highest mean population of 5.72 and 4.23 larvae/plant was recorded in T_9 with the spraying of chlorpyriphos 20 EC @ 1.5 ml/L of water as farmer's practice, and which was significantly at par with T_5, comprising spray of Azadirachtin 0.15 % @ 4 ml/L of water with larval count of 4.84 and 3.18 larvae/plant, respectively. In comparison, the mean population of 6.87 and 7.84 larvae/plant were recorded in untreated control (T_{10}). Overall lowest mean population of 2.62 larvae/plant was also recorded in T_1 which was followed by T_3 (2.96 larvae/plant) and T_8 (3.28 larvae/plant). However, T_9 (farmer's practice) recorded 4.97 larvae/plant and at par with T_5 (4.01 larvae/plant) and which were least effective in reducing the larval population (Table 3). Marked reduction of larvae/plant over untreated control varied from 32.47 to 64.40 was observed with different sets of the treatments. Similar result of effectiveness of bio-pesticides and newer insecticides in reducing the insect pests of Cole crops by Singh et al. [11]. The present results on the effectiveness of Spinosad and certain newer insecticides in management of *P. xylostella* are in conformity with those of Wale and Mohite [12], Dhawan et al. [13], Kumar et al. [14], Stanikzi et al. [15] and Mandal et al. [4].

Similarly, the treatment T_1 recorded the lowest aphid population of 63.75 and 36.95/leaf after first and second spray, respectively and which was followed by T_3 (74.52 and 48.74 aphids/leaf) and T_8 (83.34 and 55.54 aphids/leaf). Among the treatments, T_9 (Farmer's practice) was recorded higher aphid population of 123.67 and 94.86 aphids/leaf after first and second spray, respectively over untreated control (Table 4). The reduction of aphid population over untreated control was varied from 34.81 to 69.96 per cent. The present finding is in conformity with these of Shalini et al. [16] and Mandal et al. [4].

The yield data (Table 5) was found statistically higher marketable cauliflower yield of 144.26 q/ha in T_1 followed by T_3 (140.63 q/ha) and T_8 (134.70 q/ha). The next best treatment was T_7 (128.15 q/ha) and which at par with other treatments, but significantly more than T_9 as farmer's practice (110.26 q/ha) and untreated control (95.84 q/ha). The cost-benefit analysis of different sets of treatments revealed that the maximum monitory benefit of Rs. 50840/ha found from T_1. The most effective treatment in reducing the pest's incidence as well as yield realised as per hectare basis. Yet the highest cost: benefit ratio (1:11.15) obtained inT_8. This was followed by T_3 (1:9.37), T_1 (1:7:96) and T_2 (1:7.22) and rather less efficiently by T_4 (1:6.48), T_7 (1:6:34), T_6 (1:5.57) and T_5 (1.4.10). In comparison the cost: benefit ratio of 1:3.10 were to west recorded in farmer's practice (T_9) due to high cost of insecticidal treatment and received lower yield. Similar results were obtained by Muna et al. (2011) [17] and Mandal et al. [4].

The spray of Indoxacarb 14.5 SC @ 1.0 ml/L of water was found to be superior over all other package of the treatments in terms of statistically lower flower head damaged by these pests there by obtaining higher yield of 144.26 q/ha. However, the cost benefit analysis resulted the highest ratio of 1:11.15 with spray of cartap hydrochloride 50 SP @ 1.0 gm/L of water.

4. CONCLUSION

Present investigation, it could be concluded that Indoxacarb 14.5 C @ 1.0 ml/L was found most effective insecticides for all insect in cauliflower and resulted as well as provide higher yield and profit as compared to farmer's practices.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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