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Bioefficacy of insecticides against aphids and head borer in cauliflower

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Abstract
Field experiment on bioefficacy of various insecticides against aphid, *Lipaphis erysimi* Kaltenbach and head borer, *Hellula undalis* Fabricius in cauliflower were conducted during *rabi*, 2018-19 and 2019-20 at College farm, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad. Among the various insecticides tested, dimethoate was found effective against aphids by recording significantly highest per cent reduction of 78.61 and 77.68 followed by chlorpyriphos with 66.88 and 54.86 per cent reduction during 2018-19 and 2019-20, respectively at 7 days after first and second sprays. Chlorantraniliprole proved to be effective in reducing head borer by recording lowest mean per cent damaged heads of 10.36 per cent.

Keywords: insecticides, aphids, dimethoate, chlorpyriphos, head borer, chlorantraniliprole

Introduction
Cauliflower (*Brassica oleraceae* L *var. botrytis*) is one of the important winter vegetable crops. Edible part is called curd which is consumed as salad, curry, raw, pickle and widely used in preparing fried snacks, burger and sandwich in the restaurants (Ashraf *et al.*, 2017) [1]. It is low in fat but rich in dietary fibre. It contains adequate quantities of protein, carbohydrates, vitamins, minerals (phosphorous, potassium, calcium, sodium, and iron) and ascorbic acid (Fageria *et al*., 2012) [3]. India produces 8668.22 mt of cauliflower from 452.59 m ha area with 19.15 mt ha^{-1} productivity. West Bengal, Bihar, Uttar Pradesh, Orissa, Assam, Haryana, Rajasthan and Maharashtra are the major cauliflower growing states. In Telangana, the area under cauliflower is 1580 ha with a total production of 31.18 mt and average productivity of 20.21 mt ha^{-1} (https://www.indiastat.com).

The insect pests on an average are reported to cause yield loss of nearly 60-80% in cruciferous crops (Tiwari, 2009) [10]. Diamond back moth, *Plutella xylostella* (Linnaeus), aphids *Lipaphis erysimi* (Kaltenback) and *Brevicoryne brassicae* (Linnaeus), leaf webber *Crocidolomia binotalis* (Zeller.), cabbage borer *Hellula undalis* (Fabricius), cabbage looper *Trichoplusia ni* (Hubner), painted bug *Bagrada cruciferarum* (Kirk.), cabbage butterfly (*Pieris brassicae* Linnaeus), tobacco caterpillar *Spodoptera litura* (Fabricius), cabbage head eating caterpillar, *Helicoverpa armigera* (Hubner), mustard saw fly, *Athalia lugens proxima* (Klug) and flea beetle, *Phyllotreta cruciferae* (Goeze) cause significant reduction in the yield and quality of cauliflower (Patel and Patel, 2018) [9].

Aphids suck sap from the leaves throughout the season and when large colonies develop, the leaves become bleached and distorted making them unable to develop a marketable head. They contaminate the leaves with cast skins and honey dew. They play a prominent role in reducing the yield (Yonus *et al.,* 2004) [14]. They not only bring damage by their sucking nature but further aggravate the problem via transfer of viral pathogens. They may also act as vector of and transmit about 20 viral pathogens non-persistently (Kessing and Mau, 2013) [6]. In case of head borer damage, the larvae initially mine the leaves later feed on leaves, shoots sheltered within silken passage and finally bore into the stems. They prevent head initiation causing multiple shoots or heads. Shankar and Raju (2012) [13] reported yield losses of 36.5% due to aphids and 30-58% due to incidence of head borer in crucifer crops. Chemical control is the most effective and quick method especially when the population is high. Farmers resort to spraying various insecticides throughout the crop growth period. As exclusion of chemical insecticides is impracticable, the use of most selective and effective insecticides is essential. Hence, the present investigation has been contemplated to evaluate the bio-efficacy of novel and conventional insecticides against aphids and head borer in cauliflower.

Material and Methods

A field trial was taken up during *rabi*, 2018-19 and 2019-20 at College Farm, College of Agriculture, Rajendranagar. One month old cauliflower seedlings were transplanted at 60 cm x 45 cm spacing in 5m x 4m plots on ridges and furrows. The experimental design was randomized complete block design (RBD) consisting of eight treatments and three replications. The insecticides selected for determining their bioefficacy against cauliflower insect pests were chlorantraniliprole 18.5% SC 10 g *a.i.* ha^{-1}, spinosad 2.5% SC 15 g *a.i.* ha^{-1}, emamectin benzoate 5% SG 10 g *a.i.* ha^{-1}, indoxacarb 14.5% SC 40 g *a.i.* ha^{-1}, diafenthiuron 50% WP 300 g *a.i.* ha^{-1}, chlorpyriphos 50% EC 500 g *a.i.* ha^{-1} and dimethoate 30% EC 200 g *a.i.* ha^{-1}. Two sprayings at 15 days interval were given at curd initiation stage. The mean number of aphids was recorded by taking the aphid population (both nymph and adult) per leaf present on three leaves (upper, middle and lower) from each of 5 randomly selected plants per plot and expressed as numbers of aphids per three leaves/plant. The observations on aphids were recorded one day before spraying as pre treatment counts. Post treatment counts were recorded at 3, 5 and 7 days after each spraying. The data on head damage was taken at the time of harvest by counting total number curds and number of damaged curds per plot. The per cent reduction in different treatments over control was calculated by modified Abbot's formula (Fleming and Retnakaran, 1985) [4].

Population reduction (%) =

$$[1 - \left\{\frac{\text{Post-treatment population in treatment}}{\text{Pre-treatment population in treatment}}\right\} X \left\{\frac{\text{Pre-treatment population in control}}{\text{Post-treatment population in control}}\right\}]X100$$

Result and Discussion

Season I (2018-19)

The population of *L. erysimi* in various treatments a day before spraying ranged from 95.07 to 99.67 aphids/3 leaves/plant (Table 2). There was no significant difference in population among the various treatments. At 3, 5 and 7 days after spraying (DAS) dimethoate recorded significantly lowest aphid population followed by chlorpyriphos and diafenthiuron which were found to be significantly different from each other. The per cent reduction of aphids in different treatments over control in decreasing order of efficacy was dimethoate, chlorpyriphos, diafenthiuron, emamectin benzoate, chlorantraniliprole, spinosad and indoxacarb with 81.41, 67.77, 45.61, 32.07, 14.59, 12.04 and 10.06% reduction, respectively.

The pre count of leaf webber a day before second spray ranged from 65.20 to 118.67 aphids/3 leaves/plant. At 3, 5 and 7 DAS, dimethoate continued its supremacy over other treatments while chlorpyriphos was found to be next in order of effectiveness followed by diafenthiuron and were significantly different from each other. The per cent reduction in aphid population in decreasing order of efficacy after second spray was dimethoate (80.32%), chlorpyriphos (57.57%), diafenthiuron (38.17%), emamectin benzoate (26.08%), chlorantraniliprole (16.62%), spinosad (13.57%) and indoxacarb (10.62%) over control.

During 2018-19, chlorantraniliprole was the best treatment with least curd damage of 9.44% followed by emamectin benzoate 10.56%, spinosad 11.67% and indoxacarb 12.22 and were on par with each other. The other treatments *viz*., chlorpyriphos, diafenthiuron and dimethoate recorded higher curd damage of 19.44, 20.00 and 20.56 per cent but were significantly superior over control (32.78%) in reducing the per cent curd damage.

Season II (2019-20)

The aphid population in various treatments a day before spraying ranged from 122.53 to 125 aphids/3 leaves/plant. There was no significant difference in population among the various treatments (Table 2). At 3, 5and 7 DAS, dimethoate recorded significantly lower aphid population followed by chlorpyriphos and diafenthiuron. Other treatments *viz*., chlorantraniliprole, spinosad, emamectin benzoate and indoxacarb recorded higher population and were less effective in managing the aphids. The per cent reduction of aphids in different treatments over control in decreasing order of efficacy was dimethoate, chlorpyriphos, diafenthiuron, emamectin benzoate, chlorantraniliprole, indoxacarb and spinosad with 76.38, 66.13, 44.66, 29.94, 12.87, 4.19 and 3.97 per cent reduction, respectively.

The aphid population one day before second spray ranged from 48.20 to 133.67 aphids/ 3 leaves/plant. At 3, 5 and 7 DAS, similar trend was observed wherein dimethoate was significantly superior to other treatments in reducing aphid population followed by chlorpyriphos and diafenthiuron. The per cent reduction of aphid population in different treatments over control in decreasing order of efficacy was dimethoate (71.94%), chlorpyriphos (48.63%), diafenthiuron (45.48%), emamectin benzoate (17.06%), chlorantraniliprole (12.10%), indoxacarb (10.34%) and spinosad (6.73%).

During 2019-20, chlorantraniliprole recorded least curd damage (11.28%) followed by emamectin benzoate 12.31%, spinosad 13.33% and indoxacarb 15.38% which were on par with each other. They were followed by chlorpyriphos, diafenthiuron and dimethoate with 21.03, 22.05 and 25.64 per cent damage while control recorded 39.49% head borer damage.

Pooled efficacy (Season I and II)

A pooled analysis of the reduction of aphid population by various insecticides at 7 days after first and second spray over a period of two years i.e *rabi*, 2018-19 and 2019-20 is given in table 4. Dimethoate recorded highest per cent reduction and was significantly different from all the other treatments. The overall mean per cent reduction revealed that dimethoate was the most effective insecticide against aphids with reduction in population (78.15%) followed by chlorpyriphos (60.87%) while the remaining treatments recorded less than 50% reduction of aphid population.

The pooled mean of head damage for the two seasons (2018-19 and 2019-20) revealed that chlorantraniliprole recorded the lowest head borer damage (10.36%) while dimethoate (23.10%) had significantly higher head borer damage whereas in control 36.13 per cent head damage was observed. Chlorantraniliprole belonging to the anthranilic diamide chemical class has a novel mode of action. It acts as an activator of insect ryanodine receptors causing rapid muscle dysfunction and paralysis. It is a broad-spectrum foliar insecticide with contact and systemic action, widely used on vegetables in India for the management of lepidopteran insects both infield and poly houses.

Thus, from the present studies it is clearly evident that dimethoate was the best treatment in managing aphids followed by chlorpyriphos. Dimethoate and chlorpyriphos belong to organophosphorus group of insecticides which act on acetyl choline in the nervous system. These possess broad spectrum insecticidal activity against a number of important insect pests. In the present study, the conventional insecticide dimethoate gave the considerable control of aphids as compared to the other insecticides. Earlier, Sharma *et al.* (2020) [11] reported that imidacloprid and thiamethoxam among newer insecticides and oxy demeton methyl and dimethoate among conventional insecticides were effective against mustard aphid with imidacloprid recording highest incremental cost benefit ratio (1:13.28) followed by dimethoate (1:9.88) and oxydemeton-methyl (1:9.15). Similarly, Patel *et al.* (2017) [8] opined that dimethoate was effective in controlling mustard aphid while chlorpyriphos was moderately toxic to mustard aphid after the neo nicotinoids. Our results are in conformity with the reports of Sinha *et al*., (2001) [12] and Mandal *et al*., (2012) [7].

Harika *et al*., (2019) [5] reported that the lowest per cent head damage (8.48%) was recorded in spinosad followed by indoxacarb (12.36), emamectin benzoate (22.44), flubendiamide (33.64), thiodicarb (41.80), lufenuron (51.68) and acephate (56.80). Also, Chowdary *et al.* (2015) revealed that per cent head damage was significantly low in chlorantraniliprole at two different doses 30 g a.i. ha^{-1} (2.53%), 20 g a.i. ha^{-1} (5.39%) followed by emamectin benzoate (10.67%), spinosad (13.89%), flubendiamide (14.38%) and indoxacarb (20.82%) and all the treatments were effective over control (73.36%).

Table 1: Bioefficacy of insecticides against aphids and head borer in cauliflower during *rabi*, 2018-19

Insecticides	No. of aphids/3 leaves/plant*				Per cent reduction over control after I spray	No. of aphids/3 leaves/plant*				Per cent reduction over control after II spray	Per cent Head borer damage
	Pre spray	3 DAS I	DAS I	7 DAS I		Pre spray	3 DAS II	5DAS II	7 DAS II		
Chlorantraniliprole 18.5 SC	95.07 (9.80)	92.40^{e} (9.66)	90.53^{e} (9.57)	88.47^{e} (9.46)	14.59	98.53^{d} (9.98)	88.80^{e} (9.48)	84.33^{e} (9.24)	82.80^{e} (9.15)	16.62	9.44^{a} (17.79)
Spinosad 2.5 SC	96.13 (9.85)	93.33^{e} (9.71)	92.33^{e} (9.66)	92.13^{e} (9.65)	12.04	106.00^{e} (10.34)	96.07^{e} (9.85)	93.13^{e} (9.70)	92.33^{f} (9.66)	13.57	11.67^{a} (19.84)
Emamectin Benzoate 5 SG	96.73 (9.89)	75.33^{d} (8.74)	71.73^{d} (8.53)	71.60^{d} (8.52)	32.07	93.60^{d} (9.73)	72.33^{d} (8.56)	68.47^{d} (8.33)	69.73^{d} (8.41)	26.08	10.56^{a} (18.78)
Indoxacarb 14.5 SC	96.20 (9.86)	94.60^{e} (9.78)	92.80^{e} (9.69)	94.27^{e} (9.76)	10.06	100.13^{d} (10.06)	95.07^{e} (9.80)	92.93^{e} (9.69)	90.20^{ef} (9.55)	10.62	12.22^{a} (20.15)
Diafenthiuron 50 WP	96.73 (9.89)	66.40^{c} (8.21)	59.53^{c} (7.78)	57.33^{c} (7.64)	45.61	85.80^{c} (9.31)	62.07^{c} (7.94)	57.13^{c} (7.62)	53.47^{c} (7.38)	38.17	20.00^{b} (26.50)
Chlorpyriphos 50 EC	99.67 (10.03)	50.00^{b} (7.06)	40.07^{b} (6.40)	35.00^{b} (5.99)	67.77	73.27^{b} (8.61)	40.60^{b} (6.42)	32.80^{b} (5.81)	31.33^{b} (5.68)	57.57	19.44^{b} (26.13)
Dimethoate 30 EC	95.80 (9.84)	30.07 ^{a}(5.57)	24.60^{a} (5.06)	19.40^{a} (4.50)	81.41	65.20^{a} (8.13)	15.47^{a} (4.04)	13.07^{a} (3.74)	12.93^{a} (3.72)	80.32	20.56^{b} (26.84)
Control	99.67 (10.03)	104.20^{e} (10.26)	108.00^{f} (10.44)	108.60^{f} (10.47)	0	118.67^{f} (10.94)	115.13^{f} (10.77)	118.47^{f} (10.92)	119.60^{g} (10.98)	0	32.78^{c} (34.85)
C.D.	N/S	0.93	0.32	0.49		0.42	0.72	0.58	0.47		5.86

* Mean of 5 plants
Figures in parentheses are square root transformed values
DAS – Days after spray; I – 1st Spraying; II – 2nd Spraying; Similar alphabets indicate they are non-significant

Table 2: Bioefficacy of insecticides against aphids and head borer in cauliflower during *rabi*, 2019-20

Insecticides	No. of aphids/3 leaves/plant*				% reduction over control after I spray	No. of aphids/3 leaves/plant*				% reduction over control after II spray	Per cent Head borer damage
	Pre spray	3 DAS I	5 DAS I	7 DAS I		Pre spray	3 DAS II	5DAS II	7 DAS II		
Chlorantraniliprole 18.5 SC	125.00 (11.22)	119.20^{e} (10.96)	112.47^{e} (10.65)	110.80^{e} (10.57)	12.87	121.13^{e} (11.05)	113.33^{e} (10.69)	110.33^{e} (10.55)	102.33^{e} (10.16)	12.10	11.28^{a} (19.56)
Spinosad 2.5 SC	124.13 (11.19)	121.40^{e} (11.06)	120.40^{ef} (11.02)	121.27^{f} (11.06)	3.97	126.13^{ef} (11.28)	120.67^{e} (11.03)	120.07^{ef} (11.00)	113.07^{ef} (10.67)	6.73	13.33^{a} (21.28)
Emamectin Benzoate 5 SG	122.53 (11.11)	92.33^{d} (9.66)	85.47^{d} (9.30)	87.33^{d} (9.40)	29.94	100.20^{d} (10.06)	80.40^{d} (9.02)	75.40^{d} (8.74)	79.87^{d} (8.99)	17.06	12.31^{a} (20.43)
Indoxacarb 14.5 SC	123.93 (11.18)	120.67^{e} (11.03)	120.20^{ef} (11.01)	120.80^{f} (11.04)	4.19	129.2^{ef} (11.41)	120.07^{e} (11.00)	121.73^{ef} (11.08)	111.33^{ef} (10.60)	10.34	15.38^{a} (23.02)
Diafenthiuron 50 WP	123.40 (11.15)	80.87^{c} (9.05)	74.73^{c} (8.70)	69.47^{c} (8.39)	44.66	84.73^{c} (9.26)	57.40^{c} (7.64)	49.40^{c} (7.10)	44.40^{c} (6.74)	45.48	22.05^{b} (27.98)
Chlorpyriphos 50 EC	124.20 (11.19)	55.13^{b} (7.47)	46.07^{b} (6.85)	42.80^{b} (6.60)	66.13	63.20^{b} (8.01)	36.13^{b} (6.09)	35.20^{b} (6.00)	31.20^{b} (5.64)	48.63	21.03^{b} (27.22)
Dimethoate 30 EC	124.87 (11.22)	36.87^{a} (6.15)	34.73^{a} (5.98)	30.00^{a} (5.56)	76.38	48.20^{a} (7.01)	18.60^{a} (4.42)	14.60^{a} (3.93)	13.00^{a} (3.73)	71.94	25.64^{b} (30.35)
Control	123.53 (11.16)	125.93^{e} (11.27)	127.27^{f} (11.32)	125.67^{f} (11.25)	0	133.67^{f} (11.60)	133.20^{f} (11.58)	131.93^{f} (11.53)	128.47^{f} (11.37)	0	39.49 (38.90)
C.D.	N/S	0.50	0.45	0.44		0.47	0.45	0.54	0.82		4.07

* Mean of 5 plants
Figures in parentheses are square root transformed values
DAS – Days after spray; I – 1st Spraying; II – 2nd Spraying; Similar alphabets indicate they are non-significant

Table 3: Bioefficacy of insecticides against aphids and head borer in cauliflower (Pooled Mean)

Treatments	% reduction over control after I spray	% reduction over control after II spray	Overall mean % reduction	Head borer damage (%)
Chlorantraniliprole 18.5 SC	13.67 ^{e} (21.62)	17.44 ^{cd} (24.43)	15.55 (23.07)	10.36 ^{a} (18.77)
Spinosad 2.5 SC	7.61 ^{f} (15.99)	13.09 ^{cd} (20.17)	10.35 (18.41)	12.50 ^{a} (20.58)
Emamectin Benzoate 5 SG	30.86 ^{d} (33.73)	24.44 ^{c} (29.49)	27.65 (31.68)	11.43 ^{a} (19.64)
Indoxacarb 14.5 SC	6.87 ^{f} (14.88)	13.84 ^{cd} (21.19)	10.35 (18.28)	13.80 ^{a} (21.75)
Diafenthiuron 50 WP	45.07 ^{c} (42.16)	43.85 ^{b} (41.45)	44.46 (41.80)	21.03 ^{b} (27.25)
Chlorpyriphos 50 EC	66.88 ^{b} (54.85)	54.86 ^{b} (47.79)	60.87 (51.28)	20.24 ^{b} (26.69)
Dimethoate 30 EC	78.61 ^{a} (62.46)	77.68 ^{a} (61.83)	78.15 (62.11)	23.10 ^{b} (28.69)
Control	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	36.13 ^{c} (36.92)
C.D.	3.21	6.67	4.09	3.48

Figures in parentheses are angular transformed values

Conclusion

Aphids and head borer infestation may affect plant growth and curd formation. Timely intervention in the form of insecticidal spray helps to effectively manage the pest. In the present study, conventional insecticide dimethoate was found effective in managing aphids while chlorantraniliprole, emamectin benzoate, spinosad and indoxacarb were effective in managing head borer damage in cauliflower. Thus, taking up one or two sprays at vegetative stage for managing aphids followed by spraying at curd initiation stage will help to efficiently manage sucking and lepidopteran pest complex in cauliflower.

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