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Bio-efficacy of some newer insecticides against insect pests of cabbage

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Abstract
The bio-efficacy of some newer insecticides viz., cypermethrin 10 AF, indoxacarb 14.5 SC and acetamiprid 20 SP along with standard check cypermethrin 10 EC was evaluated against aphids *Lipaphis erysimi* (Kalt.), *Myzus persicae* (Sulzer) and diamondback moth *Plutella xylostella* (Linnaeus) on cabbage. As compared to the untreated check tested insecticides (at different dose levels) were significantly effective in reducing population of aphids and diamondback moth. However, three sprays of acetamiprid 20 g a.i./ha proved to be most effective in reducing the aphid population while cypermethrin 10 AF 200 g a.i./ha was effective against diamondback moth. The order of bio-efficacy in present investigation in descending order against aphids was acetamiprid 20 SP (20, 10 g a.i./ha) > indoxacarb 14.5 SC (75, 50 g a.i./ha) > cypermethrin 10 AF (200, 100, 75, 60 g a.i./ha) > cypermethrin 10 EC (75 g a.i./ha). The order of bio-efficacy in present investigation in descending order against diamondback moth was cypermethrin 10 AF (200, 100, 75, 60 g a.i./ha) > cypermethrin 10 EC (75 g a.i./ha) > indoxacarb 14.5 SC (75, 50 g a.i./ha) > acetamiprid 20 SP (20, 10 g a.i./ha).

Keywords: Bio-efficacy, insecticides, insect pests, cabbage, aphids, *Lipaphis erysimi*, *Myzus persicae*, diamondback moth, *Plutella xylostella*

Introduction
Vegetables are an important source of carbohydrates, proteins, minerals and roughages for predominantly vegetarian population of India. The area and production under the vegetables is about 10.10 million hectares with an annual production of 169.06 million tonnes during 2015-16 [4]. India is the second largest vegetable producer in the world next to China. Low intake of vegetable may be correlated with lesser availability linked with high price, which is beyond the reach of common people. Now-a-days, all over the world, more and more people are inclined towards vegetarianism, thereby expanding vegetable market. There is thus a good scope for hiking vegetable production to meet domestic demand at reasonable prices and also to tap foreign exchange in the world market. Among the winter vegetables, cole crops have their superiority over other crops and are grown throughout the country. Cole crops include Cabbage, Cauliflower, Knol-khol, Brussels sprouts, Sprouting broccoli and Chinese cabbage. They belong to the family Cruciferae and genus *Brassica*.

Cabbage (*Brassica oleracea* var. *capitata* Linn.) is an important vegetable of cole group, cultivated in about 0.39 million hectare area with a production of 8.80 million tonnes during 2015-16 [4]. It is grown for its edible enlarged terminal buds known as head, which is a rich source of vitamin A (2000 I.U.), B1 (50 I.U.) and C (124 mg/100gm) and also contains minerals including phosphorus, potassium, sodium, calcium, and iron as well. This crop is a native of West Europe and the Northern shores of the Mediterranean [41]. The crop is attacked by a number of pests *viz.*, tobacco caterpillar, diamondback moth, painted bug, cabbage semilooper, aphids, flea beetle, etc. [17, 30, 36]. In India, a total of 37 insect pests have been reported to feed on cabbage, of which the diamondback moth, *Plutella xylostella* Linneaus, cabbage butterfly, *Pieris brassicae* Linneaus and the mustard aphid, *Lipaphis erysimi* Kaltenbach are the major constraints for profitable cultivation of the crop [23, 33]. Among them diamondback moth is a worldwide pest of crucifers [37], *M. persicae* is an extremely polyphagous species of aphids which has been reported to feed on more than five hundred species of host plants from at least forty different families including several important agricultural crops [8, 38]. On the other hand, aphids secrete honeydew, which facilitates the growth of black sooty mould that makes the leaves appear dirty black [6]. The honey dew secretion of the aphids provides a suitable media for the development of sooty mould and fungi which ultimately hamper the process of photosynthesis [11].

Insecticides have been used widely to control the pests on vegetables because of their easy adaptability, effectiveness and immediate control. The indiscriminate and irrational use of insecticides at high doses has resulted in resurgence and resistance in insect pests and ultimately residues in food commodities. The indiscriminate use has also increased the cost of cultivation and has led to some irreversible changes in the biosphere. It is therefore necessary to use some new insecticide molecules with high toxicity to insect pests even at lower doses that should also be safer to the natural enemies present in agro-ecosystem and also to the consumer. Hence, studies were conducted in field conditions to evaluate the bio-efficacy of some newer insecticides viz., cypermethrin 10 AF, indoxacarb 14.5 SC and acetamiprid 20 SP along with standard check cypermethrin 10 EC against aphids *Lipaphis erysimi* (Kalt.), *Myzus persicae* (Sulzer) and diamondback moth *Plutella xylostella* (Linnaeus) on cabbage.

2. Materials and Methods

2.1 Field Studies

Field experiments were conducted at Horticulture Farm, Rajasthan College of Agriculture, Udaipur during the year 2005-06. The experiments were laid out in randomized block design and three replications in each treatment were maintained. In the all trials seedlings were transplanted in rows at a depth of 2.5-3.0 cm. Row to row and plant to plant distance was maintained as 60 and 45 cm, respectively. The size of each replicated plot was maintained as 3.60 m x 3.00 m (10.80 m^2). There were ten treatments: T1= Acetamiprid 20 SP @ 10g a.i./ha, T2= Acetamiprid 20 SP @ 20g a.i./ha, T3= Indoxacarb 14.5 SC @ 50 g a.i./ha, T4= Indoxacarb 14.5 SC @ 75 g a.i./ha, T5= Cypermethrin 10 AF @ 60 g a.i./ha, T6= Cypermethrin 10 AF @ 75 g a.i./ha, T7= Cypermethrin 10 AF @ 100 g a.i./ha,T8= Cypermethrin 10 AF @ 200 g a.i./ha, T9=Cypermethrin 10 EC @ 75 g a.i./ha and T10=Control. Five plants were selected randomly from each replicated plot and tagged. Pre spraying population of insects was recorded according to their specified technique, 24 hours before the scheduled spray.

Aphids, *Lipaphis erysimi* (Kalt.) and *Myzus persicae* (Sulzer): The method suggested by Rawat and Sahu (1973) [32] was adopted. Three leaves; basal, middle and upper leaf was selected on each of the tagged plants (5 plants/plot). The population was estimated by gently holding the leaf between two halves of a petri plate and the adults and the nymphs on each of the three leaves were counted.

Diamondback moth, *Plutella xylostella* (Linnaeus): To estimate the population of the diamondback moth "Direct visual Counting Method" was used. Five plants were selected randomly from each replicated plot and the larval population was counted on these plants weekly.

2.2 Statistical Analysis

Efficacy of different treatment in controlling the insect pests was determined by calculating percent reduction with the formula given by Henderson and Tilton (1955) [14] which is as under:

$$\text{Per cent reduction in population} = 100 \text{ x} \left(1 - \frac{T_a \text{ x } C_b}{T_b \text{ x } C_a}\right)$$

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 values of percent reduction were transformed to angular values, from which analysis of variance was calculated for determining critical difference (C.D) at 5 percent level of significance.

3. Results and Discussion

3.1 Bio-efficacy of different insecticides against insect pests of cabbage

3.1.1 Aphids, *Lipaphis erysimi* (Kalt.) and *Myzus persicae* (Sulzer)

Aphid was reported as a major pest infesting cabbage in the early stage of growth. For the control of this pest performance of three newer insecticides viz., cypermethrin 10 AF, indoxacarb 14.5 SC and acetamiprid 20 SP along with a standard check cypermethrin 10 EC was worked out and are now discussed as under.

The data recorded and presented in Table 1 on aphids during Rabi 2005-06 revealed that maximum pest population reduction was observed on the seventh day after treatment in all the three sprays. All the treatments with different doses were significantly superior over control (untreated check) in controlling aphids up to 14 days on cabbage in first spray and showed almost the same pattern of effectiveness in all three sprays. However, higher dose gave slight more percent control of pest. The present results are in conformity with the results of Matsuda and Takahaski [25] who also reported suitability of acetamiprid in controlling insect pests belonging to order Hemiptera, Thysanoptera, Lepidoptera, Coleoptera and Isoptera. Jayewar *et al.* [16] and Kendappa *et al.* [19] also reported that acetamiprid had excellent activity against aphids, white flies and some species of coleoptera and lepidoptera on cotton and chilli crops. The findings are in line with the work of Brar and Agarwal [9] who reported bio efficacy of Acetamiprid (Pride 20 SP®), at the rate of 100, 150 and 200 g/ha, to be as good as the recommended dosages of oxydemeton methyl (Metasystox 25EC) at 750 ml/ha, triazophos (Hostathion 40 EC) at 1500 ml/ha and ethion (Phosphite 50 EC) at 2000 ml/ha, in controlling whitefly, *Bemisia tabaci* on American cotton. The findings are comparable with the results of Sinha *et al.* [35] who reported that foliar spray of acetamiprid @ 20 g a.i./ha was effective in managing okra leafhopper population. Gowtham *et al.* [12] also evaluated that among the four pesticides, acetamprid 20 SP (0.125g/l) proved highly effective against *Aphis craccivora* with mortality of 98.75 percent. The results are in line with the findings of Yadav *et al.* [39] who tested nine pesticides against sucking insect-pests of chilli *viz*., Imidacloprid 17.8 SL, Thiocloprid 21.7 SC, Thiamethoxam 25 WG, Acetamiprid 20 SP, Ethion 50 EC, Dimethoate 30 EC, Azadirachtin 0.03 EC, NSKE and neem oil, among these pesticides acetamiprid 0.005% caused maximum percent reduction in thrips and whitefly population in the both sprays. The effectiveness of acetamiprid 20 SP @ 0.004 percent against jassid, whitefly and aphid in summer cowpea has been reported by Anandmurthy *et al*. [2]; hence, confirm the present findings in this respect. Similarly, Jakhar *et al.* [13] also reported the efficacy of pesticides against aphids, *Aphis craccivora* infesting Indian bean in ascending order was:

malathion (57.58%), fipronil (62.32%), thiamethoxam (65.97%), acetamiprid (70.16%), dimethoate (73.35%) and Imidacloprid (76.02).

Indoxacarb 14.5 SC (at 50 and 75 g a.i./ha) was second to acetamiprid and gave effective and significant control of aphids on cabbage and proved significantly superior to standard check cypermethrin 10 EC (75 g. a.i./ha). These findings are in line with the findings of Bheemanna and Patil [7] who also reported the moderate control of aphids with spray of indoxacarb 150, 100 and 75 g a.i./ha. Andalaro *et al*. [3] reported that steward TM 15 SC (indoxacarb) disperses well over leaf surface of cotton and penetrates into a leaf waxy cuticle optimizing control of certain sucking pests.

The treatment of cypermethrin 10 AF 100 and 200 g a.i./ha was next to the above two treatments in controlling aphids and was significantly superior to its lower doses (75, 60 g a.i./ha) and standard check cypermethrin 10 EC. These findings are well in accordance with the findings of Daneau [10], Agnihotri *et al*. [1], Kumawat [22], Rai *et al*. [31] and Jain [15] who also observed the effective control of cabbage aphid on cabbage by applying cypermethrin in the range of 30 to 100 g a.i./ha.

The order of bio-efficacy in present investigation in descending order was acetamiprid 20 SP (20, 10 g a.i./ha) > indoxacarb 14.5 SC (75, 50 g a.i./ha) > cypermethrin 10 AF (200, 100, 75, 60 g a.i./ha) > cypermethrin 10 EC (75 g a.i./ha).

3.1.2 Diamondback moth, *Plutella xylostella* (Linnaeus)

Diamondback moth was reported to cause serious damage to cabbage in the present investigation. For the control of this pest performance of three newer insecticides along with a standard check was investigated. The results obtained are discussed as under.

The data recorded and presented in Table 2 on diamondback moth during Rabi 2005-06 revealed that all the insecticides with different doses were found to be significantly superior over control (untreated check) in controlling diamondback moth on cabbage. Both the doses of cypermethrin 10 AF (100 and 200 g a.i./ha) were proved to be most effective in controlling diamondback moth on cabbage crop and were superior over other insecticides. However, its lower doses (60 and 75 g a.i./ha) were at par with standard check cypermethrin 10 EC (75 g a.i./ha). These findings are in accordance with the finding of Jain [15] and Nathu Ram *et al*. [26] that also effectively controlled the *P. xylostella* with synthetic pyrethroid cypermethrin. These findings are in line with the findings of Anwar *et al.* [5] who reported that emamectin benzoate was most effective against brinjal fruit borer and resulted in a lower infestation (40.1%) followed by cypermethrin (40.43%), whereas fenvalerate offered moderate control (41.31%) of borers. Khan *et al.* [20] that estimated high yield (1641.41 kg ha-1) and less mean no. of infested shoots (4.43) and fruits (0.76) were recorded in Cypermethrin + Neem oil + Physical control, followed by Cypermethrin + Neem oil (6.15, 1.13) and Cypermethrin (7.28, 1.42). The results are closely confirmed with the finding of Kumar *et al.* [21] revealed that all the treatments were significantly superior over control among all the treatments Carbofuran recorded highest reduction of *Chilo partellus* (Swinhoe) population *i.e*. (7.70%) which was significantly superior over control followed by Cypermethrin (9.86%) and Fipronil (13.38%) are at par with each other, followed by Indoxacarb (14.44%), Cartap recorded (15.37%), Profenophos (17.63%) then the treatment Imidacloprid (19.47%) was least effective among all the treatments.

Indoxacarb 50 and 75 g a.i./ha proved to be superior over acetamiprid but was inferior than cypermethrin 10 AF and standard check cypermethrin 10 EC in controlling diamondback moth on cabbage. These findings are in accordance with the findings of Martinelli *et al.* [24] who efficiently controlled *P. xylostella* with indoxacarb 18-42 g a.i./ha. Patel *et al.* [27] also revealed significant effectiveness of indoxacarb against the larval population of diamondback moth on cabbage. The findings are in line with the findings of Justin *et al.* [18] who reported that indoxacarb 14.5 SC @ 1 ml/ l provided an effective control of *S. litura* and *H. armigera*. The results are in line with the findings of Patra *et al.* [28] who tested five insecticides against diamondback moth of cabbage viz., pyridalyl 10 EC, indoxacarb 14.5 SC, chlorfenapyr 10 SC, chlorpyriphos 20 EC and triazophos 40 EC, among these insecticides the pooled data indicated that chlorfenapyr @ 200 g a.i./ha recorded the lowest percentage of DBM damage (1.38%) followed by pyridalyl @ 150 g a. i./ha (2.33%) and indoxacarb @ 150 g a. i./ha (2.38%). Yadav *et al.* [40] who reported that after all the three insecticidal applications spinosad, fipronil and indoxacarb were found to have better percent field efficacy compared to other treatments whereas spinosad scored highest percent field efficacy among all amounting 49.08, 47.95 and 50.44 respectively, after 1st, 2nd and 3rd the three sprayings, respectively. The results are also in line with the findings of Sharma *et al.* [34] who also reported that spinosad was found to be most effective reduced up to 94.33 percent population followed by indoxacarb (91.00%) and Flubendiamide (78.66%).

Both the doses of acetamiprid were also effective in controlling the diamondback moth but were inferior to cypermethrin 10 AF, indoxacarb and standard check. These findings are in conformity with the findings of Pramanik and Chatterjii [29] who also observed effectiveness of acetamiprid in controlling diamondback moth but it was inferior to other insecticides including bio-pesticides.

The order of bio-efficacy in present investigation in descending order was cypermethrin 10 AF (200, 100, 75, 60 g a.i./ha) > cypermethrin 10 EC (75 g a.i./ha) > indoxacarb 14.5 SC (75, 50 g a.i./ha) > acetamiprid 20 SP (20, 10 g a.i./ha).

Table 1: Bio-efficacy of different insecticides against aphids *Lipaphis erysimi* (Kalt.) and *Myzus persicae* (Sulzer)

Treatment	Dose (g a.i./ha)	Percent reduction in population after first spray			Percent reduction in population after second spray			Percent reduction in population after third spray		
		1 DAT	7 DAT	14 DAT	1 DAT	7 DAT	14 DAT	1 DAT	7 DAT	14 DAT
Acetamiprid 20 SP	10	59.56* (74.33)	62.06 (78.03)	57.68 (71.29)	58.14 (72.13)	60.15 (75.20)	56.04 (68.76)	58.74 (73.01)	59.15 (73.65)	56.12 (68.90)
Acetamiprid 20 SP	20	60.08 (74.71)	62.99 (79.37)	58.45 (72.61)	58.82 (73.18)	60.82 (76.17)	56.76 (69.93)	59.41 (74.07)	59.80 (74.63)	56.97 (70.24)
Indoxacarb 14.5 SC	50	54.50 (66.22)	55.67 (67.93)	54.24 (65.84)	55.10 (67.25)	56.25 (69.10)	52.52 (62.97)	55.07 (67.21)	55.17 (67.38)	52.26 (62.54)
Indoxacarb	75	55.11	57.95	54.40	55.86	56.94	53.20	55.81	56.07	52.89

14.5 SC		(67.28)	(71.83)	(66.07)	(68.50)	(70.21)	(64.11)	(68.42)	(68.83)	(63.54)
Cypermethrin 10 AF	60	43.16 (46.80)	46.11 (51.94)	45.65 (51.14)	49.06 (57.03)	48.02 (55.26)	45.57 (50.99)	47.32 (54.05)	47.05 (53.57)	44.20 (48.61)
Cypermethrin 10 AF	75	44.25 (48.70)	46.77 (53.08)	46.12 (51.95)	49.44 (57.72)	48.40 (55.91)	46.09 (51.90)	48.02 (55.27)	47.43 (54.23)	44.56 (49.23)
Cypermethrin 10 AF	100	48.73 (56.50)	50.82 (60.07)	49.47 (57.77)	51.68 (61.55)	51.57 (61.34)	48.98 (56.92)	51.03 (60.44)	50.54 (59.60)	47.81 (54.90)
Cypermethrin 10 AF	200	50.01 (58.69)	51.62 (61.43)	50.94 (60.27)	52.77 (63.38)	53.10 (63.90)	49.64 (58.06)	52.10 (62.21)	52.06 (62.15)	48.98 (56.92)
Cypermethrin 10 EC	75	42.92 (46.38)	45.85 (51.48)	45.40 (50.69)	48.63 (56.32)	47.89 (55.02)	45.34 (50.59)	47.07 (53.61)	46.83 (53.18)	43.93 (48.15)
Control	--	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SEm±	--	1.49	1.360	1.090	0.745	1.059	0.943	0.978	1.033	1.079
CD at 5%	--	4.43	4.041	3.237	2.213	3.146	2.802	2.907	3.069	3.206

* Angular transformed percent values; Figures in parentheses are retransformed percent values; DAT = Day/days after treatment

Table 2: Bio-efficacy of different insecticides against diamondback moth, *Plutella xylostella* (Linnaeus)

Treatment	Dose (g a.i./ha)	Percent reduction in population after first spray			Percent reduction in population after second spray			Percent reduction in population after third spray		
		1 DAT	7 DAT	14 DAT	1 DAT	7 DAT	14 DAT	1 DAT	7 DAT	14 DAT
Acetamiprid 20 SP	10	48.83* (56.64)	51.82 (61.28)	44.57 (49.25)	50.18 (58.96)	53.03 (63.82)	47.83 (54.92)	47.45 (54.27)	49.88 (58.46)	48.12 (55.43)
Acetamiprid 20 SP	20	49.94 (58.58)	52.79 (63.43)	44.95 (49.92)	50.92 (60.25)	53.76 (65.02)	48.55 (56.17)	48.13 (55.43)	50.56 (59.64)	49.09 (57.11)
Indoxacarb 14.5 SC	50	53.40 (64.43)	55.69 (68.23)	49.18 (57.24)	53.66 (64.89)	56.30 (69.22)	51.78 (61.73)	51.86 (61.82)	53.71 (64.96)	52.30 (62.59)
Indoxacarb 14.5 SC	75	53.64 (64.42)	56.02 (68.72)	49.98 (58.65)	54.45 (66.19)	56.90 (70.27)	52.45 (62.85)	52.52 (62.97)	54.79 (66.75)	52.65 (63.17)
Cypermethrin 10AF	60	57.41 (70.98)	59.41 (74.09)	54.65 (66.49)	57.58 (71.22)	59.88 (74.82)	55.89 (68.52)	56.46 (69.44)	58.27 (72.20)	56.07 (68.81)
Cypermethrin 10 AF	75	57.93 (71.80)	60.19 (75.27)	55.31 (67.55)	58.71 (73.00)	60.68 (76.01)	56.27 (69.16)	57.07 (70.44)	58.78 (73.12)	56.46 (69.41)
Cypermethrin 10 AF	100	61.41 (77.05)	63.13 (79.50)	59.47 (74.14)	61.35 (77.01)	63.16 (79.53)	59.48 (74.02)	60.72 (76.07)	61.82 (77.66)	59.64 (74.38)
Cypermethrin 10 AF	200	62.08 (77.98)	64.09 (80.83)	59.89 (74.77)	62.16 (78.17)	63.85 (80.57)	60.38 (75.57)	61.35 (76.98)	62.33 (78.43)	59.96 (74.92)
Cypermethrin 10 EC	75	57.08 (70.36)	59.00 (73.43)	54.17 (65.67)	57.13 (70.55)	59.47 (74.18)	55.66 (68.16)	56.20 (68.92)	57.89 (71.73)	55.90 (68.54)
Control	--	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SEm±		1.150	0.966	1.394	0.875	0.818	1.077	1.223	1.008	1.062
CD at 5%		3.416	2.871	4.142	2.600	2.431	3.199	3.633	2.996	3.156

* Angular transformed percent values; Figures in parentheses are retransformed percent values; DAT = Day/days after treatment

4. Conclusion

The field bio-efficacy of four insecticides in different doses was assessed against aphids and diamondback moth on cabbage crop. It was found that even the smallest dose of 60 g a.i./ha of cypermethrin 10 AF, 50 g a.i./ha of indoxacarb and 10 g a.i./ha of acetamiprid were significantly effective in reduction of a pest population compared to the untreated check. The order of bio-efficacy against aphids was acetamiprid 20 SP > indoxacarb 14.5 SC > cypermethrin 10 AF > cypermethrin 10 EC whereas the order of bio-efficacy of these insecticides in case of diamondback moth was cypermethrin 10 AF > cypermethrin 10 EC > indoxacarb 14.5 SC > acetamiprid 20 SP. Cypermethrin 10 AF synthetic pyrethroid can be used for effective control of diamondback moth whereas acetamiprid 20 SP can be used for effective control of aphids.

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