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Bioefficacy of novel insecticide molecules against sucking insect pests of Indian bean

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Abstract
The relative efficacy of twelve insecticides, *viz*., buprofezin 25 SC (0.04%), pyriproxyfen 10.8 EC (0.005%), diafenthiuron 50 WP (0.05%), vertimec 1.9 EC (9.5 mg/l), chlorantraniliprole 18.5 SC (0.005%), chlorfenapyr 10 SC (0.01%), emamectin benzoate 5 SG (0.005%), flubendiamide 39.35 EC (0.01%), pymetrozine 50 WG (0.025%), pyridalyl 10 EC (0.015%), bifenthrin 10 EC (0.016%) and dimethoate 30 EC (0.03%) against leafhopper, *Empoasea fabae* (Harris), aphid, *Aphis craccivora* Koch and whitefly, *Bemisia tabaci* (Genn.) was evaluated. The reduction in population revealed that diafenthiuron 50 WP (92.90% reduction), dimethoate 30 EC (91.77% reduction) and chlorantraniliprole 18.5 SC (90.58% reduction) were found most effective against leafhopper. The same insecticides exhibited 95.17, 94.60 and 94.04 per cent reduction in aphid population, respectively after three days of first spray. ln case of whitefly, the most effective treatments were diafenthiuron 50 WP (93.60% reduction), dimethoate 30 EC (92.04% reduction) and pyriproxyfen 10.8 EC (90.10% reduction). The treatment of pyridayl 10 EC, vertimec 1.9 EC and pymetrozine 50 WG proved to be least effective.

Keywords: Bio-efficacy, novel insecticide molecules, sucking insect pests, Indian bean

Introduction
Indian bean, *Lablab purpureus* (Linn.) Sweet commonly known as hyacinth bean, Egyptian bean, dolichos bean or *sem* (Family: Fabaceae) is one of the most ancient crops among cultivated plants. It is presently grown throughout the tropical regions in Asia and Africa. It is a perennial herbaceous plant, occupies an important place among the fruit vegetable crops grown in the field as well as in the kitchen gardens. Primarily, it is grown for green pods, while dry seeds are used in various vegetable food preparations. It is one of the major sources of proteins, minerals and dietary fibre. The green pods have a high nutritive value, comprising of protein 3.8 g, carbohydrate 6.7 g, vitamin-A 312 IU, mineral 0.9 g, fat 0.7 g and oxalic acid 1 mg in per 100 g. The foliage of the crop provides hay, silage and green manure. This crop is also grown for medicinal and ornamental purposes (Bose *et al.*, 1993) [3].

Materials and Methods
Experimental details
The experiment was laid out in simple Randomized Block Design with 13 treatments including untreated control, each replicated thrice. The variety, Dolichus diana was sown on 2nd July, 2018 in plots of 1.50 X 2.70 m^2 size keeping row to row and plant to plant distance of 60 cm and 60 cm, respectively. The details of novel insecticides used is given in table-3.2. Further, the details in concise form is appended (Appendix-I).

All the insecticides were applied as foliar spray in evening hours on the crop using pre-calibrated knapsack sprayer when the pest population sufficiently built up. The first spray was done on 15th September, 2018 and second spray was repeated after 21 days of the first spray when sufficient populations of insect pests developed again. An untreated check was maintained for comparison. The insecticidal solution was prepared using the following formula:

$$C_1V_1 = C_2V_2$$

Where
C_1 = Concentration of given formulation (%)
V_1 = Volume/ amount of formulation required (ml or g)

C_2 = Concentration of spray fluid required (%)

Table 1: Details of insecticides used

S. No.	Common Name	Trade Name	Formulation	Conc.(%)/ Dosage
1.	Buprofezin	Banzo	25 SC	0.04
2.	Pyriproxyfen	Nylar	10.8 EC	0.005
3.	Diafenthiuron	Pegasus	50 WP	0.05
4.	Vertimec	Abamectin	1.9 EC	9.5 mg a.i. l^{-1}
5.	Chlorantraniliprole	Coragen	18.5 SC	0.005
6.	Chlorfenapyr	Lepido	10 SC	0.01
7.	Emamectin benzoate	Proclaim	5 SG	0.005
8.	Flubendiamide	Fame	39.35 EC	0.01
9.	Pymetrozine	Plenum	50 WG	0.025
10.	Pyridalyl	Pleo	10 EC	0.015
11.	Bifenthrin	Marker	10 EC	0.016
12.	Dimethoate	Rogor	30 EC	0.03
13.	Untreated control	-	-	-

Method of observations

Observations on population of sucking pests were recorded on three leaves one each from top, middle and bottom canopy of the five plants selected randomly in each replications in early hours (before 8.00 AM) at one day before and 1,3,7,10 and 15 days after application of treatments in both the sparys. Yield data were recorded at every picking, compiled and converted per hectare. The details regarding population counts of each insect pest are described below:

Aphid, *Aphis craccivora* Koch

Aphid population was counted on the shoot of each of the five randomly selected and tagged plants in each plot. When the aphid population appeared, the observations were recorded early in the morning by visual counting.

Leafhopper, *Empoasea fabae* (Harris)

The population of leafhopper was recorded by counting both nymphs and adults on three leaves taken into consideration from top, middle and lower canopy of the plant (Rawat and Sahu, 1973) [12].

Whitefly, *Bemisia tabaci* (Genn.)

The population of whitefly was counted visually on three leaves from upper, middle and lower portion of each tagged plant. For counting the whitefly population, the leaf was held at the petiole by thumb and fore fingers and twisted until the entire under side of leaf became clearly visible (Butter and Vir, 1990). Absolute counts were made just before treatment (pre-treatment) and one, three, seven, ten and fifteen days after treatment.

Interpretation of data

The data obtained just before treatment and one, three, seven, ten and fifteen days after the spray were taken into consideration to find out the per cent reduction in the population which was determined by applying formula given by Henderson and Tilton (1955).

$$\text{Per cent reduction in pest population} = 1 - \frac{\text{Ta x Cb}}{\text{Tb x Ca}} \text{ X } 100$$

Where

T_a = Population in treated plots after treatment
T_b = Population in treated plots before treatment
C_a = Population in untreated plots after treatment
C_b = Population in untreated plots before treatment

The data were then statistically analyzed by transforming the per cent data of population reduction into angular transformation values (Bliss, 1937) [2].

Results and Discussion

The relative efficacy of twelve insecticides, namely, buprofezin 25 SC (0.04%), pyriproxyfen 10.8 EC (0.005%), diafenthiuron 50 WP (0.05%), vertimec 1.9 EC (9.5mg a.i./l), chlorantraniliprole 18.5 SC (0.005%), chlorfenapyr 10 SC (0.01%), emamectin benzoate 5 SG (0.005%), flubendiamide 39.35 EC (0.01%), pymetrozine 50 WG (0.025%), pyridalyl 10 EC (0.015%), bifenthrin 10 EC (0.016%) and dimethoate 30 EC (0.03%) was evaluated against sucking insect pests of Indian bean under field conditions. Two sprays were done with recommended concentrations of insecticides, the first when the sucking pest populations sufficiently built up and the second after 21 days of the first. Three sucking insect pests recorded as the major insect pests were leafhopper, *Empoasca fabae* (Harris); aphid, *Aphis craccivora* Koch and whitefly, *Bemisia tabaci* (Genn.). The reduction in population of sucking insect pests was observed after one, three, seven, ten and fifteen days of application of treatments.

Table 1: Bioefficacy of novel insecticide molecules against leafhopper, *Empoasea fabae* (Harris) infesting Indian bean (First spary)

S. No.	Insecticides	Concentration (%)	Mean per cent reduction in population days after spary				
			One	Three	Seven	Ten	Fifteen
1.	Buprofezin 25 SC	0.025	82.28 (65.11)	87.92 (69.66)	78.50 (62.38)	72.86 (58.60)	68.80 (56.04)
2.	Pyriproxyfen 10.8 EC	0.005	79.00 (62.73)	82.09 (64.96)	74.32 (59.55)	70.46 (57.08)	62.50 (52.24)
3.	Diafenthiuron 50 WP	0.05	87.36 (69.17)	92.90 (74.55)	87.58 (69.36)	80.27 (63.63)	76.77 (61.19)
4.	Vertimec 1.9 EC	9.5 mg a.i.l^{-1}	49.15 (44.51)	59.53 (50.67)	54.73 (47.71)	51.00 (45.57)	41.20 (39.93)
5.	Chlorantraniliprole 18.5 SC	0.005	85.00 (67.21)	90.58 (72.13)	83.68 (61.17)	77.30 (61.55)	69.65 (56.57)
6.	Chlorfenapyr 10 SC	0.01	62.54 (52.26)	66.91 (55.49)	61.65 (51.65)	60.40 (51.03)	46.20 (42.82)
7.	Emamectin benzoate 5 SG	0.005	70.58 (57.15)	76.59 (60.39)	68.59 (55.91)	66.44 (54.60)	49.65 (44.80)
8.	Flubendiamide 39.35 EC	0.01	76.86 (61.25)	80.00 (63.43)	73.44 (58.98)	69.59(56.53)	61.43 (51.61)
9.	Pymetrozine 50 WG	0.025	55.85 (48.36)	62.50 (52.24)	59.66 (50.57)	54.60 (47.64)	46.00 (42.71)
10.	Pyridalyl 10 EC	0.015	49.96 (44.30)	57.40 (49.25)	54.50 (47.51)	46.41 (43.52)	40.33 (39.42)
11.	Bifenthrin 10 EC	0.016	64.95 (53.70)	71.29 (57.60)	65.57 (54.07)	63.72 (52.96)	47.50 (43.57)
12.	Dimethoate 30 EC (Check)	0.03	85.23 (68.40)	91.77 (73.33)	84.41 (66.74)	78.27 (62.22)	74.36 (59.58)
13.	Control	-	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	S.Em.+		1.34	1.42	1.32	1.25	1.16
	CD (p=0.05)		3.90	4.16	3.85	3.64	3.39

Figures in the parenthesis are angular transformed values

Table 2: Bioefficacy of novel insecticide molecules against leafhopper, *Empoasea fabae* (Harris) infesting Indian bean (Second spary)

S. No.	Insecticides	Concentration (%)	Mean per cent reduction in population days after spray				
			One	Three	Seven	Ten	Fifteen
1.	Buprofezin 25 SC	0.025	78.46 (62.35)	85.52 (67.63)	75.50 (60.33)	68.44 (55.82)	58.32 (49.79)
2.	Pyriproxyfen 10.8 EC	0.005	76.64 (61.10)	83.23 (65.83)	67.57 (54.68)	66.23 (54.47)	56.37 (48.66)
3.	Diafenthiuron 50 WP	0.05	85.52 (67.63)	91.30 (72.85)	81.32 (64.39)	76.50 (61.00)	67.05 (54.97)
4.	Vertimec 1.9 EC	9.5 mg a.i.l^{-1}	50.44 (45.25)	61.06 (51.39)	49.09 (44.48)	48.25 (44.00)	42.36 (40.61)
5.	Chlorantraniliprole 18.5 SC	0.005	82.28 (65.11)	87.20 (69.04)	78.00 (62.03)	73.01 (58.70)	60.27 (50.93)
6.	Chlorfenapyr 10 SC	0.01	58.44 (49.86)	69.65 (56.57)	56.00 (48.50)	56.10 (48.50)	46.38 (42.92)
7.	Emamectin benzoate 5 SG	0.005	68.58 (55.91)	76.70 (61.14)	62.24 (52.09)	58.70 (50.01)	52.22 (46.27)
8.	Flubendiamide 39.35 C	0.01	72.44 (58.33)	81.77 (64.72)	65.30 (53.91)	63.65 (52.92)	54.61 (47.65)
9.	Pymetrozine 50 WG	0.025	52.64 (46.51)	63.27 (52.70)	51.50 (45.86)	51.46 (45.84)	43.25 (41.12)
10.	Pyridalyl 10 EC	0.015	49.09 (44.48)	60.82 (51.25)	47.92 (43.81)	45.92 (42.66)	41.16 (39.91)
11.	Bifenthrin 10 EC	0.016	63.06 (52.57)	72.44 (58.33)	58.30 (49.78)	56.44 (48.70)	48.90 (44.37)
12.	Dimethoate 30 EC (Check)	0.03	83.90 (66.36)	89.44 (71.04)	78.85 (62.62)	73.78 (59.20)	61.26 (51.51)
13.	Control	-	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	S.Em.+		1.29	1.41	1.23	1.18	1.10
	CD (p=0.05)		3.76	4.11	3.59	3.44	3.20

Figures in the parenthesis are angular transformed values

Table 3: Bioefficacy of novel insecticide molecules against aphid, *Aphis craccivora* Koch infesting Indian bean (First spary)

S. No.	Insecticides	Concentration (%)	Mean per cent reduction in population days after spary				
			One day	Three	Seven	Ten	Fifteen
1.	Buprofezin 25 SC	0.04	84.60 (66.89)	90.14 (71.57)	84.10 (66.50)	78.40 (62.31)	68.08 (55.60)
2.	Pyriproxyfen 10.8 EC	0.005	83.38 (65.94)	89.00 (70.63)	83.15 (65.76)	78.19 (62.16)	65.31 (53.92)
3.	Diafenthiuron 50 WP	0.05	91.94 (73.51)	95.17 (77.30)	91.20 (72.74)	87.44 (69.24)	75.28 (60.19)
4.	Vertimec 1.9 EC	9.5 mg a.i.l^{-1}	70.15 (56.88)	78.50 (62.38)	69.72 (56.61)	65.28 (53.90)	54.63 (47.66)
5.	Chlorantraniliprole 18. 5 SC	0.005	89.06 (70.69)	94.04 (75.87)	89.40 (71.00)	85.80 (67.86)	73.50 (59.02)
6.	Chlorfenapyr 10 SC	0.01	75.50 (60.33)	84.60 (66.89)	78.45 (62.34)	71.50 (57.73)	60.30 (50.94)
7.	Emamectin benzoate 5 SG	0.005	80.46 (63.77)	87.38 (69.19)	81.48 (64.51)	76.59 (61.06)	62.43 (52.20)
8.	Flubendiamide 39.35 EC	0.01	80.50 (63.79)	89.60 (71.19)	81.70 (64.67)	77.42 (61.63)	62.87 (52.46)
9.	Pymetrozine 50 WG	0.025	73.32 (58.90)	81.21 (64.31)	73.31 (58.89)	67.49 (55.24)	57.16 (49.12)
10.	Pyridalyl 10 EC	0.015	68.16 (55.65)	75.87 (60.58)	68.95 (56.14)	61.00 (51.35)	51.23 (45.74)
11.	Bifenthrin 10 EC	0.016	79.48 (63.06)	86.15 (68.15)	80.10 (63.51)	75.53 (60.35)	62.40 (52.18)
12.	Dimethoate 30 EC (Check)	0.03	90.94 (72.48)	94.60 (76.56)	90.44 (71.29)	86.24 (68.23)	74.34 (59.57)
13.	Control	-	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	S.Em.+		1.46	1.51	1.45	1.37	1.25
	CD (p=0.05)		4.25	4.50	4.23	3.99	3.63

Figures in the parenthesis are angular transformed values

Table 4: Bioefficacy of novel insecticide molecules against aphid, *Aphis craccivora* Koch infesting Indian bean (Second spary)

S. No.	Insecticides	Concentration (%)	Mean per cent reduction in population days after spary				
			One	Three	Seven	Ten	Fifteen
1.	Buprofezin 25 SG	0.04	85.15 (67.33)	88.60 (70.27)	79.00 (62.73)	73.40 (58.95)	62.16 (52.04)
2.	Pyriproxyfen 10.8 EC	0.005	81.23 (64.33)	87.30 (69.12)	78.68 (62.50)	72.00 (58.05)	61.21 (51.48)
3.	Diafenthuron 50 WP	0.05	91.24 (72.78)	94.34 (76.24)	86.10 (68.11)	81.44 (64.48)	71.21 (57.55)
4.	Vertimec 1.9 EC	9.5 mg a.i.l^{-1}	70.10 (56.85)	77.51 (61.69)	64.31 (53.32)	60.94 (51.32)	50.50 (45.29)
5.	Chlorantraniliprole 18.5 SC	0.005	89.60 (71.19)	92.32 (73.91)	84.58 (66.88)	79.10 (62.80)	68.50 (55.86)
6.	Chlorfenapyr 10 SC	0.01	78.50 (62.38)	84.60 (66.89)	71.00 (57.42)	68.72 (55.99)	55.32 (48.05)
7.	Emamectin benzoate 5SG	0.005	79.34 (62.92)	87.00 (68.87)	76.34 (60.89)	69.40 (56.42)	58.60 (49.95)
8.	Flubendiamide 39.35 EC	0.01	79.50 (63.08)	87.10 (68.95)	76.74 (61.17)	70.46 (57.08)	59.42 (50.43)
9.	Pymetrozine 50 WG	0.025	71.20 (57.54)	84.17 (66.15)	70.00 (56.79)	62.00 (51.94)	51.40 (45.80)
10.	Pyridalyl 10 EC	0.015	65.58 (54.88)	77.15 (61.44)	64.27 (53.29)	59.76 (50.63)	48.37 (44.07)
11.	Bifenthrin 10 EC	0.016	78.60 (62.44)	86.14 (68.14)	73.40 (58.95)	69.00 (56.17)	56.15 (48.53)
12.	Dimethoate 30 EC (Check)	0.03	91.00 (72.54)	93.09 (74.76)	85.60 (67.70)	80.94 (64.11)	69.40 (56.42)
13.	Control	-	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	S.Em.+		1.44	1.55	1.37	1.29	1.19
	CD (p=0.05)		4.20	4.53	3.99	3.75	3.46

Figures in the parenthesis are angular transformed values

Table 5: Bioefficacy of novel insecticide molecules against whitefly, *Bemisia tabaci* (Genn.) infesting Indian bean (First spary)

S. No.	Insecticides	Concentration (%)	Mean per cent reduction in population days after spary				
			One	Three	Seven	Ten	Fifteen
1.	Buprofezin 25 SC	0.04	84.50 (66.82)	89.50 (71.09)	82.67 (65.40)	76.30 (60.87)	63.14 (52.62)
2.	Pyriproxyfen 10.8 EC	0.005	87.13 (68.98)	90.10 (71.66)	87.06 (68.92)	77.98 (62.01)	66.28 (54.50)
3.	Diafenthiuron 50 WP	0.05	90.60 (72.15)	93.60 (75.35)	88.20 (69.91)	82.10 (64.97)	71.12 (57.49)
4.	Vertimec 1.9 EC	9.5 mg a.i.l^{-1}	61.67 (51.75)	72.10 (58.12)	60.00 (50.77)	52.30 (46.32)	48.00 (43.85)
5.	Chlorantraniliprole 18.5 SC	0.005	82.64 (65.38)	88.10 (69.82)	80.60 (63.87)	73.15 (58.79)	62.06 (51.98)
6.	Chlorfenapyr 10 SC	0.01	63.64 (52.92)	75.15 (60.10)	64.93 (53.69)	60.60 (51.12)	55.15 (47.96)
7.	Emamectin benzoate 5 SG	0.005	73.25 (58.86)	82.12 (64.99)	72.93 (58.65)	69.00 (56.17)	56.50 (48.73)
8.	Flubendiamide 39.35 EC	0.01	76.10 (60.73)	85.15 (67.33)	75.80 (60.53)	71.00 (57.42)	59.00 (50.18)
9.	Pymetrozine WG 50	0.025	61.90 (51.88)	72.30 (58.24)	60.10 (50.83)	55.30 (48.04)	48.40 (44.08)
10.	Pyridalyl 10 EC	0.015	55.48 (48.15)	65.60 (54.09)	56.53 (48.75)	48.19 (43.96)	45.12 (42.20)
11.	Bifenthrin 10 EC	0.016	71.46 (57.71)	81.38 (64.44)	71.42 (57.68)	66.42 (54.57)	56.30 (48.62)
12.	Dimethoate 30 EC (Check)	0.03	89.23 (70.84)	92.04 (73.61)	87.38 (69.19)	79.28 (62.92)	70.44 (57.06)
13.	Control	-	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	S.Em.+		1.26	1.38	1.25	1.17	1.09
	CD (p=0.05)		3.69	4.02	3.66	3.40	3.19

Figures in the parenthesis are angular transformed values

Table 6: Bioefficacy of novel insecticide molecules against whitefly, *Bemisia tabaci* (Genn.) infesting Indian bean (Second spary S)

S. No.	Insecticides	Concentration (%)	Mean per cent reduction in population days after spary				
			One	Three	Seven	Ten	Fifteen
1.	Buprofezin 25 SC	0.04	80.27 (63.63)	84.93 (67.16)	72.65 (58.47)	69.23 (56.31)	58.10 (49.66)
2.	Pyriproxyfen 10.8 EC	0.005	84.60 (66.89)	90.06 (71.62)	78.54 (62.40)	73.10 (58.76)	63.54 (52.86)
3.	Diafenthiuron 50 WP	0.05	87.20 (69.04)	93.36 (75.07)	82.12 (64.99)	77.08 (61.40)	67.05 (54.97)
4.	Vertimec 1.9 EC	9.5 mg a.i.l^{-1}	60.25 (50.91)	70.50 (57.10)	50.12 (45.07)	48.65 (44.23)	45.80 (42.59)
5.	Chlorantraniliprole 18.5 SC	0.005	78.45 (62.34)	84.77 (67.03)	71.64 (57.82)	70.00 (56.79)	57.13 (49.02)
6.	Chlorfenapyr 10 SC	0.01	67.00 (54.94)	72.80 (58.56)	58.59 (49.95)	56.32 (48.63)	51.31 (45.75)
7.	Emamectin benzoate 5 SG	0.005	71.09 (57.47)	79.25 (62.90)	65.60 (54.09)	63.00 (52.54)	55.27 (48.03)
8.	Flubendiamide 39.35 EC	0.01	72.60 (58.44)	82.60 (65.35)	66.15 (54.42)	63.79 (53.20)	56.95 (48.99)
9.	Pymetrozine 50 WG	0.025	65.10 (53.79)	71.90 (57.99)	55.95 (48.42)	54.06 (47.33)	48.09 (43.91)
10.	Pyridalyl 10 EC	0.015	56.07 (48.49)	66.00 (54.33)	49.00 (44.43)	48.44 (41.11)	44.80(42.02)
11.	Bifenthrin 10 EC	0.016	70.40 (57.04)	78.17 (62.15)	63.78 (53.00)	61.44 (51.61)	55.21 (47.99)
12.	Dimethoate 30 EC (Check)	0.03	86.28 (68.26)	92.00 (73.57)	79.23 (62.89)	75.53 (60.35)	65.54 (54.05)
13.	Control	-	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	S.Em.+		1.35	1.46	1.26	1.21	1.14
	CD (p=0.05)		3.94	4.27	3.67	3.53	3.34

Figures in the parenthesis are angular transformed value

Leafhopper, *Empoasca fabae* (Harris)

The per cent reduction in leafhopper population was observed maximum after three days of application and subsequently decreased after seven, ten and fifteen days of application. In the present investigation, the treatment diafenthiuron 50 WP 0.05 per cent exhibited maximum reduction in leafhopper population (92.90%) which was found at par with dimethoate 30 EC 0.03 per cent (91.77%) and chlorantraniliprole 18.5 SC 0.005 per cent (90.58%). The treatments of buprofezin 25 SC 0.04 per cent, pyriproxyfen 10.8 EC 0.005 per cent, flubendiamide 39.35 EC 0.01 per cent, emamectin benzoate 5 SG 0.005 per cent, bifenthrin 10 EC 0.016 per cent and chlorfenapyr 10 SC 0.01 per cent ranked in middle order of efficacy (66.91-87.92% reduction). The treatment of pyridayl 10 EC 0.015 per cent (57.40% reduction) followed by vertimec 1.9 EC 9.5 mg a.i./l (59.53% reduction) and pymetrozine 50 WG 0.025 per cent (62.50% reduction) proved to be least effective against leafhopper, *E. fabae* on Indian bean crop in the first insecticidal application. More or less the same trend of effectiveness of various treatments was registered in second application.

The present findings are in agreement with that of Shaikh and Patel (2012) [13] who reported that the diafenthiuron 0.05 per cent was the most effective insecticide in suppression of jassid population on brinjal crop. Razaq *et al.* (2005) reported that the diafenthiuron 0.05 per cent quite effective in reducing the incidence of jassid on cotton crop which supports the present investigation. Choudhary and Singh (2015) [4] revealed that the pyriproxyfen 0.005 per cent cent (125 g a.i./ ha) and diafenthiuron 0.05 per cent (300 g a.i./ ha) was also proved superior in reduction of leafhopper population on cotton crop which conforms the present findings. Kharel *et al.* (2016) [7] reported that the diafenthiuron 0.05 per cent (312 g a.i./ ha) was the most effective insecticide in suppression of jassid population on greengram crop. Jadhav (2017), Kalyan *et al.* (2017) and Namade *et al.* (2017) [5, 8] conducted the experiment on the efficacy of diafenthiuron (600 g a.i./ ha and 300 g a.i./ ha, respectively) which was found effective in reduction of jassid population on okra crop and Bt cotton which support the present results. Dimethoate 30 EC 0.03 per cent was found very effective insecticide next to diafenthiuron 0.05 per cent in the present study. The findings is in agreement with that of Singh *et al.* (2010 [15]). The present results are in conformity with that of Shivanna *et al.* (2011) [14], who reported higher effectiveness of these insecticides against leafhopper on cotton crop. Anandmurthy *et al.* (2017) [1] observed that the dimethoate 0.03 per cent was found effective in reduction of jassid population on cowpea crop, which support the present finding. Choudhari *et al.* (2015) [4] and Kharade *et al.* (2018) [6] found chlorantraniliprole as

effective insecticide which supports the present findings.
The descending order of effectiveness of novel insecticides against leafhopper, *E. fabae* was found to be: diafenthiuron, dimethoate, chlorantraniliprole, buprofezin, pyriproxyfen, flubendiamide, bifenthrin, chlorfenapyr, pymetrozine, vertimec, pyridalyl.

Aphid, *Aphis craccivora* Koch

In the present investigation, the treatment diafenthiuron 50 WP 0.05 per cent was found most effective against aphid (95.17% reduction) which was found at par with dimethoate 30 EC 0.03 per cent (94.60% reduction) and chlorantraniliprole 18.5 SC 0.005 per cent (94.04% reduction). The treatments of buprofezin 25 SC 0.04 per cent, pyriproxyfen 10.8 EC 0.005 per cent, flubendiamide 39.35 EC 0.01 per cent, emamectin benzoate 5 SC 0.005 per cent, bifenthrin 10 EC 0.016 per cent and chlorfenapyr 10 SC 0.01 per cent ranked in middle order of efficacy (84.60-90.14% reduction). The treatment of pyridayl 10 EC 0.015 per cent followed by vertimec 1.9 EC 9.5 mg a.i./l and pymetrozine 50 WG 0.025 per cent proved to be least effective against aphid, *A. craccivora* on Indian bean crop.
The present findings got support from the results of Choudhary and Singh (2015) [4] which revealed that the pyriproxyfen 0.005 per cent (125 g a.i./ ha) and diafenthiuron 0.05 per cent (300 g a.i./ ha) were proved superior in reduction of aphid population on cotton crop. The present results are in agreement with that of Kharel *et al.* (2016**)** [7] who reported diafenthiuron 0.05 per cent (312 g a.i./ ha) as the most effective insecticide in suppression of aphid population on greengram. Namade *et al.* (2017) [8] observed that the efficacy of diafenthiuron 0.05 per cent (300 g a.i./ ha) was found effective in reduction of aphid population on Bt cotton crop which supports the present findings. The present findings are in agreement with that of Surwase *et al.* (2017) [16] who reported that diafenthiuron 0.05 per cent (300 g a.i./ha) was the most effective insecticide in suppression of aphid population on cotton crop. Dimethoate 0.03 per cent was found very effective insecticide against the aphid which got support from the findings of Jangu *et al.* (2005).

Whitefly, *B. tabaci*

In the present investigation, the treatment diafenthiuron 0.05 per cent was found most effective against whitefly and found at par with dime thoate 0.03 per cent and pyriproxyfen 0.005 per cent after three days of first spray (90.10-93.60% reduction). The treatments of buprofezin 0.04 per cent, chlorantraniliprole 0.005 per cent, flubendiamide 0.01 per cent, emamectin benzoate 0.005 per cent, bifenthrin 0.016 per cent and chlorfenapyr 0.01 per cent ranked in middle order of efficacy (75.15-89.50% reduction). The treatment of pyridayl 0.015 per cent followed by vertimec 9.5 mg a.i./l and pymetrozine 0.025 per cent proved to be least effective against whitefly (65.60-72.30% reduction) on Indian bean crop. The order of effectiveness of various novel insecticides was more or less same in the second application.
The present results got support from the findings of Vichiter and Ramesh (2009), Rajawat *et al.* (2017) and Rajesh *et al.* (2017) [18, 10-11]. The present findings are in agreement with that of Shaikh and Patel (2012) [13] who reported that the diafenthiuron 0.05 per cent was the most effective insecticide in suppression of whitefly population on brinjal crop. The present findings are also in agreement with that of Kharel *et al.* (2016) [7] who reported that diafenthiuron 0.05 per cent (187.5g a.i./ ha) was proved to be most effective insecticides in reducing whitefly population on greengram crop. Kalyan *et al.* (2017) and Namade *et al.* (2017) [7, 8] observed that the efficacy of diafenthiuron 0.05 per cent (300g a.i./ ha) was found effective in reduction of whitefly population on Bt cotton crop also support the present findings. Dimethoate 0.03 per cent was found very effective insecticide next to diafenthiuron 0.05 per cent in the present study. Anandmurthy *et al.* (2017) and Patil *et al.* (2018) [1, 9] observed that the efficacy of dimethoate 0.03 per cent was found effective in reduction of whitefly population on cowpea and cowpea, respectively, also support the present findings. Pyriproxyfen 0.005 per cent was found very effective insecticide next to dimethoate 0.03 per cent in the present study. Choudhary and singh (2015) [4]. revealed that the pyriproxyfen 0.005 per cent cent (125 g a.i./ ha) and diafenthiuron 0.05 per cent (300 g a.i./ ha) was also proved superior in reduction of whitefly population on cotton crop which is in agreement with the present finding. The present findings are in agreement with that of Swami *et al.* (2018) [17] who observed that pyriproxyfen 10 EC (75 g a.i./ ha) was found most effective in its efficacy against whitefly.
The descending order of effectiveness of insecticides fifteen days after treatment was found to be: diafenthiuron, dimethoate, pyriproxyfen, buprofezin, chlorantraniliprole, flubendiamide, bifenthrin, chlorfenapyr, pymetrozine, vertimec, pyridalyl.

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