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Bioefficacy of newer insecticides against aphid, *Aphis craccivora* Koch on cowpea

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Abstract
Investigations were conducted on the "Bioefficacy of newer insecticides against aphid, *Aphis craccivora* Koch on cowpea". at Agronomy farm, of S.K.N. College of agriculture, Jobner Rajasthan) during *kharif*, 2016. The insecticides *viz*., imidacloprid, thiamethoxam and dimethoate were found effective against the pests whereas, the azadiracthin and malathion were found least effective against the pest. The highest grain yield of 20.38 qha^{-1} was recorded in the plots treated with imidacloprid, followed by thiamethoxam (19.32 q ha^{-1}). The minimum grain yield of 11.98 q ha^{-1} was obtained in the plots treated with azadirachtin (0.002) followed by the treatment malathion 0.05 percent (12.02 q ha^{-1}) which was found statistically at par with each other. The highest B: C ratio (19.01:1) was recorded in the treatment of thiamethoxam followed by imidacloprid 0.005 percent and dimethoate 0.03 percent, which resulted in a benefit: cost ratio of 16.52 : 1 and 8.74: 1, respectively whereas, lowest benefit : cost ratio of 1.21: 1 was recorded from plots treated with chlorantraniliprole 0.005 percent.

Keywords: Cowpea, *Aphis craccivora*, bioefficacy

Introduction
Cowpea (*Vigna unguiculata* Linn.) is one of the most important legume crop also known as lobia, belongs to family Leguminaceae. It is used as green legume, fodder, vegetable as well as green manure crop. The seeds of cowpea contain 23.4 percent protein, 18 percent fat, 60.3 percent carbohydrate and also a rich source of lysine and tryptophane (Singh, 1983) [23].

In India, the pulses occupy nearly 25.26 lakh hectare area with a production of 16.47 million tonnes during the year 2015-16 (Anonymous 2016) [3]. In Rajasthan, cowpea is of great important because of its short duration, high yielding and quick growing capacity along with high protein content. The crop is also known to provide quick cover on the ground and this help in conservation of soil. The area under cowpea cultivation in Rajasthan was 66.32 lakh hectare with the production of 30.68 million tonnes (Anonymous 2016) [4]. In Rajasthan the major cowpea growing districts are Jaipur, Sikar, Jhunjhunu and Nagaur.

As many as 21 insect pests of different groups are recorded damaging the cowpea crop from germination to maturity (Sardhana and Verma, 1986) [21]. The important insect species attacking to cowpea crop are aphid, *Aphis craccivora* Koch; jassid, *Empoasca fabae* (Harris); thrips, *Megaleurothrips distalis* Karny; army worm, *Mythimna separata* (Walker); semilooper, *Thysanoplusia orichalcea* (Fab.); Leafminer, *Phytomyza horticola* Meigen and pod borer, *Helicoverpa armigera* (Hubner) resulting in heavy yield losses (Prasad *et al.*, 1983 and Satpathy *et al*., 2009) [18, 22]. Among these, cowpea aphid, *Aphis craccivora* Koch is the most serious pest of this crop and occurs in different parts of India (Ganguli and Raychaudhuri, 1984) [11], causes 20-40 percent yield loss (Singh and Allen, 1980) [24].

The cowpea aphid, *A. craccivora* belongs to the family Aphididae of order Hemiptera, suborder Homoptera. Both nymph and adult cause damage by sucking cell sap from leaves, petioles, tender stems, inflorescence and pods. Due to their fast multiplication within few days, aphids usually cover the entire surface of apical shoots and with the result of continuous feeding, by such a large population yellowing, curling and subsequent drying of leaves take place, which ultimately leads to the formation of weak pods and undersized grain in the pods and decreased yield. David and Kumaraswami (1982) [8] observed that the cowpea aphid also act as vector of several viral diseases like cowpea mosaic and papaya mosaic.

Many workers have suggested the use of various non-systemic insecticides for the control of cowpea aphid. It is a common observation that the aphid population is brought down by the application of non-systemic insecticides due to high initial kill of aphids, but at the sometime the survivor individuals soon build up their population because of high rate of multiplication and absence of natural enemies.

Keeping in this view most of the workers have emphasized the use of newer and systemic insecticides to control this aphid. As such, this study includes a range of insecticides for evaluating an effective control schedule.

Material and Methods

The materials used and methodologies adopted during the course of investigation on Bioefficacy of newer insecticides against aphid, *Aphis craccivora* Koch on cowpea, as envisaged in the plan of work has been described in detail hereunder.

The experiment was laid out in a randomized block design (RBD) with nine treatments including the control and each treatment was replicated thrice. The individual plot size was 3 m x 4 m, keeping row to row and plant to plant distance of 30 cm and 10 cm, respectively. The seed of cowpea genotype RC-19 was sown on 16th July, 2016. The recommended package of practices was followed to raise the crop.

Insecticides and their application

All the insecticides were applied as a foliar spray. The spraying was done by using a pre-calibrated foot sprayer. The first insecticidal spray was given on 16th August 2016 and the second after 15 days of first spraying *i.e.* 31st August, 2016. The quantity of spray solution was 500 litres per hectare in each spray application. The insecticidal solution was prepared according to the following formula.

$$V = \frac{C \times A}{\%\, a.i.}$$

Where,
V= Volume of the insecticide
C = Concentration required
A = Amount of spray solution needed
% *a.i.* = Percentage of active ingredient of the insecticide

The observations on aphid population were recorded on five randomly selected and tagged plants on three leaves each from top, middle and bottom canopy of plants in each plot. Aphid population was counted one day before and 1, 3, 7 and 10 days after application of insecticides in both the sprays. The observations on aphid population were recorded early in the morning by visual counting method. The crop was harvested when pods attained full maturity. The harvested plants were kept separately and sun dried. The dried plants were threshed manually, grains were cleaned and weighed. Grain yield per plot was converted into quintal per hectare and yield data were statistically analysed.

The data thus obtained were taken into consideration to calculate the percentage reduction in the population which was determined by applying a correction factor given by Henderson and Tilton (1995) [12] referring it to be a modification of Abbott (1925) [1] formula.

$$\text{Percentage reduction} = 100 \times \left(1 - \frac{T_a \times C_b}{T_b \times C_a}\right)$$

Where,
T_a = Number of insects after treatment
T_b = Number of insects before treatment
C_a = Number of insects in untreated control after treatment, and
C_b = Number of insects in untreated control before treatment.

The data were than statistically analyzed. The analysis was carried out by transforming the percentage reduction data into angular transformation values.

Results and Discussion

The bioefficacy of different newer insecticides was determined on the basis of percent reduction of cowpea aphid, *a. craccivora* and effect on grain yield, and economics of insecticidal treatments which is mentioned below.

First insecticidal application

One day after application of insecticides, it was observed that all the treatments were found significantly superior over the untreated control. However, their existed a considerable difference in between the different insecticidal treatments. The maximum reduction in aphid population (77.64%) was recorded in imidacloprid 0.005 percent treatment which was at par with thiamethoxam 0.005 percent which resulted in 74.16 percent reduction. However, these treatments were found significantly superior over rest of the treatments (Table 1). The next effective treatment was dimethoate 0.03 percent, which caused 70.58 percent reduction in aphid population. The treatment of acetamiprid 0.04 percent gave 66.15 percent reduction followed by emamectin benzoate 0.002 percent (64.95% reduction) and both were at par with each other. Chlorantraniliprole 0.005 percent (56.94% reduction) and malathion 0.05 percent gave 54.91 percent reduction have no significant difference. The minimum reduction of 48.87 percent was recorded in plots treated with azadirachtin 0.002 inferior to all the other insecticidal treatments. After three days of insecticidal application the maximum reduction (96.46%) in aphid population was recorded from imidacloprid 0.005 percent followed by thiamethoxam 0.005 percent (94.98%) however both the treatment was statistically at per. The next effective treatment was dimethoate 0.03 percent (88.51%) which was at par with acetamiprid 0.04 percent caused 86.50 percent reduction followed by emamectin benzoate 0.002 percent which recorded 84.95 percent reduction in aphid population. It was followed by chlorantraniliprole 0.005 percent (81.74%) which was at par with the treatment malathion 0.05 percent (78.96%). The minimum reduction of 76.95 percent aphid population was recorded with the treatment of azadiracthin 0.002 percent and it was at par with malathion 0.05 percent (78.96% reduction) and both were proved significantly inferior over rest of the insecticidal treatments.

After seven and ten days of application, same pattern of effectiveness was recorded in all the insecticidal treatments. On the basis of first spay data the order of effectiveness of insecticides was found to be azadiracthin = malathion < chlorantraniliprole = emamectin benzoate ≤ acetamiprid < dimethoate = thiamethoxam ≤ imidacloprid.

Second insecticidal application

The data presented in table 1 revealed that the all the treatments remained significantly superior after one day of application of insecticides over untreated control. However, these existed a considerable difference in between different treatments. The maximum reduction of aphid population of 72.25 percent was recorded in treatment of imidacloprid 0.005 percent which was statistically at par with thiamethoxam 0.005 percent (68.50%) followed by dimethoate 0.03 percent (64.85%). The next effective treatments were acetamiprid 0.04 percent and emamectin benzoate 0.002 percent which resulted in 61.52 and 60.36 percent reduction, respectively, however, these treatments were at par in their efficacy. The next effective treatment was chlorantraniliprole 0.005 percent and malathion 0.05 percent which gave 55.63 and 51.66 percent reduction in aphid population, respectively, and both were at par with each other. The minimum reduction of 46.91 percent was recorded in plots treated with azadirachtin 0.002 inferior to all the other insecticidal treatments.

The maximum reduction (89.40%) in aphid population after three days of spraying was recorded in the treatment of imidacloprid 0.005 percent followed by thiamethoxam 0.005 percent with 87.92 percent reduction, however, both these treatments were at par in their efficacy. The next best treatment was dimethoate 0.03 percent with 76.76 percent reduction in aphid population which was at par with acetamiprid 0.04 percent (73.92%) followed by emamectin benzoate 0.002 percent (71.60%) ranked in middle order of efficacy. respectively, however no significant difference was observed between these two treatments. The minimum reduction of 53.31 percent was recorded in the treatment of azadiracthin 0.002 percent, which was significantly at par to malathion 0.05 percent which had 55.87 percent reduction in aphid population followed by chlorantraniliprole 0.005 percent with 59.08 percent reduction in aphid population.

After seven and ten days of application, same pattern of effectiveness was recorded in all the insecticidal treatments. On the basis of second spay data the order of effectiveness of insecticides was found to be azadiracthin = malathion < chlorantraniliprole = emamectin benzoate ≤ acetamiprid < dimethoate = thiamethoxam ≤ imidacloprid.

The treatment imidacloprid (0.03%) was found most effective against aphid, *A. craccivora* followed by thiamathoxam (0.005%). The treatments of dimethoate (0.03%), acetamiprid (0.04%), emamectin benzoate (0.002%), chlorantraniliprole (0.005%) and malathion (0.05%) ranked in middle order of efficacy. The treatment of azadirachtin (0.002%). proved least effective against aphid, *A. craccivora*, on cowpea.

The present findings are in agreement with that of Sreekanth and Babu (2001) [25] reported that imidacloprid 20 EC (0.008 and 0.02%) was the most effective insecticides and registered 99.06 percent suppression of aphid population. Similarly Khade *et al*. (2014) [14] also revealed that the imidacloprid 17.8 SL (0.005%) proved superior on the mean percent reduction of aphids, thrips and jassids population in cowpea crop. Swarnalata *et al.* (2015) [26] observed that the efficacy of imidacloprid (0.005%) was found most effective (0.19 aphid index/ plant) in cowpea support the present findings.

Thiamethoxam was found very effective insecticide next to imidacloprid in present study. The present findings are in agreement with those of Swarnalata *et al.* (2015) [26] who observed that thiamethoxam 0.01 percent (0.33 aphid index/ plant) was found most effective in their efficacy against *A. craccivora.* The present results are also in conformity with that of Reddy *et al*. (2014) [19] who reported that thiamethoxam (0.005%) showed more than 80 percent mortality against cowpea aphid.

The treatment of dimethoate was found effective next to thiamethoxam in reducing the population of aphid *A. craccivora* on cowpea crop. The present results are in agreement with those of Kotadia and Bhalani (1992) [15] they revealed that the sprays of dimethoate was found most effective insecticide for controlling *A. craccivora* on cowpea. The present results are also in agreement with those of Decri and Hadi (2000) [9], Choudhary (2002) [7], Jangu (2005) [13], Khade *et al*. (2014) [14], Reddy *et al*. (2014) [19] and Swarnalata *et al.* (2015) [26] who reported that dimethoate 30 EC was found effective in reducing the aphid population in cowpea.

Acetamiprid and emamectin benzoate were found moderately effective for the control of aphid, *A. craccivora* on cowpea crop. The present finding are corroborate with those of Abdou *et al.* (2015) [2] they revealed that acetamprid 20 SP was the most effective treatment against *A. craccivora*. Chaudhari *et al*. (2015) [6] also support thr present finding who reported that acetamiprid was found effective against sucking pests infesting Indian bean. The present results were also in agreement with those of Mishra and Mukherjee (2015) [16] they reported that emmamectin benzoate was found effective against *Aphis craccivora* on green gram crop.

The treatment of chlorantraniliprole and malathion were found moderately effective group of insecticides in the present investigation. These results are in agreement with those of Chaudhari *et al*. (2015) [6] who reported that chlorantraniliprole (0.005%) was found moderately effective against sucking pests of Indian bean. Saleh *et al.* (1971) [20] also support the present finding. Who reported that the 50 percent malathion applied at the rate of 350 ml per fedan (0.42 ha) was the effective treatment for the control of *A. craccivora.* Jangu (2005) [13] observed that the treatment malathion (0.05%) was found moderately effective in reducing the aphid population in cowpea also support the present findings.

The neem based insecticides azadirachtin proved least effective in reducing the aphid population on cowpea crop. The present investigations are in conformity with that of Dimetry and El-Hawary (1995) [10] and Pandey and Faruqui (1998) [17] who observed that neem based preoaration had aphidcidal properties. The present findings are in conformity with those of Jangu (2005) [13] who reported that azadirachtin 5 ml/ lit. was found least effective in reducing the aphid population on cowpea. Reddy *et al*. (2014) [19] are also support the present results who found that azadiracthin (0.03%) as least effective treatment with 50.0 percent mortality against *A. craccivora.s*

Effect of insecticides on the seed yield of cowpea

The ultimate aim of any investigation on the control schedule is to increase the grain yield. The present investigation also included the effect of insecticidal treatments on the yield of marketable crop. The results showed that yield of all the insecticidal treatments were significantly superior over control. The highest grain yield of 20.38 q ha^{-1} was observed from the plots treated with imidacloprid followed by thiamathoxam and dimethoate which gave grain yield of 19.32 and 16.28 q ha^{-1}, respectively. The next best group includes acetamiprid and emamectin benzoate that gave grain yield of 15.08 and 14.35 q ha^{-1}, respectively and both were found at par. The grain yield of 13.96 and 12.02 q ha^{-1} were obtained in chlorantraniliprole and malathion, respectively. The minimum grain yield (11.98 q ha^{-1}) was observed in the plot treated with azadirachtin (0.002%). The findings are partially in conformity with that of Swarnalata *et al.* (2015) [26] evaluated eleven different insecticides for their efficacy against *A. craccivora* on cowpea. They reported that highest marketable pod yield (30.37 q/ha) and maximum percent increase in pod yield of cowpea over control (84.28%) was recorded from the plots treated with thiamethoxam 25 WG @ 0.01 percent partially support the present findings. Yadav et al. (2015) [27] also obtained highest seed yield of *Cyamopsis tetragonoloba* in the treatment of dimethoate (10.20 q/ha) followed by imidacloprid (10.05 q/ha) and thiamethoxam (10.00 q/ha) also partially support the present findings.

Economics of insecticidal treatments

The maximum benefit: cost ratio of 19.01:1 was recorded from the plots treated with thiamathoxam followed by imidacloprid and dimethote, which resulted in a benefit: cost ratio of 16.52:1 and 8.74:1, respectively. Azadirachtin, malathion, acetamiprid and emamectin benzoate were resulted in 3.88:1, 3.10:1, 2.42:1 and 2.31:1 benefit: cost ratio, respectively. The lowest benefit: cost ratio of 1.21: 1 was recorded from plots treated with chlorantraniliprole.

Bora *et al*. (2014) [5] reported that highest benefit: cost ratio was obtained from plot treated with imidacloprid 30g a.i./ ha and 20g a.i./ ha support the present results. Khade *et al*. (2014) [14] tested some insecticide for the control of sucking pests of cowpea and observed that highest incremental benefit : cost ratio registered in the treatment dimethoate 30 EC (20.13) and it was followed by treatments imidacloprid 17.8 SL (18.25), difenthiuron 50WP (7.18), neem oil 1% (5.07), karanj oil 1% (3.57), NSE 5% (3.52), *Verticilium lecanii* (2× 109 cfu/ ml) (2.70).

Table 1: Bioefficacy of newer insecticides against cowpea aphid, *Aphis craccivora* Koch on cowpea in *Kharif*, 2016

3	Insecticides	Formulations	Conc.(%) or dosages ha^{-1}	Percent reduction days after spray								Yield	B:C Ratio
				First spray				Second spray					
				1st Day	3rd Days	7th Days	10th Days	1st Day	3rd Days	7th Days	10th Days		
1	Dimethoate	30 EC	0.03	70.58	88.51	89.25	56.27	64.85	76.76	87.37	95.47	16.28	8.74
				(57.15)	(70.19)	(70.86)	(48.60)	(53.64)	(61.18)	(69.18)	(77.71)		
2	Imidacloprid	17.8 SL	0.005	77.64	96.46	93.36	64.62	72.25	89.40	94.58	98.24	20.38	16.52
				(61.78)	(79.16)	(75.07)	(53.50)	(58.21)	(71.00)	(76.54)	(82.38)		
3	Thiamethoxam	25 WG	0.005	74.16	94.98	91.42	60.26	68.50	87.92	92.74	97.12	19.32	19.01
				(59.45)	(77.05)	(72.97)	(50.92)	(55.86)	(69.66)	(74.37)	(80.23)		
4	Malathion	50 EC	0.05	54.91	78.96	69.62	15.08	51.66	55.87	68.11	69.46	12.02	3.10
				(47.82)	(62.70)	(56.55)	(22.85)	(45.95)	(48.37)	(55.62)	(56.45)		
5	Chlorantraniliprole	18.5 SC	0.005	56.94	81.74	71.78	16.00	55.63	59.08	70.66	87.98	13.96	1.21
				(48.99)	(64.70)	(57.91)	(23.58)	(48.23)	(50.23)	(57.20)	(69.71)		
6	Emamectin benzoate	5 SG	0.002	64.95	84.95	77.83	30.25	60.36	71.60	84.16	90.36	14.35	2.31
				(53.70)	(67.17)	(61.91)	(33.37)	(50.98)	(57.80)	(66.55)	(71.91)		
7	Acetamiprid	20 SP	0.04	66.15	86.50	78.72	33.24	61.52	73.92	84.96	92.75	15.08	2.42
				(54.42)	(68.44)	(62.53)	(35.21)	(51.66)	(59.29)	(67.18)	(74.38)		
8	Azadirachtin	20 EC	0.002	48.87	76.95	66.71	13.92	46.91	53.31	62.17	66.25	11.98	3.88
				(44.35)	(61.31)	(54.76)	(21.91)	(43.23)	(46.90)	(52.04)	(54.48)		
9	Control	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.20	-
				0.00	0.00	0.00	0.00	(0.00)	(0.00)	(0.00)	(0.00)		
	SEm±			0.84	0.73	0.78	0.94	0.80	0.70	0.74	0.90	0.38	
	CD (P=0.05)			2.50	2.18	2.31	2.80	2.38	2.08	2.20	2.68	1.10	

* Figures in the parentheses are angular transformation values

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Biorational Management of Sucking Pests of Cowpea *Vigna sinensis* L. *Trends in Biosciences*, 2014; 7(17):2570-2573.
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