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Bioefficacy of Newer Insecticides against Major Sucking Insect Pests of Cowpea [*Vigna unguiculata* (Linn.) Walp.]

Suresh Choudhary[1], S.K. Khinchi[1], Neelam Kumari[1], Jitendra Singh Shivran[2]

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ABSTRACT

Background: The repeated use of conventional insecticides to combat the sucking pests resulted in development of resistance to insecticides. Now, several newer insecticides with their novel mode of action are very effective at lower doses against target pests and safe to natural enemies.

Methods: The experiment was conducted during *kharif*, 2018 in a randomized block design (RBD) with 9 treatments including the untreated control and 3 replications.The observations on population of aphid, *Aphis craccivora* Koch, leafhopper, *Empoasca fabae* (Harris) and whitefly, *Bemisia tabaci* (Genn) were recorded early in the morning from (10 cm terminal shoot) for aphid and from three leaves, *viz*., one each from top, middle and lower canopy of the plant for leafhopper and whitefly one day before and 1, 3, 7 and 15 days after application of insecticides in both the sprays.

Result: Out of eight insectcides evaluated against aphid, leaf hopper and whitefly imidacloprid 0.005 per cent was found most effective followed by thiamethoxam 0.005 per cent and acetamiprid 0.004 per cent in terms of per cent reduction in the population and seed yield. Azadirachtin 1.5 ml/l and malathion 0.05 per cent were least effective against these insect pests. The highest benefit cost ratio of 18.48 was obtained from imidacloprid 0.005 per cent treated plots followed by thiamethoxam 0.005 per cent (17.30), acetamiprid 0.004 per cent (9.73) and dimethote 0.03 per cent (7.42), vis-à vis, lowest (1.62) in the chlorantraniliprole 0.005 per cent treated plots.

Key words: Bioefficacy, Cowpea, Imidacloprid, Sucking insect pests, Thiamethoxam.

INTRODUCTION

Cowpea [*Vigna unguiculata* (Linn.) Walp.] is one of the important legume crops grown in Rajasthan that belongs to family Leguminosae. It is used as a green legume, vegetable and fodder as well as green manure crop. Its seeds contain 23.4 per cent protein, 1.8 per cent fat, 60.3 per cent carbohydrate and also rich source of lysine and tryptophan (Singh, 1983). Sardhana and Verma (1986) reported 21 insect pests of different groups damaging the crop from germination to maturity. The important insect species infesting cowpea 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). It is a common observation that the sucking insect pests population is brought down by the application of non-systemic insecticides due to high initial kill of sucking insect pests, but some time the surviving individuals soon build up their population because of high rate of multiplication and absence of natural enemies. In the recent years, these pests created a serious threat to agriculture industry due to development of resistance towards regularly used insecticides. In this view there is scope of utilizing the newer pesticide molecules, which are required in small quantity to control the pests and are comparatively environmentally safe and economically effective for control of sucking insect pests in cowpea ecosystem.

[1]Department of Entomology, Sri Karan Narendra College of Agriculture, Sri Karan Narendra Agriculture University, Jobner-303 329, Rajasthan, India.

[2]Department of Horticulture, Sri Karan Narendra College of Agriculture, Sri Karan Narendra Agriculture University, Jobner-303 329, Rajasthan, India.

Corresponding Author: Suresh Choudhary, Department of Entomology, Sri Karan Narendra College of Agriculture, Sri Karan Narendra Agriculture University, Jobner-303 329, Rajasthan, India.
Email: sureshjunjadiya498@gmail.com

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MATERIALS AND MEHTODS

The experiment was laid out in a simple randomized block design (RBD) with nine treatments including the untreated control (Table 1), each treatment replicated thrice. Each plot was measured 3.0 m × 2.5 m each at the Agronomy farm of S.K.N College of Agriculture, Jobner during *kharif* 2018. The seeds of cowpea variety, RC-19 (recommended for this region) were sownon 1st July, 2018 at row to row and plant to plant distance of 30 cm and 10 cm, respectively. The experiment was conducted as per recommended agronomics practices and fertilized with 20 kg N ha^{-1} as a starter dose and 40 kg P_2O_5 ha^{-1} in the soil before sowing.

Treatments and their application

All the newer insecticides were applied as a foliar spray. The spraying was done by using a pre-calibrated knap sack sprayer. The first spray was given on 2nd August 2018 when sufficient population built up and the second after three weeks of first spraying when populations re-built up. The quantity of spray solution was at the rate of 500 liters per hectare in each spray application. The 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 population of aphid, *Aphis craccivora* Koch, leafhopper, *Empoasca fabae* (Harris) and whitefly, *Bemisia tabaci* (Genn) were recorded early in the morning from (10 cm terminal shoot) for aphid and from Three leaves, *viz*., one each from top, middle and lower canopy of the plant for leafhopper and whitefly one day before and 1, 3, 7 and 15 days after application of insecticides in both the sprays.The crop was harvested when pods attained full maturity. The harvested plants were kept separately and sun dried. The dried plants were threshed manually, seed were cleaned and weighed. Seed yield per plot was converted into quintal per hectare.

The population data thus recorded were converted to per cent reduction in population using the method utilized by Henderson and Tilton (1955) as under:

$$\text{Percentage reduction (\%)} = 100 \times \left[1 - \frac{Ta \times Cb}{Tb \times Ca}\right]$$

Where,
Ta = Number of pest after treatment in treated plot.
Tb = Number of pest before treatment in treated plot.
Ca = Number of pest in untreated check after treatment.
Cb = Number of pest in untreated check before treatment.

The data were than statistically analyzed. The analysis was carried out by transforming the percentage reduction data into angular transformation values (Gomez and Gomez, 1976).The data of seed yield obtained as a result of application of different treatments were also subjected to analysis of variance.

The avoidable loss and increase in seed yield over control was calculated for each treatment by the following formula.

% avoidable loss =

$$\frac{\text{Highest yield in treated plots - Yield in utreated plots}}{\text{Highest yield in treated plot}} \times 100$$

$$\text{\% increase in yield} = \frac{\text{Yield in treatments - Yield in control}}{\text{Yield in control}}$$

The economics of treatments were worked out by computing the cost of insecticides as well as their cost of application. The gross income was worked out by multiplying the yield with the whole sale rate of cowpea seed prevailing at the time of threshing.

RESULTS AND DISCUSSION

The bioefficacy of different treatments were evaluated on the basis of per cent reduction of aphid, leaf hoppers and whitefly population and effect on grain yield, and economics of insecticidal treatments. The differences in population of aphid, leaf hoppers and whitefly recorded before spraying were found to be non-significant among different treatments which indicated that the infestation of aphid, leaf hoppers and whitefly were in homogenous condition. The insecticides *viz*., imidacloprid 17.8 SL @ 0.005%, thiamethoxam 25 WG @ 0.005%, malathion 50 EC @ 0.05%, chlorantraniliprole 18.5 SC @ 0.005%, emamectin benzoate 5 SG @ 0.002%, acetamipird 20 SP @ 0.004%, azadirachtin 0.15 EC @ 1.5 ml/l and Dimethoate 30 EC @ 0.03% against aphids, leafhopper and whitefly, were evaluated. All of the treatments were applied twice. First spray was given when appearance of the pests and second spray after 3 weeks of the first spray. The data on the mean reduction in the population of pest species were calculated on 1st, 3rd, 7th and 15th day after each spray.

Bioefficacy of newer insecticides on population of aphid, leafhopper and whitefly

Among the different insecticides tested (Table 2) maximum reduction (77.03%) was recorded in the treatment of

Table 1: Details of insecticides used.

Common name	Formulation	Trade name	Conc. (%) or dosage ha^{-1}
Imidacloprid	17.8 SL	Admire	0.005
Thiamethoxam	25 WG	Actara	0.005
Malathion	50 EC	Cythion	0.05
Chlorantraniliprole	18.5 SC	Coragen	0.005
Emamectin benzoate	5 SG	Proclaim	0.002
Acetamiprid	20 SP	Pride	0.004
Azadirachtin	0.15EC	Neem baan	1.5 ml/ l
Dimethoate (check)	30 EC	Rogor	0.03
Control (untreated)	-		-

Table 2: Bioefficacy of newer insecticides against aphid, *Aphis craccivora* Koch on cowpea.

Treatments	Conc.% /dosage ha^{-1}	PTP/10 cm terminal shoot	Mean per cent reduction days after spray								
			First spray				PTP/10 cm terminal shoot	Second spray			
			1	3	7	15		1	3	7	15
Imidacloprid 17.8 SL	0.005	48.66 (7.01)	77.03 (61.36)	92.08 (73.65)	89.70 (71.28)	59.58 (50.52)	68.60 (8.31)	69.04 (56.19)	86.53 (68.46)	91.57 (73.12)	94.42 (76.33)
Thiamethoxam 25 WG	0.005	48.53 (7.00)	74.88 (59.92)	90.26 (71.81)	88.42 (70.10)	56.65 (48.82)	68.06 (8.28)	65.52 (54.04)	85.02 (67.22)	89.70 (71.28)	93.35 (75.05)
Malathion 50 EC	0.05	48.13 (6.97)	55.78 (48.31)	74.99 (59.99)	68.48 (55.84)	12.44 (20.65)	67.33 (8.23)	48.67 (44.23)	52.85 (46.63)	65.10 (53.78)	65.77 (54.19)
Chlorantraniliprole 18.5 SC	0.005	48.33 (6.98)	66.00 (54.33)	81.67 (64.65)	75.48 (60.31)	27.74 (31.78)	67.93 (8.27)	57.34 (49.22)	68.69 (55.95)	81.05 (64.19)	86.58 (68.51)
Emamectin benzoate 5 SG	0.002	48.46 (7.00)	57.87 (49.52)	78.55 (62.41)	72.19 (58.17)	14.46 (22.35)	68.13 (8.28)	52.25 (46.29)	65.87 (54.25)	67.71 (55.05)	84.40 (66.73)
Acetamiprid 20 SP	0.004	48.73 (7.02)	71.94 (58.01)	85.01 (67.22)	85.82 (67.87)	53.70 (47.12)	67.86 (8.26)	61.83 (51.84)	73.85 (59.24)	84.34 (66.68)	92.03 (73.60)
Azadirachtin 0.15 EC	1.5 ml/l	48.20 (6.98)	49.82 (44.89)	72.93 (58.64)	64.03 (53.15)	11.99 (20.25)	67.86 (8.26)	43.58 (41.31)	50.41 (45.23)	59.26 (50.33)	62.70 (52.35)
Dimethoate 30 EC	0.03	48.80 (7.02)	67.42 (55.19)	82.95 (65.61)	78.63 (62.46)	30.57 (33.57)	68.46 (8.30)	58.60 (49.95)	70.10 (57.48)	82.00 (64.89)	89.09 (70.71)
Control		50.13 (7.11)	-	-	-	-	69.20 [8.34]	-	-	-	-
S.Em.±		0.08	0.89	0.76	0.82	0.69	0.14	0.72	0.94	0.84	0.90
CD (p=0.05)		NS	2.71	2.33	2.51	2.09	NS	2.19	2.88	2.57	2.70

Figures in parentheses are angular transformed values, figures in square brackets are $\sqrt{x + 0.5}$ values. PTP = Pre treatment population.

imidacloprid 17.8 SL which was at par with thiamethoxam 25 WG that gave 74.88 per cent reduction followed by acetamiprid 20 SP which recorded 71.94 per cent reduction at one day after spraying. The treatment of dimethoate 30 EC gave 67.42 per cent reduction followed by chlorantraniliprole 18.5 SC (66.00% reduction) and both were at par with each other. Emamectin benzoate 5 SG (57.87%) and malathion 50 EC gave 55.78 per cent reduction have no significant difference. The minimum reduction of 49.82 per cent was recorded in plots treated with azadirachtin 0.15 EC inferior to all the other insecticidal treatments. Similar trend of mean per cent reduction in aphid population was observed on 3, 7 and 15 days of insecticidal spray. The present findings were in full agreement with Choudhary *et al*. (2017) who reported that the imidacloprid (0.005%), thiamethoxam (0.005%) and dimethoate (0.03%) were found effective against aphid whereas, the azadirachtin (0.002%) and malathion (0.05%) were found least effective against aphid. In addition, Anandmurthy *et al.* (2017) reported that application of dinotefuran (0.006%), acetamiprid (0.004%) and dimethoate (0.03%) proved effective in recording minimum aphid population. Likewise, Swarnalata *et al*. (2015) observed that the efficacy of imidacloprid (0.005%) was found most effective (0.19 aphid index/plant) in cowpea which support the present findings. Jangu (2005) also reported that azadirachtin 5 ml/l was found least effective in reducing the aphid population on cowpea.

Data presented in (Table 3) indicated that all the treatments were significantly superior in reducing the population of leafhopper in the field. The maximum reduction (76.84%) was recorded in the treatment of imidacloprid 17.8 SL which was at par with thiamethoxam 25 WG that gave 73.61 per cent reduction followed by acetamiprid 20 SP (70.52%) at one day after spraying. The treatment of dimethoate 30 EC gave 65.99 per cent reduction followed by chlorantraniliprole 18.5 SC (65.69% reduction) and both were at par with each other. Emamectin benzoate 5 SG (57.71% reduction) and malathion 50 EC gave 55.19 per cent reduction have no significant difference. Azadirachtin 0.15 EC was recorded as least effective (72.13%) and was at par with malathion 50 EC (73.40%). Similar trend of mean per cent reduction in leafhopper population was observed on 3, 7 and 15 days of insecticidal spray. Similar results have been reported by Hithesh *et al.* (2022) who found that thiomethoxam+lambda-cyhalothrin (0.007%), imidacloprid (0.006%) and triazophos (0.1%) proved to be most effective in controlling jassid, whitefly and thrips population on green gram. Khade *et al*. (2014) also revealed that the imidacloprid 17.8 SL (0.005%) proved superior on the mean per cent reduction of jassids, thrips and aphids population in cowpea crop. Likewise, Choudhari *et al*. (2015) observed that imidaclorpid (0.015%), acetamiprid (0.025%) and clothianidin (0.025%) found effective against leafhopper, aphid, whitefly, and thrips on Indian bean. Yadav *et al*. (2015) observed that dimethoate (0.03%), imidacloprid (0.005%) and thiamethoxam (0.025%) proved most effective against sucking insect pests, *viz*., leaf hopper, *E. motti*; whitefly, *B. tabaci* and aphid, *A. craccivora* of cluster bean which support the present findings.

The data on per cent reduction in whitefly population (Table 4) revealed that maximum reduction (73.98%) was recorded in the treatment of imidacloprid 17.8 SL which was at par with thiamethoxam 25 WG that gave 71.21 per cent reduction followed by acetamiprid 20 SP (67.78 %) at one day after spraying. The treatment of dimethoate 30 EC gave 62.66 per cent reduction followed by chlorantraniliprole 18.5 SC (61.41% reduction) and both were at par with each other. Emamectin benzoate 5 SG (54.05% reduction) and malathion 50 EC gave 51.72 per cent reduction have no significant difference. The minimum reduction of 45.23 per cent was recorded in plots treated with azadirachtin 0.15 EC inferior to all the other insecticidal treatments. Similar trend of mean per cent reduction in whitefly population was observed on 3, 7 and 15 days of insecticidal spray. The findings are in line with Jakhar *et al*. (2022) who found that imidacloprid (0.00 5%) resulted in highest reduction in whitefly, jassid and aphid population followed by dimethoate (0.03%) on indian bean. In addition, Singh *et al*. (2010) also reported that dimethoate 30 EC (0.03%) most effective followed by imidacloprid 17.8 SL (0.005%) and thiamethoxam 25 WG (0.025%) against whitefly, jassid and thrips on moth bean. Dhamaniya *et al*. (2005) reported the azadirachtin 5 ml/ l was found least effective for the control of whitefly, jassid and thrips.

Effect of newer insecticides on seed yield of cowpea

The data presented on the (Table 5) reveal that all the plots treated with insecticides gave significantly higher seed yield over control (10.05 q ha^{-1}). The maximum seed yield of 19.88 q ha^{-1} was obtained in the plots treated with imidacloprid 0.005 per cent followed by thiamathoxam 0.005 per cent (18.92 q ha^{-1}). The seed yield obtained in the treatment of acetamiprid 0.004 per cent was (15.88 q ha^{-1}). The seed yield (14.68 q ha^{-1}) obtained in the treatment of dimethoate 0.03 per cent with treatment of chlorantraniliprole 0.005 per cent (13.95 q ha^{-1}), followed by the treatment emamectin benzoate 0.002 with seed yield of (13.56 q ha^{-1}). The minimum seed yield of (11.58 q ha^{-1}) was obtained in the plots treated with azadirachtin 1.5 ml/ l followed by the treatment malathion 0.05 per cent (11.75 q ha^{-1}). Choudhary *et al*. (2017)who reported highest grain yield of 20.38 q ha^{-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 per cent) followed by the treatment malathion 0.05 per cent (12.02 q ha^{-1}).

Economics of insecticidal treatments

The maximum profit was recorded in imidacloprid 0.005 per cent which gave a benefit : cost ratio of 18.48:1 (Table 6). It was followed by thiamethoxam 0.005 per cent and acetamiprid 0.004 per cent, which resulted in a benefit: cost

Table 3: Bioefficacy of newer insecticides against leafhopper, *Empoasca fabae* (Harris) on cowpea.

Treatments	Conc. %/dosage ha^{-1}	PTP/ three leaves	Mean per cent reduction days after spray								
			First spray				PTP/ three leaves	Second spray			
			1	3	7	15		1	3	7	15
Imidacloprid 17.8 SL	0.005	5.93	76.84	92.80	90.66	63.68	7.86	72.69	88.79	92.30	95.73
		[2.53]	(61.23)	(74.43)	(72.20)	(52.94)	[2.89]	(58.49)	(70.43)	(73.88)	(78.07)
Thiamethoxam 25 WG	0.005	6.26	73.61	91.72	87.82	60.26	8.06	69.87	87.29	90.87	94.20
		[2.60]	(59.08)	(73.27)	(69.57)	(50.92)	[2.92]	(56.70)	(69.11)	(72.41)	(76.06)
Malathion 50 EC	0.05	6.13	55.19	73.40	64.90	18.68	7.73	51.46	54.94	66.00	67.64
		[2.57]	(47.98)	(58.95)	(53.66)	(25.61)	[2.86]	(45.83)	(47.83)	(54.93)	(55.32)
Chlorantraniliprole 18.5 SC	0.005	6.20	65.69	81.75	74.22	34.76	8.20	60.22	71.77	81.18	85.12
		[2.58]	(54.14)	(64.70)	(59.48)	(36.12)	[2.94]	(50.89)	(57.90)	(64.28)	(67.30)
Emamectin benzoate 5 SG	0.002	5.86	57.71	78.14	72.73	32.19	7.80	55.51	69.40	69.88	82.66
		[2.52]	(49.43)	(62.12)	(58.51)	(34.57)	[2.88]	(48.16)	(56.41)	(56.71)	(65.39)
Acetamiprid 20 SP	0.004	6.06	70.52	85.60	85.18	56.62	8.26	66.44	76.93	85.35	92.61
		[2.56]	(57.11)	(67.70)	(67.35)	(48.81)	[2.95]	(54.60)	(61.29)	(67.49)	(74.22)
Azadirachtin 0.15 EC	1.5 ml/ l	6.20	49.46	72.13	61.92	17.47	8.06	45.69	52.59	60.84	64.67
		[2.58]	(44.69)	(58.13)	(51.89)	(24.70)	[2.92]	(42.52)	(46.48)	(51.26)	(53.53)
Dimethoate 30 EC	0.03	5.86	65.99	83.06	75.04	37.88	7.93	61.49	74.16	82.20	88.07
		[2.52]	(54.32)	(65.69)	(60.02)	(37.98)	[2.90]	(51.64)	(59.44)	(65.04)	(69.79)
Control		6.33	-	-	-	-	8.40	-	-	-	-
		[2.61]					[2.98]				
S.Em.±		0.02	0.74	0.91		0.85	0.70	0.03 0.91	0.71	0.80	1.05
CD (p=0.05)		NS	2.26	2.80		2.63	2.12	NS 2.79	2.17	2.45	3.22

Figures in parentheses are angular transformed values, figures in square brackets are $\sqrt{x + 0.5}$ values. PTP = Pre treatment population.

Table 4: Bioefficacy of newer insecticides against whitefly, *Bemisia tabaci* (Genn.) on cowpea.

Treatments	Conc.% /dosage ha^{-1}	PTP/ three leaves	Mean per cent reduction days after spray								
			First spray				PTP/ three leaves	Second spray			
			1	3	7	15		1	3	7	15
Imidacloprid 17.8 SL	0.005	5.06	73.98	93.40	90.68	61.34	7.13	69.20	86.23	91.93	95.96
		(2.35)	(59.32)	(75.11)	(72.22)	(51.55)	(2.76)	(56.29)	(68.21)	(73.49)	(78.40)
Thiamethoxam 25 WG	0.005	5.26	71.21	91.15	88.31	57.98	7.26	65.79	84.59	90.13	93.90
		(2.40)	(57.55)	(72.69)	(70.00)	(49.59)	(2.78)	(54.20)	(66.88)	(71.68)	(75.70)
Malathion 50 EC	0.05	5.33	51.72	69.61	65.39	22.93	7.40	47.28	54.35	65.81	66.16
		(2.41)	(45.98)	(56.54)	(53.96)	(28.61)	(2.81)	(43.44)	(47.49)	(54.21)	(54.42)
Chlorantraniliprole 18.5 SC	0.005	5.13	61.41	79.08	74.83	32.70	6.93	56.01	69.54	80.26	83.05
		(2.37)	(51.59)	(62.78)	(59.88)	(34.87)	(2.72)	(48.45)	(56.50)	(63.62)	(65.68)
Emamectin benzoate 5 SG	0.002	5.73	54.05	76.51	67.81	29.50	7.53	51.02	66.36	68.28	79.40
		(2.49)	(47.32)	(61.00)	(55.43)	(32.89)	(2.83)	(45.58)	(54.54)	(55.72)	(63.00)
Acetamiprid 20 SP	0.004	5.53	67.78	84.26	86.47	54.01	7.13	62.18	74.39	84.77	91.76
		(2.45)	(55.41)	(66.62)	(68.41)	(47.30)	(2.76)	(52.04)	(59.59)	(67.02)	(73.31)
Azadirachtin 0.15 EC	1.5 ml/l	5.53	45.23	67.05	60.53	19.88	7.26	42.30	51.58	59.17	63.38
		(2.45)	(42.26)	(54.96)	(51.07)	(26.47)	(2.78)	(40.57)	(45.90)	(50.28)	(52.76)
Dimethoate 30 EC	0.03	4.93	62.66	82.34	76.51	35.32	7.00	57.36	71.95	82.47	85.28
		(2.33)	(52.33)	(65.15)	(61.00)	(36.46)	(2.73)	(49.23)	(58.02)	(65.24)	(67.43)
Control		5.80	-	-	-	-	7.60	-	-	-	-
		(2.50)					(2.84)				
S.Em.±		0.03	0.94	1.08	0.91	0.77	0.04	0.78	1.01	0.80	0.99
CD (p=0.05)		NS	2.86	3.31	2.79	2.36	NS	2.39	3.08	2.45	3.01

Figures in parentheses are angular transformed values, figures in square brackets are $\sqrt{x + 0.5}$ values. PTP = Pre treatment population.

Table 5: Effect of newer insecticides on the seed yield of cowpea.

Insecticide	Formulation	Concentration (%)/dosage ha^{-1}	Mean yield (q/ha)
Imidacloprid	17.8 SL	0.005	19.88
Thiamethoxam	25 WG	0.005	18.92
Malathion	50 EC	0.05	11.75
Chlorantraniliprole	18.5 SC	0.005	13.95
Emamectin benzoate	5 SG	0.002	13.56
Acetamiprid	20 SP	0.004	15.88
Azadirachtin	0.15 EC	1.5 ml/ l	11.58
Dimethoate	30 EC	0.03	14.68
Control	-	-	10.05
SEm ±			0.37
CD (P=0.05)			1.10

Table 6: Comparative economics of insecticides treatments on cowpea.

Insecticide	Formulation	Conc. (%) or dosage ha^{-1}	Mean yield (q ha^{-1})	Increased yield over control (q ha^{-1})	Cost of increased yield (Rs)*	Total cost of production (Rs)**	Net profit (Rs ha^{-1})	Benefit-cost ratio
Imidacloprid	17.8 SL	0.005	19.88	9.83	39320	2018	37302	18.48
Thiamethoxam	25 WG	0.005	18.92	8.87	35480	1938	33542	17.30
Malathion	50 EC	0.05	11.75	1.70	6800	2458	4342	1.76
Chlorantraniliprole	18.5 SC	0.005	13.95	3.90	15600	5944	9656	1.62
Emamectin benzoate	5 SG	0.002	13.56	3.51	14040	3858	10182	2.63
Acetamiprid	20 SP	0.004	15.88	5.83	23320	2172	21148	9.73
Azadirachtin	0.15 EC	1.5 ml/l	11.58	1.53	6120	2058	4062	1.97
Dimethoate	30 EC	0.03	14.68	4.63	18520	2198	16322	7.42
Control	-	-	10.05	0		-		

*Cost of seed of cowpea at current season was 4000 Rs. per quintal.

** It includes cost of insecticides and labour charges.

ratio of 17.30:1 and 9.73:1, respectively. dimethote 0.03 per cent, emamectin benzoate 0.002 per cent, azadirachtin 1.5 ml/l and malathion 0.05 per cent were resulted in 7.42:1, 2.63:1, 1.97:1 and 1.76:1 benefit : Cost ratio, respectively. The lowest benefit: cost ratio of 1.62:1 was recorded from plots treated with chlorantraniliprole 0.005 per cent. Choudhary *et al*. (2017) reported the highest B: C ratio (19.01:1) was recorded in the treatment of thiamethoxam followed by imidacloprid 0.005 per cent and dimethoate 0.03 per cent, 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 per cent support the present results.

CONCLUSION

The overall order of effectiveness of insecticides against aphid, leafhoppers and whitefly were found to be imidacloprid 17.8 SL> thiamethoxam 25 WG> acetamiprid 20 SP> dimethoate 30 EC> chlorantraniliprole 18.5 SC> emamectin benzoate 5 SG> malathion 50 EC> azadirachtin 0.15 EC. The maximum benefit cost ratio was obtained from imidacloprid 17.8 SL treated plots followed by thiamethoxam 25 WG and acetamiprid 20 SP. The newer groups of insecticides are very effective at lower doses and have low risk to non-target organisms and environment, and their adaptability in application methods. So there is scope of utilizing the newer pesticide molecules, for control of sucking insect pests in cowpea ecosystem.

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