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Field efficacy of selected insecticides against cowpea aphid, *Aphis craccivora* (Koch)

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Abstract
Field evaluation of new insecticide molecules for the management of Cowpea aphid and flea beetle was carried out in Student's farm, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad during 2014-2015. The study revealed that the overall efficacy in% reduction of aphid and flea beetle population over control clearly indicated that imidacloprid 17.5 SL @ 50 g a.i./ha (56.62%) and dimethoate 30 EC @ 300 g a.i./ha (55.60%) were superior than other molecules. The incremental cost: benefit ratio (ICBR) analysis of pesticidal treatments in cowpea showed that imidacloprid treated plot recorded highest average green fodder yield (10.47 t/ha) followed by dimethoate (9.73 t/ha), thiamethoxam (9.55 t/ha) and acetamiprid (9.55 t/ha). The other treatments recorded average green fodder yield of 8.81 t/ha (diafenthiuron), 8.26t/ha (spiromesifen), 8.17 t/ha (chlorfenapyr) and 7.52 t/ha (untreated control). The highest cost: benefit ratio was recorded by acetamiprid (1:1.59) followed by dimethoate (1:1.48) and imidacloprid (1:1.41). Thiamethoxam showed the next best ratio (1:1.33). Whereas, diafenthiuron, chlorfenapyr and spiromesifen had ICBR ratios of 1:1.17, 1:1.15 and 1:1.14, respectively.

Keywords: Field efficacy, newer molecules, percent reduction, ICBR

1. Introduction
Cowpea [*Vigna unguiculata* (L) Walp.] is a warm season annual leguminous fodder crop mainly grown in Northern and Central India [1, 2]. Besides causing direct damage to the host by sucking the sap from various plant parts, they also lower the yield, quality and market ability of crops by transmitting plant viruses which result in early death of plants and the production of an excess of honey dew.

To protect the crops from aphids, insecticides are considered essential for their management. A large number of insecticides have been evaluated and recommended from time to time for their control [3]. In recent years, selective insecticides were introduced into the market instead of traditional insecticides because insect pests became resistant to conventional insecticides and are increasingly replacing the organophosphates and methyl carbamates [4].

The mode of action of neonicotinoid insecticides is modelled after the natural insecticide, nicotine. They act on the central nervous system of insects. Their action causes excitation of the nerves and eventual paralysis, which leads to death. Because they bind at a specific site (the postsynaptic nicotinic acetylcholine receptor), they are not cross-resistant to the carbamate, organophosphate, or synthetic pyrethroid insecticides, which was an impetus for their development. As a group, they are effective against sucking insects [5]. Diafenthiuron, a thiourea derivative acts specifically on sucking pests such as mites, whiteflies and aphids [6-8]. Spiromesifen belongs to new class of chemicals called ketoenols and is a spirocyclic phenyl substituted tetronic acid derivative which acts on whiteflies, mites and other sucking pests. Chlorfenapyr, a member of the pyrrole group, is a pro-insecticide which uncouples oxidative phosphorylation at the mitochondria resulting in disruption of production of ATP, cellular death and ultimately mortality of the organism. In view of the resistance development to conventional insecticides and introduction of selective insecticides into the market, the present study is aimed to elucidate the effect of certain selected insecticides on *A. craccivora* under field conditions.

2. Material and methods
2.1 Field Studies
The present experiment was laid out in a randomized complete block design in the Student's farm, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad during 2014-2015.

Cowpea variety KBC-2 was sown on October 31st 2014 as folded replication. The net plot size for each treatment was 5×4m and was replicated thrice. There were twelve rows in each plot, 30cm apart, while plant-to plant distance was 10 cm. Fertilizers were applied at recommended doses (20:40:40NPK) as basal application and 25 DAS. The crop was irrigated at weekly intervals.

There were eight treatments including a control. Seven insecticides namely imidacloprid, thiamethoxam, acetamiprid, diafenthiuron, chlorfenapyr, spiromesifen and dimethoate were sprayed at recommended doses at 25 and 40 DAS. The population of aphids and flea beetles were counted from twenty plants, selected randomly in each treatment. The pre and post counts were taken as number of insects/ plant at 1,3 and 5 days after spraying in various treatments. At 55 DAS, the cowpea (green fodder) was harvested from each plot and yield in kg/plot for each of the treatments in the three replications was recorded.

2.2 Statistical Analysis

The data was subjected to angular transformation wherever necessary. Randomized block design analysis [9] was followed using OPSTAT. The values of percent reduction were transformed to angular values and subjected to analysis of variance to test the significance between treatments. Average yield (kg/plot) of green fodder for each of the treatments was calculated and converted to t/ha. The Incremental Cost: Benefit Ratio (ICBR) was also calculated.

3. Results and Discussion

3.1 Field efficacy of selected insecticides against insect pests of cowpea

3.1.1 Cowpea Aphid

Data on field efficacy of selected insecticides against cowpea aphid is presented in Table 1. The population of aphids before I and II spray ranged between 2.633 to 3.843 and 2.968 to 4.105 aphids/plant respectively. The results indicated that all treatments reduced pest population over untreated control at 1, 3 and 5 days after application. The reduction in population over control in different treatments ranged between 46.66% to 54.40%, 47.36% to 55.26% and 49.73% to 57.93% at 1, 3 and 5 days after first spray, respectively. The mean% reduction in population over control was highest in imidacloprid (55.33%). It was on par with dimethoate (54.60%) but significantly differed from the rest of the insecticides. Acetamiprid (50.81%), thiamethoxam (49.92%) and chlorfenapyr (49.54%) were statistically on par with each other and differed significantly from diafenthiuron (48.83%) and spiromesifen (47.89%).

After the second spray the reduction in population over control in different treatments ranged between 49.94% to 57.48%, 50.42% to 58.49% and 51.14% to 59.05% at 1, 3 and 5 days after application, respectively. The mean% reduction in population over control was highest with imidacloprid (57.91%). It was on par with dimethoate (56.60%) but significantly differed from the rest of the insecticides. Acetamiprid (53.24%), thiamethoxam (53.64%) and chlorfenapyr (53.44%) were statistically on par with each other and differed significantly from diafenthiuron (50.69%) and spiromesifen (50.51%).

The overall efficacy in% reduction of aphid population over control clearly indicated that imidacloprid 17.5 SL @ 50 g a.i./ha (56.62%) and dimethoate 30 EC @ 300 g a.i./ha (55.60%) were superior than acetamiprid 20 SP @ 15 g a.i./ha (52.02%), thiamethoxam 25 WG @ 50g a.i./ha (51.78%) and chlorfenapyr 10 SC @100 g a.i./ha (51.49%), which in turn showed greater efficacy than diafenthiuron 50 WP @ 50 g a.i./ha (49.76%) and spiromesifen 22.9 SC @ 120g a.i./ha (49.20%). These results corroborate the findings of earlier workers.

Khade *et al.* [10] reported highest percent reduction in population of sucking pests in cowpea by imidacloprid 17.8 SL @ 0.005% i.e. aphids – 76.83%, thrips - 76.37% and jassids – 73.44% and lowest in difenthiuron 50 WP 1.2 g-1 i.e. aphids 73.95%, thrips -72.63% and jassids –70.08% 3, 7 and 10 DAS. Mohamed and Aziza [11] also reported that thiamethoxam was the most effective followed by diafenthiuron (thiourea compounds), carbosulfan (carbamate) and fenvalerate (pyrethroid) against the different field strains of *A. craccivora*. Jehan *et al*. [12] reported that treatments with imidacloprid and thiamethoxam as foliar applications were highly effective against aphids up to 14 days in the case of jassids, while the effect was moderate on the whitefly population (mature and immature stages). Imidacloprid had more initial and residual effect than thiamethoxam against jassids on cotton crop. Preetha *et al*. [13] opined that imidacloprid 17.8 SL was quite promising in reducing the population of aphids and leafhoppers on cotton crop. Muhammad Afzal [14] showed that imidacloprid and diafenthiuron gave maximum mortality against sucking pests of cotton during first spray (92.42 and 88.56%) and second spray (90.87 and 85.67%) after 72 h of application. Fenpropathrin showed superior efficacy in bringing down all the sucking pest population of transgenic cotton followed by dimethoate, imidacloprid and the standard check, acetamiprid. Dimethoate and imidacloprid were most effective against aphids [15]. On the contrary, Patel [16] reported that diafenthiuron 50 SC @ 400 g a.i./ha was found to be the most effective and recorded maximum reduction in population of cotton aphid, with maximum increase in yield over control. However, thiomethoxam 25 WG 75 g a.i. /ha and imidacloprid 200 SL @ 100 g a.i. /ha were next effective chemicals.

Anjumoni *et al.* [17] showed that the lowest incidence and the highest population reduction of the mustard aphid population with imidacloprid at 30 g a.i./ha and the highest mean yield from the experimental trial treated with imidacloprid 30 g a.i./ha (7.32 q/ha). Gopal *et al*. [18] revealed that imidacloprid was most effective in control of mustard aphids followed by β-cyfluthrin, the residues being more in imidacloprid compared to β-cyfluthrin.

The insecticides Provado 1.6F (imidacloprid) and Actara 25WG (thiamethoxam) significantly suppressed the *M. persicae* population by 74.92 and 67.79%, respectively on two potato varieties [19]. Sarwar *et al.* [20] reported that imidacloprid, thiomethoxam and acetamiprid were superior in reducing the population of canola aphids. However, chlorpyrifos (16.2%) and dimethoate (17.5%) were also found to be effective in maintaining the aphid population at lower levels on canola (*B. napus*) crop.

3.1.2 Flea Beetle

Cowpea was infested with flea beetles (Brown flea beetle: *Chaetocnema confinis*, and Striped flea beetle: *Phyllotreta striolata*). The data recorded on the efficacy of selected insecticides against flea beetles is presented in table 2.

The population of flea beetles before the I and II sprayings ranged between 0.222 to 0.513 and 0.300 to 0.565 beetles/plant respectively. The results indicated that all treatments reduced pest population over untreated control at

1, 3 and 5 days after application. The reduction in population over control in different treatments ranged between 40.97% to 44.69%, 42.63% to 46.36%, 44.30% to 48.36% at 1, 3 and 5 days after first spray, respectively. The mean% reduction in population over control was highest in dimethoate (46.47%) followed by imidacloprid (44.59%) and acetamiprid (44.58%) but significantly differed from the rest of the insecticides. Diafenthiuron (43.96%), spiromesifen (43.95%) and chlorfenapyr (43.80%) were statistically on par with each other and differed significantly from thiamethoxam (42.63%).

After the second spray the reduction in population over control in different treatments ranged between 42.77% to 46.17%, 43.63% to 47.73%, 45.00% to 49.27% at 1, 3 and 5 days after application, respectively. The mean% reduction in population over control was highest in dimethoate (47.72%) followed by imidacloprid (46.00%) and acetamiprid (45.83%) but significantly differed from the rest of the insecticides. Spiromesifen (45.02%), diafenthiuron (44.90%) and chlorfenapyr (44.84%) were statistically on par with each and differed significantly from thiamethoxam (43.17%).

The overall efficacy in% reduction of flea beetle population over control clearly indicated that dimethoate 30 EC @ 300 g a.i./ha (47.09%), imidacloprid 17.5 SL @ 50 g a.i./ha (45.29%) and acetamiprid 20 SP @ 15 g a.i./ha (45.20%) were superior than spiromesifen 22.9 SC @ 120g a.i./ha (44.48%), diafenthiuron 50 WP @ 50 g a.i./ha (44.43%) and chlorfenapyr 10 SC @ 100 g a.i./ha (44.32%) and thiamethoxam 25 WG @ 50g a.i./ha (43.17%). Khuara *et al*. [21] reported that seed treatments with imidacloprid and thiamethoxam reduced flea beetle (*Chaetocnema pulicaria* Melsheimer) feeding injury to leaves in all the three varieties of sweet corn and reduced Stewart's bacterial wilt disease incidence in the susceptible variety 'Sprint'.

3.2 Incremental Cost: Benefit Ratio (ICBR) analysis of insecticidal treatments in cowpea

The incremental cost: benefit ratio (ICBR) analysis of insecticidal treatments in cowpea is presented in table 3. Imidacloprid treated plots recorded highest average yield of green fodder (10.47 t/ha) followed by dimethoate (9.73 t/ha), thiamethoxam (9.55 t/ha) and acetamiprid (9.00 t/ha). The other treatments recorded average yield of (8.81 t/ha) diafenthiuron, (8.26 t/ha) spiromesifen and (8.17 t/ha) chlorfenapyr and lowest in untreated control (7.52 t/ha). The highest cost: benefit ratio was recorded by acetamiprid (1:1.59) followed by dimethoate (1:1.48) and imidacloprid (1:1.41). The highest ICBR ratio of acetamiprid may be because of the low cost of treatment compared to imidacloprid and dimethoate. Thiamethoxam showed the next best ratio (1:1.33) whereas diafenthiuron, chlorfenapyr and spiromesifen had ratios of 1:1.17, 1:1.15 and 1:1.14, respectively.

Gaikwad *et al*. [22] showed that dimethoate 0.03% and imidacloprid 0.004% were the most effective for the control of safflower aphids. Highest yield of safflower was recorded in dimethoate 0.03% but highest incremental cost benefit ratio was recorded in the application of imidacloprid 0.004% followed by dimethoate 0.03%. These results are in tune with the present findings. Khade *et al*. [23] indicated that with respect to yield, imidacloprid (17.8 SL) obtained maximum yield of cowpea (45.27 q/ha) with 20.40 q/ ha increased yield over control. It was significantly superior over rest of the treatments, followed by dimethoate 30EC (43.25 q/ha), diafenthiuron (50WP) (41.95 q/ha) and Neem oil 1% (38.59) with 18.38 q/ ha, 17.08 q/ha and 13.72q/ha increased yield over control, respectively and they were at par among themselves. Abdul *et al*. [24] reported highest marketable potato yield (34.58 mt/ha) in the plot treated with Systoate 40 EC (dimethoate), followed by 34.05 mt/ha and 33.95 mt/ha in plots treated with Confidor 200 SL (imidacloprid) and Primor 50 DG (pyrimicarb), respectively. The lowest marketable potato yield (29.58 mt/ha) was obtained in plot treated with Pan-star 20 EC (Chlorpyriphos). These results showed that Confidor 200 SL, Systoate 40 EC and Primor 50 DG could be used effectively for aphid management to increase marketable potato yield.

Table 1: Mean aphid population and % reduction on different days before and after spray

			% reduction in population over control*										
			First spray				Second spray						
Treatments	**Dose (g a.i./ha)**	**(No. of aphids/plant) BS**	**1 DAS**	**3 DAS**	**5 DAS**	**Mean**	**(No. of aphids/plant) BS**	**1 DAS**	**3 DAS**	**5 DAS**	**Mean**	**Over all efficacy**
Imidacloprid 17.8 SL	300	3.000	54.40 (47.44)	55.26 (48.15)	56.34 (48.15)	55.33 (48.38)	3.633	56.20 (48.69)	58.49 (49.60)	59.05 (50.53)	57.91 (49.53)	56.62 (48.90)
Acetamiprid 20 SP	50	3.033	49.70 (46.74)	50.10 (45.13)	52.64 (45.26)	50.81 (45.54)	3.100	50.20 (45.26)	53.82 (46.98)	55.71 (48.29)	53.24 (46.84)	52.02 (46.17)
Thiamethoxam 25WG	15	3.100	49.39 (44.69)	49.47 (44.69)	50.92 (44.69)	49.92 (45.62)	2.968	52.95 (45.26)	55.12 (48.27)	52.85 (48.29)	53.64 (47.06)	51.78 (46.22)
Diafenthiuron50 WP	50	2.967	49.11 (44.37)	47.63 (43.47)	49.76 (43.91)	48.83 (44.47)	4.087	49.94 (44.79)	50.71 (45.26)	51.42 (45.86)	50.69 (45.37)	49.76 (44.89)
Chlorfenapyr 10 SC	100	3.483	48.10 (43.91)	49.47 (44.37)	51.05 (44.69)	49.54 (45.59)	3.367	52.70 (45.26)	53.33 (45.26)	54.31 (47.39)	53.44 (46.95)	51.49 (46.13)
Spiromesifen 22.SC	120	2.633	46.66 (42.89)	47.36 (43.47)	49.73 (43.47)	47.89 (44.42)	3.367	49.97 (44.79)	50.42 (45.17)	51.14 (45.97)	50.51 (45.27)	49.20 (44.73)
Dimethoate 30 EC	50	3.417	52.73 (44.37)	53.15 (47.08)	57.93 (47.52)	54.60 (48.53)	3.717	57.48 (49.27)	58.49 (45.17)	54.85 (45.72)	56.6 (48.96)	55.6 (48.56)
Control	-	3.843	-	-	-	-	4.105	-	-	-	-	-
SEm±	-	-	0.115	0.251	0.049	0.327	-	0.084	0.211	0.149	0.462	0.121
CD	-	-	0.357	0.782	0.152	1.019	-	0.260	0.658	0.464	1.439	0.378

Figures in parenthesis are angular/arcsine transformed values; DAS=Days after spray ; *Pooled mean of three replications ;BS=before spray

Table 2: Mean flea beetle population and % reduction on different days before and after spray

			% reduction in population over control*									
			First spray				Second spray					
Treatments	Dose (g a.i./ha)	(No. of beetle/plant) BS	1 DAS	3 DAS	5 DAS	Mean	(No. of beetle/plant) BS	1 DAS	3 DAS	5 DAS	Mean	Over all efficacy
Imidacloprid 17.8 SL	300	0.383	42.82 (40.85)	44.48 (41.81)	46.48 (42.96)	44.59 (41.87)	0.417	44.27 (41.69)	45.73 (42.53)	48.00 (43.83)	46.00 (42.68)	45.29 (42.14)
Acetamiprid 20 SP	50	0.433	42.80 (40.84)	44.47 (41.80)	46.47 (42.95)	44.58 (41.87)	0.333	44.33 (41.72)	45.73 (42.53)	47.43 (43.51)	45.83 (42.59)	45.20 (42.11)
Thiamethoxam 25WG	15	0.333	40.97 (39.78)	42.63 (40.74)	44.30 (41.70)	42.63 (40.74)	0.300	42.53 (40.68)	43.63 (41.32)	45.00 (42.11)	43.72 (41.37)	43.17 (40.95)
Diafenthiuron50 WP	50	0.367	41.62 (40.16)	43.96 (41.51)	46.29 (42.85)	43.96 (41.51)	0.380	42.77 (40.82)	44.90 (42.05)	47.03 (43.28)	44.90 (42.05)	44.43 (41.69)
Chlorfenapyr 10 SC	100	0.239	41.69 (40.20)	43.69 (41.35)	46.02 (42.70)	43.80 (41.42)	0.320	42.80 (40.84)	44.90 (42.05)	46.83 (43.16)	44.84 (42.02)	44.32 (41.62)
Spiromesifen 22.SC	120	0.222	41.72 (40.22)	44.06 (41.56)	46.06 (42.72)	43.95 (41.50)	0.300	42.77 (40.82)	45.20 (42.22)	47.10 (43.32)	45.02 (42.12)	44.48 (41.71)
Dimethoate 30 EC	50	0.350	44.69 (41.93)	46.36 (42.89)	48.36 (44.04)	46.47 (42.95)	0.383	46.17 (42.78)	47.73 (43.68)	49.27 (44.56)	47.72 (43.67)	47.09 (43.19)
Control	-	0.513	-	-	-	-	0.565	-	-	-	-	-
SEm±	-	-	0.195	0.177	0.220	0.267	-	0.206	0.172	0.222	0.123	0.030
CD	-	-	0.608	0.550	0.684	0.086	-	0.641	0.535	0.691	0.384	0.095

Figures in parenthess are angular/arcsine transformed values; DAS=Days after spray; *Pooled mean of three replications ;BS=before spray

Table 3: Incremental Cost: Benefit Ratio (ICBR) analysis of insecticidal treatments in cowpea

Treatment	Average yield (t/ha)	Incremental yield over control (t/ha)	Value of incremental yield (Rs/ha)	Cost of treatments (Rs/ha)	Profit due to treatments (Rs)	Incremental Cost: Benefit Ratio (ICBR)
Imidacloprid	10.47	2.95	6690	3920	2770	1:1.41
Acetamiprid	9.00	1.48	3357	2050	1307	1:1.59
Thiamethoxam	9.55	2.03	4604	2630	1974	1:1.33
Diafenthiuron	8.81	1.29	2926	1580	1346	1:1.17
Chlorfenapyr	8.17	0.65	1475	790	685	1:1.15
Spiromesifen	8.26	0.74	1678	895	783	1:1.14
Dimethoate	9.73	2.21	5012	2995	2017	1:1.48
Untreated control	7.52	-	-	-	-	-

4. Conclusion
From the present studies, it can be concluded that imidacloprid and dimethoate were most toxic among the seven selected insecticides against Cowpea pests. And also imidacloprid and dimethoate treated plots recorded highest yields of green fodder.

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