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Relative efficacy of selected insecticides on cowpea aphid, *Aphis craccivora* (Koch)

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Abstract
Laboratory bioassay of seven selected insecticides namely imidacloprid, acetamiprid, thiamethoxam, diafenthiuron, spiromesifen and chlorfenapyr and dimethoate was evaluated against cowpea aphid *A. craccivora*, during October to December, 2014 in Department of Entomology, College of Agriculture, Rajendranagar, PJTSAU. Relative efficacy based on LC_{50} values was found using two bioassay methods *viz.*, leaf dip and direct spray method. Relative efficacy of imidacloprid (8.022) was highest in leaf dip method followed by thiamethoxam (2.419) while in direct spray method spiromesifen (1.948) showed highest efficacy followed by thiamethoxam (1.617). Results of this study indicated that out of selected seven insecticides, neonicotinoid insecticides were highly effective against cowpea aphid.

Keywords: LC_{50}, relative efficacy, bioassay, leaf dip method and direct spray method

1. Introduction
Aphids are an important group of insects with worldwide distribution. They are a truly interesting group of herbivorous insects and can affect plants directly or indirectly by feeding on the plant's sap [1]. They have experienced some adaptations in relation to host plants so that many aphid taxa have biologically complex life cycles. *Aphis craccivora* (Koch) (Aphididae: Homoptera) is associated with many host plants in the family Fabaceae and also in many other plant families such that it attacks about 50 crops in 19 different plant families [2]. The cowpea aphid, *Aphis craccivora* Koch, is one of the most serious pests of legumes, such as faba bean, cowpea and pea [3]. It causes direct damage by feeding, which may induce plant deformation and indirect damage caused either by honeydew or by transmission of viruses[4]. It has been reported to cause considerable loss in yield in different parts of the country[5]. Controlling aphid in crops is very important to increase the quality and quantity of the products. Chemical control is the major effective method that is used by farmers. In recent years, selective insecticides (e.g. neonicitinoids, Thiourea compounds, halogenated pyrrole, tetronic acid derivative) were introduced into the market instead of traditional insecticides because insect pests became resistant to the most conventional insecticides and are increasingly replacing the organophosphates and methylcarbamates [6]. In view of the resistance development to conventional insecticides and introduction of selective insecticides into the market, the present study was aimed to elucidate the relative efficacy of certain selected insecticides on *A. craccivora* under laboratory.

2. Materials and methods
Insecticides and Concentrations
Seclected seven insecticides used for the study *viz.*, imidacloprid 17.8 SL (Confidor, 0.5 ml/l), thiamethoxam 25 WG (Actara, 0.5 mg/l), acetamiprid 20 SP (Rapid, 0.25mg/l), diafenthiuron 50 WP (Pegasus, 0.5mg/l), chlorfenapyr 10 SC (Interpid, 1.5ml/l), spiromesifen 22.9 SC (Oberon, 0.8ml/l) and dimethoate 30 EC (Tafgor, 2.0 ml/l). 1000, 100, 10, 1, 0.1, 0.01, 0.001, 0.0001 ppm 1000, 100, 10, 1, 0.1, 0.01, 0.001 ppm and 1000, 100, 50, 5, 0.5, 0.05, 0.005, 0.0005 ppm concentrations were used for the studies in the month of October and December, 2014 in laboratory of Department of Entomology, College of Agriculture, Rajendranagar, PJTSAU.

2.1 Bio-assay studies
Leaf dip method

Cowpea leaves with petiole intact and free from aphids were collected from the sown plot and washed thoroughly. Later they were dipped in a series of concentrations of each insecticide (causing mortality of aphids between 15-95%) for 20 seconds and dried. Then they were transferred to clean petriplates. To avoid dessication of leaves, the petiole was inserted in a small ball of moistened cotton was placed in each periplate and 10 apterous viviparous aphids were carefully placed on the central side of the treated leaf using a soft camel hair brush. The treatments were replicated thrice. For control, the cowpea leaf was dipped in water, dried and used. The mortality of the larvae was observed at 24 hours after treatment.

Direct spray method

About 10 aphids were placed in each petridish and directly sprayed with one ml of each concentration of different insecticides using Potter`s tower at 340 gm/cm^2 pressure. The sprayed petridishes containing the aphids were dried for five minutes under fan. The treated insects were then transferred to separate glass specimen petriplates containing fresh uninfested and untreated cowpea leaves as food. Each treatment was replicated thrice. For assessment of toxic effect, mortality counts were taken 24 hours after the treatment. The moribund insects were also counted as dead.

2.2 Statistical analysis
The mortality of the test insects due to insecticidal treatment was calculated by subjecting the observed mortality to [7] formula based on mortality in control:

$$\text{Corrected mortality (\%)} = \frac{\text{Test mortality (\%)-control mortality (\%)}}{\text{100-control mortality (\%)}} \times 100$$

The data was further analysed using probit analysis using Biostat 5.8.0.3 version for calculating LC_{50} values. The relative toxicity of different insecticides was calculated by taking LC_{50} value of dimethoate as unity.

3. Results and Discussion
Highest mortality (96.6%) at 1000 ppm concentration was observed with chlorfenapyr and spiromesifen followed by imidacloprid, acetamiprid and dimethoate (93.3%) while it was 91.6% for thiamethoxam and 90.0% for diafenthiuron. The mortality response and relative efficacy of chemicals are given in Table 1 and 2. LC_{50} values based on bioassay studies indicated that among the selected insecticides imidacloprid exhibited greater toxicity by leaf dip method after 24 hours of treatment. LC_{50} values of insecticides *viz*., chlorfenapyr, spiromesifen, acetamiprid, dimethoate, diafenthiuron, thiamethoxam and imidacloprid were 0.9312, 0.9297, 0.4731, 0.3498, 0.2924, 0.1446 and 0.0436 ppm, respectively by leaf dip method and the LC_{50} values of insecticides *viz*., imidacloprid, diafenthiuron, dimethoate, chlorfenapyr, acetamiprid, thiamethoxam, spiromesifen were 0.7383, 0.4797, 0.3258, 0.2038, 0.2037, 0.2014 and 0.1672 ppm, respectively by direct spray method.

The superior performance of imidacloprid against the cowpea aphid, *A. craccivora* giving 98% mortality followed by acetamiprid was indicated by [8, 9]. noted that imidacloprid 0.004% was effective for the control of okra aphids and jassids. Imidacloprid, acetamiprid and thiamethoxam belong to the neonicotinoid group and are effective against sucking insects [10, 11]. They interact with nicotinic acetylcholine receptors (nAChR) at central and peripheral nervous system and show a strong affinity to the insect receptors. Imidacloprid is a very important agent for controlling aphids, leafhoppers and whiteflies. It is considered as a relatively polar material with good xylem mobility.

Diafenthiuron, a thiourea derivative was found to be next best insecticide after thiamethoxam and superior than dimethoate. Diafenthiuron acts specifically on sucking pests such as mites, whiteflies and aphids [12-14] revealed that diafenthiuron is a powerful toxicant for controlling the sweet potato whitefly *B. tabaci.* Effectiveness of diafenthiuron in controlling cowpea aphids was also reported by [8]. Among the various OP insecticides evaluated by [15], dimethoate was reported to be moderately toxic to *A. gossiypii*. The present studies also show that dimethoate is moderately toxic.

The results revealed that imidacloprid had the maximum toxicity against *Aphis craccivora* (LC_{50}= 0.0436 ppm) at 24 hours after exposure in leaf dip method followed by thiomethoxam (LC_{50}= 0.1446 ppm) and diafenthiuron (LC_{50}= 0.2924 ppm). Earlier [16], also reported the higher efficacy of imidacloprid against green peach aphid, *M. persicae* by leaf dip method with the LC_{50} value being 8.87 ppm followed by acetamiprid (10.72 ppm), chlorfenapyr (12.98 ppm), thiamethoxam (48.75 ppm), spiromesifen (87.10 ppm) and oxydemeton methyl (338.02 ppm) [17]. Also reported that thiamethoxam was the second best insecticide in controlling aphids in cruciferous vegetables like cabbage and raddish with LC_{50} values of 0.0004 and 0.0003 %, respectively [18]. reported higher toxicity of thiamethoxam (LC_{50}= 0.60ml/lt) over acetamiprid against *A. craccivora* which was treated using leaf-dip bioassay method. The remaining insecticides *viz*., acetamiprid, spiromesifen and chlorfenapyr were relatively less toxic than the conventional insecticide dimethoate by leaf dip method.

In the direct spray method, the order of toxicity of insecticides changed perceptibly. Spiromesifen was found to be the most toxic insecticide followed by thiamethoxam, acetamiprid, chlorfenapyr and dimethoate. Diafenthiuron and imidacloprid were found to be less toxic than dimethoate. Though spiromesifen is recommended for the control of whiteflies and mites [19], have reported their efficacy against the chilli aphids. The two neonicotinoids thiamethoxam and acetamiprid were toxic to the cowpea aphid by direct spray method also, as they are good contact insecticides besides being systemic in nature. Studies by bioassay methods clearly indicated that the relative efficacies of insecticides vary considerably with respect to the method of bioassay and primarily depends on the properties and uptake of insecticides by the organisms. Potentially more realistic testing methods use treated excised leaves [20-24] or treated potted plants grown in green house [25-27] opined that in evaluating the effects of pesticides on any insect, the method used may have an effect on the final results. Confounding factors include solar radiations, rainfall, substrate treated, temperature etc.

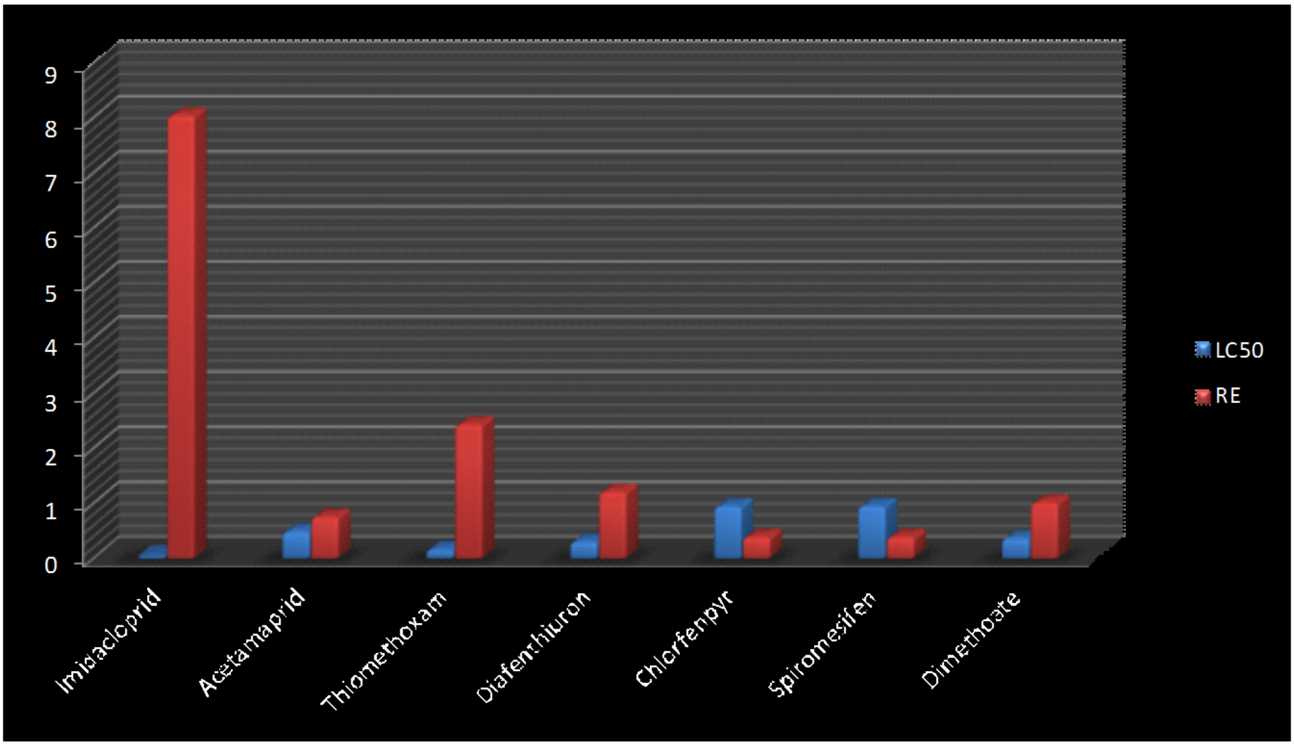

Fig 1: LC_{50} and relative efficacy of selected insecticides against cowpea aphid, *Aphis craccivora* by leaf dip method.

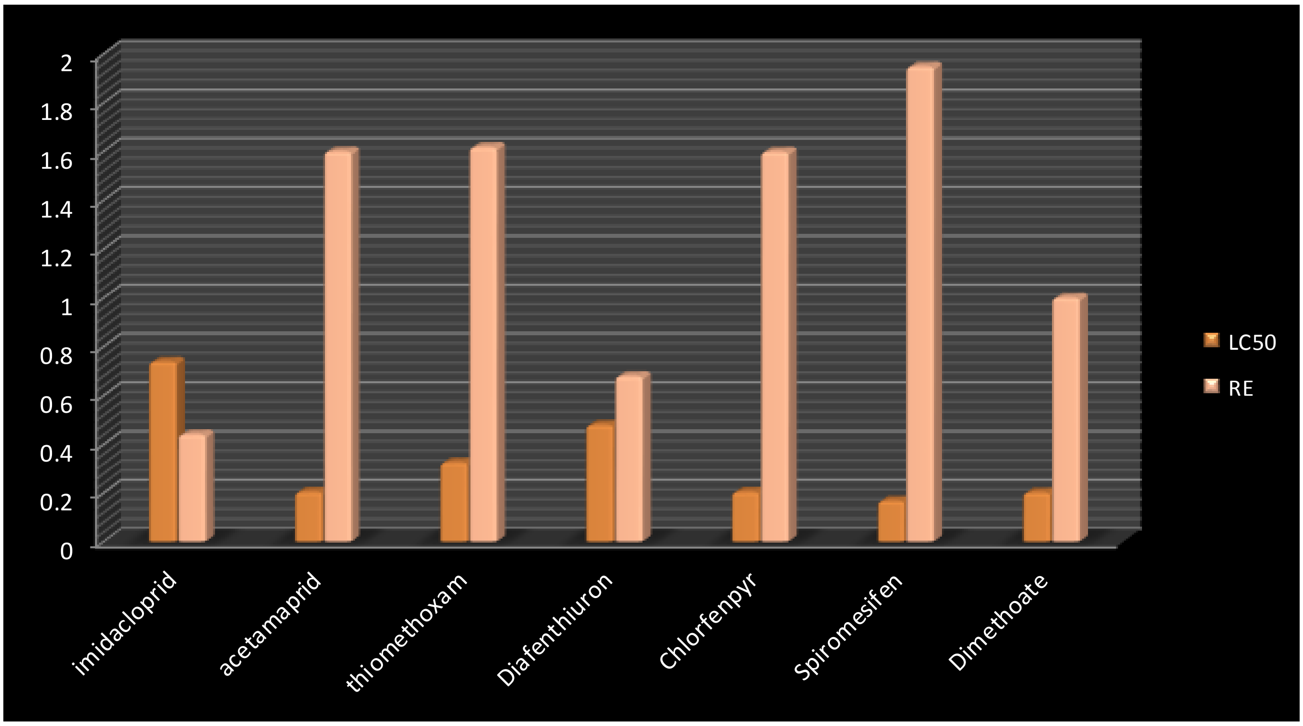

Fig 2: LC_{50} and relative efficacy of selected insecticides against cowpea aphid, *Aphis craccivora* by direct spray method.

Table 1: Relative efficacy of selected insecticides against cowpea aphids, *Aphis craccivora (*Koch) by leaf dip method.

Insecticide	Heterogeneity (χ^2)	df	Regression Equation	LC_{50}(ppm)	Relative efficacy	Order of efficacy	LC_{90}(ppm)	Slope±SE (b)
Imidacloprid	0.3167	6	Y= 5.3734+0.4175 x	0.0436	8.022	1	770.9202	0.4175±0.0474
Acetamiprid	3.6901	4	Y= 5.1506+0.4635 x	0.4731	0.739	5	68.3174	0.4635±0.0475
Thiamethoxam	2.1600	4	Y= 4.8474+ 0.0336 x	0.1446	2.419	2	42.6634	0.0336±0.0534
Diafenthiuron	1.7848	4	Y = 4.6695+0.03441 x	0.2924	1.196	3	46.8394	0.0344±0.0484
Chlorfenapyr	2.7506	6	Y = 5.0147 +0.4646 x	0.9297	0.376	7	620.868	0.4646±0.0585
Spiromesifen	1.1443	4	Y = 4.7361+0.00238 x	0.9312	0.375	6	649.3276	0.0023±0.0009
Dimethoate	0.5578	4	Y = 4.6887+0.02775 x	0.3498	1.00	4	57.3962	0.0277±0.0184

Table 2: Relative efficacy of selected insecticides against cowpea aphids, *Aphis craccivora (*Koch) by Direct spray method.

Insecticide	Heterogeneity (χ^2) DF		Regression Equation	LC50(ppm)	Relative efficacy	Order of efficacy	LC90(ppm)	Slope±SE (b)
Imidacloprid	0.5071	5	Y = 5.0503 + 0.3825 x	0.7383	0.441	7	794.2552	0.3825 ±0.00074
Acetamiprid	0.3747	5	Y = 5.2614 + 0.3784 x	0.2037	1.599	3	778.2294	0.3784 ±0.05259
Thiamethoxam	0.6248	5	Y = 5.1975 + 0.2838 x	0.2014	1.617	2	805.8654	0.2838 ±0.04828
Diafenthiuron	1.5569	5	Y = 5.0936 + 0.2935 x	0.4797	0.679	6	1396.968	0.2935 ±0.04833
Chlorfenapyr	0.8692	5	Y = 5.2126 + 0.3079 x	0.2038	1.598	4	938.7757	0.3079 ±0.04923
Spiromesifen	0.5499	5	Y = 5.3710 + 0.4778 x	0.1672	1.948	1	470.179	0.4778 ±0.05926
Dimethoate	1.1189	5	Y= 5.2353 + 0.4832 x	0.3258	1.00	5	625.8608	0.4832 ±0.05866

4. Conclusion
From the present studies, it can be concluded that imidacloprid was the most toxic among the seven selected insecticide by leaf dip method. While, spiromesifen was effective using direct spray method. Leaf dip method was more sensitive compared with direct spray method.

5. Acknowledgments
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