Journal of Entomology and Zoology Studies
Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(6): 606-608

Received: 13-09-2018
Accepted: 14-10-2018

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Determination of LC_{50} and relative toxicity of some insecticides against cowpea aphid, *Aphis craccivora* Koch

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Abstract
Experiments were conducted in the laboratory to determine the LC_{50} and relative toxicity of seven insecticides viz., clothianidin 100 g *a.i.*/ha, bifenthrin 80 g *a.i.*/ha, imidacloprid 20 g *a.i.*/ha, spinosad 45 g *a.i.*/ha, thiacloprid 100 g *a.i.*/ha, flubendiamide 60 g *a.i.*/ha, flonicamid 60 g *a.i.*/ha and dimethoate 450 g *a.i.*/ha along with control against cowpea aphid, *Aphis craccivora* Koch. Based on the LC_{50} values, flubendiamide showed more toxicity at 0.027 ppm and 0.017 ppm after 24 and 48 hours, while spinosad was least toxic with 0.912 ppm and 0.246 ppm after 24 and 48 hours, respectively. The order of toxicity on the basis of relative toxicity was flubendiamide > clothianidin > thiacloprid > imidacloprid > flonicamid > bifentrin > spinosad, at 24 hours, while flubendiamide > thiacloprid > clothianidin > imidacloprid > bifenthrin > flonicamid > spinosad at 48 hours by taking dimethoate as unity.

Keywords: *Aphis craccivora*, cowpea, imidacloprid, relative toxicity

1. Introduction
Cowpea plays an important role to the millions of the people as dietary complement which is originated in the Africa and is widely grown in Africa, Latin America, South East Asia and in the southern united states. The history of cowpea dates to ancient West African cereal farming, 5 to 6 thousand years ago, where it was closely associates with the cultivation of sorghum and pearl millet (Davis *et al*., 1991) [6]. The other name of cowpea is vegetable meat because of its rich protein content in the grain which contains 26.61 per cent protein, 56.24 per cent carbohydrates and 3.99 per cent lipids (Owolabi *et al.*, 2012) [16].
Among the different insect pests, cowpea aphid (*Aphis craccivora*) has been recorded as one of the major pest (Jackai and Daoust, 1986) [10] which on continuously increase in aphid population causes the major yield loss (Singh *et al.*, 1990) [20]. They cause direct damage by sucking sap and indirect damage is caused by transmission of the aphid borne mosaic virus (Atiri *et al.*, 1986) [3]. They also secrete honey dew which retards photosynthesis and causes sooty mould (Anonymous. 2009) [2].
Use of insecticide is the only quick and effective method to control this pest. Insecticides belong to organochlorines (Bakhetia and Sekhon, 1989) [5], organophosphate (Mathur *et al.*, 1987) [12], synthetic pyrethroids (Prasad *et al.*, 1983) [17] and neonicotinoids (Ghosal *et al.*, 2013) [8] have been used earlier to control this pest.
In the recent year several new insecticides *viz.*, imidacloprid, bifenthrin, thiacloprid, clothianidin, flonicamid, dimethoate, flubendiamide and spinosad have been developed which are active on hemipteran pest species such as aphid and other sucking pests like whiteflies, thrips and plant hoppers (Nauen *et al.*, 2003; Morita *et al.*, 2007; Khan *et al.*, 2001; Maula *et al.*, 2010; Radha, 2013) [15, 14, 11, 13, 18]. Information on the toxic effect of these insecticides *viz.*, clothianidin, bifenthrin, imidacloprid, spinosad, flubendiamide, flonicamid, thiacloprid and dimethoate against *Aphis craccivora* Koch is scanty. Hence, an attempt was made to study the efficacy of these insecticides against cowpea aphid, *Aphis craccivora* Koch.

2. Materials and Methods
Laboratory experiments were conducted in the Department of Entomology, Assam Agricultural University, Jorhat during the year 2014 - 2015 for the determination of LC_{50} values of *A. craccivora*. The stock solution of known strength of the insecticides was prepared from standard.

Subsequent concentration of the insecticides was prepared from the stock solution. Insecticides were applied in the form of a dry film, deposited on the inner surface of the petriplate. Thin and uniform film of insecticides was prepared by taking 1 ml of insecticide solution in a petriplate and rotated till dryness. Toxicity of these films was determined against fourth instar nymph of *A. craccivora*. Ten nymphs were released into each petriplate, which served as one replication. Four replications of each concentration of the insecticides were maintained. Simultaneously, a control set was also run. Petriplates in control set had only dry film of acetone. The plates were kept in an incubator at 28±2 ˚C for six hours. Then the aphids were transferred to battery jars (20 cm ×10cm diameter) containing flowers and pods of cowpea. The mouth of each jar was kept closed with a piece of muslin cloth held in position with the help of rubber bands. These jars were kept in incubator at 28±2 ˚C and after 24 and 48 hours at which mortality counts were made. Per cent nymph mortality in each treatment was worked out. The observed mortality was corrected if there were mortality in control by using Abbott's formula (1925). The dosages mortality data so obtained were subjected to Probit analysis to find out LC_{50} values. Relative toxicity of different insecticides was calculated by taking LC_{50} value of dimethoate as a unit.

The experimental data were subjected to 'Probit analysis' as described by Finney (1952) [7]. The median lethal concentration (LC_{50}) was obtained from the regression equation. The values for relative toxicity of insecticides were calculated as follows:

$$\text{Relative Toxicity} = \frac{LC_{50} \text{ value of dimethoate}}{LC_{50} \text{ value of insecticides}}$$

3. Results and Discussion

To evaluate the LC_{50} values and relative toxicity of clothianidin, bifenthrin, imidacloprid, spinosad, thiacloprid, flubendiamide, flonicamid and dimethoate against cowpea aphid (*Aphis craccivora*), an experiment was carried out in the laboratory, Department of Entomology, Assam Agricultural University, Jorhat.

The mortality data obtained by the bioassay study against *A. craccivora* caused by different insecticides for 24 and 48 hours revealed that 0.05 ppm clothianidin caused the highest mortality (87.5%) at 24 hours as well as at 48 hours (95%). In case of bifenthrin the highest mortality of 77.5 and 87.5 per cent after 24 and 48 hours was recorded at 0.2 ppm respectively. For imidacloprid, the highest mortality was recorded as 75 and 77.5 per cent after 24 and 48 hours at 0.08 ppm respectively. The highest mortality of 65 and 77.5 per cent after 24 and 48 hours was recorded at 2 ppm spinosad. In case of thiacloprid, at 0.05 ppm the highest mortality was recorded as 70 and 92.5 per cent after 24 and 48 hours. The highest mortality of 80 and 95 per cent was recorded after 24 and 48 hours at 0.05 ppm of flubendiamide. In case of flonicamid, the highest mortality was recorded as 77.5 and 85 per cent after 24 and 48 hours at 0.095 ppm. In case of dimethoate the highest mortality was recorded 72.5 and 82.5 per cent after 24 and 48 hours at 0.07 per cent.

The LC_{50} values of clothianidin, bifenthrin, imidacloprid, spinosad, thiacloprid, flubendiamide, flonicamid and dimethoate were 0.031, 0.117, 0.063, 0.912, 0.042, 0.027, 0.079 and 0.057 ppm respectively after 24 hours (Table 1) exposure period and 0.029, 0.063, 0.044, 0.246, 0.028, 0.017, 0.068 and 0.047 ppm respectively for 48 hours (Table 2). The order of toxicity with respect to LC_{50} values was as flubendiamide > clothianidin > thiacloprid > dimethoate > imidacloprid > flonicamid > bifenthrin > spinosad after 24 hours while it was flubendiamide > thiacloprid > clothianidin > imidacloprid > dimethoate > bifenthrin > flonicamid > spinosad after 48 hours.

To evaluate the relative toxicity, a unit value (1.00) was assigned to dimethoate in the present investigation. The comparison of relative toxicity revealed that after 24 hours clothianidin 1.83 times, thiacloprid 1.35 times, flubendiamide 2.11 times more toxic than dimethoate while spinosad (0.06) was the least toxic insecticide. After 48 hours flubendiamide 2.76, thiacloprid 1.67 times, clothianidin 1.6.2 times and imidacloprid 1.06 times more toxic than dimethoate while the other tested insecticides were less toxic. The order of toxicity on the basis of relative toxicity was flubendiamide > clothianidin > thiacloprid > imidacloprid > flonicamid > bifentrin > spinosad, at 24 hours (Table 1), while flubendiamide > thiacloprid > clothianidin > imidacloprid > bifenthrin > flonicamid > spinosad at 48 hours (Table 2).

Aswathi *et al.* (2013) reported that the order of toxicity against cotton aphid (*Aphis gossypii*) was acetamiprid > acephate > imidacloprid > emamectin benzoate > indoxacarb > spinosad with their relative toxicity values 82.28, 23.04, 16.18, 1.57, 1.45 and 1 respectively which supports the present findings.

Rouhani *et al.* (2013) [19] reported that the LC_{50} values for imidacloprid, thiamethoxam, thiacloprid and flonicamid after 24 h were estimated 0.24 µl/ml, 0.31 mg/ml, 0.48 µl/ml and 0.05 mg/ml, respectively. His findings demonstrated that this tested insecticide gives a rapid and strong toxicity towards *Aphis punicae*.

Herk *et al*. (2008) [9] evaluated relative toxicity of ten insecticides against the European wireworm, *Agriotes obscurus*. The result revealed that fipronil was highly toxic to wireworms (LC_{50} =0.0001%) followed by lindane (LC_{50} =0.06%), clothianidin (LC_{50}=0.07%), chlorpyrifos (LC_{50}=0.10%), thiamethoxam (LC_{50}=0.17%), tefluthrin (LC_{50}=0.23%), spinosad (LC_{50}=0.51%), diazinon (LC_{50}=0.54%), imidacloprid (LC_{50}=0.83%) and acetamiprid (LC_{50}=1.82%).

Table 1: LC_{50} values and relative toxicity of some insecticides to *Aphis craccivora* on residual film after 24 hours.

Insecticides	Regression equation	Standard error of regression coefficient	Heterogeneity (χ^2)	LC_{50} (ppm)	Fiducial limit	Relative toxicity	Order of toxicity
Clothianidin	Y = 6.373 + 4.230 X	0.240	102.391	0.031	0.030 0.033	1.83	II
Bifenthrin	Y = 3.264 +3.498 X	0.174	176.072	0.117	0.108 0.128	0.48	VI
Imidacloprid	Y = 5.142 + 4.278 X	0.318	139.915	0.063	0.059 0.068	0.90	IV
Spinosad	Y = 0.026 + 0.659 X	0.908	66.648	0.912	0.684 1.105	0.06	VII

Thiacloprid	Y = 3.852 + 2.806 X	0.215	222.104	0.042	0.038 0.050	1.35	III
Flubendiamide	Y = 3.142 + 2.000 X	0.189	90.614	0.027	0.024 0.030	2.11	I
Flonicamid	Y = 7.681 + 6.957 X	0.357	109.454	0.079	0.076 0.081	0.72	V
Dimethoate	Y =7.495 + 6.035 X	0.324	83.066	0.057	0.055 0.059	1.00	_

Table 2: LC_{50} values and relative toxicity of some insecticides to *Aphis craccivora* on residual film after 48 hours.

Insecticides	Regression equation	Standard error of regression coefficient	Heterogeneity (χ^2)	LC_{50} (ppm)	Fiducial limit	Relative toxicity	Order of toxicity
Clothianidin	Y = 6.078 + 3.960 X	0.235	153.250	0.029	0.027 0.031	1.62	III
Bifenthrin	Y = 2.630 + 2.193 X	0.199	153.799	0.063	0.040 0.077	0.74	V
Imidacloprid	Y = 2.917 + 2.156 X	0.188	1108.421	0.044	0.039 0.049	1.06	IV
Spinosad	Y = 0.376 + 0.618 X	0.030	85.808	0.246	0.182 0.332	0.19	VII
Thiacloprid	Y = 3.554 + 2.293 X	0.166	331.682	0.028	0.024 0.038	1.67	II
Flubendiamide	Y = 4.525 + 2.572 X	0.185	151.649	0.017	0.017 0.022	2.76	I
Flonicamid	Y = 7.023 + 6.021 X	0.361	92.543	0.068	0.065 0.074	0.69	VI
Dimethoate	Y = 7.032 + 5.295 X	0.307	173.289	0.047	0.044 0.050	1.00	_

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