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Persistent toxicity of selected insecticides on cowpea aphid, *Aphis craccivora* (Koch)

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Abstract
The persistent toxicity of commercial formulations of seven selected insecticides was conducted against cowpea aphid *A. craccivora*, using pot culture in the green house of Department of Entomology, College of Agriculture, Rajendranagar, and PJTSAU. Of different treatments, highest persistence was shown by the imidacloprid (19 and 20 days) followed by acetamiprid (15 and 16 days) > dimethoate (13 and 14 days) > thiamethoxam (11 and 19 days) > diafenthiuron, spiromesifen and chlorfenapyr (9 days each and 10 days each) at 24 and 48 hours of exposure, respectively. The PT (product of toxicity) of test insecticides were in the order: Imidacloprid, acetamiprid, dimethoate, thiamethoxam, diafenthiuron, spiromesifen and chlorfenapyr at 24 and 48 hours, respectively, which indicated that imidacloprid was more persistent followed by acetamiprid and dimethoate than the remaining insecticides.

Keywords: Persistent toxicity, product of toxicity, pot culture, insecticides

Introduction
Cowpea [*Vigna unguiculata* (L) Walp.] is a warm season annual leguminous fodder crop mainly grown in Northern and Central India. It has a great potential for sustainable agriculture in marginal lands and semi-arid regions of the country and is now rapidly spreading to the entire country. A number of new and promising varieties have been released at national/zonal levels. The green cowpea fodder is rich in protein and forms an excellent mixture with maize, jowar, bajra and teosinte etc. and considered as balanced diet for animals for higher milk and meat production. Cowpea is attacked by many insect-pests which are the principal limiting factor for its productivity throughout the country. The losses in green fodder yield are estimated to a tune of 30%. Aphids are economically important insects causing severe damage to the crop. Both nymphs and adults suck plant sap and cause serious damage right from the seedling to pod bearing stage. Cowpea aphids inject toxins into the plant while feeding and mostly reduce vigour and yields. 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 (Sharma and Singh, 1993) [7].

Materials and Methods
Bioassay Studies
Pot studies were undertaken in the premises of green house, Department of Entomology, to determine the persistent toxicity of selected insecticides at the recommended concentrations against cowpea aphids. Cowpea plants were raised in plastic pots of diameter 10 × 10 cm. The pots were filled each with soil to which vermicompost (15 g) was applied and mixed. The fodder cowpea variety KBC-2 was used for the studies. When the seedlings were 15 days old fertilizers in the form of DAP (10g) and MOP (10 g) were applied.

The pots were watered using rose can at an interval of 2 days till the seedlings were well established and thereafter as and when required i.e., when the soil showed dryness. Three sets of seedlings, each set containing 24 pots were maintained. At 25 days age of seedlings, the plants were sprayed with recommended dose (Table No. 1) of selected insecticides viz., imidacloprid, thiamethoxam, acetamiprid, diafenthiuron, chlorfenapyr, spiromesifen, and dimethoate with the help of hand operated atomizer till the foliage was uniformly and thoroughly covered till runoff stage. The treatments including control were replicated thrice and 100ml of spray solution sufficed all three replications in the treatment. After 24 hours of spraying, ten aphids were released in each potted plant and confined within Mylar tube and covered on top by muslin cloth. Care was taken to remove aphids, if any, on the plants before

and after spraying with insecticides. Mortality was assessed after 24 and 48 hours and then, both the live and dead aphids were removed. Subsequently, at every 2 days interval the aphids were released and mortality was assessed till zero mortality was obtained.

Table 1: Details of insecticides tested against *A. craccivora*

SI.No.	Common name	Chemical group	Trade Name	Formulation	Manufacturer	Recommended Dose* (mg or ml/l)	Recommended Dose** (g a.i./ha)
1	Imidacloprid	Neonicotinoid (Chloronicotinyl)	Confidor	17.8 SL	Bayer Crop Science, Mumbai	0.5	50
2	Acetamiprid	Neonicotinoid (Chloronicotinyl)	Rapid	20 SP	Crystal Crop Protection Pvt. Ltd.	0.25	15
3	Thiamethoxam	Neonicotinoid (Thionicotinyl)	Actara	25 WG	Syngenta India Limited, Mumbai	0.5	50
4	Diafenthiuron	Thiourea derivative	Pegasus	50 WP	Syngenta India Limited, Mumbai	0.5	50
5	Chlorfenapyr	Halogenated pyrrole	Interpid	10 SC	BASF, Mumbai	1.5	100
6	Spiromesifen	Tetronic acid derivative	Oberon	22.9 SC	Bayer Crop Science, Mumbai	0.8	120
7	Dimethoate*	Organophosphate	Tafgor	30 EC	TATA Enterprises	2.0	300

Data Analysis

The observed mortality was corrected using Abbott`s formula (Abbott, 1925) based on the mortality in control. For determining the persistent toxicity of each insecticide, the product (PT) of average residual toxicity (T) and the period (P) for which the toxicity persisted was used as an index of persistent toxicity. The persistent (PT) values were calculated by the criterion developed by Pradhan (1967) [5] as given below:

$$\text{Average residual toxicity (T)} = \frac{\text{Sum of corrected mortalities at different intervals}}{\text{Number of observations}}$$

Persistent toxicity (PT) = Average residual toxicity × period for which toxicity was observed

The order of relative persistence of the insecticides was calculated based on PT values.

Results and Discussion

The mortality recorded at 24 and 48 hours after exposure of cowpea aphids to selected insecticides on potted cowpea plants are given in tables 2 and 3.

After 24 hours of Exposure

A perusal of table 2 clearly showed that none of the selected insecticides caused cent per cent mortality, one day after treatment (DAT). The highest mortality was recorded in dimethoate (93.3 %), 24 hours after treatment. In case of neonicotinoids, mortality of >80 % was recorded. However, the mortality was ≤ 50 % in diafenthiuron, chlorfenapyr and spiromesifen.

The average residual toxicity of test insecticides viz., imidacloprid, acetamiprid, dimethoate, thiamethoxam, diafenthiuron, spiromesifen and chlorfenapyr was 518.89, 374.61, 353.50, 194.20, 128.66, 109.90, and 77.62, respectively. The period of toxicity was higher for imidacloprid (19 days) followed by acetamiprid (15 days) > dimethoate (13 days) > thiamethoxam (11 days) > diafenthiuron, spiromesifen and chlorfenapyr (9 days, each). The order of relative efficacy and persistent toxicity values of test insecticides after 24 hours of exposure was as follows in the decreasing order: imidacloprid (985.89) > acetamiprid (702.39) > dimethoate (656.50) > thiamethoxam (356.03) > diafenthiuron (231.58) > spiromesifen (197.82) and chlorfenapyr (139.71) which indicated that imidacloprid was more persistent followed by acetamiprid and dimethoate than the remaining insecticides.

Table 2: Persistent toxicity of selected insecticides against *A. craccivora* at 24 hrs after treatment

	Corrected mortality (%)						
Days	Imidacloprid (0.5 ml/l)	Acetamiprid (0.25mg/l)	Thiamethoxam (0.5 mg/l)	Diafenthiuron (0.5 mg/l)	Chlorfenapyr (1.5ml/l)	Spiromesifen (0.8ml/l)	Dimethoate (2.0 ml/l)
1	86.6	84.5	86.6	50	46.6	40	93.3
3	74	63.01	53.8	38.4	10	26.6	92.5
5	60	56.6	26.6	26.6	10	23.3	84.5
7	53.7	43.3	16.6	10	7.72	10	33.3
9	50	40.6	7.3	3.66	3.3	10	33.3
11	48.09	30	3.3	0	0	0	10
13	43.3	30	0	0	0	0	6.6
15	43.3	26.6	0	0	0	0	0
17	33.3	0	0	0	0	0	0
19	26.6	0	0	0	0	0	0
21	0	0	0	0	0	0	0
ART	518.89	374.61	194.2	128.66	77.62	109.9	353.5
P	19	15	11	9	9	9	13
T	51.88	46.82	32.36	25.73	15.52	21.98	50.50
PT	985.89	702.39	356.03	231.58	139.71	197.82	656.50
RE	7.06	5.02	2.54	1.65	1.00	1.41	4.69
ORE	1	3	4	5	7	6	2

ART=Average residual toxicity; P=Period of toxicity; T= Mean per cent mortality; PT= Persistent toxicity; O.R.E=order of relative efficacy

After 48 hours of Exposure

A perusal of table 3 showed that all the three neonicotinoids, the conventional insecticide, dimethoate and spiromesifen caused 100 % mortality after 48 hours of exposure while 80 % mortality was recorded with diafenthiuron and 76.6 % mortality by chlorfenapyr.

The average residual toxicity of test insecticides viz., imidacloprid, acetamiprid, dimethoate, thiamethoxam, spiromesifen diafenthiuron and chlorfenapyr was 690.70, 455.40, 429.02, 302.10, 249.60, 154.00 and 139.70, respectively. The period of toxicity was higher for imidacloprid (20 days) followed by acetamiprid (16 days) > dimethoate (14 days) > thiamethoxam (12 days) > diafenthiuron, spiromesifen and chlorfenapyr (10 days each). The order of relative efficacy and persistent toxicity values of test insecticides after 48 hours of exposure was: imidacloprid (1381.40) > acetamiprid (910.00) > dimethoate (858.03) > thiomethoxam (604.32) > spiromesifen (499.20) > diafenthiuron (308.06) and chlorfenapyr (279.40) which indicated that imidacloprid was more persistent followed by acetamiprid and dimethoate than the remaining insecticides.

The results revealed that imidacloprid had the maximum period of toxicity against *A. craccivora* at both 24 hours (19 days) and 48 hours (20 days) after treatment. The results corroborate with previous reports. Patil and Lingappa (2001) [8] reported that imidacloprid (40gm a.i/ha) as plant hole treatment (PTH) was the most persistent to aphids (upto 25 days) followed by acephate (0.075%). Prolonged effectiveness of imidacloprid spray against *M. persicae* on tobacco has been reported by Shantappanavar *et al*. (1995). Preetha *et al.* (2009) [6] reported that the higher dose of imidacloprid (0.56 ml /l) showed longest persistence upto 27 days for aphids. The present findings are in agreement with those of Sivaveerapandian (2000) [9] who reported that foliar applied imidacloprid persisted for 23 days against aphids in bhendi. Gaikwad *et al.* (2015) [2] reported the persistence of tested insecticides upto 14 days causing mortality in the range of in the range of 19.58 to 26.49 per cent.

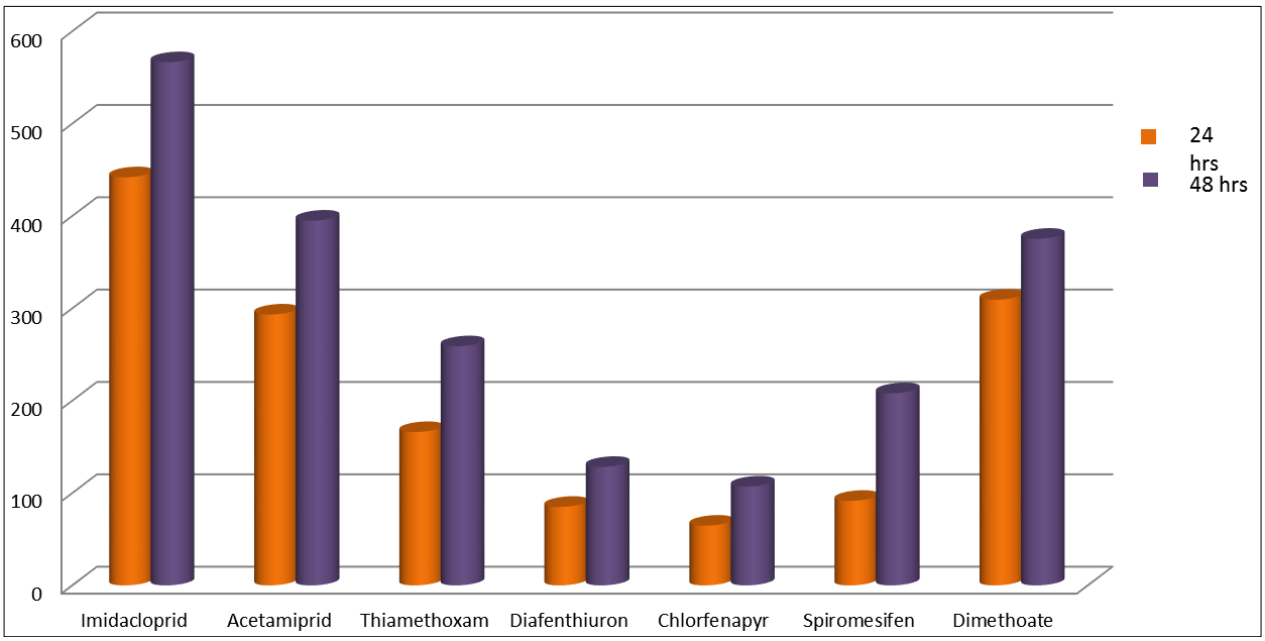
Besides imidacloprid, the other two neonicitinoids *viz* acetamiprid and thiamethoxam persisted for 15 and 11 days, respectively (24 hours after treatment) and 16 and 12 days, respectively (48 hours after treatment). McCornack and Ragsdale (2006) demonstrated that in an excised leaf bioassay the period of toxicity of thiamethoxam against soyabean aphid was upto 23 to 25 days. In an in-field bioassay intact plants showed longer persistence of thiamethoxam and aphid mortality persisted 49 days after planting and mortality was significantly higher in the older leaves than in newly-expanded leaves. Thiamethoxam 0.005 % concentration showed comparatively high percentage mortality of U. compositae (31.03 %) even at 14 days after spraying (Gaikwad *et al*., 2015) [2]. The organophosphrous insecticide dimethoate showed persistence upto 14 days (48 hours after treatment) while the remaining three insecticides viz diafenthiuron, spiromesifen and chlorfenapyr for 10 days, each. Earlier, Gaikwad *et al.* (2015) [2] reported the persistence of dimethoate on the leaves and apical shoot of safflower upto 14 days against the aphid *U. compositae.*

In the present studies, PT values of the tested insecticides indicated that the two neonicotinoids, imidacloprid and acetamiprid followed by an organophosphorus insecticide, dimethoate (fig.1) showed greater persistence than the remaining insecticides both at 24 and 48 hours after treatment against the cowpea aphid. However, Gaikwad *et al.* (2015) [2] found that the PT of dimethoate 0.03 % (909.16) > imidacloprid 0.004 % (866.74) > acephate 0.03 per cent (849.94) > profenofos 0.05 % (831.88) > thiamethoxam 0.005 % (826) > acetamiprid 0.004 % (812). This variation could probably be due to difference in aphid species tested and the bioassay method used.

Table 3: Persistent toxicity of selected insecticides against *A. craccivora* at 48 hrs after treatment

	Corrected mortality (%)						
Days	**Imidacloprid** (0.5 ml/l)	**Acetamiprid** (0.25mg/l)	**Thiamethoxam** (0.5 mg/l)	**Diafenthiuron** (0.5 mg/l)	**Chlorfenapyr** (1.5ml/l)	**Spiromesifen** (0.8ml/l)	**Dimethoate** (2.0 ml/l)
2	100	100	100	80	76.6	100	100
4	96.2	90	61.4	46.1	26.6	46.6	100
6	88.4	55.5	50	13.3	16.6	40	93.3
8	80	53.3	48.1	7.3	13.3	33	59.22
10	73.3	46.6	26.0	7.3	6.6	30	33.3
12	70	43.3	16.6	0	0	0	26.6
14	63	40.1	0	0	0	0	16.6
16	56.6	26.6	0	0	0	0	0
18	36.6	0	0	0	0	0	0
20	26.6	0	0	0	0	0	0
22	0	0	0	0	0	0	0
ART	690.7	455.4	302.1	154	139.7	249.6	429.02
P	20	16	12	10	10	10	14
T	69.07	56.87	50.36	30.80	27.94	49.92	61.28
PT	1381.40	910.00	604.32	308.06	279.40	499.20	858.03
RE	4.94	3.25	2.16	1.10	1.00	1.78	3.06
ORE	1	3	4	6	7	5	2

Fig. 1. Persistent toxicity of selected insecticides against *A. craccivora* at 24 hrs and 48 hrs after treatment



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