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COMPARATIVE TOXICITY OF SOME COMMONLY USED INSECTICIDES TO COTTON APHID AND THEIR SAFETY TO PREDATORY COCCINELLIDS

NIKITA S. AWASTHI*, U. P. BARKHADE, S. R. PATIL AND G. K. LANDE
Department of Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth,
Akola - 444 104, Maharashtra, INDIA
e-mail: awasthi_nik@rediffmail.com

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***Corresponding author**

ABSTRACT
Experiments were conducted in the laboratory to evaluate relative toxicity of six insecticides, viz., Spinosad 45 SC, Indoxacarb 15.8 EC, Emamectin benzoate 5 SG, Acephate 75 SP, Acetamiprid 20 SP and Imidacloprid 17.8 SL against cotton aphid *Aphis gossypii* Glover and different stages of predatory coccinellids. On the basis of LC_{50} values, acetamiprid was the most toxic whereas; spinosad was the least toxic insecticide to cotton aphid. The order of relative toxicity of insecticides over spinosad was acetamiprid > acephate > imidacloprid > emamectin benzoate > indoxacarb, with their relative toxicity values being 82.28, 23.04, 16.18, 1.57 and 1.45, respectively. On the basis of LC_{50} values, spinosad was the safest insecticide for the different stages of the predatory coccinellids and acetamiprid was the most toxic followed by imidacloprid, indoxacarb, emamectin benzoate and acephate. But comparison of LC_{50} values of various insecticides in respect of various stages of predatory coccinellids *vis-a-vis* important aphid pest, *Aphis gossypii* indicated that acephate was relatively safe and indoxacarb was toxic for the predator. The neonicotinoids despite higher relative resistance showed very low LC_{50} values which were much below their recommended concentrations.

INTRODUCTION

Aphis gossypii is an important sucking pest of cotton. Both nymphs and adults damage cotton plants by actively sucking the sap. Also their honeydew attracts black sooty mould, which inhibits photosynthesis thus reducing the yield. Recently, highly efficacious insecticides with novel mode of action are available which are becoming increasingly important in agriculture as a component of integrated pest management and resistance management strategies. These insecticides are required only in few grams in comparison to older class of compounds which are required in few hundred grams and are perceived to carry higher safety/ environmental risks (Wing *et al.*, 2000). But the insecticides applied in agro ecosystem not only affect the target pest but also have adverse effect on natural enemies. The population of predators has declined by 68.4 % during the last two decades and many parasitoids have been eliminated from cotton ecosystem (Dhawan and Simwat, 1996). Hence, before incorporating these newer insecticides in IPM programs, it is imperative to screen them for their safety to natural enemies. Selective insecticides integrated with biological control can minimize adverse effects to natural enemies (Johnson and Tabashnik 1999).

Coccinellids, popularly known as ladybird beetles or lady bugs are the most successful group of predators. About 90% of approximately 4,200 Coccinellid species are considered beneficial because of their predatory activity, mainly against homopterous insects and mites (Swaminathan *et al.*, 2010). Conservation of predators particularly coccinellids being potential predator is very necessary. Thus, an attempt was made to determine the comparative toxicity of some commonly used insecticides for cotton aphid and predatory coccinellids. Also assessment of relative resistance of coccinellid predators in relation to the host, *i.e.,* safety limit for the predator. Outcome of the present investigation will be very much useful to cultivators for the management of the sucking pests of any crop from the point of view of IPM or organic pest management. It will also be useful to research worker for carrying out further research work on this aspect.

MATERIALS AND METHODS

Insects

Apterous cotton aphids were collected at random from several unsprayed cotton plants in and around the Dr. PDKV, University Campus, Akola. Grubs and adults of predatory coccinellids were collected from different unsprayed field. The grubs of 1st and 2nd instars were considered as early instars and that of 3rd and 4th as late instars. The commonly observed predatory coccinellids were *Cheilomenes* sp. Collected insects were pre-conditioned in the laboratory for about 3-4h before treatment.

Preparation of insecticide solutions

Commercial formulations of insecticides were used for the laboratory bioassay. Insecticides tested were Spinosad 45 SC

(Tracer), Indoxacarb 15.8 EC (Avuant), Emamectin benzoate 5 SG (Proclaim), Acephate 75 SP (Tamron Gold), Acetamiprid 20 SP (Pride) and Imidacloprid 17.8 SL (Confidor). Serial dilutions as parts per million of active ingredients of the test insecticides were prepared using distilled water.

Bioassay on aphid (Leaf dip method)

Cleaned non-infested cotton leaves were dipped in different concentrations of insecticides, one leaf per concentration. Five concentrations were tested for each insecticide. Leaf dipped in distilled water served as control. Surface water from leaves was allowed to dry and leaves were placed in petri plates individually. Field collected apterous cotton aphids were placed on each leaf at the rate 30 aphids/ leaf with the help of pointed brush. Damped cotton wool was placed around petiole of each leaf. The petri plates were maintained at 27 ± 1°C. Dose-mortality response was recorded upto 72 hours.

Bioassay on grubs and adults of predatory coccinellids (Topical Method)

Ten randomly selected adults and grubs were placed in each petri dish (10cm diameter) covered with a wire guaze (9 mesh/ cm), separately and sprayed directly with two mL of each concentration. Five concentrations of each insecticide were tested. Each treatment including control was replicated thrice. The petri dishes containing the predators were dried under ceiling fan for five minutes. Then the treated adults and grubs were transferred to clean jars containing tender aphid infested twig of plant to serve as food. The jars were covered with pieces of muslin held in position by rubber bands and kept at 27 ± 1°C. Dose-mortality response was recorded upto five days.

Statistical analysis

The LC_{50} values of insecticides for aphid and different stages of predatory coccinellids were estimated. LC_{50} values expressed as parts per million (ppm) were estimated by probit analysis by using EPA PROBIT ANALYSIS PROGRAM Version 1.5.

Evaluation of relative toxicity of insecticides

The values of relative toxicity of different insecticides were calculated by formula,

$$\text{Relative Toxicity} = \frac{LC_{50} \text{ of less Toxic compound}}{LC_{50} \text{ of more Toxic compound}}$$

Estimation of relative resistance of the coccinellid predator in relation to aphid (safety limit of insecticides)

The relative resistance (Safety limit for predator) of the coccinellid predator in relation to aphid pest to various insecticides was work out as the ratio of LC_{50} value of predator to the LC_{50} value of aphid host (Dhingra *et al*. 1995).

Safety limit for Predator = LC_{50} for Predator

(Relative Resistance) LC_{50} for aphid

Estimation of comparative safety index of insecticides for predatory coccinellids

The comparative safety index of different insecticides for different stages of predatory coccinellids was worked out as a ratio of safety limit of the insecticide (relative resistance) to the safety limit of the least safe insecticide.

$$\text{Comparativ esafety index} = \frac{\text{Rrlative resistance to the insecticides}}{\text{Relative resistance to the least safe insecticide}}$$

RESULTS

Table 1 provides LC_{50} values and relative toxicity of insecticides against cotton aphids. On the basis of LC50, acetamiprid was found as most effective insecticide against aphids. Maximum LC_{50} was recorded in treatment with spinosad (0.576ppm) and found the least toxic one. Taking relative toxicity of spinosad as unity, the order of toxicity of insecticides against cotton aphid was acetamiprid > acephate > imidacloprid > emamectin benzoate > indoxacarb, with their relative toxicity values being 82.28, 23.04, 16.18, 1.57 and 1.45, respectively. Table 2 provides LC_{50} values and relative toxicity of insecticides against different stages of predatory coccinellids.

Relative toxicity of insecticides against early instar grubs of predatory coccinellids

Maximum LC_{50} value was recorded in the treatment with spinosad (0.445ppm) and found comparatively safer, followed by acephate (0.065ppm), emamectin benzoate (0.033ppm), indoxacarb (0.02ppm), imidacloprid (0.017ppm). Minimum LC_{50} was recorded in treatment with acetamiprid (0.014ppm) and found comparatively toxic. The relative toxicity was calculated over spinosad. It revealed that, acetamiprid was 31.79 times, imidacloprid was 26.18 times, indoxacarb was 22.25 times, emamectin benzoate was 13.48 and acephate was 6.85 times more toxic than spinosad. Order of toxicity was acetamiprid > imidacloprid > indoxacarb > emamectin benzoate > acephate > spinosad.

Relative toxicity of insecticides against late instar grubs of predatory coccinellids

Spinosad was the safest insecticide with LC_{50} 0.501 ppm and acetamiprid was the most toxic one with LC_{50} 0.018 ppm. Order of toxicity was acetamiprid > imidacloprid > indoxacarb > emamectin benzoate > acephate > spinosad. Acetamiprid was 27.83 times, imidacloprid was 21.78 times, indoxacarb was 14.31 times, emamectin benzoate was 9.11 times and acephate was 5.11 times more toxic than spinosad.

Relative toxicity of insecticides against adults of predatory coccinellids

Acephate was found safest with LC_{50} 0.64 ppm and acetamiprid was the most toxic one with LC_{50} 0.097 ppm. Order of toxicity was acetamiprid > indoxacarb > imidacloprid > emamectin benzoate > spinosad > acephate. Acetamiprid was 6.08 times, indoxacarb was 5.96 times, imidacloprid was 3.51 times and emamectin benzoate was 2.21 times more toxic than spinosad. Acephate was 0.92 times less toxic than spinosad. Lower value of c^2 shows The heterogeneous response of test population to the insecticide doses. Grubs of predatory coccinellids were more susceptible to the insecticides than the adults.

Table 3 provides the values of relative resistance of different stages of predatory coccinellids, in relation to their aphid host and the comparative safety index of insecticides for predatory coccinellids. The relative resistance of grubs to the insecticides was highest for acephate followed by acetamiprid, spinosad,

Table 1: Relative toxicity of insecticides to Cotton Aphid (*Aphis gossypii*)

Sr. No.	Insecticides	LC50(ppm)	95 % Fiducial limits Lower	Upper	LC90(ppm)	Heterogenity (χ)*	Slope	Relative toxicity
1	Acetamiprid	0.007	0.0008	0.034	2.82	0.337	0.488	82.28
2	Acephate	0.025	0.0032	0.126	10.58	0.338	0.491	23.04
3	Imidacloprid	0.036	0.0048	0.161	13.82	0.487	0.495	16.18
4	Emamectin benzoate	0.368	0.0350	3.196	932.29	2.106	0.377	1.57
5	Indoxacarb	0.397	0.0542	1.801	140.99	0.354	0.502	1.45
6	Spinosad	0.576	0.0720	2.529	210.03	0.156	0.500	1

Tabular value of χ^2 at 0.05 level = 7.815; * In none of these cases, the data were found to be significant.

Table 2: Relative toxicity of insecticides against different stages of predatory coccinellids

Sr.No.	Insecticides	LC50(ppm)	95 % Fiducial limits Lower	Upper	LC90(ppm)	Heterogenity(χ^2)*	Slope	Relative toxicity
Early instar grubs								
1	Acetamiprid	0.014	0.003	0.051	6.646	0.651	0.4800	31.79
2	Imidacloprid	0.017	0.004	0.059	6.02	1.041	0.5036	26.18
3	Indoxacarb	0.020	0.003	0.081	8.262	0.38	0.4890	22.25
4	Emamectin benzoate	0.033	0.006	0.122	11.867	1.146	0.4724	13.48
5	Acephate	0.065	0.012	0.266	52.944	0.999	0.4405	6.85
6	Spinosad	0.445	0.074	1.974	490.73	0.171	0.4212	1
Late instar grubs								
1	Acetamiprid	0.018	0.003	0.070	10.967	0.102	0.4595	27.83
2	Imidacloprid	0.023	0.034	0.098	14.095	0.751	0.4575	21.78
3	Indoxacarb	0.035	0.008	0.129	10.442	0.306	0.5183	14.31
4	Emamectin benzoate	0.055	0.011	0.211	28.293	0.412	0.4724	9.11
5	Acephate	0.098	0.016	0.410	44.394	0.007	0.4825	5.11
6	Spinosad	0.501	0.080	2.111	271.667	0.943	0.4687	1
Adults								
1	Acetamiprid	0.097	0.019	0.360	108.75	0.431	0.4199	6.08
2	Imidacloprid	0.099	0.025	0.327	48.72	0.506	0.4764	5.96
3	Indoxacarb	0.168	0.037	0.647	165.13	0.457	0.4283	3.51
4	Emamectin benzoate	0.267	0.05	1.039	362.32	0.022	0.4091	2.21
5	Spinosad	0.590	0.140	2.276	471.04	0.007	0.4415	1
6	Acephate	0.640	0.157	2.213	365.45	0.049	0.4651	0.92

* In none of these cases, the data were found to be significant.

Table 3: Relative resistance of predatory coccinellids to the insecticides in relation to aphid host (Safety limits of insecticides) and comparative safety index of the insecticide

S.N.	Insecticide	Early instar grubs Relative Resistance(RR)	Comparative Safety Index	Late instar grubs Relative Resistance(RR)	Comparative Safety Index	Adults Relative Resistance(RR)	Comparative Safety Index
1	Acetamiprid	2.00	40	2.57	28.55	13.86	55.44
2	Imidacloprid	0.47	9.4	0.64	7.11	4.67	18.68
3	Indoxacarb	0.05	1	0.09	1	0.25	1
4	Emamectin benzoate	0.09	1.8	0.15	1.67	0.73	2.92
5	Acephate	2.60	52	3.92	43.55	25.6	102.40
6	Spinosad	0.77	15.6	0.87	9.67	1.02	4.08

imidacloprid, emamectin benzoate. Relative resistance to indoxacarb was the lowest. In case of adults, the relative resistance of was the highest for acephate (25.6) followed by acetamiprid (13.86), imidacloprid (4.67), spinosad (1.02), emamectin benzoate (0.73). Relative resistance to indoxacarb (0.25) was the lowest. It indicates that safety limit of insecticides for predatory coccinellid was the highest for acephate and the lowest for indoxacarb. As the relative resistance was the lowest for indoxacarb, comparative safety index of other insecticides were assessed by taking comparative safety index of indoxacarb as unity. It was highest for acephate.

DISSCUSSION

Acetamiprid was found most toxic to cotton aphid. Our findings are supported by the findings of Reddy and Gowdar (2006) and Suganya Kanna *et al.* (2007) who find acetamiprid as the effective insecticide against *Aphis gossypii*. On the basis of LC 50 value acephate was found toxic to aphid and ranked 2nd in case of toxicity. Our findings are in collaboration with the results of Konar and Paul (2005) who found acephate effective for controlling aphid. Imidacloprid was found moderately toxic to aphid. Preetha *et al.* (2007) revealed that imidacloprid 17.8 SL at the recommended dose of 25 g a.i.ha^{-}

[1]was effective in controlling the population of aphid *Aphis gossypii* Glover up to 25 days. Emamectin benzoate and indoxacarb and spinosad were found comparatively less toxic. On the basis of LC_{50} it can be predicted that acetamiprid is the most effective insecticide for the control of cotton aphid followed by acephate and imidacloprid.

In case of predatory coccinellids, acetamiprid was found highly toxic to all the stages on the basis of LC_{50} values and present investigation is in accordance with Youn *et al.* (2003) who reported that, LC_{50} values of acetamiprid for all the stages of coccinellid, *Harmonia axyridis* were much below than the dose recommended for aphid control. Also Arif *et al.* (2012) reported similar results. Imidacloprid was found toxic to all the stages of predatory coccinellids. Our results are in line with those of Khani *et al.* (2012) who reported little compatibility between *Cryptolaemus montrouzieri* and the use of imidacloprid. Indoxacarb was found moderately toxic to predatory coccinellids. Our results are supported by the results of Galvan *et al.* (2005) and Galvan *et al.* (2006) who reported adverse effects of indoxacarb on *Harmonia axyridis*. Emamectin benzoate was moderately toxic to predatory coccinellids. Our results are in line with the findings of Sharma and Kaushik (2010) who found emamectin benzoate toxic to natural enemies including lady bird beetle on egg plant (*Solanum melongena* L.). Acephate was found less toxic to grubs and adults of predatory coccinellids. Gour and Pareek (2005) found acephate as less toxic insecticide to 4th instar grubs and adults of *Coccinella septempunctata*. Spinosad was found the safest to predatory coccinellids. Similar results were reported Jalali *et al.* (2009). Due to want of literature the findings on relative resistance of coccinellid predators in relation to aphid host *i.e.,* safety limits for predator could not be compared.

The insecticides, acephate, acetamiprid and imidacloprid are widely used against sucking pests of different crops, as they are having systemic action. The insecticides spinosad, emamectin benzoate and indoxacarb are used widely against lepidopteran pest and are stomach poisons with contact activity. The predatory coccinellids present in the field may get adversely affected at the time of application of these insecticides. The neonicotinoids, acetamiprid and imidacloprid despite higher safety margin to coccinellid predators as compared to aphids, still showed very low LC_{50} values which were much below their recommended values. Acephate is safer for predatory coccinellids at the same time being effective against sucking pests. Relative resistance of coccinellid predator, in relation to aphid was exceptionally low to spinosad and it was comparatively lower for emamectin benzoate and indoxacarb. It shows that aphids are comparatively more resistant to these insecticides than the coccinellid predators. Despite lower safety margin to coccinellid predators as compared to aphids, spinosad showed higher LC_{50} values, hence can be considered as safe insecticide. The data will help plant protection workers to select the insecticides which are safer to predatory coccinellids. However, laboratory data may be of limited value to predict compatibility of insecticides and predatory coccinellids because coccinellid susceptibility to insecticides varies with the nature of exposure. Further field or semi-field studies under more realistic conditions may confirm the present results.

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