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Acute contact toxicity of selected conventional and novel insecticides to *Trichogramma japonicum* Ashmead (Hymenoptera: Trichogrammatidae)

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ABSTRACT

Eighteen insecticides belonging to conventional and novel chemical classes were evaluated for their toxic effects on the hymenopteran egg parasitoid *Trichogramma japonicum* Ashmead following the protocols recommended by International Organization for Biological Control (IOBC) in the Toxicology laboratory at College of Horticulture, Kerala Agricultural University during 2012-13. Commonly used conventional insecticides comprising six organophoshates (acephate 75 SP, chlorpyriphos 20 EC, dichlorvos 76 EC, dimethoate 30 EC, malathion 50 EC and quinalphos 25 EC); one carbamate (carbaryl 5 DP); one synthetic pyrethroid (fenvalerate 20 EC) and ten novel insecticides *viz*; acetamiprid 20 SP, emmamectin benzoate 5 SG, fipronil 80 WG, imidachloprid 200 SL, indoxacarb 14.5 SC, buprofezin 25 SC, chlorantraniliprole 18.5 SC, flubendiamide 480 SC, spinosad 2.5 SC and thiamethoxam 25 WDG at field recommended concentrations were tested for their acute contact toxicity against *T. japonicum* by adopting residual film bioassay method. The toxicity of insecticides was manifested as lethal effect on the adult parasitoids. Among the eighteen insecticides tested, acephate caused the highest mortality of 88.75 % and chlorantraniliprole caused the lowest mortality (21.25 %) to the adults of *T. japonicum*. Novel insecticides *viz*., emmemectin benzoate, fipronil, imidachloprid, indoxacarb, buprofezin and chlorantraniliprole were rated as 'harmless' as per IOBC safety classification whereas spinosad, thiamethoxam and flubendiamide were found 'slightly harmful' to *T. japonicum*. Conventional organophosphates *viz.*, acephate, chlorpyriphos and dichlorvos were 'moderately harmful'. Dimethoate, malathion, quinalphos carbaryl, fenvalerate and acetamiprid caused a mortality of 30 – 79 % leading them to be rated as 'slightly harmful' to adults of *T. japonicum*.

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INTRODUCTION

Egg parasitoids belonging to Trichogrammatidae family are known to be effective biocontrol agents against many pests in various crops (Takada *et al*., 2001). Nearly 200 species of Trichogramma have been identified of which 25 are used for pest management in 34 crops in 30 countries (Parra and Zuchi, 1997). Moura *et al*., 2004 reported that the use of *Trichogramma* species is a potential key strategy in pest management. But its effectiveness largely depends on the use of insecticide that does not interfere with parasitism and parasitism viability. A key principle of integrated pest management (lPM) is to maximize pest control from natural mortality factors such as predators and parasitoids. These are supplemented with pesticides, by ensuring minimal disruption of biological control agents. It is important that chemical agents are compatible with natural enemies. (Schuld and Schmuck, 2002; Nasreen *et al.*, 2003; Youn *et al.*, 2003). One major purpose of Integrated Pest Management (IPM) strategies is to unify the safe and sustainable use of chemical and biological control method. Therefore the side effects of pesticides on biocontrol agent should be evaluated for induction in IPM programmes.

MATERIALS AND METHODS

Insect: *T. japonicum* was maintained on eggs of the host, *Corcyra cephalonica* Stainton (Lepidoptera: Pyralidae) reared on broken bajra. The host eggs were glued on paper cards (5 X 1 cm) impregnated with glue and the developing embryo were killed by ultra violet (UV) irradiation before being offered to parasitoids for parasitisation. After the parasitism period (24 h), parasitized eggs were transferred to sealed plastic covers and were kept for adult emergence.

Insecticides: Eighteen conventional and novel insecticides were selected on the basis of their current and potential use for the management of insect pests in paddy. Commonly used conventional insecticides of 6 organophoshates (acephate 75 SP, chlorpyriphos 20 EC, dichlorvos 76 EC, dimethoate 30 EC, malathion 50 EC and quinalphos 25 EC); one carbamates (carbaryl 5 DP); 1 Synthetic pyrethroid (fenvalerate 20 EC) and 10 novel insecticides *viz*; acetamiprid 20 SP, emmamectin benzoate 5 SG, fipronil 80 WG, imidachloprid 200 SL, indoxacarb 14.5 SC, buprofezin 25 SC, chlorantraniliprole 18.5 SC, flubendiamide 480 SC, spinosad 2.5 SC and thiamethoxam 25 WDG were tested at their field recommended concentration for their acute contact toxicity by adopting residual film bioassay method.

Acute contact toxicity. A dry film residue method was used to assess the acute toxicity of insecticides on *T.japonicum* (Desneux *et al*. 2006). The experiments were carried out in Completely Randomised Design (CRD) with five insecticide treatment along with an untreated control and four replications for each treatment. Insecticide solutions at the field recommended concentration were used to determine the acute contact toxicity which was manifested as lethal effect. A quantity of 0.5 ml of insecticide solution was introduced into test tubes (45 ml capacity with an internal surface area of 80 cm^2) for preparing dry film residue and the tube was then manually rotated on the palms so as to ensure uniform residue within the test tube. An untreated control with water alone was also maintained. Twenty freshly emerged adult wasps were transferred into each test tube and covered with a muslin cloth secured with a rubber band. After four hours of exposure to the insecticide residue in the treated test tube, the wasps were transferred to other clean test tubes. Cotton swabbed with 50 % honey was kept inside the tube as adult food. Mortality of adult wasps was recorded at 24 hrs.

RESULTS AND DISCUSSION

Results of acute contact toxicity of selected conventional and novel insecticides to the hymenopteran egg parasitoid are summarised in Table 1. Results indicated that mortality of the egg parasitoid to insecticides ranged between 21.25 % to 88.75 % at 24 hrs after treatment. The highest mortality was observed in acephate treatment (88.75 %) followed by dichlorvos and chlorpyriphos and were thus rated as moderately harmful to *T. japonicum* adults according to IOBC safety scale classification. All the insecticides belonging to the cateogary of moderately harmful came under organophosphates. Conventional insecticides *viz.*, dimethoate, malathion, quinalphos, carbaryl, fenvalerate and acetamiprid and novel insecticides including flubendiamide, spinosad and thiamethoxam were rated as slighly harmful to the adults of *T. chilonis* at 24 hrs after treatment. Imidachloprid, indoxacarb, buprofezin, fipronil and chlorantraniliprole were found to be harmless. Chlorantraniliprole belonging to phthalic acid group was found to be the safest to *T. japonicum* adults at 24 hrs after treatment.

Organophosphates and carbamates are toxic to insects by virtue of their ability to inactivate acetylcholinesterase (Carmo *et al*., 2010). This type of poisoning causes loss of the available acetylcholinesterase and over-stimulations of organs by excessive acetylcholine at the nerve endings. The effects of organophosphates and carbamates on pests and natural enemies are similar (Fukuto, 1990). Thus the two classes of insecticides had high acute toxicity to *T. japonicum.* Noxious results of organophosphates and carbamates on beneficial arthropods have been reported in the literature (Hassan *et al*., 1988; Bueno *et al.*, 2008). Generally, the organophosphate and carbamates are among the cheapest insect-control products available to the rice growers, thus they are often overused. However, our results as well as previous studies showed that these insecticides were not compatible with natural enemies (Wang *et al*., 2008b; Carmo *et al*., 2010). Therefore, organophosphates and carbamates should be limited or replaced by relatively safe plant protection products in IPM programs.

JBiopest 7(Supp.): 133-136(2014)

Our results also showed that imidacloprid had low toxicity to *T. japonicum,* which was consistent with previous studies. Imidacloprid was relatively safe to *Trichogramma* nr. *Brassicae* (Hewa-Kapuge *et al.*, 2003). Emamectin benzoate belongs to macrocyclic lactone group of insecticides with broad-spectrum and high efficiency against target insect pests (Lastota and Dybas, 1991). Our study also indicated that Emamectin benzoate was safe to *T. japonicum.* Similar results were reported with regard to the effects of Emamectin benzoate on *T. chilonis* and *T. pretiosum,* confirming its compatibility with biological control strategies (Giraddi and Gundannavar 2006). Emmamectin benzoate was reported to be safe to *T. absoluta* which is in line with our results (Sayed *et al*., 2014).

Table 1. Acute contact toxicity of conventional and novel insecticides to *Trichogramma japonicum* at 24 hrs after treatment

Insecticide	Chemical class	FRC (g a.i/ha)	Adult mortality	IOBC safety scale
Acephate 75 SP	Organophosphate	500	88.75^{n}	Moderately harmful
Chlorpyriphos 20 EC	Organophosphate	200	81.25^{l}	Moderately harmful
Dichlorvos 76 EC	Organophosphate	375	86.25^{m}	Moderately harmful
Dimethoate 30 EC	Organophosphate	200	73.75^{k}	Slightly harmful
Malathion 50 EC	Organophosphate	500	71.25^{k}	Slightly harmful
Quinalphos 25 EC	Organophosphate	250	66.25^{j}	Slightly harmful
Carbaryl 5 DP	Carbamate	1250	48.75^{h}	Slightly harmful
Fenvalerate 20 EC	Synthetic pyrethroid	60	57.50^{i}	Slightly harmful
Acetamiprid 20 SP	Neonicotinoid	10	72.50^{k}	Slightly harmful
Emmemectin benzoate 5 SG	Avermectin	10	28.75^{dc}	Harmless
Fipronil 80 WG	Fiprole	40	23.75^{bc}	Harmless
Imidachloprid 200 SL	Neonicotinoid	30	30.00^{f}	Harmless
Indoxacarb 14.5 SC	Oxadiazine	75	27.50^{cde}	Harmless
Buprofezin 25 SC	Thiadiazine	200	25.00^{bcd}	Harmless
Chlorantraniliprole 18.5 SC	Anthranilic diamide	30	21.25^{b}	Harmless
Flubendiamide 480 SC	Phthalic acid Diamide	25	37.50^{g}	Slightly harmful
Spinosad 2.5 SC	Spinosyn	75	38.50^{g}	Slightly harmful
Thiamethoxam 25 DG	Neonicotinoid	25	40.00^{g}	Slightly harmful
Untreated control			0.0000^{a}	

In a column, means superscripted by a common letter are not significantly different by DMRT (P=0.05)
Rating of insecticide (IOBC safety scale); 1 - Harmless (< 30 % mortality), 2 - Slightly harmful (30 – 79 % mortality), 3 - Moderately harmful (80 –99 % mortality), 4 - Harmful (> 99% mortality).

Results from this study showed that both nitenpyram and thiamethoxam had high acute contact toxicity and thiamethoxam had slightly to moderately toxic risk to *T. japonicum.* This high toxicity of neonicotinoids to *Trichogramma* spp. has been demonstrated in other studies. For example, thiamethoxam has been shown to be toxic to the egg parasitoids of *Trichogramma pretiosum* Riley, *Trichogramma chilonis* Ishii, and *Trichogramma platneri* Nagarkatti (Brunner *et al*., 2001; Williams and Price, 2004; Preetha *et al*., 2009). It is important to point out that the dry film residue method does not account for possible influences of the plant surfaces (e.g. absorption) on insecticide residues. Therefore, in addition to mortality, an assessment of the impact of an insecticide on natural enemies together with information on the residue activity of insecticides on plant surfaces under field conditions as well as their potential sub-lethal effects are also important (Carmo *et al*., 2010).

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