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Susceptibility of Males and Females of Cucumber Fruit Fly, *Dacus ciliatus*, to Various Insecticides in the Laboratory Conditions

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Abstract

The cucumber fly, *Dacus ciliatus* Loew., is a destructive pest of cucurbit crops in some regions of Iran. Susceptibility of adults of *D. ciliatus* to various insecticides (deltamethrin, dimethoate, trichlorofon, spinosad, acetamiprid, and malathion) was investigated. The insecticide toxicity was tested through contact method in three stages (males only, females only, and a mixture of males and females). The results showed that the used insecticides excellently affected on males and females of *D. ciliatus* through contact toxicity. Also, their effect on the mixture of males and females was acceptable. In addition, dimethoate and deltamethrin were better than the others. The LC_{50} values of these two were less than 1 mg L^{-1}. Also, except for acetamiprid, LC_{50} vales of all other insecticides on males and females were close.

Keywords: *Dacus ciliatus*, LC_{50}, chemical control, deltamethrin, dimethoate, trichlorofon, spinosad, acetamiprid, malathion

1. Introduction

Fruit flies (Diptera: Tephritidae) are among the most important pests worldwide. The genus *Dacus* causes severe damage to fruits and vegetables in Asia. The cucumber fly, *Dacus ciliatus* Loew., is a major pest of cucurbits in some countries (Azab *et al.*, 1970; Nagappan *et al.*, 1971). *D. ciliatus* is a pest of the most of eastern, southern, and central Africa, Arabian Peninsula, Pakistan and India. Its color is orange, with facial spots. The costal band in it is apically extended to form an apical spot and a basal sloping spot. There are two black spots in abdomen particularly in females (White and Elson-Harris, 1994). In Iran, this pest is a major pest of cucumber, watermelon and cantaloupe. Also milkweed and colocynth are other hosts of this pest in Iran (Arghand, 1983).

The used insecticides in this study were deltamethrin, dimethoate, trichlorofon, spinosad, acetamiprid and malathion. A pyrethroid compound, deltamethrin (1R,3S) [α-cyano(3-phenoxyphenyl) methyl]- 3- (2, 2-dibromo-ethenyl)- 2, 2-dimethylcyclopropanecarboxylate) kills insects through contact and ingestion. Its mode of action has not been known though; pyrethroids affect neuroactivity by delaying the closing the channels of sodium (Corbett *et al.*, 1984).

Acetamiprid ((E)-N1-[(6-chloro-3-pyridyl) methyl]-N2-cyano-N1-methylacetamidine) is neonicotinoid that has high activity and is used to controlling insects of various orders on a broad range of plants, particularly vegetables and fruits (Roberts and Hutson 1999; Tomlin 2000). Spinosad (mixture of 50–95% (2*R*,3a*S*,5a*R*, 5b*S*,9*S*,13*S*,14*R*,16a*S*,16b*R*)-2-(6-deoxy-2,3,4-tri-*O*-methyl-α-L-mannopyranosyloxy)-13-(4-dim-ethylamino-2,3,4,6-tetradeoxy-β-D-erythropyrano-syloxy)-9-ethyl-2, 3,3a,5a,5b,6,7,9,10,11,12,13, 14,15,16a, 16b-hexadecah-ydro-14-methyl-1*H-as*-indaceno[3,2-*d*]ox acyclododecine-7,15-dione and 50–5% (2*S*,3a*R*,5a*S*, 5b*S*, 9*S*, 13*S*, 14*R*, 16a*S*,16b*S*)-2-(6-deoxy-2,3,4-tri-*O*-methyl-α-L-manno-pyranosyloxy)-13-(4-dimethylamino-2,3,4,6-tetradeoxy-β-D-erythropyranosyloxy)-9-ethyl-2,3,3a,5a, 5b,6,7,9,10, 11, 12,13,14,15,16a,16b-hexadecahydro-4,14-dimethyl-1*H-as*-indaceno[3,2-*d*]oxacyclododecine-7,15-dione) is a selective insecticide based on a fermentation product of the soil bacterium actinomycete (*Saccharopolyspora spinosa*) (Miles and Dutton,2000). Malathion, as organophosphorus insecticide, is most used insecticide in agriculture. Its mode of action is anticholinesterase (Sharma *et al.*, 2005). Low toxicity of malathion on mammalian and its low price have changed it as a good choice for control of fruit flies (Rossler 1989; Steiner *et al.*, 1961). Trichlorfon is another organophosphorus insecticide. It is widely used in agriculture as a selective insecticide based on its mode of action (inhibitor of acetylcholinesterase) (Staples *et al.*, 1976).

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The fruit fly *D. ciliatus* is important in Iran and it is a major pest in many provinces of Iran. The main method for controlling this pest and other fruit flies is chemical control in Iran. Therefore, applying the effective insecticide for this method can be efficient and useful. In this study, we investigated the contact effect of various insecticides (deltamethrin, dimethoate, trichlorofon, spinosad, acetamiprid, and malathion) on *D. ciliatus* in three stages (effect on males, on females, and on a combination of males and females). LC_{50} values of these insecticides were calculated separately.

2. Materials and Methods

2.1. Insect stock

Dacus ciliatus colony was collected from cucumber fields of Varamin in the east of Tehran, Iran in early October of 2008. For this, the infested small cucumbers, *Cucumis sativus*, having larvae of this pest, were collected and transferred to laboratory. The cucumbers were placed in the trays (1×1m) with their bottoms covered by loam soil, 1cm in thickness, until leaving the larvae. For preventing the escape of the adults, the trays were covered by plastic cages, too. A sugar solution (10%) was used for feeding the adults in the cages. Insect rearing and all bioassay tests were performed at 25 ± 2 °C and 65 ± 5% relative humidity under a 12:12 (L:D) photoperiod in the growth chamber.

2.2. Insecticides

The formulated insecticides, used in the present study, were spinosad [Tracer 240 SC (AI)] deltamethrin [Decis 2.5% EC (AI)], dimethoate [40% EC (AI)], trichlorofon [Diptrix 80% SP (AI)], acetamiprid [Mospilan 20% SP (AI)], and malathion [50% EC (AI)].

2.3. Bioassay tests

The bioassay tests of this study were performed in three sections (Bioassay on males only, on females only, and on a mixture of males and females). For bioassay tests, the contact toxicity was used. All concentrations of insecticides were prepared in water. As a control, water was used. For bioassays, Petri dishes (9 cm in diameter) were sprayed with various concentrations of insecticides, and, then, they were permitted to dry at room temperature for 2 h. Ten 5 day-old adult insects were placed in each Petri dish after catching by aspirator. In the test on mixture sexes, 5 individuals were selected from each sex. A sugar solution (10%) was used to feed the insects. These tests were repeated 4 times. Mortality was recorded 24 h after treatment. The data were analyzed by Proc Probit using SAS software (SAS Institute 1997). This method for all tests was alike.

3. Results

3.1. Toxicity on males

Table 1 shows the values of LC_{50} of various insecticides on males of the cucumber fly. Values of LC_{50} of tested deltamethrin, dimethoate and trichlorfon were 0.39, 0.24 and 1.57 mg L^{-1}, respectively. LC_{50} values of spinosad, acetamiprid and malathion were 8.03, 6.87 and 2.28 mg L^{-1}, too. Results of bioassay showed that the dimethoate LC_{50} was the lowest compared to others. On the other hand, the susceptibility to spinosad was lower than others. Toxicity ratio of dimethoate on males was 1.62, 6.54, 33.45, 28.65 and 9.5 folds higher than deltamethrin, trichlorfon, spinosad, acetamiprid and malathion, respectively.

3.2. Toxicity on females

In table 2, the effects of the mentioned insecticides on females of cucumber fly are shown. Values of LC_{50} of deltamethrin, dimethoate, trichlorfon, spinosad, acetamiprid and malathion on *D. ciliatus* females were 0.52, 0.4, 2.4, 8.52, 19.88 and 3.57 mg L^{-1}. The toxicity of dimethoate on females was the highest compared to others. It was 0.76, 6, 21.3, 49.7 and 8.92 folds higher than deltamethrin, trichlorfon, spinosad, acetamiprid and malathion. It is clear that toxicity of acetamiprid is the lowest on females. Also, comparing the toxicity of these insecticides on males and females is shown in fig. 1. Figure 1 shows that males of *D. ciliatus* were more susceptible than females. This difference was clearer in acetamiprid.

3.3. Effect on mixture of males and females

Table 3 displays the effect of insecticides on mixture of 50% males: 50% females of *D. ciliatus*. Similar to the results of table 2, the highest susceptibility of adults was showed in dimethoate compared to others (table 3). LC_{50} values of deltamethrin, dimethoate, trichlorfon, spinosad, acetamiprid and malathion on adults were 0.45, 0.28, 1.95, 8.20, 11.50 and 2.85 mg L^{-1}, respectively; their lowest toxicity was seen in acetamiprid.

4. Discussion

In this study, the effectiveness of various insecticides belonging to organophosphorus, pyrethroids, biorationals and neonicotinoides (deltamethrin, dimethoate, trichlorofon, spinosad, acetamiprid and malathion) on male, female and both sexes of *D. ciliatus* was investigated. Aetamiprid was selected because of its safe effect on human beings and trichlorofon due to its selectivity on Diptera. This is the first research on the toxicity of these insecticides to investigate *D. ciliatus*; hence, the results were compared with the results on other insects.

Our results showed that dimethoate had the lowest toxicity on males, females, and both males and females. On the other hand, LC_{50} values of spinosad and acetamiprid were higher than the others. Also a pyrethroid insecticide, deltamethrin, has a good toxicity on this pest compared to malathion. Similar to this, Malakov *et al.* (2001) reported that toxicity of a pyrethroid insecticide (fenpropathrin) was higher than malathion. Using broad spectrum insecticides causes adverse effects on natural enemies, natural resource and human health. Also, secondary pest outbreaks in this condition (Emden and Peakall 1996). Hence, replacing these compounds with low side effect insecticides such as spinosad might be important. Vargas *et al.* (2003) stated that spinosad is a good replacement for DDVP and naled for killing the male oriental fruit flies and melon flies (Dipter: Tephritidae).

Table 1. Susceptibility of *Dacus ciliatus* males exposed to various insecticides in the laboratory conditions

	n[a]	df	LC_{50} (mg L^{-1})	Slope ± SE	χ^2	Toxicity Ratio
Deltamethrin	300	6	0.39 (0.29-0.55)	1.58 ± 0.23	3.32	1.62
Dimethoate	300	4	0.24 (0.13-0.28)	1.82 ± 0.28	1.09	1
Trichlorfon	300	5	1.57 (1.32-1.85)	1.89 ± 0.15	4.2	6.54
Spinosad	300	4	8.03 (2.94-11.64)	3.26 ± 1.26	2.04	33.45
Acetamiprid	300	4	6.87 (3.31-11.07)	1.5 ± 0.33	0.65	28.65
Malathion	300	4	2.28 (0.90-3.27)	3.79 ± 1.3	2.2	9.5

n[a]: number of subjects

Table 2. Susceptibility of females of *Dacus ciliatus* exposed to various insecticides in the laboratory conditions

	n[a]	df	LC_{50} (mg L^{-1})	Slope ± SE	χ^2	Toxicity Ratio
Deltamethrin	300	6	0.52 (0.38-0.75)	1.48 ± 0.22	2.8	0.76
Dimethoate	300	4	0.4 (0.25-0.53)	1.89 ± 0.41	1.1	1
Trichlorfon	300	5	2.4 (2.02-2.80)	2 ± 0.17	2.4	6
Spinosad	300	4	8.52 (1.46-12.26)	3.69 ± 1.58	1.9	21.3
Acetamiprid	300	4	19.88 (7.30-12.10)	2.8 ± 0.75	0.74	49.7
Malathion	300	4	3.57 (1.87-6.24)	2. 9 ± 1.18	2.61	8.92

n[a]: number of subjects

Table 3. Susceptibility of mixture of males and females of *Dacus ciliatus* exposed to various insecticides in the laboratory conditions

	n[a]	df	LC_{50} (mg L^{-1})	Slope ± SE	χ^2	Toxicity Ratio
Deltamethrin	300	6	0.45 (0.36-0.57)	1.51 ± 0.16	3.7	1.6
Dimethoate	300	4	0.28 (0.21-0.35)	1.71 ± 0.21	2.04	1
Trichlorfon	300	5	1.95 (1.72-2.18)	1.92 ± 0.11	5.44	6.94
Spinosad	300	4	8.20 (5.04-10.60)	3.45 ± 0.98	3.71	29.28
Acetamiprid	300	4	11.50 (7.34-15.76)	1.76 ± 0.33	2.3	41.07
Malathion	300	4	2.85 (1.99-3.76)	3.18 ± 0.8	2.65	10.17

n[a]: number of subjects

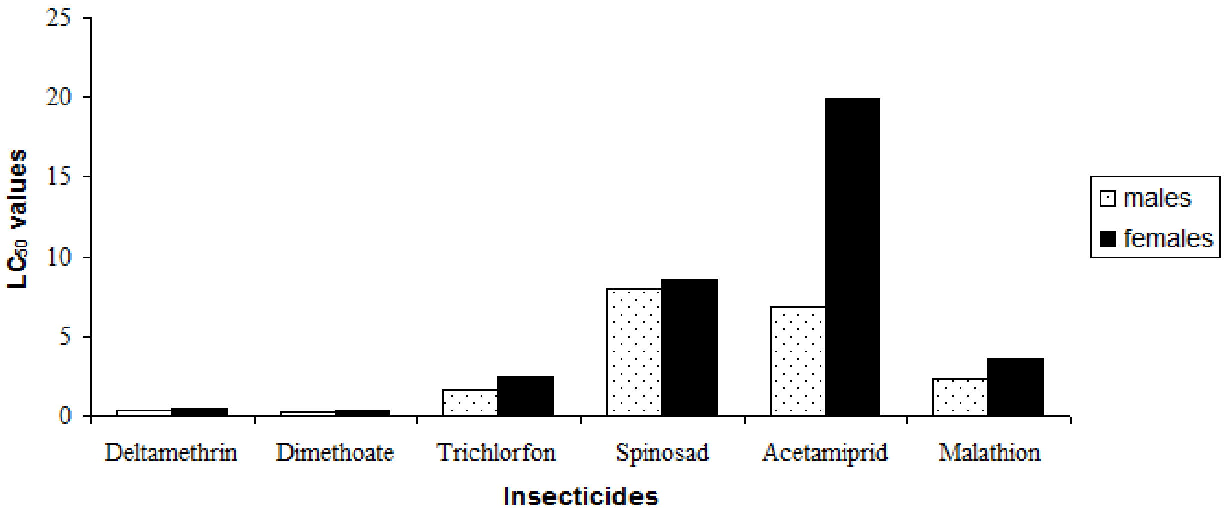

Figure 1. Comparing LC_{50} values of various insecticides on mixture of males and females of *Dacus ciliatus* in the laboratory conditions.

King and Hennessey (1996) underlined the effect of spinosad on males and females of Caribbean fruit fly, *Anastrepha suspense* (Loew) (Diptera:Tephritidae) and reported that spinosad is a good candidate for controlling it. Barry *et al.* (2004) investigated the effect of neonicotinoids (imidacloprid and acetamiprid) on a fruit fly, *Rhagoletis mendex*. They reported that acetamiprid, unlike imidacloprid, had no knock down property on that pest. Similar to this research, Olszak and Maciesiak (2004) found that acetamiprid had a good effect on blueberry maggot fly, *Rhagoletis cerasi* (Diptera: Tephritidae). Similar to the current results, Hu *et al.* (2000) stated that dimethoate is a good choice for controlling the females of *Rhagoletis pomonella* (Diptera: Tephritidae). Khan and Khattak (2000) stated that trichlorofon and malathion decreased populations of melon fruit fly, *Bactrocera cucurbitae* (Coq) and muskmelon fruit fly, *Cucumis melo* (L.) compared to the untreated group.

In Conclusion, the insecticides used in this study excellently affected males and females of *D. ciliates*; these insecticides can be useful for their chemical control. Among these insecticides, deltamethrin and dimethoate were better than others. The LC_{50} values of these two were <1 and therefore, can be important for selecting the best choice. Also, except acetamiprid, the efficacy of insecticides on males and females was approximately similar.

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