Selectivity of insecticides with and without mineral oil to *Brachygastra lecheguana* (Hymenoptera: Vespidae), a predator of *Tuta absoluta* (Lepidoptera: Gelechiidae)

G. L. D. Leite, M. Picanço, R. N. C. Guedes and M. R. Gusmão[1]

Abstract. Dose-response regression lines were estimated for adults of *Brachygastra lecheguana* (Latreille) (Hymenoptera: Vespidae) exposed to the insecticides abamectin, cartap, phentoate, and permethrin with or without 0.5% (v/v) mineral oil. Insects were exposed to treated tomato leaves and mortality was evaluated after 24 hours. The estimated LC_{50}s and LC_{99}s for *B. lecheguana* were compared to estimated LC_{50}s and LC_{99}s previously obtained for larvae of *Tuta* (= *Scrobipalpuloides*) *absoluta* (Meyrick) (Lepidoptera: Gelechiidae), the main tomato pest in much of South America. The most selective insecticides favoring the predator were abamectin and cartap with differential selectivity indexes (LC_{50} predator, LC_{50} pest) of 9.5 and 8.6, respectively. The worst differential selectivity was obtained with permethrin. Mineral oil increased selectivity in favor of the predator when in mixture with abamectin, permethrin, and cartap, but had a strong negative effect on phentoate selectivity.

Key words: Tomato leafminer, insecticide selectivity, tomato, predator.

Resumen. Las curvas de regresión para respuesta a dosis fueron estimadas en adultos de *Brachygastra lecheguana* (Latreille) (Hymenoptera:Vespidae) expuestos a los insecticidas abamectina, cartap, fentoato, y permetrina, con y sin aceite mineral al 0.5% (v/v). Los insectos fueron expuestos a hojas de tomate aplicadas con los insecticidas, y la mortalidad fue evaluada después de 24 horas. Los valores estimados para LC_{50}s y LC_{99}s para *B.lecheguana* fueron comparados a los valores LC_{50}s y LC_{99}s obtenidos previamente para las larvas de *Tuta* (= *Scrobipalpuloides*) *absoluta* (Meyrick) (Lepidoptera: Gelechiidae), la principal plaga del tomate en la mayor parte de Sur América. Los insecticidas más selectivos y que favorecieron al depredador fueron la abamectina y el cartap con índices selectivos (LC_{50} predador, LC_{50} plaga) de 9.5 y 8.6, respectivamente. La menor selectividad fue obtenida con permetrina. El aceite mineral incrementó la selectividad en favor del depredador cuando fue mezclado con abamectina, permetrina y cartap, pero tuvo un efecto negativo sobre la efectividad del fentoato

Palabras claves: Minador de la hoja, selectividad de insecticida, tomate, depredador.

INTRODUCTION

The tomato leafminer, *Tuta (= Scrobipalpuloides) absoluta* (Meyrick) (Lepidoptera: Gelechiidae), is considered the main pest of tomato in Brazil (Souza *et al.*, 1992; Guedes *et al.*, 1994). It was reported for the first time in Brazil by Moreira *et al.* (1981), but its existence in other South American countries is known since the 1970s (Vargas, 1970; Razuri and Vargas, 1975; Moore, 1983). At present, this pest is widely distributed not only in Brazil, but also throughout South America.

Current control of *T. absoluta* is achieved through 10 to 14 insecticide applications during the tomato cycle (Souza *et al.*, 1992). Abamectin, cartap, phentoate, and permethrin are the main insecticides used, but the control is frequently unsatisfactory (Andrei, 1993; Guedes *et al.*, 1995). It is believed that the maintenance of the pest's natural enemies in the area would be very beneficial to its control, but there is virtually no information available concerning the selectivity of insecticides in favor of predaceous wasps, despite their importance as natural biological control agents for integrated pest management programs (Nakasuji *et al.*, 1976; Hebling-Beraldo *et al.*, 1982; Dowell and Johnson, 1986).

[1] Departamento de Biologia Animal, Universidade Federal de Viçosa, Viçosa, Minas Gerais 36571-000, Brasil.

Ceiba, 1998. Volumen 39 (2): 191-194

The use of mineral oil in insecticide mixtures against *T. absoluta* has been recently introduced due to its synergistic effect on insecticide efficiency towards this pest (Souza *et al.* 1992; Guedes *et al.*, 1995). However, the effect of mineral oil in insecticide toxicity to natural enemies, especially predaceous wasps, is still unknown. Therefore, this study was carried out to investigate the selectivity of insecticides currently recommended against *T. absoluta* to one of its main predators in Brazil, the wasp *Brachygastra lecheguana* (Latreille) (Hymenoptera: Vespidae).

MATERIAL AND METHODS

The insecticides used were abamectin (Vertimec® 18 EC), cartap (Cartap® 500 WP), phentoate (Phentoate® 500 EC), and permethrin (Ambush® 500 EC) with and without 0.5% mineral oil (Triona® 80%) without emulsifier. Each insecticide or insecticide mixture was diluted in water to the desired concentration and non-infested tomato leaves were immersed in the insecticide solutions for 5 seconds, air dried for 2 hours, and placed in Petri dishes of 9 cm diameter and 1.5 cm height. Ten field-collected adult wasps were released in each Petri dish which were covered with cloth and left for 24 hours under controlled conditions of 25 ± 0.5 C and 75 ± 5% relative humidity. Mortality was assessed after 24 hours of exposition to the dried insecticide residues; honey + sugar (1:1) was provided during this period. Insects were considered dead if they were unable to walk. At least four concentrations were used for each insecticide with and without mineral oil, and four replicates were used for each concentration. The concentrations used were 0.135, 0.088, 0.068, 0.044, and 0.022 mg/ml for abamectin; 0.176, 0.088, 0.044, 0.034, and 0.017 mg/ml for abamectin + mineral oil; 4.0, 3.0, 2.0, 1.0, 0.75, and 0.37 mg/ml for cartap; 4.0, 3.0, 2.0, 1.50, 0.37 mg/ml for cartap + mineral oil; 0.060, 0.045, 0.023, and 0.015 mg/ml for phentoate; 0.100, 0.045, 0.030, 0.015, and 0.011 mg/ml for phentoate + mineral oil; 0.010, 0.004, 0.003, 0.002, 0.001, and 0.0005 mg/ml for permethrin; 0.020, 0.004, 0.002, 0.001, and 0.0005 mg/ml for permethrin + mineral oil. Control treatments were water only, since water provided results similar to water with mineral oil, as observed in preliminary assays.

The results obtained were subjected to probit analysis (Finney, 1971) using the procedure REGREPRO from the System of Statistical and Genetics Analysis of the Federal University of Viçosa. With the estimated values of LC_{50}s and LC_{99}s for *B. lecheguana* and *T. absoluta,* the differential selectivity indexes (DSI = LC_{50} or LC_{99} predator, LC_{50} or LC_{99} pest) were calculated for each insecticide. The toxicity rate (TR = LC_{50} or LC_{99} insecticide, LC_{50} or LC_{99} insecticide + mineral oil) was also calculated for each insecticide. The estimated LC_{50}s and LC_{99}s for *T. absoluta* that we used to calculate DSI were obtained by Guedes *et al.* (1995) using the same methods employed here.

Table 1. Dose-response regression lines and LC_{50} and LC_{99} estimates for *Brachygastra lecheguana* using four insecticides with or without the addition of mineral oil (MO) at 0.5 % (v/v).

Insecticides	Equations[a]	LC_{50} (CI 95%) (mg/ml)	LC_{99} (CI 95%)(mg/ml)	X^2	Probability
Abamectin	y= 7.574 + 1.213x	0.0076 (0.0018-0.0138)	0.6292 (0.2907-3.9281)	0.4	0.95
Abamectin + MO	y= 8.122 + 1.952x	0.0251 (0.0204-0.0296)	0.3928 (0.2601-0.7289)	4.8	0.19
Cartap	y= 3.357 +-2.532x	2.9896 (2.6939-3.3779)	17.8905 (13.0080-27.9206)	2.4	0.67
Cartap + MO	y= 1.687 + 4.440x	5.5758 (4.7207-7.6728)	18.6684 (11.7539-48.1409)	5.9	0.11
Phentoate	y= 8.357 + 2.532x	0.0472 (0.0415-0.0558)	0.3929 (0.2438-0.8445)	3.5	0.17
Phentoate + MO	y=10.520 + 3.710x	0.0325 (0.0298-0.0356)	0.1379 (0.1120-0.1811)	7.2	0.06
Permethrin	y=15.726 + 3.731x	0.0013 (0.0012-0.0015)	0.0056 (0.0047-0.0070)	2.3	0.69
Permethrin + MO	y=11.459 + 2.566x	0.0030 (0.0027-0.0035)	0.0246 (0.0175-0.0390)	1.7	0.63

[a] y = probit; x = log concentration (mg/ml).

RESULTS

The dose-response regression lines for *B. lecheguana* for each insecticide and insecticide mixture are presented in Table 1. The toxicities of the insecticides with and without mineral oil were significantly ($P < 0.05$) different based on the overlap of confidence limits at LC_{50} and LC_{99}. Cartap was the least toxic insecticide to the predator followed by phentoate and abamectin. Permethrin was the most toxic with and without the addition of mineral oil.

The addition of mineral oil to the insecticide mixture affected insecticide toxicity to *B. lecheguana* (Table 2). Mineral oil decreased the toxicity of permethrin, cartap, and abamectin to the predator. However, phentoate toxicity increased with the use of mineral oil.

Table 3 shows the estimated values of DSI for each insecticide with and without mineral oil. Abamectin and cartap were the most selective insecticides in favor of the predator, while permethrin and phentoate were not selective. The use of mineral oil in mixture with abamectin, cartap, and permethrin improved the selectivity of these compounds in favor of the predator, but the mixture phentoate + mineral oil had the opposite effect.

Table 2. Effect of mineral oil on the toxicity of four insecticides to *Brachygastra lecheguana*.

Insecticides	Toxicity rate 50 (TR_{50}[a])	Toxicity rate 99 (TR_{99}[b])
Abamectin	0.30	1.60
Cartap	0.54	0.96
Phentoate	1.45	2.85
Permethrin	0.43	0.23

[a] $TR_{50} = LC_{50}$ insecticide, LC_{50} insecticide + mineral oil
[b] $TR_{99} = LC_{99}$ insecticide, LC_{99} insecticide + mineral oil

Table 3. Differential selectivity indices (DSI) for four insecticides with and without 0.5% mineral oil (MO) toward the predator *Brachygastra lecheguana* in relation to its prey, the tomato leafminer *Tuta absoluta*.

Insecticides	DSI_{50}[a] No MO	DSI_{50}[a] Plus MO	DSI_{99}[b] No MO	DSI_{99}[b] Plus MO
Abamectin	9.500	83.667	4.195	417.872
Cartap	8.569	38.322	8.021	17.909
Phentoate	0.105	0.467	0.086	0.054
Permethrin	0.002	0.023	0.00001	0.003[a]

[a] Differential selectivity index 50 (DSI_{50}) = LC_{50} predator, LC_{50} pest
[b] Differential selectivity index 99 (DSI_{99}) = LC_{99} predator, LC_{99} pest

DISCUSSION

We provide here information regarding the selectivity of insecticides to the predaceous wasp *B. lecheguana* in relation to its prey (*T. absoluta*) and the effect of mineral oil on the toxicity and selectivity of insecticides to this insect species. Insecticide toxicity differed among compounds with permethrin being the most toxic compound to the predator and cartap the least toxic. These results differ from those observed in *T. absoluta*, the common prey of *B. lecheguana* in tomato fields, where abamectin was the most toxic compound and permethrin was the least toxic compound to the insect pest (Guedes *et al.*, 1995).

One of the possible factors contributing for the differential insecticide toxicity to *B. lecheguana* is the differences in the lipophilic nature of the compounds used (water solubilities of 17.8, 0.02, 9×10^{-7}, and 10^{-4}% for cartap, phentoate, abamectin, and permethrin, respectively). These differences in water solubility may have led to differential rates of insecticide penetration through the lipophilic insect cuticle. In other words, more lipophilic compounds (i.e. compounds with lower water solubility) may have penetrated faster through the insect cuticle (Finlayson and MacCarthy, 1965, Awad and Castro, 1986).

Mineral oil presented a synergistic effect on all four insecticides used here when employed against *T. absoluta* (Guedes *et al*, 1995), but a different pattern was observed for *B. lecheguana*. Mineral oil has a rather antagonistic effect on the toxicity of permethrin, cartap, and abamectin to the predaceous wasp, whereas only phentoate is slightly synergized by mineral oil. These results suggest that the use of mineral oil will benefit the predator when in mixture with abamectin, cartap and permethrin in comparison with its prey. In fact, the use of mineral oil improved the selectivity in favor of *B. lecheguana* for not only abamectin, cartap, and permethrin, as expected, but also to phentoate when this insecticide was used in low concentrations. This may be due to the improved penetration of the insecticides into the tomato leaves when mineral oil is used, which not only may favor the control of *T. absoluta*, but may also decrease the contact of the predator *B. lecheguana* with the insecticides since smaller amounts of them are likely to be present on the leaf surface.

In summary, we report here the toxicity of insecticides to the predator *B. lecheguana* and report the beneficial effect of mineral oil in improving the selectivity of insecticides commonly used against *T. absoluta* in favor of its main predator in tropical areas of South America. The use of mineral oil in insecticide mixtures against *T. absoluta* is likely to provide a better control of this pest and be less harmful to its predator, therefore its use should be considered. Cartap was the least toxic insecticide to the predator, while permethrin was the most toxic and its use should be avoided when *B. lecheguana* is abundant in the area to be treated.

LITERATURE CITED

Andrei, E. 1993. Compêndio de Defensivos Agrícolas. São Paulo: Andrei.

Awad, M. and P.R.C. Castro. 1986. Introdução à Fisiologia Vegetal. p. 114-121. São Paulo, Nobel.

Dowell, R.V. and M. Johnson. 1986. *Polistes major* (Hymenoptera: Vespidae) predation of the treehopper, *Umbonia crassicornis* (Homoptera: Membracidae). Pan-Pacific Entomologist 62: 150-152.

Finlayson, D.G. and H.R. MacCarthy. 1965. The movement and persistance of insecticides in plant tissue. Residue Review 9: 14-52.

Finney, D. J. 1971. Probit Analysis. London, Cambridge University.

Guedes, R.N.C.; M.C. Picanço; A.L. Matioli and D.M. Rocha. 1994. Efeito de inseticidas e sistemas de condução do tomateiro no controle de *Scrobipalpuloides absoluta* (Meyrick) (Lepidoptera: Gelechiidae). Anais da Sociedade Entomológica do Brasil 23: 321-325.

Guedes, R.N.C.; M.C. Picanço; N.M.P. Guedes and N.R. Madeira. 1995. Sinergismo do óleo mineral sobre a toxicidade de inseticidas para *Scrobipalpuloides absoluta* (Lepidoptera: Gelechiidae). Pesquisa Agropecuária Brasileira 30: 313-318.

Hebling-Beraldo, M.J.A.; E.A. Rocha and V.L.L. Machado. 1982. Toxicidade de inseticidas (em laboratório) para *Polybia (Myrapetra) paulista* (Ihering, 1896) (Hymenoptera: Vespidae). Anais da Sociedade Entomológica do Brasil 10: 261-267.

Moore, J.E. 1983. Control of tomato leafminer (*Scrobipalpula absoluta*) in Bolivia. Tropical Pest Management 29: 231-238.

Moreira, J.O.T.; F.M. Lara and M.G.C. Churata-Masca. 1981. Ocorrência de *Scrobipalpula absoluta* (Meyrick) (Lepidoptera: Gelechiidae) danificando tomate rasteiro em Jaboticabal, São Paulo. *In*: Resumos do congresso brasileiro de entomologia, 7. Fortaleza: SEB, 58.

Nakasuji, F.; H. Yamanaka and K. Kiritani. 1976. Predation of larvae of tobacco cutworm *Spodoptera litura* (Lepidoptera: Noctuidae) by *Polistes* wasps. Konchu 44: 205-213.

Razuri, V.and E. Vargas. 1975. Biologia e comportamento de *Scrobipalpula absoluta* Meyrick (Lep.: Gelechiidae) em tomatera. Revista Peruana del Entomologia 18: 84-89.

Souza, J.C.; P.R. Reis and L.O. Salgado. 1992. Traça-do-tomateiro: histórico, reconhecimento, biologia, prejuízos e controle. Belo Horizonte: EPAMIG. (Bol. Téc. 38).

Vargas, H.C. 1970. Observaciones sobre la biologia y enemigos naturales de la polilla del tomate, *Gnorismoschema absoluta* (Meyrick) (Lepidoptera: Gelechiidae). Idesia 1: 75-110.

Resúmenes de Tesis/Thesis Abstracts