Vol. 51, n. 6 : pp. 1115-1119, November-December 2008
ISSN 1516-8913 Printed in Brazil

BRAZILIAN ARCHIVES OF BIOLOGY AND TECHNOLOGY
AN INTERNATIONAL JOURNAL

Mortality of *Bemisia tabaci* Biotype B (Sternorrhyncha: Aleyrodidae) Adults by Aliphatic and Aromatic Synthetic Sucrose Esters

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ABSTRACT

The B-strain of Bemisia tabaci *Gennadius is a key pest of several crops and chemical control is the main control method used by growers, although reduction in efficacy due to insecticide resistance has already been reported. The aim of this work was to investigate the insecticidal effect of an array of synthetic sucrose esters with the aliphatic and aromatic groups on whitefly adults. Sucrose butyrate, caprate, octanoate, palmitate, oleate, octaacetate, phthalate, benzoate, and sucrose diacetate hexaisobutyrate were tested. The solutions were prepared and applied on the adults caught on yellow sticky traps using the Potter spray tower. Long-chains sucrose aliphatic esters were more effective against the silverleaf whiteflies and the highest mortality was obtained with sucrose oleate and sucrose octanoate. Since these compounds were tensoactive, sodium dodecylsulphate was also tested for the comparison but no effect was observed. Sucrose butyrate and other aliphatic and aromatic sucrose polyesters showed negligible effect on the silverleaf whiteflies.*

Key words: Sucroesters, silverleaf whitefly, pest control, integrated pest management

INTRODUCTION

The whitefly, *Bemisia tabaci* (Gennadius) is a non-endemic and polyphagous pest of more than 500 species of the crops, vegetables, and ornamental plants (e.g., soybean, tomato, cotton, melon, and poinsettia) (Sundaramurthy, 1992; Fernandes, 1998). This pest is responsible for the direct and indirect damages to the crops. It is also a vector of several viruses (Brown and Czosnek, 2002). Initially, two biotypes (A and B) were described for *Bemisia tabaci* (Drost et al., 1998) but presently, several biotypes have been described. The infestation of B-biotype, classified as one of the most aggressive, occurred in the early 1990's in Brazil and increased tremendously during the next years (Lourenção and Nagai, 1994).

Whitefly chemical control is challenging because it causes natural enemies mortality (Michaud and McKenzie, 2004) and insecticide resistance development (Denholm et al., 2003; Gunning,

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2003). Furthermore, the latter has been a key factor for whitefly outbreaks (Prabhaker et al., 2003). Sucrose esters have been claimed as an alternative strategy to control the aphids and soft-bodied insects. The insecticidal activity of some natural and synthetic sucroesters has been reported (Liu et al., 1996; Chortyk et al., 1997). The natural sucroesters were obtained from several species of *Nicotiana* and *Petunia.* These sucroesters were mainly formed by different carboxylic acids whose chains varied from C_2 to C_{12} (Chortyk et al., 1996; Chortyk et al., 1997). It seems that sucroesters have a physical action on insects. These compounds remove the waxy protective coating of the insect's tegument causing dehydration (Puterka and Severson, 1995). The efficacy of these products increases in high humidity environments or by mixing them with the wetting agents (Xia and Johnson, 1997; Xia et al., 1997). Compared to the conventional pesticides, sucrose esters offer many advantages. However, large scale use of the natural sugar esters as pesticides might not be commercially viable because the amount found in the plants is very low. *Nicotiana trigonophylla* Dun. shows the highest content, although the concentration is less than 158 $\mu g/cm^2$ of the leaf surface (Chortyk et al., 1996). Therefore, it is necessary to develop new production methodologies for the sugar esters, preferentially by non-pollutant processes.

Sucrose esters can be produced by combining the common table sugar with (*i*) fatty acid chlorides (Thévenet et al., 1999), (*ii*) anhydrides (Gaertner, 1961), and (*iii*) methyl fatty acid esters or vegetables/animals glycerides by the transesterification process (Schuchardt et al., 1998; Polat and Linhardt, 2001). Because soybean oil contains mainly unsaturated long-chain fatty acids (oleic and linoleic acids) and a review of the literature indicated a lack of the studies on the insecticidal properties of sucrose oleate and sucrose linoleate on several arthropods, the aim of this work was to evaluate the effectiveness of sucrose oleate and an array of the synthetic sucrose esters on the mortality of the adult silverleaf whiteflies and to compare their toxicity with sucrose octanoate, the sole sucroester registered for the pesticide use with the Environmental Protection Agency (EPA) registration (#70950).

MATERIALS AND METHODS

Sucrose diacetate hexaisobutyrate (SAIB-100), sucrose octaacetate, sucrose benzoate, sucrose monopalmitate, and sucrose monocaprate were purchased from Sigma–Aldrich (Milwaukee, WI, USA). Sucrose octanoate, sucrose palmitate and sucrose oleate were synthetized by the transesterification reaction of sucrose with the respective fatty acid methyl esters and K_2CO_3 as catalyst (10% m/m of sucrose) at about 90-120^oC in dimethyl sulphoxide (DMSO) (Polat and Linhardt, 2001). Sucrose phthalate was prepared by reacting the phthalic anhydride with sucrose in DMSO at 80^oC. In all the cases, a stoichiometry of 1.1:1 (sucrose/other reagent) was used to obtain most of the monoesters. The sucroesters production was tracked by the thin layer chromatography using a mixture CCl_3/MeOH (5:1) as solvent. The synthesized compounds were isolated by the flash chromatograph silica gel (200 mash.) using acetone/hexane in different proportions as solvent.

The solutions used for the insect treatment were prepared in the water, methanol, ethanol, and acetone as a function of their solubility. The insects were also treated with the pure solvents used in the pulverization or with DMSO. An anionic surfactant, sodium dodecylsulfate (SDS) was also applied for the comparisons.

Whiteflies bioassays were carried out with the adult insects collected from the cabbage plants using the yellow sticky strips with 4 x 4 cm of exposed surface (Chortyk et al., 1997). Nine strips (replicates) were used per treatment onto which ca. 15 adults were adhered. The insects were sprayed with 2.0 ml of the test compound solutions using a Potter spray tower (Burkard Manufacturing, Hertfordshire, UK) at 5 lb/in^2 pressure. All the treatments were applied at two concentrations (1.0 and 2.0 g/L) (Puterka et al., 2003) for further comparison. After the pulverization, the insects were maintained at 25±1 ºC and 70±10% RH) for two hours. A stereoscopic microscope was used to examine the insects, which were considered dead when no movement was observed after gentle probing with a single bristle brush. The percentage mortality was calculated and the analysis of variance was performed (SAS Institute, 1996). The means were separated by the Tukey´s test. Data were arcsine $\sqrt{x/100}$ transformed to stabilize the error variance. The mortality was corrected according to Abbott (1925).

RESULTS AND DISCUSSION

Among the control solutions, ethanol was the most toxic (ca. 10% of mortality) to adult silverleaf whitefly followed by methanol (ca. 8%) and acetone (< 4%) (Table 1). The mortality caused by the DMSO at 2.0% (v/v) in water was very low (< 5 %). Therefore, the possibility of the interference of solvents on the bioassays was negligible. It was observed that only the sucroesters with the alquilic chains with eight or more carbons showed mortality rates higher than 50%. Sucrose octanoate and sucrose oleate caused the highest mortality (> 93%), followed by sucrose palmitate and sucrose monocaprate. In fact, all these compounds are characterized as surfactants, conversely to the other sucroderivatives tested, indicating that long-chain sucrose esters may act on the protective waxy cover of the insects, causing their death. Similar efficacy was expected for a common surfactant, but tests with the SDS showed non-satisfactory results at 2.0 g/L with a mortality rate around 10% and at 1.0 g/L even lower than pure sucrose at the same concentration (Table 1).

Table 1 - Mortality of *Bemisia tabaci* B-biotype adults caused by sucrose esters and control solutions after 2 h of application.

Treatment [1]	Conc. (g/L)	Mortality (± SEM)[2,3]	Corrected Mortality
Oleate (MeOH)	2.0	100.00±0.00 a	100.00
Octanoate	2.0	100.00± 0.00a	100.00
Oleate (EtOH)	2.0	99.42±0.58 a	99.40
Oleate (EtOH)	1.0	99.35±0.65 a	99.33
Octanoate	1.0	93.77±2.59 ab	93.64
Unpurified Palmitate (MeOH)	2.0	93.09±2.54 abc	92.94
Monopalmitate (MeOH)	2.0	88.08±4.47 abcd	87.83
Unpurified Palmitate (MeOH)	1.0	86.89±3.64 abcd	86.61
Monocaprate (MeOH)	2.0	83.39±3.77 bcde	83.04
Monocaprate (MeOH)	1.0	79.11±4.41 bcde	78.67
Oleate (MeOH)	1.0	78.98±6.33 bcde	78.54
Monopalmitate (MeOH)	1.0	76.89±1.62 bcdef	76.40
Oleate (Acetone)	2.0	67.41±5.88 def	66.72
Oleate (Acetone)	1.0	48.81±3.11 fgh	47.72
SAIB (MeOH)	2.0	38.25±5.93 ghi	36.94
Benzoate (Acetone)	1.0	35.87±3.87 ghi	34.51
SAIB (MeOH)	1.0	32.85±2.46 ghi	31.43
Benzoate (Acetone)	2.0	27.83±4.48 hij	26.30
Octaacetate (Acetone)	2.0	26.63±4.28 hij	25.03
Octaacetate (Acetone)	1.0	18.93±6.19 ijk	17.21
Ethanol	-	10.61±3.84 jkl	8.72
SDS	2.0	9.53±3.60 jkl	7.62
Methanol	-	8.02±2.37 jkl	6.07
Phthalate	1.0	7.67±2.96 kl	5.72
Sucrose	1.0	5.79±2.87 kl	3.80
Butyrate	1.0	5.38±1.49 kl	3.38
Phthalate	2.0	5.21±1.90 kl	3.21
DMSO	2% v/v	4.44±2.42 kl	2.42
SDS	1.0	4.13±1.93 kl	2.10
Acetone	-	3.69±1.93 kl	1.65
Butyrate	2.0	2.34±1.21 kl	0.27
Water	-	2.07±1.05 kl	-
Sucrose	2.0	1.74±1.04 l	0.00

1 All solvents but water are shown within parenthesis. SAIB: Sucrose diacetate hexaisobutyrate; SDS: Sodium dodecylsulfate; DMSO: Dimethyl sulphoxide.

2 Means followed by the same letter are not significantly different (P≤0.05) by Tukey's test.

3 Means (original data) are expressed in percentage mortality, although data were arc sine $\sqrt{\%/100}$ transformed for analysis of variance.

Although the hydrophilic-lipophilic balance (HLB) value decreased considerably from monoesters to di- and three-esters, it was no significant variation in the toxicity was found between the high-pure sucrose monopalmitate and a mix of the isomers of an unpurified sucrose palmitate solution. This indicated that the costly purification processes for the pesticide use were not necessary. Puterka et al. (2003) did not find a correlation between the pesticide activity and the HLB value of other types of sugar esters either.

The compounds with high esterification degree (SAIB, sucrose octaacetate, and sucrose benzoate) showed a low mortality and the type of the substitute group (acyl or benzyl) did not affect the mortality rate. Sucrose butyrate and sucrose phthalate were harmless to *B. tabaci*. Long-chain alquilic sucroesters proved to be an interesting strategy for the silverleaf whitefly control because they were cheapwith low environmental impact. The water solubility of sucrose octanoate could be a great advantage over other sucroesters with higher alquilic chain, but the high mortality caused by sucrose oleate associated to the possibility of using a practical and economical source like soybean oil could be a promising proposition. Thus, although Liu et al. (1996) and Chortik et al. (1996) have shown that sucrose esters have insecticidal properties against the whiteflies, this work showed that the longer chain sucroesters of easier making process were also effective against the soft-bodied insects. The next step for this study would be to increase the water solubility of these compounds by using the additives such as the non-polluter surfactants (Rodriguez et al., 2003). Although these products were appropriate for controlling the adult silverleaf whiteflies, the growers should also consider some other factors prior to the utilization. The effect of sucroesters on plant development, on the seed germination (Peterson et al. 1997), and on the natural enemies should also be investigated.

RESUMO

O biótipo B de *B. tabaci* Gennadius tem se destacado como uma praga-chave de diversas culturas. O controle químico tem sido a principal tática de controle utilizada, embora já se tenha observado redução na eficiência dos produtos devido ao desenvolvimento de resistência. Assim, o objetivo do presente trabalho foi avaliar o efeito de diversos ésteres de sacarose com grupos alifáticos ou aromáticos sobre adultos de mosca-branca. Butirato de sacarose, caprato, octanoato, palmitato, oleato, actaacetato, ftlato, benzoato e diacetato hexaisobutirato de sacarose foram testados. Soluções de éster de sacarose foram preparadas e aplicadas sobre adultos capturados em armadilhas adesivas utilizando Torre de Potter. Ésteres alifáticos de sacarose com longas cadeias foram mais efetivos contra mosca-branca e as maiores taxas de mortalidade foram obtidas com oleato e octanoato de sacarose. Uma vez que estes compostos são caracterizados como tensoativos, dodecilsulfato de sódio foi testado para comparação e não se observou qualquer efeito. Butirato de sacarose e outros poliésteres de sacarose alifáticos ou aromáticos foram praticamente inócuos para mosca-branca.

ACKNOWLEDGMENT

We thank A.R. Generoso for the technical assistance during the preliminary trials and review of the manuscript. This study was partly funded by FAPESP (01/07093-7).

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Received: March 29, 2006;
Revised: November 19, 2007;
Accepted: April 25, 2008.

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