MONITORING RESISTANCE TO INSECTICIDES ON SILVERLEAF WHITEFLY (*Bemisia argentifolii*) FROM NORTHWESTERN MEXICO

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Abstract

The silverleaf whitefly *Bemisia argentiflolii* Bellows and Perring has become one of the most important insect pest in the agricultural areas of northwestern Mexico. After the middle of the 1990's the problem is no longer the huge populations observed, but the geminivirus transmission. In order to reduce the damage caused by this insect, growers response has been the overuse of insecticides without any strategy for resistance management. This situation creates several problems including soil and fruit contamination, health hazards for field workers, decimation of natural enemies and insecticide resistance. In order to generate data on the level of resistance that whiteflies have developed to various commonly used chemical groups of insecticides, a resistance monitoring program was established in some of the agricultural areas of Mexico. The glass vial bioassay was used as a monitoring tool and technical grade insecticides dissolved in acetone were used to coat the inner surface of the vials. Twenty whiteflies were introduced in each 20 ml vial and mortality and survival were determined 3 hours later. Diagnostic concentrations were decided based on data from bioassays performed on a whitefly population collected from La Paz South Baja, California that had not been exposed to insecticides for two years. Results obtained in 1999 indicated that there was a differential response to insecticides in whitefly populations from northwestern Mexico. The most resistant population to cypermethrin, endosulfan and methyl parathion was collected in Culiacan, Sinaloa from tomato. The population from Ensenada, Baja California also collected from tomato, followed second in resistance to these products and first in resistance to methamidophos. The whitefly population from La Laguna in Coahuila and the population from the Yaqui Valley in Sonora were the most susceptible to all the insecticides evaluated.

Introduction

The silverleaf whitefly *Bemisia argentifolii* Bellows and Perring has become one of the most important insect pest of several agricultural crops, as well as ornamental and other plant species in Mexico (Martinez-Carrillo, 1994). This species was detected since 1991 in the Mexicali valley and since then, it has been identified from 17 states (Montealegre, 1998), although it is believed to be present in most of Mexico. Cotton, soybeans, cucurbits, sesame and tomato, have been the main crops damaged in the northwestern region. The problem with this insect is no longer the huge populations that were observed in the middle of the 1990´s, but the transmission of geminivirus mainly in horticultural crops. Growers response to this problem has been the overuse of insecticides without any resistance management strategy. This situation creates several problems including soil and fruit contamination, health hazards for field workers, decimation of natural enemies and insecticide resistance. Whiteflies have demonstrated the capacity to develop high resistance levels (Dittrich et al. 1989, Prabhaker et al. 1985, Dennehy et al. 1996, Horowitz et al. 1998, Cahill et al. 1996). Resistance develops as a response to selection pressure, which is different in each agricultural area depending on the insect problems and production systems involved. According to this, it is expected that whiteflies have a differential response to insecticides in the various agricultural areas of Mexico. In order to generate data on the level of resistance that whiteflies have developed to various commonly used chemical groups of insecticides, in some of the agricultural areas of Mexico, a resistance monitoring program was established and results obtained in 1999 are presented in this paper.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:872-874 (2001)
National Cotton Council, Memphis TN

Materials and Methods

Bioassay

The glass vial technique (Cahill and Hacker 1992) was used for resistance monitoring; 20 ml scintillation vials were coated in the inner surface by introducing 1 ml of technical grade insecticide dissolved in acetone. Once the insecticide solution was deposited in the vials, they were rolled for 15 min. in a conventional hot-dog roller to evenly coat the inner surface as the acetone evaporated. Treated vials were then placed in front of an electric fan for 15 min. ventilation to eliminate all acetone residues. Each vial was capped with a plastic cap that had two perforations, one covered with cloth screen to allow ventilation and the other plugged with a piece of paper until used.

Insects

Whiteflies were collected directly from host plants in the field. The crops varied according to the agricultural area and included tomato, cotton, squash, soybeans, cantaloupe, and watermelon. Whiteflies were collected through a mouth aspirator. Twenty adults were introduced to each vial and transported to the laboratory in ice chests. Mortality was assessed 3 h after they were introduced to the vials.

Insecticides

Four commonly used insecticides for whitefly control were evaluated. Technical grade material of cypermethrin, endosulfan, methamidophos and methyl parathion was dissolved in acetone to obtain the diagnostic concentration for each. Diagnostic concentrations were defined as the LC_{95} values obtained from a whitefly population collected in La Paz Baja California and maintained isolated from commercial crops for two years without insecticide applications (Servin, 1996). The diagnostic concentrations used for resistance monitoring were 300 µg/ml for cypermethrin, 1000 µg/ml for endosulfan, 650 µg/ml for methamidophos and 850 µg/ml for methyl parathion. Higher concentrations (two and four times the diagnostic concentration) were also tested.

Results and Discussion

Data obtained from whiteflies collected in La Paz Baja California, that were used as a reference to evaluate the resistance levels of whiteflies from several agricultural areas in northwestern Mexico are presented in Table 1. The results observed with cypermethrin are presented in Table 2. It is clear that the 300 µg/ml concentration did not eliminated the whitefly population from Culiacan, as expected if this population was susceptible to cypermethrin. The 96.24% survival of the treated insects indicates that the population is highly resistant to this insecticide. Insects collected from Ensenada followed second as 35.23% of the population evaluated survived the diagnostic concentration, while the population from the Yaqui Valley had only 6.92% survival. The population from La Laguna was the most susceptible and all the treated insects were eliminated by the diagnostic concentration. Increasing twice the diagnostic concentration produced similar results, with the Culiacan population resulting in 95.02% survival, followed by the population from Ensenada with 22.42%. Populations from the Yaqui Valley and La Laguna did not showed any survivors at this concentration. Data obtained with four times the diagnostic concentration indicated that the Culiacan whitefly population evaluated was highly resistant to this product, since 91.76% of the treated insects survived. The whitefly population from Ensenada had 9.96% survival and no survivors were observed in the whitefly population from La Laguna (Table 2)

Results with Endosulfan are shown in table 3, where again the whitefly population from Culiacan showed the highest percent survival (86.82%) at the diagnostic concentration, followed by the population from Ensenada (54.09%), La Laguna (18.35%) and finally the population from the Yaqui Valley (6.09). When twice the diagnostic concentration (2000 µg/ml) was used, a similar pattern was observed, with the highest percent survival detected in the Culiacan population (94.71%), followed by the Ensenada population (43.05%), and La Laguna population (10.70%). The Yaqui Valley population did not had any survivors. The concentration four times the diagnostic (4000 µg/ml), showed that the population from Culiacan was highly resistant to Endosulfan presenting 94.10% survival followed by the population from Ensenada with 26.34% and La Laguna with 10.00.

The data obtained with Methamidophos are presented in table 4. In this case the diagnostic concentration was 650 µg/ml and the highest survival was observed in the whitefly population collected in Ensenada (55.51%), followed by the population from the Yaqui Valley (4.26%). The whitefly population from La Laguna did not presented any survival at this concentration. Increasing the concentration to 1300 µg/ml., showed that the whitefly population from Ensenada remained the most resistant of all the populations evaluated for methamidophos, percent survival was 42.70%, followed by the population from Culiacan with 19.69%. The populations evaluated from the Yaqui Valley and La Laguna did not presented any survivors at this concentration. The evaluation with four times the diagnostic concentration (2300 µg/ml) indicated that the Ensenada whitefly population had 32.03% survival and the Culiacan population 6.28% indicating that these populations were the most resistant to this insecticide.

In the case of methyl parathion, the highest survival at the diagnostic concentration (850 μg/ml) was obtained in the whitefly population from Culiacan (90.13%), followed by the population collected in Ensenada (48.04%). The data from La Laguna (2.81%) and the Yaqui Valley (1.68%), indicated low percent survival at this concentration. Increasing twice the diagnostic concentration, showed again that the populations from Culiacan (83.00%) and Ensenada (36.30%) had high survival, while the whitefly population from La Laguna (2.76%) presented a low survival and the one from the Yaqui Valley did not showed any survivors. When a concentration four times the diagnostic one was used, there were still a high percentage of survivors in the population from Culiacan (72.92%), as compared to the one from Ensenada (29.54%) and La Laguna where no one of the evaluated individuals survived to this concentration. These results indicate that those whitefly populations evaluated from Culiacan and Ensenada were highly resistant to methyl parathion.

Conclusions

The vial bioassays performed in this study showed that there is a differential response to insecticides in whitefly populations from northwestern Mexico. The most resistant population to cypermethrin, endosulfan and methyl parathion was collected in Culiacan, Sinaloa from tomato. The population from Ensenada, Baja California, also collected from tomato followed second in resistance to these products and first in resistance to methamidophos. The whitefly populations from La Laguna in Coahuila and the Yaqui Valley in Sonora were the most susceptible to all the insecticides evaluated.

Acknowledgements

We acknowledge the collaboration of Dinora G. Romero for the assistance in preparing and sending the vials used in bioassays.

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Table 1. Bioassay results on a whitefly population from South Baja California, maintained isolated for two year and considered as a reference for monitoring resistance in northwestern Mexico.

Insecticide	CL_{50} µg/ml	95% Fiducial Limits	CL_{95} µg/ml	Slope
Cypermethrin	17.1	13.7 - 21.2	268.2	1.37
Endosulfan	51.9	41.0 - 65.0	988.3	1.29
Methamidophos	75.6	60.0 - 91.0	630.2	1.78
Methyl Parathion	118.9	99.0 - 141.0	838.5	1.93

Table 2. Data on resistance monitoring for Cypermetrhin in northwestern Mexico. 1999.

Agricultural Area and State	Diagnostic Concentration	Insects Treated	Percent Survival
Culiacan Valley, Sinaloa	300	400	96.24
Ensenada, Baja California	300	300	35.23
Yaqui Valley, Sonora	300	1600	6.92
La Laguna, Coahuila	300	405	0.00
Culiacan Valley, Sinaloa	600	1000	95.02
Ensenada, Baja California	600	300	22.42
Yaqui Valley, Sonora	600	1500	0.00
La Laguna, Coahuila	600	426	0.00
Culiacan Valley, Sinaloa	1200	1000	91.76
Ensenada, Baja California	1200	300	9.96
La Laguna, Coahuila	1200	411	0.00

Table 3. Data on resistance monitoring for Endosulfan in northwestern Mexico. 1999.

Agricultural Area and State	Diagnostic Concentration	Insects Treated	Percent Survival
Culiacan Valley, Sinaloa	1000	400	86.82
Ensenada, Baja California	1000	300	54.09
La Laguna, Coahuila	1000	904	18.35
Yaqui Valley, Sonora	1000	1600	6.09
Culiacan Valley, Sinaloa	2000	1000	94.71
Ensenada, Baja California	2000	300	43.05
La Laguna, Coahuila	2000	908	10.70
Yaqui Valley, Sonora	2000	1500	0.00
Culiacan Valley, Sinaloa	4000	1000	94.10
Ensenada, Baja California	4000	300	26.34
La Laguna, Coahuila	4000	898	10.00

Table 4. Data on resistance monitoring for Methamidophos in northwestern Mexico. 1999.

Agricultural Area and State	Diagnostic Concentration	Insects Treated	Percent Survival
Ensenada, Baja California	650	300	55.51
Yaqui Valley, Sonora	650	1600	4.26
La Laguna, Coahuila	650	1008	0.00
Ensenada, Baja California	1300	300	42.70
Culiacan Valley, Sinaloa	1300	600	19.69
Yaqui Valley, Sonora	1300	1500	0.00
La Laguna, Coahuila	1300	986	0.00
Ensenada, Baja California	2600	300	32.03
Culiacan Valley, Sinaloa	2600	600	60.28
La Laguna, Coahuila	2600	994	0.00

Table 5. Data on resistance monitoring for Methyl Parathion in northwestern Mexico. 1999.

Agricultural Area and State	Diagnostic Concentration	Insects Treated	Percent Survival
Culiacan Valley, Sinaloa	850	400	90.13
Ensenada, Baja California	850	300	48.04
La Laguna, Coahuila	850	413	2.81
Yaqui Valley, Sonora	850	1600	1.68
Culiacan Valley, Sinaloa	1700	1000	83.00
Ensenada, Baja California	1700	300	36.30
La Laguna, Coahuila	1700	421	2.76
Yaqui Valley, Sonora	1700	1400	0.00
Culiacan Valley, Sinaloa	3400	1000	72.92
Ensenada, Baja California	3400	300	29.54
La Laguna, Coahuila	3400	403	0.00