

Susceptibility of *Bemisia tabaci* to chemical and organic insecticides in the Comarca Lagunera

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Abstract

Melon crops are affected by *Bemisia tabaci*, which causes losses of up to 100% of the production; to control this pest, chemical active ingredients that can generate resistance are used. This research aimed to determine the susceptibility of *B. tabaci* populations through chemical and organic pesticides in melon-producing areas in the Comarca Lagunera. In 2023, four populations of *B. tabaci* were collected in the localities of Matamoros, Coahuila, Esmeralda, Tlahualilo and Ceballos, Durango. Bioassays were performed using the leaf immersion technique to determine the median lethal concentration (LC50), as well as to obtain the dose-mortality curve and the resistance ratio based on a susceptible line (Njcs). According to the results, the extracts of mustard and garlic and the active ingredients Imidacloprid and Dimethoate obtained the highest LC50, with values of 430.84, 404.19, 449.71 and 1 607 ppm in the Matamoros population. For the active ingredients Lambda-cyhalothrin and Chlorantraniliprole, the Ceballos population presented LC50 values of 234.18 and 165.31 ppm, respectively. In the case of the resistance ratio, the Matamoros population obtained the highest values for mustard and garlic extracts, Imidacloprid, and Dimethoate, with 16.23, 11.85, 11.89, and 6.12 X, respectively. For the active ingredients Lambda-cyhalothrin and Chlorantraniliprole, the Ceballos population reached values of 12.7 and 6.71 X. According to the results, the Matamoros population showed greater resistance to the active ingredients evaluated compared to the susceptible line.

Keywords:

Bemisia tabaci, *Cucumis melo*, extracts.

Introduction

In Mexico, *Bemisia tabaci* began to be reported as an agricultural pest from the 80s and 90s, causing great losses in horticultural crops; the direct damage of this pest is the suction of sap and leaf deformations (Macias-Flores *et al.*, 2013). Indirect damage is the excretion of honeydew, in which fungi that reduce the photosynthetic activity of plants develop; in addition, these insects can be vectors of phytopathogenic viruses, such as the cucurbit yellow stunting disorder virus (CYSDV), which reduces the value of the crop (Chew *et al.*, 2008); this pest is also a transmitter of other viruses belonging to the genus Begomovirus (Romay *et al.*, 2016).

Mexico is the twelfth largest producer of melon worldwide; in 2023, production grew by 11.2%; of the 23 producing states, Michoacán, Sonora, Coahuila, Guerrero and Durango stand out (SADER-SIAP, 2024). According to a descriptive study, in the melon-producing area of the Comarca Lagunera, the most commonly used pesticides are carbofuran, endosulfan, imidacloprid and methamidophos (Vargas-González *et al.*, 2016).

Some mechanisms of resistance in insects are the overproduction of metabolic enzymes, which bind to pesticides and cause their detoxification, as well as a series of mutations in proteins, which make them less susceptible to pesticides (Bass and Field, 2011). Therefore, worldwide laboratory and field studies have been conducted to determine resistance levels of *B. tabaci* (Horowitz *et al.*, 2020). On the other hand, for biorational products, Regnault *et al.* (2012) mention that essential oils are of global interest since they are environmentally friendly and have effects similar to those of chemical products; according to the mode of action, they can be multi-site and some can act on chitin synthesis or the central nervous system.

Currently, there is a lack of information on the status of resistance in whiteflies and alternatives for the rotation of agrochemicals; therefore, this research aims to determine the susceptibility of field and laboratory populations of *B. tabaci* through chemical and organic pesticides in melon-producing areas in the Comarca Lagunera.

Materials and methods

Susceptible line (Njcs)

Adults of *B. tabaci* were collected in April 2023 with a mouth aspirator from plants of chili (*Capsicum annuum* L.), zucchini (*Cucurbita pepo*), and tomato (*Solanum lycopersicum*) in the experimental field (El Bajío-UAAAN) in Saltillo, Coahuila; the insects collected were transferred to the greenhouse of Agricultural Parasitology of the Antonio Narro Autonomous Agrarian University (UAAAN, for its acronym in Spanish) and multiplied on plants of Cantaloupe melon (*Cucumis melo* L.) and beans (*Phaseolus vulgaris* L.), at a temperature of 28 ± 5 °C and a relative humidity of 50%; bioassays were performed after 24 generations.

Field populations

Four populations were collected from different melon-producing agricultural fields in ejidos of the Comarca Lagunera; L1 Matamoros, Coahuila, and L2 Esmeralda, Durango, which presented little crop rotation and early planting; for L3 Tlahualilo and L4 Ceballos, Durango, the farms had conventional production systems, differing in the cultural work and the type of agrochemicals for pest management. Leaflets of *C. melo* infested with *B. tabaci* nymphs were collected and transferred in insulated thermal containers to a chamber with controlled environment facilities; the leaflets were separated by populations and placed in conditions similar to those of the susceptible line, 28 ± 5 °C, relative humidity of 50%, and a photoperiod of 12 h light: darkness; the bioassays were subsequently carried out.

Bioassays

For the bioassays, the leaf immersion technique proposed by Irac 002 (version 03, June 2009) was implemented; *C. melo* leaflets were used, and irregular cuts were made in each leaflet, which contained 30 nymphs of instars II and III of *B. tabaci*. These cuts were immersed in the corresponding concentrations for 10 s and three replications were performed for each one. The submerged leaflets were placed in a medium Fda Pet hinged container (24.9 x 18.4 x 7.4), which had cotton sponges inside, to which 10 ml of water was added to maintain the moisture of the leaflets and prevent dehydration.

For the control, the aforementioned methodology was used; however, the leaflets were immersed in 100 ml of distilled water; mustard and garlic extract and the active ingredients Imidacloprid, Lambda-cyhalothrin, Dimethoate and Chlorantraniliprole, were evaluated. These ingredients were selected according to what was reported by melon producers in the Comarca Lagunera.

Determination of LC50 and LC90 of the evaluated products

The evaluated concentrations were as follows: from 18 to 7 000 ppm for the mustard-based insecticide, from 25 to 3 300 ppm for the garlic product, from 18 to 2 600 ppm for Imidacloprid, from 18 to 2 700 ppm for the active ingredient Lambda-cyhalothrin, from 200 to 3 800 ppm for the product with the active ingredient Dimethoate and from 18 to 2 600 ppm for Chlorantraniliprole. The treatments consisted of six doses of each product evaluated (active ingredients) and each one consisted of three replications with 30 nymphs of instars II and III; in addition, there was absolute control treated only with water. A maximum likelihood analysis was performed.

For the nymphs, the criterion of mortality considered was a change in coloration and stimulation with a brush. The bioassays were evaluated at 24, 48 and 72 h with a stereoscopic microscope.

Resistance ratio

The resistance ratio was determined by dividing the result of the LC50 of each field population by the LC50 of the control or susceptible line, which was done for each insecticide evaluated, where a result <5 is considered slightly resistant; a result >5 but <10 is considered moderately resistant and a result >10 is considered resistant (Georghiou, 1962).

Statistical analysis

For the results of all the evaluations of this experiment, if the control presented mortality, it was corrected by Abbott's (1925) formula; once the mortality correction was completed, the data was run in a Probit analysis (Finney, 1971). To obtain the dose-response curve and to estimate the LC50, SAS System for Windows 9.0 was used.

Results and discussion

The results obtained from the bioassays for the reference line (Njcs) in *B. tabaci* are presented in Table 1. The pesticides showed differences in the LC50, being 26.55, 34.1, 37.82, 18.44, 262.42, and 24.45 ppm for mustard, garlic, Imidacloprid, Lambda-cyhalothrin, Dimethoate, and Chlorantraniliprole, respectively. As can be seen, the mustard product obtained an LC50 of 26.55 ppm, which is higher compared to what was reported by Hassan *et al.* (2023), who report an LC50 of 0.83 ppm for a mustard extract on a susceptible line of *B. tabaci*.



Table 1. Lethal concentration, fiducial limits, and slope value of insecticides applied to *B. tabaci* nymphs in the Njcs control population.

Product	N	LC50 ppm	LFL-UFL	LC95	Slope	df	r ²
Mustard extract	630	26.55	16.52-39.46	6414	-0.9829 ±0.6902	5	0.797
Garlic extract	630	34.1	20.28-52.4	1 1090	-1.0036 ±0.6547	5	0.852
Imidacloprid	630	37.82	23.4-56.53	1 2371	-1.032 ±0.6541	5	0.837
Lambda cyhalothrin	630	18.44	4.35-45.39	915.4	-1.2279 ±0.97	5	0.795
Dimethoate	630	262.42	153.86-380.93	5 294	-3.0495 ±1.2606	5	0.84
Chlorantraniliprole	630	24.65	7.07-54.34	5 098	-0.9887 ±0.7103	5	0.838

n= population size; LC50= median lethal concentration; LC95= lethal concentration 95; LFL= lower fiducial limit; UFL= upper fiducial limit; df= degrees of freedom; r²= R-squared coefficient; population I vs Njcs= resistance ratio.

On the other hand, for garlic extract, the LC50 was 34.1 ppm, a result lower than that reported by Guerra *et al.* (2020), who obtained an LC50 of 890 ppm for the same extract. In the case of the insecticide Imidacloprid, we obtained an LC50 of 37.82 ppm, which is lower than that mentioned by El-Zahi *et al.* (2017), who reported an LC50 of 136.41 ppm. For the active ingredient Lambda-cyhalothrin, the LC50 obtained was 18.44 ppm; Grávalos *et al.* (2015) report an LC50 of 557.7 ppm for alpha cypermethrin in the susceptible laboratory line (LAB-S), which is a higher figure than that reported in this research.

For the insecticide Dimethoate, the LC50 was 262.42 ppm, obtaining a value higher than that reported by Ranjbar *et al.* (2022), with an LC50 of 1.57 for the product malathion. In the case of the insecticide Chlorantraniliprole, it reached an LC50 of 24.45 ppm, being lower than that reported by Dângelo (2018), with an LC50 of 24.81 ppm, demonstrating with these results that the susceptible line (Njcs) can be used as a reference for research work with insecticides.

Table 2 presents the data of the field populations; for the mustard extract product, the LC50 values obtained were 430.84, 235.93, 191.41 and 104.59 ppm for the populations of Matamoros, Ceballos, Tlahualilo, and Esmeralda, respectively. The Matamoros population presented the highest LC50, which is higher than that reported by Mostafiz *et al.* (2018), where they evaluated methyl benzoate on whiteflies, obtaining an LC50 of 0.2 ppm.

Table 2. Lethal concentration, fiducial limits, and slope value of insecticides applied to *B. tabaci* nymphs in field populations.

Population	Product	N	LC50	LFL-UFL	LC95	Slope	df	r ²	Population vs Njcs
Population I Matamoros, Coahuila	Mustard extract	630	430.84	194.19-744.68	15 304	-2.7946 ±1.0608	5	0.806	16.23
	Garlic extract	630	404.19	159.97-785.23	8 217	-3.2775 ±1.2574	5	0.865	11.85
	Imidacloprid	630	449.71	335.54-567.14	12 076	-3.0536 ±1.151	5	0.853	11.89
	Lambda cyhalothrin	630	164.56	110.36-225.89	8 194	-2.148 ±0.9691	5	0.813	8.92
	Dimethoate	630	1607	1 485-1727	4 622	-11.49 ±3.584	5	0.943	6.12
	Chlorantraniliprole	630	137.18	42.07-264.07	5 391	-2.205 ±1.0316	5	0.999	5.57
Population II Esmeralda, Durango	Mustard extract	630	104.59	46.53-178.86	17 015	-1.5021 ±0.7438	5	0.791	3.94

Population	Product	N	LC50	LFL-UFL	LC95	Slope	df	r ²	Population vs Njcs
Population III Tlahualilo, Durango	Garlic extract	630	180.89	83.87-313.04	7 382	-2.3052 ±1.0211	5	0.799	5.3
	Imidacloprid	630	201.21	95.41-335.4	6 095	-2.5579 ±1.1103	5	0.829	5.32
	Lambda cyhalothrin	630	226.58	99.85-391.38	10 223	-2.3416 ±0.9942	5	0.823	12.29
	Dimethoate	630	1581	1 459-1 699	4 650	-11.234 ±3.5117	5	0.948	6.02
	Chlorantraniliprole	630	149.67	55.73-273.85	5 595	-2.2749 ±1.0458	5	0.786	6.07
	Mustard extract	630	191.41	73.47-411.84	27 263	-1.7428 ±0.7637	5	0.79	7.21
	Garlic extract	630	213.59	127.84-330.53	14 516	-2.0913 ±0.8977	5	0.823	6.26
	Imidacloprid	630	117.15	55.55-210.39	8 623	-1.8227 ±0.881	5	0.804	3.1
	Lambda cyhalothrin	630	231	95.79-412.51	6 669	-2.662 ±1.1262	5	0.89	12.53
	Dimethoate	630	1126	781.34-1 473	5 514	-7.2761 ±2.3843	5	0.94	4.29
	Chlorantraniliprole	630	156.77	120.64-198.32	6 766	-2.2084 ±1.006	5	0.816	6.36
	Mustard extract	630	235.93	176.4-314.2	30 501	-1.8483 ±0.7789	5	0.803	8.89
Population IV Ceballos, Durango.	Garlic extract	630	276	217.23-345.91	12 396	-2.4298 ±0.9954	5	0.863	8.09
	Imidacloprid	630	113.09	62.28 196.62	6 918	-1.8905 ±0.9206	5	0.803	2.99
	Lambda cyhalothrin	630	234.18	177.24-307.21	17 476	-2.081 ±0.8782	5	0.844	12.7
	Dimethoate	630	891.51	778.09-1011	7 162	-5.3626 ±1.8177	5	0.891	3.4
	Chlorantraniliprole	630	165.31	100.35-257.55	18 389	-1.7831 ±0.8038	5	0.86	6.71

n= population size; LC50= median lethal concentration; LC95= lethal concentration 95; LFL= lower fiducial limit; UFL= upper fiducial limit; d.f.= degrees of freedom; r²= R-squared coefficient; population I vs Njcs= resistance ratio.

For garlic extract, LC50 of 404.19, 276, 213.59 and 180.89 ppm were obtained for the populations of Matamoros, Ceballos, Tlahualilo, and Esmeralda; for this product, the highest LC50 was also shown by the Matamoros population (404.19 ppm); for their part, Guerra *et al.* (2020) reported an LC50 of 890 ppm, which is 2.2 times higher than that reported in this research.

The Imidacloprid product reached LC50 values of 449.71, 201.21, 117.15 and 113.09 ppm for the populations of Matamoros, Esmeralda, Tlahualilo, and Ceballos, respectively. The Matamoros population had the highest LC50, with 449.71 ppm, this result is similar to that reported by Rajna *et al.* (2024), who evaluated a field population and obtained an LC50 of 418.19 ppm on second and third instar nymphs. On the other hand, Naveen *et al.* (2017) mention an LC50 of 664 ppm on a field population, which is higher than that reported in this research.

For the active ingredient Lambda-cyhalothrin, the Ceballos population presented an LC50 of 234.18 ppm, followed by Tlahualilo, Esmeralda, and Matamoros, with values of 231, 226.58 and 164.56

ppm, respectively; Da#li *et al.* (2020) report an LC₅₀ of 232.86 ppm on a field population, a result similar to those of the populations of Ceballos and Tlahualilo. The Matamoros population obtained the highest value for the active ingredient Dimethoate, with an LC₅₀ value of 1 607 ppm, followed by Esmeralda, Tlahualilo, and Ceballos, with values of 1 581, 1 126 and 891.51 ppm, respectively; in this regard, Álvarez (2024) reports an LC₅₀ of 132.83 ppm for the active ingredient Acephate in a field population, which is 12 times lower compared to the Matamoros population.

For their part, Longhurst *et al.* (2013) mention an LC₅₀ of 374 ppm for the active ingredient Profenofos in cucumber plants and Saleem *et al.* (2022) report an LC₅₀ of 1 157.3 ppm for the active ingredient Chlorpyrifos in a field population. For the ingredient Chlorantraniliprole, the Ceballos population showed an LC₅₀ of 165.31 ppm, followed by Tlahualilo, Esmeralda and Matamoros, which obtained an LC₅₀ of 156.77, 149.67 and 137.18 ppm, respectively. Chen *et al.* (2018) report an LC₅₀ of 47.78 ppm on *B. tabaci* nymphs in a field population; these results are lower than those obtained in the four populations evaluated.

According to the results obtained, it was observed that the highest median lethal concentration in most of the insecticides evaluated was obtained by the Matamoros population, which can be attributed to the low crop rotation and early planting of the crop.

Resistance ratio

Table 2 shows the values of the resistance ratio that was calculated based on the susceptible line Njcs and the field populations. The Matamoros population obtained resistance ratio values of 16.23, 11.85, 11.89, 8.92, 6.12 and 5.57 times; the Esmeralda population presented the values 3.94, 5.3, 5.32, 12.29, 6.02 and 6.07 times; in the Tlahualilo population, values of 7.21, 6.26, 3.1, 12.53, 4.29 and 6.36 times were obtained; the Ceballos population reached resistance ratios of 8.89, 8.09, 2.99, 12.7, 3.4 and 6.71 times for the products mustard extract, garlic extract, Imidacloprid, Lambda-cyhalothrin, Dimethoate, and Chlorantraniliprole, respectively.

For mustard and garlic extracts, the highest resistance ratio was presented by the Matamoros population, with values of 16.23 times and 11.85 times, respectively. For the active ingredient Imidacloprid, it corresponded to the Matamoros population, with a value of 11.89 times. Balkan and Kara (2020) obtained a value of 8.74 times the field population in tomato plants, results lower than those reported in the evaluated populations.

For the chemical group of pyrethroids, Rajna *et al.* (2024) mention a resistance ratio of 24.44 times depending on the susceptible line. This data is higher than that reported in this work, which was 12.7 times for the field population of Ceballos. For the chemical group of organophosphorus compounds, the Matamoros population presented a higher resistance ratio with 6.12, which differs from what was reported by Longhurst *et al.* (2013), who report a value of 189 times for the active ingredient Profenofos in the line that was highly treated with organophosphorus compounds. However, in this research, the resistance factor does not exceed 10 times to be considered a problem.

In the case of the chemical group of the Diamides, the Ceballos population was the one that presented a higher resistance ratio, with a value of 6.71 times. On the other hand, Hopkinson and Pampa (2019) obtained a resistance ratio of three times. It can be mentioned that the aforementioned resistance ratios together with the value found in this research are less than 10 times; therefore, these values correspond to low to moderate resistance.

Conclusions

Regarding the products evaluated, Chlorantraniliprole obtained the lowest value of the median lethal concentration, whereas the highest values of the median lethal concentration correspond to Dimethoate, Lambda-cyhalothrin and plant extracts.

In relation to the laboratory line (Njcs), we can mention that it can be used as a reference point since low LC₅₀ values confirm this.

The results in the Matamoros population confirm that it has greater resistance to the active ingredients, which coincides with the low rotation of pesticides and frequent applications.

The result of this research contributes with information on the state of resistance for each population; in addition, the results of the use of biorational products are described, which can be an alternative for the management and rotation of pesticides.

Bibliography

- 1 Abbott, W. S. 1925. A method of computing the effectiveness of an insecticide. *Journal of Economic Entomology*. 3(2):265-267.
- 2 Álvarez, D. D. L.; Hayashida, R.; Cavallaro, M. C.; Santos, D. M.; Santos, L. M.; Müller, C.; Watanabe, L. F. M.; Bello, V. H.; Krause-Sakate, R.; Hoback, W. W. and Oliveira, R. C. 2024. Susceptibility of *Bemisia tabaci* Gennadius (Hemiptera: aleyrodidae) mediterranean populations found in São Paulo, Brazil to 11 Insecticides and Characterization of Their Endosymbionts. *Insects*. 15(9):670. <https://doi.org/10.3390/insects15090670>.
- 3 Balkan, T. and Kara, K. 2020. Neonicotinoid resistance in adults and nymphs of *Bemisia tabaci* (Genn., 1889) (Hemiptera: Aleyrodidae) populations in tomato fields from Tokat, Turkey. *Turkish Journal of Entomology*. 44(3):319-331. <https://doi.org/10.16970/entoted.650742>.
- 4 Bass, C. and Field, L. M. 2011. Gene amplification and insecticide resistance. 8(67):886-890. <https://doi.org/10.1002/ps.2189>.
- 5 Chen, J. C.; Wang, Z. H.; Cao, L. J.; Gong, Y. J.; Hoffmann, A. A. and Wei, S. J. 2018. Toxicity of seven insecticides to different developmental stages of the whitefly *Bemisia tabaci* MED (Hemiptera: aleyrodidae) in multiple field populations of China. *Ecotoxicology*. 27(4):742-751. <https://doi.org/10.1007/s10646-018-1956-y>.
- 6 Chew, M. Y.; Vega, P. A.; Palomo, R. M. y Jiménez, D. F. 2008. Enfermedades del melón (*Cucumis melo* L.) En diferentes fechas de siembra en la región Lagunera. México. *Revista Chapingo Serie Zonas Áridas*. 7(2):133-138.
- 7 Da#li, F.; Yükselbaba, U.; Ikten, C.; Topakci, N. and Gocmen, H. 2020. insecticide resistance in *Bemisia tabaci* (GENN.) populations collected from the mediterranean and Aegean regions of turkey. *Applied Ecology and Environmental research*. 18(6):7757-7768. <http://dx.doi.org/10.15666/aeer/1806-77577768>.
- 8 Dângelo, R. A. C.; Michereff # Filho, M.; Campos, M. R.; Da-Silva, P. S. and Guedes, R. N. C. 2018. Insecticide resistance and control failure likelihood of the whitefly *Bemisia tabaci* (MEAM1; B biotype): a neotropical scenario. *Annals of Applied Biology*. 172(1):88-99. <https://doi.org/10.1111/aab.12404>.
- 9 El-Zahi, E.; El-Sarand, E. and El-Masry, G. 2017. Activity of flonicamid and two neonicotinoid insecticides against *Bemisia tabaci* (Gennadius) and its associated predators on cotton plants. *Egyptian Academic Journal of Biological Sciences. A, Entomology*. 10(8):25-34. <https://doi.org/10.21608/eajb.2017.11990>.
- 10 Finney, D. J. 1971. Probit analysis. Cambridge at the Univ. Press. 3rd. Ed. 120 p.
- 11 Georgiou, G. P. 1962. Carbamate insecticides: toxic action of synergized carbamates against twelve resistant strains of the housefly. *J. Econ Entomol*. 55(1):768-862.
- 12 Grávalos, C.; Fernández, E.; Belando, A.; Moreno, I.; Ros, C. and Bielza, P. 2015. Cross # resistance and baseline susceptibility of Mediterranean strains of *Bemisia tabaci* to cyantraniliprole. *Pest Management Science*. 71(7):1030-1036. <https://doi.org/10.1002/ps.3885>.
- 13 Guerra, J. G. O.; Chávez, E. C.; Ochoa, F. Y. M.; Flores, J. L.; Uribe, L. A. A. and Juárez, A. H. 2020. Insecticidal activity of plant extracts against whitefly nymphs *Bemisia tabaci* (Hemiptera: aleyrodidae) in laboratory. *Journal of Entomology and Zoology Studies*. 8(1):595-599.

- 14 Hassan, E.; Obaidoon, Y.; Mostafiz, M. M. and Senior, L. 2023. Effect of plant essential oil formulations on *Bemisia tabaci* MEAM1 (Gennadius) and its parasitoid *Eretmocerus hayati* (Zolnerowich and Rose). *Plants*. 12(24):4137. <https://doi.org/10.3390/plants12244137>.
- 15 Hopkinson, J. E. and Pumpa, S. M. 2019. Baseline susceptibility of *Bemisia tabaci* MEAM 1 (Hemiptera: aleyrodidae) in Australia to spirotetramat, cyantraniliprole and dinotefuran, with reference to pyriproxyfen cross # resistance. *Austral Entomology*. 58(4):762-771. <https://doi.org/10.1111/aen.12390>.
- 16 Horowitz, A. R.; Ghanim, M.; Reditakis, E.; Nauen, R. and Ishaaya, I. 2020. Insecticide resistance and its management in *Bemisia tabaci* species. *Journal of Pest Science*. 93(3):893-910. <https://doi.org/10.1007/s10340-020-01210-0>.
- 17 IRAC 001. 2009. Insecticide resistance action committee. Método de prueba de susceptibilidad.
- 18 Longhurst, C.; Babcock, J. M.; Denholm, I.; Gorman, K.; Thomas, J. D. and Sparks, T. C. 2013. Cross#resistance relationships of the sulfoximine insecticide sulfoxaflor with neonicotinoids and other insecticides in the whiteflies *Bemisia tabaci* and *Trialeurodes vaporariorum*. *Pest Management Science*. 69(7):809-813. <https://doi.org/10.1002/ps.3439>.
- 19 Macias-Flores, A.; Santillan-Ortega, C.; Robles-Bermúdez, A.; Caton, O. M. y Cambero-Campos, O. J. 2013. Casos selectos de resistencia a insecticidas en moscas blancas (Hemiptera: aleyrodidae) en el mundo. *Biociencias*. 2(2):4-16. <https://doi.org/10.15741/revbio.02.02.02>.
- 20 Mostafiz, M. M.; Jhan, P. K.; Shim, J. K. and Lee, K. Y. 2018. Methyl benzoate exhibits insecticidal and repellent activities against *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae). *PLoS One*. 13(12):1-14. <https://doi.org/10.1371/journal.pone.0208552>.
- 21 Naveen, N. C.; Chaubey, R.; Kumar, D.; Rebijith, K. B.; Rajagopal, R.; Subrahmanyam, B. and Subramanian, S. 2017. Insecticide resistance status in the whitefly, *Bemisia tabaci* genetic groups Asia-I, Asia-II-1 and Asia-II-7 on the Indian subcontinent. *Scientific reports*. 7(1):40634. <https://doi.org/10.1038/srep40634>.
- 22 Rajna, S.; Mahapatro, G.; Subramanian, S. and Chander, S. 2024. Determination of insecticide resistance in cotton whitefly in north India. *The Indian Journal of Agricultural Sciences*. 94(4):404-409. <https://doi.org/10.56093/ijas.v94i4.143044>.
- 23 Ranjbar, S.; Allahyari, H.; Talebi-Jahromi, K. and Heidari, A. 2022. Susceptibility of *Bemisia tabaci* (Gennadius) (Hemiptera: aleyrodidae) to different insecticides under water hardness condition and additives. *Journal of Agricultural Science and Technology*. 24(6):1385-1395. <http://dx.doi.org/10.52547/jast.24.6.1385>.
- 24 Regnault-Roger, C.; Vincent, C. and Arnason, J. T. 2012. Essential oils in insect control: low-risk products in a high-stakes world. *Annual review of entomology*. 57(1):405-424. <https://doi.org/10.1146/annurev-ento-120710-100554>.
- 25 Romay, G. G. J.; Geraud, P. F.; Chirinos, T. D. and Demey, J. 2016. *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae): historia, situación actual y su rol como vector de enfermedades virales de plantas en Venezuela. *Entomotropica*. 31(35):276-293.
- 26 SADER-SIAP. 2024. Secretaría de Agricultura y Desarrollo Rural (SADER)-Servicio de Información Agroalimentaria y Pesquera (SIAP). Melón mexicano, un fruto con creciente demanda y producción nacional: Agricultura. <https://www.gob.mx/agricultura/prensa/melon-mexicano-un-fruto-concrecientedemandayproduccionnacionalagricultura#:~:text=Cifras%20del%20Servicio%20de%20Informaci%C3%B3n,toneladas%20contabilizadas%20el%20a%C3%B1o%20previo/>

- 27 Saleem, M.; Hussain, D.; Hasan, M. U.; Sagheer, M.; Ghouse, G.; Zubair, M.; Brown, J. K. and Cheema, S. A. 2022. Differential insecticide resistance in *Bemisia tabaci* (Hemiptera: aleyrodidae) field populations in the Punjab province of Pakistan. *Heliyon*. 8(12): e12010. <https://doi.org/10.1016/j.heliyon.2022.e12010>.
- 28 Vargas-González, G.; Alvarez-Reyna, V. P.; Guigón-López, C.; Cano-Ríos, P.; Jiménez-Díaz, F.; Vásquez-Arroyo, J. y García-Carrillo, M. 2016. Patrón de uso de plaguicidas de alto riesgo en el cultivo de melón (*Cucumis melo* L.) en la Comarca Lagunera. *Ecosistemas y Recursos Agropecuarios*. 3(9):367-378.

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