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José Guadalupe Ontiveros Guerra

Universidad Autónoma Agraria
Antonio Narro, Calzada Antonio
Narro 1923, Buenavista, Saltillo,
Coahuila, México C.P. 25315

Ernesto Cerna Chávez

Universidad Autónoma Agraria
Antonio Narro, Calzada Antonio
Narro 1923, Buenavista, Saltillo,
Coahuila, México C.P. 25315

Yisa María Ochoa Fuentes

Universidad Autónoma Agraria
Antonio Narro, Calzada Antonio
Narro 1923, Buenavista, Saltillo,
Coahuila, México C.P. 25315

Jerónimo Landeros Flores

Universidad Autónoma Agraria
Antonio Narro, Calzada Antonio
Narro 1923, Buenavista, Saltillo,
Coahuila, México C.P. 25315

Luis Alberto Aguirre Uribe

Universidad Autónoma Agraria
Antonio Narro, Calzada Antonio
Narro 1923, Buenavista, Saltillo,
Coahuila, México C.P. 25315

Agustín Hernández Juárez

Universidad Autónoma Agraria
Antonio Narro, Calzada Antonio
Narro 1923, Buenavista, Saltillo,
Coahuila, México C.P. 25315

Corresponding Author:

José Guadalupe Ontiveros Guerra
Universidad Autónoma Agraria
Antonio Narro, Calzada Antonio
Narro 1923, Buenavista, Saltillo,
Coahuila, México C.P. 25315

Insecticidal activity of plant extracts against whitefly nymphs *Bemisia tabaci* (Hemiptera: Aleyrodidae) in laboratory

José Guadalupe Ontiveros Guerra, Ernesto Cerna Chávez, Yisa María Ochoa Fuentes, Jerónimo Landeros Flores, Luis Alberto Aguirre Uribe and Agustín Hernández Juárez

Abstract

21 plant extracts were evaluated against nymphs *Bemisia tabaci* under laboratory conditions. For the establishment of the test, the nymphs (N2) immersion technique was used, using a completely randomized design with 8 concentrations and 10 repetitions evaluating after 72 hours. For the estimation of the susceptibility (LC₅₀ and LC₉₅) the Probit Analysis was used, the main phytochemical compounds in the extracts were determined using the infrared spectrophotometer. The results show a high susceptibility to cat's claw (*Mimosa zygophylla*), dragon's blood (*Jatropha dioica*), garlic (*Allium sativum*), ribwort (*Plantago lanceolata*) and lechuguilla (*Agave lechuguilla*), with a LC₅₀ of 778, 795, 890, 996 and 1035 ppm respectively. The compounds present in the evaluated extracts were different types of acids (benzoic, linoleic, palmitic, shikimic, cinnamic, coumaric and tartaric), 1, 8-cineole and eugenol, possibly responsible for the insecticidal activity.

Keywords: *Bemisia tabaci*, susceptibility, extracts, phytochemical

Introduction

Bemisia tabaci (Gennadius) attacks and damages around 600 species of plants of agricultural importance (Nombela and Muniz 2010; Alemandri *et al.* 2015) ^[23, 31] in 162 countries (CABI, 2018) ^[6]. *B. tabaci* causes direct damage by sucking the phloem sap, also causes indirect damage by transmitting different viruses (Singh *et al.* 1994) ^[27], this whitefly is an important vector of begomovirus (family Geminiviridae), transmitting approximately 111 viruses (Tiwari *et al.* 2013) ^[28].

The main control strategies for this whitefly contemplate chemical control, with a significant number of substances reported for the manage (Roy *et al.* 2014; Chen *et al.* 2018) ^[26, 8], but there are disadvantages such as the rapid development of resistance (Kliot *et al.* 2016) ^[15] also the substances used are dangerous for humans and the environment (Abbassy, 2017) ^[1]. Different alternatives of plant origin which can contribute in the management strategies, botanical insecticides (BIs) are products derived from plants with many active substances (Isman, 2006) ^[13]. Historically, the properties and potential of some plants and their secondary metabolites against different insects are known (Jaber *et al.* 2018) ^[14].

The BIs have been tested for whitefly control with good results, but there is a necessity to explore more about the BIs involved in whitefly control (Ashfaq *et al.* 2019) ^[5] in order to offer efficient control alternatives and biorational. In the present study, 21 plant extracts were evaluated against whitefly nymphs, with the aim of generating a contribution for their management.

Materials and Methods

The present investigation was carried out in the Entomology and Acarology Laboratory of the Department of Parasitology of the Universidad Autonoma Agraria Antonio Narro (UAAAN).

Extract Preparation

The plants used for the preparation of the extracts were obtained commercially and collected in the experimental field "El Bajío" (Table 1), this vegetal material subsequently individualized and cut into small pieces and then placed on newspaper in a drying oven (weber anhidro

incubator, model; 4252 Arthur H. Thomas Co.) a temperature of 30 ± 1 °C for a period of 15 days. After the drying period, the vegetal material were ground in two phases; the first in a manual mill (Estrella, Model: 11539) this to avoid problems with the lignified tissues of some of the plants used and the second in an electric mill (Hamilton Beach, Model: 80393), at the end of the milling process the powder was passed through a sieve of 250 μ m to homogenize the particle size. For the preparation of the extracts a 1:6 ratio (w / v) was used, the

extraction process was carried out with a 250 mL soxhlet (Pyrex® 50X250MM) for a period of 5 hours, the temperature was regulated to prevent the equipment exceed 100 °C. Half of the solvent was removed from the resulting extract using the rotary evaporator (R-205 Base model; Büchi Labortechnik AG, Flawil, Switzerland). The concentrated extracts were stored in 250 mL glass bottles and kept refrigerated at 2 ± 2 °C.

Table 1: Species of plants and solvents used to obtain the extracts evaluated against nymphs of *Bemisia tabaci*.

Family	Common and scientific name	Tissue	Solvent	Place of obtaining the plants
Amaryllidaceae	Garlic (<i>Allium sativum</i>)	Bulb	Ethanol/Water (1:1)	Commercial (Saltillo, Coahuila)
Apiaceae	Cumin (<i>Cuminum cyminum</i>)	Seed	Ethanol	Commercial (Saltillo, Coahuila)
Asparagaceae	Mojave yucca (<i>Yucca schidigera</i>)	Leaf	Ethanol/Water (1:1)	Collect (University experimental field "El Bajio")
	Lechuguilla (<i>Agave lechuguilla</i>)	Leaf	Ethanol/Water (1:1)	Collect (University experimental field "El Bajio")
Asteraceae	Marigold (<i>Tagetes erecta</i>)	Complete plant	Ethanol	Collect (University experimental field "El Bajio")
Cucurbitaceae	Buffalo gourd (<i>Cucurbita foetidissima</i>)	Leaf and stem	Ethanol	Collect (University experimental field "El Bajio")
Euphorbiaceae	Castor bean (<i>Ricinus communis</i>)	Seed	Ethanol	Collect (University experimental field "El Bajio")
	Dragon's blood (<i>Jatropha dioica</i>)	Complete plant	Ethanol	Collect (University experimental field "El Bajio")
Fabaceae	Jicama (<i>Pachyrhizus erosus</i>)	Seed	Ethanol	Commercial (Irapuato, Guanajuato)
	Huizache (<i>Acacia farnesiana</i>)	Leaf and stem	Ethanol	Collect (University experimental field "El Bajio")
	Mezquite (<i>Prosopis laevigata</i>)	Leaf and stem	Ethanol	Collect (University experimental field "El Bajio")
	Cat's claw (<i>Mimosa zygophylla</i>)	Leaf and stem	Ethanol	Collect (University experimental field "El Bajio")
Lamiaceae	Thyme (<i>Thymus vulgaris</i>)	Leaf	Ethanol	Commercial (Saltillo, Coahuila)
Lauraceae	Cinnamon (<i>Cinnamomum verum</i>)	Stem bark	Ethanol	Commercial (Saltillo, Coahuila)
Meliaceae	Lilac (<i>Melia azedarach</i>)	seed	Ethanol	Collect (University experimental field "El Bajio")
Myrtaceae	Eucalyptus (<i>Eucalyptus globulus</i>)	Leaf	Ethanol	Collect (University experimental field "El Bajio")
Piperaceae	Black pepper (<i>Piper nigrum</i>)	Seed	Ethanol	Commercial (Saltillo, Coahuila)
Plantaginaceae	Ribwort (<i>Plantago lanceolata</i>)	Complete plant	Ethanol	Collect (University experimental field "El Bajio")
Resedaceae	Dyer's Rocket (<i>Reseda luteola</i>)	Complete plant	Ethanol	Collect (University experimental field "El Bajio")
Rutaceae	Orange (<i>Citrus sinensis</i>)	Orange peel	Ethanol	Commercial (Saltillo, Coahuila)
Solanaceae	Tree tobacco (<i>Nicotiana glauca</i>)	Leaf and stem	Ethanol	Collect (University experimental field "El Bajio")

Determination of phytochemicals

The concentrated extract was dried in the oven at a temperature of 35 ± 3 °C for 120 hours, completely removing the solvent. The solid fraction was used to determine the phytochemical compounds using the infrared spectrophotometer (Bruke, Model; ALPHA II FTIR), the compounds were corroborated in the database of Duke and Beckstrom (1994)^[9].

Bioassays

For the establishment of the bioassays *B. tabaci* was collected from merlot vine leaves, located in the ejido San Juan de la Vaquería, Saltillo Coahuila ($25^{\circ} 15'0''$ N and $101^{\circ} 13'1''$ W), the whiteflies were multiplied on bean plants (*Phaseolus vulgaris*) under laboratory conditions inside a bioclimatic chamber (Lab-Line Biotronette Mark III Environmental Chamber, Model: 846) a temperature of 26 ± 2 °C, relative humidity ($70 \pm 10\%$) and photoperiod (12:12).

The whitefly adults from the principal colony were placed inside of entomological cages with bean plants for a period of 24 hours, after this time the adults were withdrawn. The second instar nymphs (N2) were used for the test, the infested

leaf were collected for later by the immersion method to perform the evaluations. The treated leaves were placed on a sponge saturated with distilled water, with the abaxial side up. For the evaluation of plant extracts it was used a completely randomized design with eight concentrations and ten repetitions. Distilled water and Tween (0.1%) were used to prepare the concentrations. The death criteria used was total immobilization, dehydration and starvation at 120 hours after application.

Statistical analysis

The results obtained from the different concentrations were corrected by Abbott (1925)^[2]. The data were analyzed with the Probit using the maximum likelihood method (Finney, 1971)^[11], for the determination of LC₅₀ and LC₉₅ using the Rstudio program.

Results and Discussion

The different lethal concentrations (LC₅₀ and LC₉₅) of the 21 extracts evaluated against *B. tabaci* after 120 hours are shown below.

Table 2: Lethal concentrations, fiducial limits and confidence parameters of plant extracts against *B. tabaci*.

Extract	LC ₅₀	Fiducial limits	LC ₉₅	Fiducial limits	df	Slope+SE	X ²	P value
<i>R. communis</i>	1257	1058-1455	6042	4622-8996	8	2.41+0.16	17.1	0.029
<i>C. sinensis</i>	2804	2151-3561	19185	12919-35082	7	1.97+ 0.11	21.9	0.003
<i>N. glauca</i>	1260	1035-1497	6498	4646-11154	6	2.31+0.17	12.4	0.054
<i>M. azedarach</i>	1394	1164-1647	8685	6131-14767	7	2.07+ 0.14	13.2	0.067
<i>P. erosus</i>	2026	1773-2303	7519	5877-10796	6	2.89+ 0.19	10.2	0.118
<i>E. globulus</i>	1295	1122-1477	5009	3865-7417	7	2.80+ 0.18	14.6	0.041

<i>T. erecta</i>	2008	1622-2430	11639	8120-20560	6	2.16+ 0.15	13.1	0.042
<i>A. farnesiana</i>	1638	1474-1832	10585	7904-15753	6	2.03+ 0.17	2.57	0.861
<i>P. laevigata</i>	1365	1149-1616	5015	3726-8048	5	2.91+ 0.20	10.9	0.053
<i>P. nigrum</i>	1528	1243-1886	10648	6608-24703	5	1.95+ 0.17	8.44	0.133
<i>M. zygophylla</i>	778	638-924	3885	2782-6705	5	2.36+ 0.19	8.47	0.132
<i>Y. schidigera</i>	1233	1104-1364	7709	6171-10296	7	2.07+ 0.15	8.66	0.278
<i>A. lechuguilla</i>	1035	932-1137	4983	4100-6448	6	2.41+0.19	7.22	0.301
<i>A. sativum</i>	890	823-956	2853	2472-3442	6	3.25+ 0.24	5.22	0.516
<i>C. foetidissima</i>	1656	1325-2005	8266	5504-18022	7	2.36+ 0.18	23.5	0.001
<i>J. dioica</i>	795	698-885	4301	3466-5796	6	2.24+ 0.20	6.96	0.324
<i>T. vulgaris</i>	1808	1415-2281	10422	6636-23733	7	2.16+ 0.15	26.9	0.001
<i>C. cyminum</i>	2803	2221-3398	15740	10209-36640	6	2.19+ 0.19	15.2	0.019
<i>C. verum</i>	1420	1137-1739	6512	4542-11975	6	2.49+ 0.16	18.7	0.005
<i>R. luteola</i>	1948	1777-2142	9294	7502-12243	6	2.42+ 0.17	4.73	0.579
<i>P. lanceolata</i>	996	730-1253	11098	6856-25663	6	1.57+ 0.14	9.97	0.126

CL: Lethal concentrations (ppm). Fiducial limits: Confidence intervals. $P \leq 0.05$.

B. tabaci was susceptible to the extracts *M. zygophylla*, *J. dioica*, *A. sativum*, *P. lanceolata*, *A. lechuguilla*, *Y. schidigera* and *R. communis* with the lowest concentrations (LC₅₀ and LC₉₅) of the assay (Figure 1 and Figure 2), the LC₅₀ of this group is between the values of 778 to 1257 ppm. The other group of extracts to which *B. tabaci* showed medium susceptibility; *N. glauca*, *E. globulus*, *P. laevigata*, *M. azedarach*, *C. verum*, *P. nigrum* and *A. farnesiana* with LC₅₀

values between 1260 and 1638 ppm. The extracts that showed lower susceptibility were *C. foetidissima*, *T. vulgaris*, *R. luteola*, *T. erecta*, *P. erosus*, *C. cyminum* and *C. sinensis* with values from 1656 to 2804 ppm (Table 2). The *M. zygophylla* extract showed the lowest values of LC₅₀ and LC₉₅ in the bioassay with 778 and 3885 ppm respectively (Figure 1 and Figure 2). *C. sinensis* with LC₅₀ and LC₉₅ of 2804 and 19185 ppm respectively, showed a low susceptibility against *B. tabaci*.

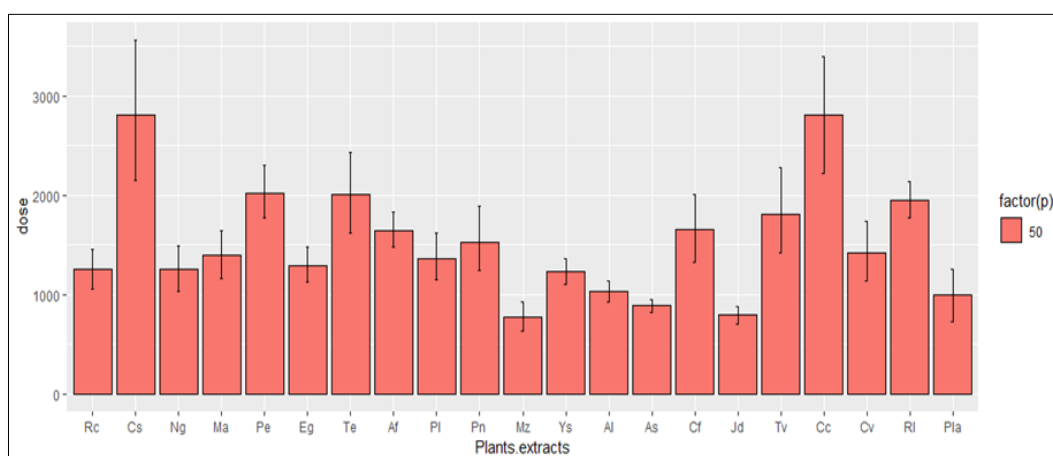


Fig 1: Lethal Concentration 50 (ppm) of plant extracts against nymphs of *B. tabaci*. Rc: *R. communis*, Cs: *C. sinensis*, Ng: *N. glauca*, Ma: *M. azedarach*, Pe: *P. erosus*, Eg: *E. globulus*, Te: *T. erecta*, Af: *A. farnesiana*, Pl: *P. laevigata*, Pn: *P. nigrum*, Mz: *M. zygophylla*, Ys: *Y. schidigera*, Al: *A. lechuguilla*, As: *A. sativum*, Cf: *C. foetidissima*, Jd: *J. dioica*, Tv: *T. vulgaris*, Cc: *C. cyminum*, Cv: *C. verum*, Ri: *R. luteola*, Pla: *P. lanceolata*.

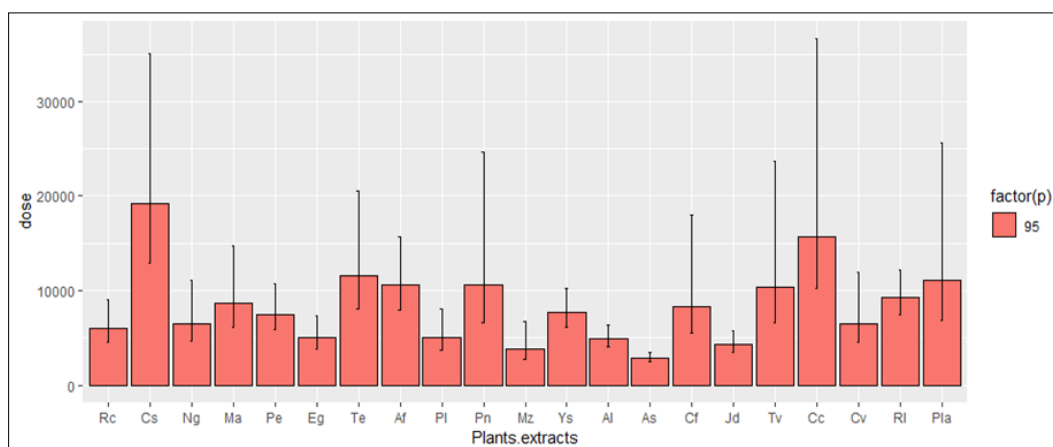


Fig 2: Lethal Concentration 95 (ppm) of plant extracts against nymphs of *B. tabaci*. Rc: *R. communis*, Cs: *C. sinensis*, Ng: *N. glauca*, Ma: *M. azedarach*, Pe: *P. erosus*, Eg: *E. globulus*, Te: *T. erecta*, Af: *A. farnesiana*, Pl: *P. laevigata*, Pn: *P. nigrum*, Mz: *M. zygophylla*, Ys: *Y. schidigera*, Al: *A. lechuguilla*, As: *A. sativum*, Cf: *C. foetidissima*, Jd: *J. dioica*, Tv: *T. vulgaris*, Cc: *C. cyminum*, Cv: *C. verum*, Ri: *R. luteola*, Pla: *P. lanceolata*.

The main phytochemical compounds present in the extracts evaluated against *B. tabaci* are shown below, by readings in

the infrared spectrophotometer with the solid fraction.

Table 3: Main phytochemical compounds present in the solid fraction of the extracts evaluated against *B. tabaci*.

Extract	Phytochemical compounds
<i>R. communis</i>	linoleic acid, palmitic acid, lectins, ricin, shikimic acid
<i>C. sinensis</i>	D-limonene, p-cumaric acid, P-cimeno, terpenes, ascorbic acid
<i>N. glauca</i>	nicotine, rutin, alkaloids, cinnamic acid, phenols
<i>M. azedarach</i>	palmitic acid, cinnamic acid, benzoic acid, 1-terpen-4-ol, 6-hydroxy-7-methoxycoumarin.
<i>P. erosus</i>	tartaric acid, flavonoids, phenols, D-mannose, rotenone
<i>E. globulus</i>	tartaric acid, terpenes, eucalyptol, 1,8-Cineole, chlorogenic acid
<i>T. erecta</i>	1,8-Cineole, D-limonene, beta-sitosterol, p-cumaric acid, kaempferol
<i>A. farnesiana</i>	tannins, methyl eugenol, terpineol, tartaric acid, stigmaterol
<i>P. laevigata</i>	tartaric acid, phenols, D-mannose, 4-5-7-trihydroxy flavone, linoleic acid
<i>P. nigrum</i>	tartaric acid, piperine, benzoic acid, beta-elemene, piperidine
<i>M. zygophylla</i>	tartaric acid, tannins, mimosine, phenols, D-mannose
<i>Y. schidigera</i>	gitogenin, phenols, saponins, yucca-saponin-B-2, flavonoids
<i>A. lechuguilla</i>	2-4-6 trinitrophenol, flavonoids, 2-hydroxy 1-2-3 propanetricarboxylic acid, 2-amino-2 methyl-1- propanol, vasaponins
<i>A. sativum</i>	2-3 dihydroxybutanedioic acid, 2,4,6-trinitrophenol, phenols, flavonoids, chloroquine, lectins, allicin
<i>C. foetidissima</i>	Cucurbitacin D, oleic acid, alanine, glycine, tryptophan
<i>J. dioica</i>	tartaric acid, 4-methylaniline, palmitic acid, alkaloids, flavonoids, saponins
<i>T. vulgaris</i>	ascorbic acid, alpha-terpineol, 1-8-cineol, tartaric acid, eugenol, thymol
<i>C. cuminum</i>	1-8-cineole, cinnamaldehyde, phenols, ascorbic acid, eugenol
<i>C. verum</i>	1-8-cineole, phenols, flavonoids, alpha terpineol, eugenol
<i>R. luteola</i>	kaempferol, quercetin, flavonoids, isoflavones, luteolin
<i>P. lanceolata</i>	coumar R-15, benzoic acid, phenols, apigenina, alkaloids, ascorbic acid

The most abundant compounds were different types of acids; oleic, linoleic, palmitic, tartaric, ascorbic, cinnamic, benzoic and shikimic present in most of the extracts evaluated, these acids are known to have important insecticidal activity (Table 3). The eugenol is a compound with important biological activity, present in cinnamon, cumin, huizache and thyme. In garlic and castor bean we found lectins, another important compound is 1,8-cineole present in cumin, cinnamon, thyme, marigold. D-Limonene, compound with important insecticidal activity is present in orange and calendula. The coumarins are present in ribwort and orange. D-Manosa is present in jicama, mesquite and cat's claw, finally different amino acids; alanine, glycine and tryptophan in buffalo gourd.

B. tabaci shows a high susceptibility (LC₅₀ and LC₉₅) to *M. zygophylla*, *J. dioica*, *A. sativum*, *P. lanceolata*, *A. lechuguilla*, *Y. schidigera* and *R. communis*. The effectiveness of this extracts is due to their different secondary metabolites with insecticidal action, Phenolic compounds and mimosine responsible for insecticidal activity against whiteflies are found in cat's claw. (Duke and Beckstrom, 1994; Marimuthu *et al.* 2010) [9, 18]. Dragon's blood has important metabolic composition; alkaloids, flavonoids and saponins (Valenzuela *et al.* 2019) [29], compounds with important effects against insects (Moreno *et al.* 2016) [21]. The garlic is one of the plants with the highest metabolic composition, sulphurous compounds and allyl groups (Farag *et al.* 2017; Misiorek *et al.* 2017) [10, 20], saponins (voghioside A1, A2, B1 and B2) (Lanzotti *et al.* 2012) [16], allicin, alliin, malic acid, pyroglutamic acid and some amino acids such as proline and isoleucine (Hrbek *et al.* 2018) [12]. Navarrete *et al.* (2016) [22] pointed out the compounds in Ribwort (catalpol, aucubina and verbascoside), Mazzutti *et al.* (2017) [19] reported the presence of polyphenolic compounds (plantamajoside and isobasbasoside). Almaraz *et al.* (2013) [4] described the potential of lechuguilla, phenolic compounds, flavonoids, isoflavonoids, saponins and phenolic acids are responsible for cytotoxic activity (Ramos *et al.* 2012) [25]. Yucca mojave is an important source of steroidal saponins and polyphenols

(Piacente *et al.* 2005) [24], resveratrol, stilbenes, for example, yuccaols of different groups (A, B, C, D and E) with important cytotoxic function (Cheeke *et al.* 2006) [7]. Different fatty acids are present in the seed of *R. communis* with multiple applications in pest control, ricinoleic, stearic, linoleic acid (Lin and Arcinas, 2007) [17] and pyrimidine alkaloid (Wachira *et al.* 2014) [30].

Conclusion

The most efficient plants extracts for whitefly control are *M. zygophylla*, *J. dioica*, *A. sativum*, *P. lanceolata*, *A. lechuguilla*, *Y. schidigera* and *R. communis*, this plants extracts presented metabolites such as saponins, fatty acids, flavonoids, terpenes and phenolic compounds, all with reports insecticidal activity.

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References

- Abbassy MMS. Farmer's Knowledge, Attitudes and Practices, and their Exposure to Pesticide Residues after Application on the Vegetable and Fruit Crops. Case Study: North of Delta, Egypt. Journal of Environmental and Analytical Toxicology. 2017; 7(5):1-6.
- Abbott WS. A method for computing the effectiveness of an insecticide. Journal Economic Entomology. 1925; 18:265-267.
- Alemandri V, Medina CG, Dumón AD, Argüello CEB, Mattio MF, García MS *et al.* Three members of the *Bemisia tabaci* (Hemiptera: Aleyrodidae) cryptic species complex occur sympatrically in horticultural crops. Journal Economic Entomology. 2015; 108(2):405-413.
- Almaraz AN, Delgado AE, Ávila RJA, Uribe SJN, González VLS. The Phenols of the Genus Agave (Agavaceae). Journal of Biomaterials and Nanobiotechnology. 2013; 04(03):9-16.

5. Ashfaq N, Amjad BM, Noreen M, Jameel N, Ayoub A, Latif A. Insecticidal efficiency of native plant extracts against whitefly (*Bemisia tabaci*) on cotton crop. *Pure and Applied Biology*. 2019; 8(1):727-732.
6. CABI. Invasive Species Compendium. Wallingford, UK: CAB International, 2018. <https://www.cabi.org/isc>. 16 Jan, 2020.
7. Cheeke PR, Piacente S, Oleszek W. Anti-inflammatory and anti-arthritic effects of *Yucca schidigera*: a review. *Journal of Inflammation*. 2006; 3(1):6.
8. Chen JC, Wang ZH, Cao LJ, Gong YJ, Hoffmann AA, Wei SJ. Toxicity of seven insecticides to different developmental stages of the whitefly *Bemisia tabaci* MED (Hemiptera: Aleyrodidae) in multiple field populations of China. *Ecotoxicology*. 2018; 27(6):742-751.
9. Duke JA, Beckstrom SSM. Dr. Duke's phytochemical and ethnobotanical databases, 1994. United States, Beltsville, Md. ARS/USDA <https://phytochem.nal.usda.gov/phytochem/search/list> 16 Jan, 2020.
10. Farag M, Ali S, Hodaya R, El Seedi H, Sultani H, Laub A *et al.* Phytochemical profiles and antimicrobial activities of *Allium cepa* red cv. and *A. sativum* subjected to different drying methods: a comparative MS-based metabolomics. *Molecules*. 2017; 22(5):1-18.
11. Finney DJ. Probit Analysis. Cambridge at the University Press. 1971; 3:50-80.
12. Hrbek V, Rektorisova M, Chmelarova H, Ovesna J, Hajslova J. Authenticity assessment of garlic using a metabolomic approach based on high resolution mass spectrometry. *Journal of Food Composition and Analysis*. 2018; 67:19-28.
13. Isman MB. Botanical insecticides, deterrents, and repellents in modern agricultural and an increasingly regulated world. *Annual Review of Entomology*. 2006; 51(1):45-56.
14. Jaber LR, Araj SE, Qasem JR. Compatibility of endophytic fungal entomopathogens with plant extracts for the management of sweetpotato whitefly *Bemisia tabaci* Gennadius (Homoptera: Aleyrodidae). *Biological Control*. 2018; 117:164-171.
15. Kliot A, Kontsedalov S, Lebedev G, Ghanim M. Advances in Whiteflies and Thrips Management. *Advances in Insect Control and Resistance Management*, 2016, 205-218.
16. Lanzotti V, Barile E, Antignani V, Bonanomi G, Scala F. Antifungal saponins from bulbs of garlic, *Allium sativum* L. var. Voghiera. *Phytochemistry*. 2012; 78:126-134.
17. Lin JT, Arcinas A. Regiospecific Analysis of Diricinoleoylacylglycerols in Castor (*Ricinus communis* L.) Oil by Electrospray Ionization-Mass Spectrometry. *Journal of Agricultural and Food Chemistry*. 2007; 55(6):2209-2216.
18. Marimuthu S, Rahuman AA, Rajakumar G, Santhoshkumar T, Kirthi AV, Jayaseelan C *et al.* Evaluation of green synthesized silver nanoparticles against parasites. *Parasitology Research*. 2010; 108(6):1541-1549.
19. Mazzutti S, Ferreira SR, Herrero M, Ibañez E. Intensified aqueous-based processes to obtain bioactive extracts from *Plantago major* and *Plantago lanceolata*. *The Journal of Supercritical Fluids*. 2017; 119:64-71.
20. Misiorek M, Sekuła J, Ruman T. Mass Spectrometry Imaging of low Molecular Weight Compounds in Garlic (*Allium sativum* L.) with Gold Nanoparticle Enhanced Target. *Phytochemical Analysis*. 2017; 28(6):479-486.
21. Moreno AR, Gallardo LBS, Ledezma LB, Escorza MA, Pérez VR, Guzmán DD. Determinación de los compuestos polifenólicos en extractos de *Jatropha dioica* y su capacidad antioxidante. *Revista Mexicana de Ciencias Farmacéuticas*. 2016; 47(4):42-48.
22. Navarrete S, Kemp PD, Pain SJ, Back PJ. Bioactive compounds, aucubin and acteoside, in plant in (*Plantago lanceolata* L.) and their effect on *in vitro* rumen fermentation. *Animal Feed Science and Technology*. 2016; 222:158-167.
23. Nombela G, Muñoz M. Host plant resistance for the management of *Bemisia tabaci*: A multicrop survey with emphasis on tomato. In: Stansly PA, Naranjo SE (eds) *Bemisia: Bionomics and Management of a Global Pest*. Springer Science Business Media B.V, 2010, 357-383.
24. Piacente S, Pizza C, Oleszek W. Saponins and Phenolics of *Yucca schidigera* Roetzl: Chemistry and Bioactivity. *Phytochemistry Reviews*. 2005; 4(2-3):177-190.
25. Ramos CF, Cardenas OA, Morales RC, Verde S, Cruz V. Cytotoxic activity of *Agave lechuguilla* Torr. *African Journal of Biotechnology*. 2012; 11(58):12229-12231.
26. Roy S, Ali M, Mony F, Islam S, Matin MD. Chemical Control of Whitefly and Aphid Insect Pest of French Bean (*Phaseolus vulgaris* L.). *Journal of Bioscience and Agriculture Research*. 2014; 2(2):69-75.
27. Singh J, Sohi AS, Mann HS, Kapur SP. Studies on whitefly *Bemisia tabaci* (Genn.) transmitted cotton leaf curl disease in Punjab. *Journal of Insect Science*. 1994; 7:194-198.
28. Tiwari SP, Nema S, Khare MN. Whitefly- a strong transmitter of plant viruses. *Journal of Plant Pathology*. 2013; 02:102-120.
29. Valenzuela SR, Jiménez V, García G, Betancourt D, Lozoya M, Almaráz C *et al.* Evaluation of the Antioxidant Activity of *Cnidioscolus chayamansa* (Chaya), *Euphorbia prostrata* (Herb of the Swallow) and *Jatropha dioica* (Drago blood) in Wistar rats Induced to Hyperglycemia. *International Journal of Morphology*. 2019; 37(1):36-42.
30. Wachira S, Omar S, Jacob J, Wahome M, Alborn HT, Spring DR *et al.* Toxicity of six plant extracts and two pyridone alkaloids from *Ricinus communis* against the malaria vector *Anopheles gambiae*. *Parasites & Vectors*. 2014; 7(1):1-8.