Evaluation of Ecuadorian genotypes of *Capsicum* spp. against infestations of *Bemisia tabaci*

Evaluación de genotipos ecuatorianos de *Capsicum* spp. ante infestaciones de *Bemisia tabaci*

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Abstract

The genus *Capsicum,* native to tropical and subtropical America, belongs to the Solanaceae family, which includes commercially important vegetables such as chilies and green peppers. The silverleaf whitefly *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae), causes losses to vegetables including *Capsicum* species. Among the alternatives of pest control, an effective, economical, and environmentally compatible method is the resistance of the host plant. Infestation by *B. tabaci* was evaluated in 73 *Capsicum* genotypes, corresponding to the species *C. annuum*, *C. baccatum*, *C. sinense*, *C. frutescens* and *C. pubescens* from an Ecuadorian genebank. Eighty-four percent of the *C. baccatum* genotypes evaluated showed the highest population densities of *B. tabaci*, while all the genotypes of *C. sinense* and *C. frutescens* had the lowest values (p < 0.05). The non-preference of adults and the scarce oviposition of *B. tabaci* on genotypes of *C. sinense* and *C. frutescens* suggests resistance due to antixenosis. These results could guide breeding programs for the resistance of *Capsicum* species to *B. tabaci* infestations.

Resumen

El género *Capsicum* es nativo de América tropical y subtropical, pertenece a la familia Solanaceae e incluye ajíes y pimientos, que son hortalizas comercialmente importantes. La mosca blanca *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) ocasiona pérdidas en hortalizas incluyendo especies de *Capsicum*. Entre las alternativas de control de plagas, un método eficaz, económico y ambientemente compatible es la resistencia de la planta hospedera. Se evaluó la infestación por *B. tabaci* en 73 genotipos de *Capsicum* nativos de Ecuador, correspondientes a las especies *C. annuum, C. baccatum*, *C. chinense*, *C. frutescens* y *C. pubescens*, provenientes de un banco de germoplasma ecuatoriano. El 84% de los genotipos de *C. baccatum* evaluados mostraron las mayores densidades poblacionales de *B. tabaci*, mientras que los menores valores los tuvieron todos los genotipos de *C. sinense* y *C. frutescens* (p < 0.05). La no preferencia de adultos y la escasa oviposición de *B. tabaci* sobre genotipos de *C. sinense* y *C. frutescens* sugiere resistencia por antixenosis. Estos resultados podrían orientar programas de mejoramiento genético para la resistencia de especies de *Capsicum* ante infestaciones por *B. tabaci*.

Introduction

The genus *Capsicum* belongs to the Solanaceae family and includes chili peppers and peppers; within this botanical family, *Capsicum*, stands out among the 90 genera of commercially important vegetables worldwide (Tripodi & Kumar 2019). This genus is native to tropical and subtropical America in an extensive region from Mexico to the southern part of the Andes, in which archaeological evidence suggests its use from the year 6000 BC (Tripodi & Kumar 2019). *Capsicum* comprises 42 species, including *Capsicum annuum* L., *C. baccatum* L., *C. frutescens* L., *C. pubescens* (Ruiz and Pavon) and *C. chinense* Jacq., (Qin et al. 2014, Vallejo-Gutiérrez et al. 2019); the first three are the most cultivated in the world (Anjos et al. 2018). Chili peppers and peppers have a wide variety of shapes, sizes, and colours of fruits, in which the hot ones are used as spices, and the sweet ones as vegetables, in addition to having decorative, medicinal, and cosmetologically purposes (Gálvez et al. 2021).

In Ecuador, the use of genus *Capsicum* dates from the Valdivia culture (3800 - 1500 BC). Eleven species are reported including the five already mentioned, as well as *Capsicum dimorphum* (Miers) Kuntze, *C. hookerianum* (Miers) Kuntze, *C. lycianthoides* Bitter, and *C. rhomboideum* (Dunal) Kuntze (Yánez et al. 2015) and *C. galapagoense* Hunz and *C. chesmanii* endemics to Galapagos Islands (Lucatti et al. 2013). More than 70 traditional varieties are cultivated and have been collected according to the Instituto Nacional de Investigaciones Agropecuarias (INIAP) (Yánez et al. 2015, Monteros-Altamirano et al. 2018).

The whitefly *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) causes losses in vegetables in tropical and subtropical areas of the world (Latournerie-Moreno et al. 2015, Li et al. 2021), due to the direct damage caused by the sap sucking involving chlorosis, leaf deformation and plant weakening, as well as indirect damage resulting from the presence of a fungus (*Capnodium* spp.) that produces sooty mould and interferes with the photosynthetic process (Ortega et al. 2019). However, the transmission of viral diseases is the most important damage caused by *B. tabaci* (Lorenzo et al. 2016, Guo et al. 2020).

The commonly used control measures against insect pests in horticultural crops are based on the use of organo-synthetic pesticides; however, these products are mostly toxic to the environment and to non-target species and favour the development of resistant populations (Nombela & Muñiz 2010). An effective, economical, and environmentally compatible method for the control of insect pests is host plant resistance (Ballina-Gomez et al. 2013).

Painter (1951) defined resistance as the genotypic condition of a plant that allows it to be less damaged than another of the same species under similar environmental conditions. It includes three categories: antixenosis, antibiosis, and tolerance. In antixenosis, the plant may not be preferred for oviposition, shelter, or feeding because it has certain qualities that make it a poor host (Painter 1951, Kogan & Ortman 1978, Jeevanandham et al. 2018), while antibiosis describes the adverse effects of the host plant on the biology of the insect, including death of the early stages, abnormal growth rates, failure to pupate, under size of adults (Painter 1951). Finally, resistant plants may be tolerant if they survive below levels of infestation that could kill or severely injure susceptible ones.

Studies have shown that *Bemisia tabaci* is affected by the physical characteristics of the leaf surface, such as villi, glandular trichomes, and leaf shape (Ballina-Gomez et al. 2013, Al-Aloosi et al. 2020, Sripontan et al. 2022). It is also known that pepper varieties and cultivars have different chemical composition, antioxidant and allelochemical compounds that influence resistance against phytophagous insects (Sripontan et al. 2022). Particularly, domesticated plants and wild relatives of *Capsicum* can be important sources of resistance to reduce damage by phytophagous (Ballina-Gomez et al. 2013, Tripodi & Kumar 2019). Therefore, the local germplasm of domesticated chillies and peppers could be sources of resistance especially in Ecuador, which is a country of high diversity of *Capsicum* species. Consequently, the objective of this study was to evaluate the response of Ecuadorian *Capsicum* genotypes to *B. tabaci* infestations.

Material and methods

The experiment was conducted from February until May 2018 inside a shade house of 1625 m² (25 m x 60 m) built with high-density polyethylene shade cloths and a transparent polyurethane roof, at the Experimental Station "La Teodomira", Faculty of Agricultural Engineering, Universidad Técnica de Manabí (UTM), Lodana, Manabí province, Ecuador (coordinates: 01° 09' 51" S and 80° 23' 24" W), altitude 60 meters above sea level. Inside the shade house, the average temperature was 26.25°C and the relative humidity was 79.75%. The life zone corresponds to a tropical dry forest.

Capsicum genotypes native to Ecuador (73 accessions) were evaluated, corresponding to *C. annuum*, *C. baccatum*, *C. frutescens*, *C. pubescens* and *C. chinense* (Syn. *C. sinense* Murray), from INIAP genebank originally collected from different provinces of Ecuador (Monteros-Altamirano et al. 2018). The accessions are being characterized morphologically and molecularly, whose genebank codification (numbers), respective species classifications as well as the provinces where the accessions were collected are presented in Table 1.

Seeds of each genotype were sown in 50-well germination trays (one seed per well) with peat moss where they remained for 30 days. Subsequently, plantlets were transplanted in the shade house at 1.30 m between rows and 0.70 m between plants (10 plants per genotype) in a completely randomized design. Irrigation was carried

Table 1. List of Ecuadorian *Capsicum* spp. accessions from INIAP's genebank evaluated in the present study.

No.	Species	Code	Province	No.	Species	Code	Province	No.	Species	Code	Province
1	C. annuum	ECU-2254A	El Oro	26	C. baccatum	ECU-12863	Loja	50	C. sinense	ECU-2239B	Manabí
2	C. annuum	ECU-2254B	El Oro	27	C. baccatum	ECU-12864	Azuay	51	C. sinense	ECU-2240	Manabí
3	C. annuum	ECU-2255	Loja	28	C. baccatum	ECU-12978	Morona Santiago	52	C. sinense	ECU-2241	Manabí
4	C. annuum	ECU-12860	Los Ríos	29	C. frutescens	ECU-2237	Manabí	53	C. sinense	ECU-2256	Galápagos
5	C. baccatum	ECU-2231	Los Ríos	30	C. frutescens	ECU-2246	El Oro	54	C. sinense	ECU-9119	Sucumbíos
6	C. baccatum	ECU-2232	Los Ríos	31	C. frutescens	ECU-2247	El Oro	55	C. sinense	ECU-9121	Napo
7	C. baccatum	ECU-2233	Los Ríos	32	C. frutescens	ECU-2251	El Oro	56	C. sinense	ECU-9122	Napo
8	C. baccatum	ECU-2250	Los Ríos	33	C. frutescens	ECU-2259	Loja	57	C. sinense	ECU-9123	Napo
9	C. baccatum	ECU-2253	Los Ríos	34	C. frutescens	ECU-5360	Sin dato	58	C. sinense	ECU-9126	Zamora Chinchipe
10	C. baccatum	ECU-2269	Los Ríos	35	C. frutescens	ECU-6553	Manabí	59	C. sinense	ECU-9129	El Oro
11	C. baccatum	ECU-11993	Imbabura	36	C. frutescens	ECU-11994A	Santo Domingo T.	60	C. sinense	ECU-11996	Morona Santiago
12	C. baccatum	ECU-12831	Imbabura	37	C. frutescens	ECU-11994B	Santo Domingo T.	61	C. sinense	ECU-12969	Morona Santiago
13	C. baccatum	ECU-12833	Imbabura	38	C. frutescens	ECU-11995	Santo Domingo T.	62	C. sinense	ECU-12970A	Morona Santiago
14	C. baccatum	ECU-12840	Loja	39	C. frutescens	ECU-12838	Loja	63	C. sinense	ECU-12972A	Morona Santiago
15	C. baccatum	ECU-12841	Loja	40	C. frutescens	ECU-12968	Morona Santiago	64	C. sinense	ECU-12973A	Morona Santiago
16	C. baccatum	ECU-12842	Loja	41	C. frutescens	ECU-12967A	Morona Santiago	65	C. sinense	ECU-12973B	Morona Santiago
17	C. baccatum	ECU-12843	Loja	42	C. frutescens	ECU-12967B	Morona Santiago	66	C. sinense	ECU-12973C	Morona Santiago
18	C. baccatum	ECU-12845	Loja	43	C. frutescens	ECU-12970B	Morona Santiago	67	C. sinense	ECU-12979	Morona Santiago
19	C. baccatum	ECU-12846	Loja	44	C. frutescens	ECU-12974	Morona Santiago	68	C. sinense	ECU-12982	Morona Santiago
20	C. baccatum	ECU-12847	Loja	45	C. frutescens	ECU-12975	Morona Santiago	69	C. sinense	ECU-12984	Morona Santiago
21	C. baccatum	ECU-12853	Loja	46	C. pubescens	ECU-2262	Imbabura	70	C. sinense	ECU-12985	Morona Santiago
22	C. baccatum	ECU-12854	Loja	47	C. pubescens	ECU-2263	Sin dato	71	C. sinense	ECU-12989	Pastaza
23	C. baccatum	ECU-12857	Loja	48	C. pubescens	ECUp-11991	Carchi	72	C. sinense	ECU-12990	Pastaza
24	C. baccatum	ECU-12859	Loja	49	C. sinense	ECU-2239A	Manabí	73	C. sinense	ECU-12991	Pastaza
25	C. baccatum	ECU-12862	Loja								

Note: ECU + # are codes of INIAP's genebank.

out twice a week for 15 minutes at the beginning of the cycle (first 35 days) and later for 30 minutes through a drip system with 0.02 mm tapes, located every 20 cm and a capacity of 3 L. hour⁻¹. Following previously established methodologies to induce populations of whiteflies through insecticide applications in tomato crops (Chirinos et al. 1996, Geraud-Pouey et al. 1996), all plants by *Capsicum* genotypes were sprayed with insecticides; four applications were made every 15 days starting with the transplant. The first two sprays were conducted with imidacloprid (15 days) and thiamethoxam (30 days) at doses of 2 cc.L⁻¹. For the other two applications chlorpyrifos (2.5 cc.L⁻¹) and Thiocyclam hydrogen oxalate (1 g.L⁻¹) were used, following local recommendations.

After insecticide spraying, observations were made on leaves to corroborate the establishment of *B. tabaci* individuals in all genotypes, which occurred approximately one month after the last spraying. Since then, the populations were monitored weekly on the leaves in each genotype until 90 days. The populations of *B. tabaci* were counted on four random leaves in four plants per genotype, two leaves in the upper layer and two in the middle layer of the plant. The leaves were kept in trans-

parent plastic bags, labelled for each genotype, and taken to the Entomology Laboratory of the Faculty of Agricultural Engineering, Universidad Técnica de Manabí. There were observed under a $10 - 40X$ magnification stereoscope Carl-Zeiss® brand, counting per leaf the number of: eggs, nymphs, and adults, of *B. tabaci*.

The number of eggs, nymphs and adults per leaf was analysed by ANOVA ($p < 0.05$). The comparison of means by genotype were evaluated with the Scott-Knott test ($p < 0.05$) and by species with the LSD Fischer test ($p < 0.05$). A dendrogram including the average of the total number of individuals of *B. tabaci* per leaf by genotype was plotted to establish similarity relationships based on infestations, using the unweighted arithmetic average method and Euclidean distance. The analyses were performed using the statistical software InfoStat professional version 2019 (Di Rienzo et al. 2019).

Results

In relation to number of adults, the Scott-Knott test determined three groups according to media differentiation (a, b, and c) (Fig. 1, $p < 0.05$).
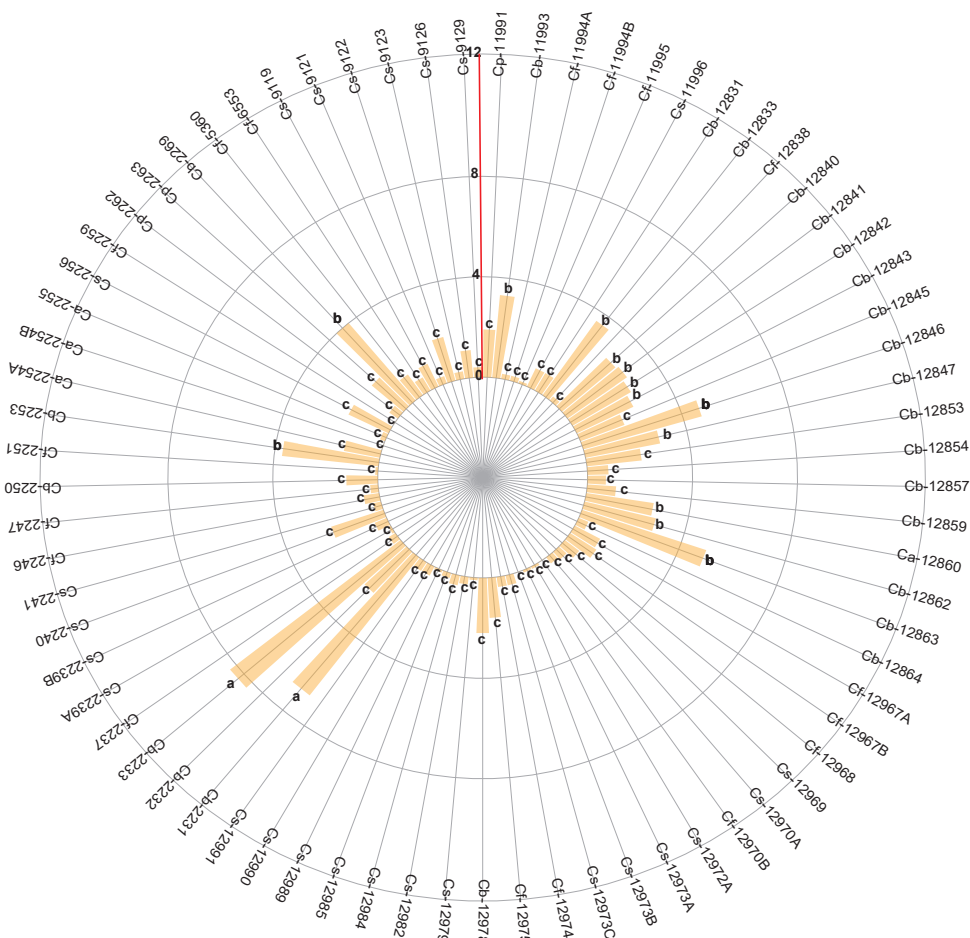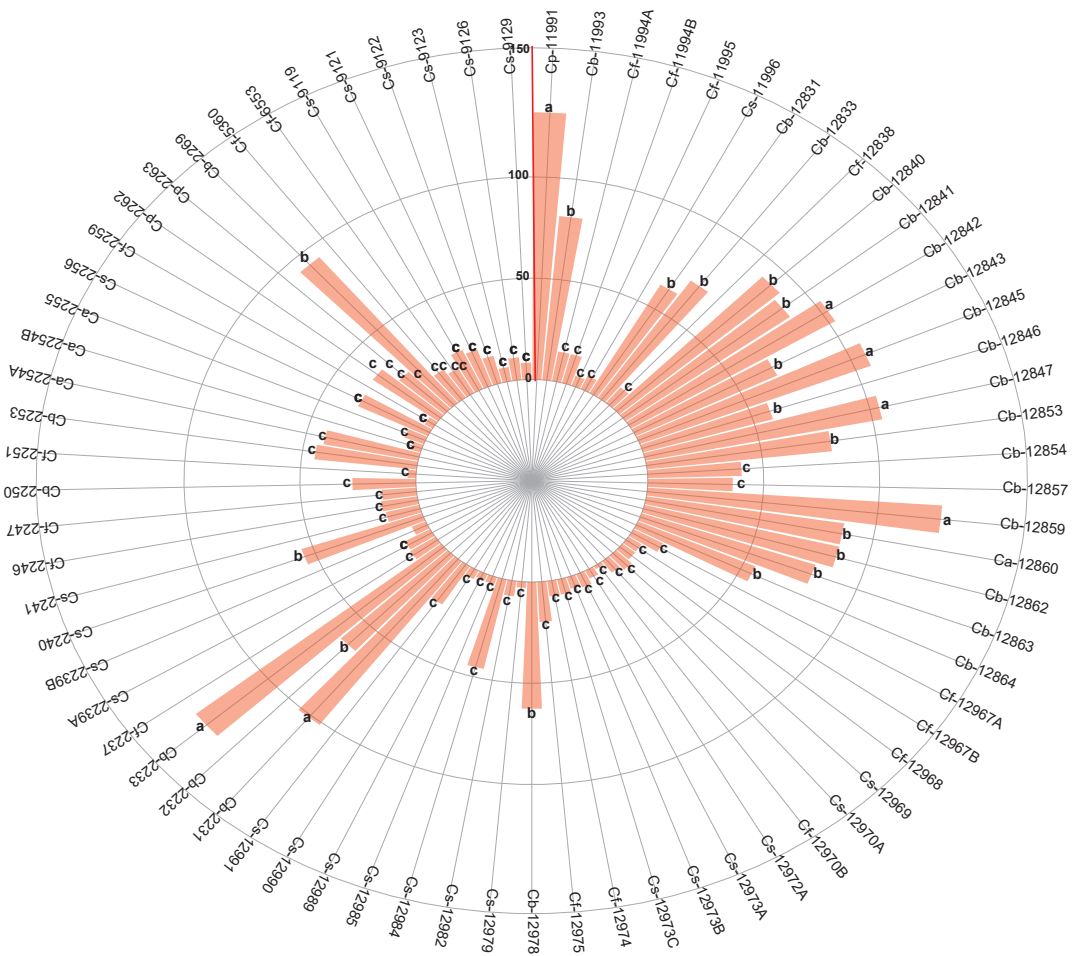

Figure 1. Number of adults of *Bemisia tabaci* evaluated in the 73 genotypes of the five cultivable *Capsicum* species. *C. annuum* (Ca); *C. baccatum* (Cb); *C. frutescens* (Cf); *C. pubescens* (Cp); *C. sinense* (Cs). The bars represent the means by genotype. Mean followed by different letters in each bar is significantly different at 0.05 level of significance using Scott-Knott test ($p < 0.05$).

The first group (a) identified high number of adults of *B. tabaci* in two genotypes of *C. baccatum* (2231 and 2233 codes). The second group included 15 accessions of *C. baccatum* and one accession of *C. annuum*. The third group with the least number of adults included 25 accessions of *C. sinense*, 10 of *C. baccatum* 16 of *C. frutescens* and 3 of *C. annuum*. Regarding the higher number of eggs (range or group "a") (Fig. 2, p < 0.05) were found in 4 accessions of *C. baccatum* (12859, 12847, 12845, 12842) one accession of *C. pubescens* (11991) and one *C. baccatum* (2269). The second group includes 14 accessions of *C. baccatum* and one accession of *C. sinense*. Finally, the third group with the lesser number of eggs includes 24 accessions of *C. sinense*, 4 of *C. baccatum*, 17 of *C. frutescens*, 3 of *C. annuum* and 2 of *C. pubescens*. Average of the number of nymphs are also separated in three groups according to the Scott-Knott test (Fig. 3, p < 0.05).

The first group with the higher number of nymphs are 3 accessions of *C. baccatum* (12853, 12845 and 2232). The second group includes other 3 *C. baccatum* accessions (12847, 12842, 12831) and the third group

with the lesser number of nymphs includes 17 accessions of *C. baccatum*, 25 of *C. sinense*, 17 of *C. frutescens*, 4 of *C. annuum* and 3 of *C. pubescens* (Fig. 3). When comparing the variables by species according to the differences in the degrees of significance, the number of adults, eggs, and nymphs of *B. tabaci* were significantly higher in *C. baccatum* and lower in *C. frutescens* and *C. sinense* (Table 2).

The dendrogram constructed by genotype including average of density per leaf of all individuals of *B. tabaci* shows three groups with similar genotypes depending on the level of pest infestation (Fig. 4). A first group (right to left) made up of 14 genotypes that showed a high infestation, of which 13 belong to *C. baccatum*, one to of *C. annuum*. The second group is made up of 6 genotypes of *C. baccatum*. A third grouping includes those genotypes of *Capsicum* spp. with lower infestations including all genotypes of *C. frutescens* and *C. sinense*, as well as three of the four genotypes of *C. annuum*, two of *C. pubescens* and three of *C. baccatum*.


Figure 2. Number of eggs of *Bemisia tabaci* evaluated in the 73 genotypes of the five cultivable *Capsicum* species. *C. annuum* (Ca); *C. baccatum* (Cb); *C. frutescens* (Cf); *C. pubescens* (Cp); *C. sinense* (Cs). The bars represent the means by genotype. Mean followed by different letters in each bar is significantly different at 0.05 level of significance using Scott-Knott test (p < 0.05).
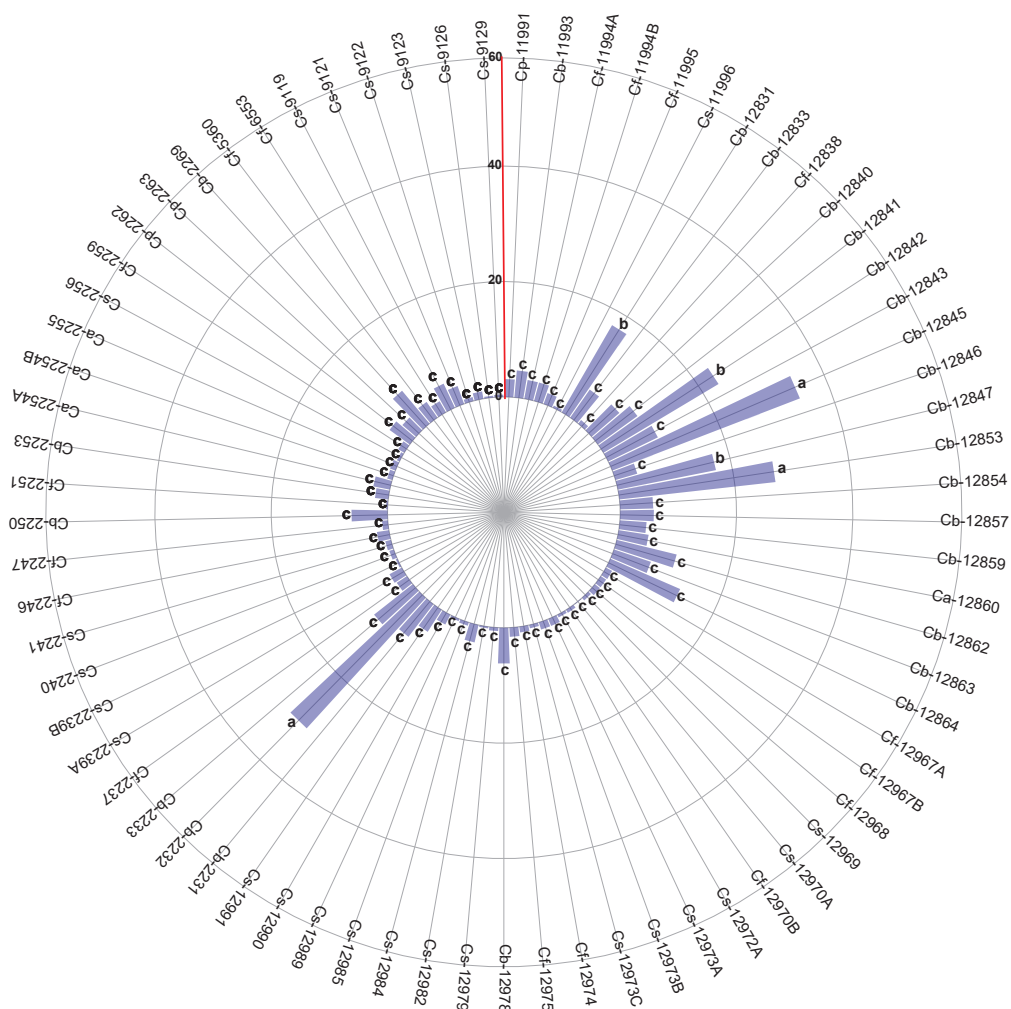
Figure 3. Number of nymphs of *Bemisia tabaci* evaluated in the 73 genotypes of the five cultivable *Capsicum* species. *C. annuum* (Ca); *C. baccatum* (Cb); *C. frutescens* (Cf); *C. pubescens* (Cp); *C. sinense* (Cs). The bars represent the means by genotype. Mean followed by different letters in each bar is significantly different at 0.05 level of significance using Scott-Knott test (p < 0.05).

Table 2. Average of the number of adults, eggs, and nymphs of *Bemisia tabaci* per leaf in accessions of *Capsicum* species. Means ± standard error. Mean followed by different letters in each column is significantly different at 0.05 level of significance using Fischer test (p < 0.05).

Species host	Adults	Eggs	Nymphs
C. annuum	1.1 ± 0.4 b	35.3 ± 8.1 b	2.5 ± 1.8 bc
C. baccatum	2.9 ± 0.2 a	79.6 ± 3.4 a	11.6 ± 0.7 a
C. sinense	0.5 ± 0.2 c	13.6 ± 3.2 c	1.3 ± 0.8 d
C. frutescens	0.5 ± 0.2 c	10.9 ± 3.9 c	1.7 ± 0.7 c
C. pubescens	1.2 ± 0.4 b	64.3 ± 8.1 a	3.5 ± 1.8 b
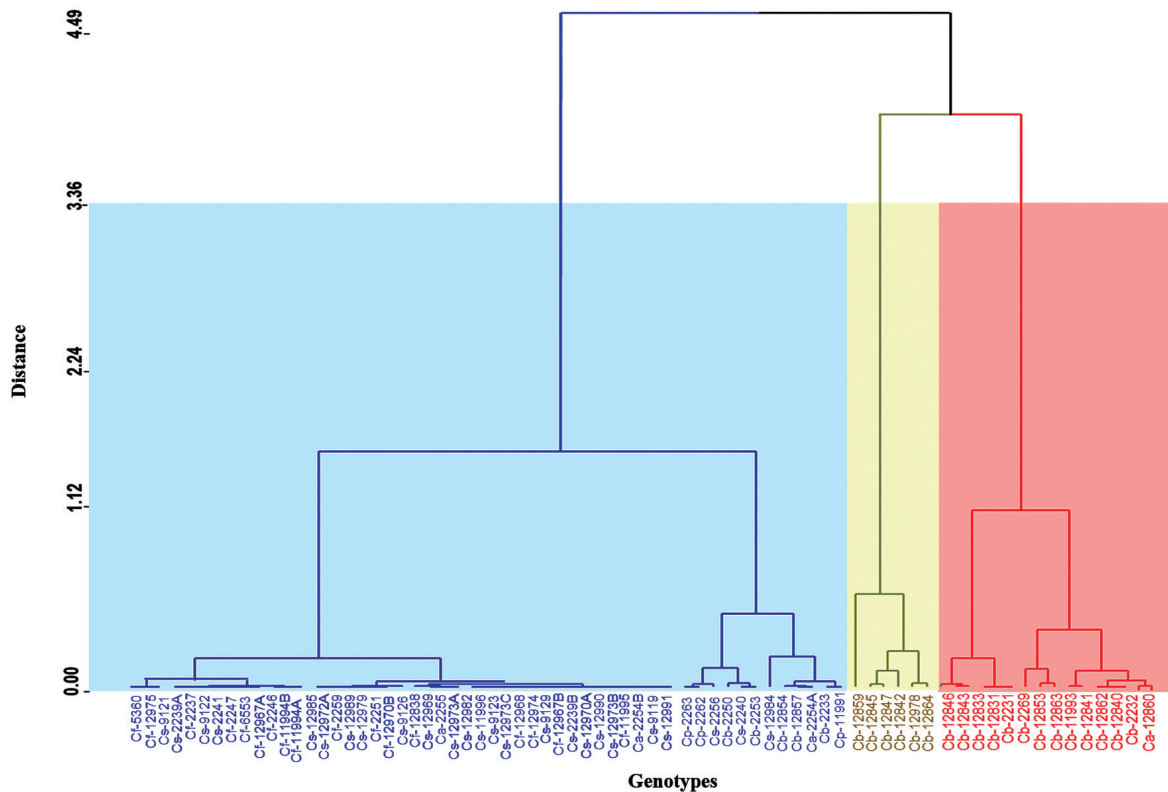
Figure 4. Dendrogram of 73 genotypes of *Capsicum* spp. in relation to the infestation of *Bemisia tabaci. C. annuum* (Ca); *C. baccatum* (Cb); *C. frutescens* (Cf); *C. pubescens* (Cp); *C. sinense* (Cs). Each color includes the genotypes with infestations similar to the distance at which the dendrogram was cut.

Discussion

Resistance of *C. annuum* genotypes to *B. tabaci* infestations has been proven in field and laboratory research carried out in different geographical areas e.g. Al-Aloosi et al. (2020) in field conditions at Iraq, evaluated a local variety and two commercial varieties of *C. annuum* "Anaheim chili" and "Aleppo"; the last one showed the lowest infestations by *B. tabaci*, whose resistance is attributed to the presence of secondary metabolites and other factors, such as the high density of trichomes, thickness and colour of the leaves. Jeevanandham et al. (2018) in a study conducted under shade house conditions, detected fewer adults and eggs of *B. tabaci* in 4 genotypes of *C. annuum* suggesting their strong antixenotic and antibiotic effects. Free-choice tests conducted inside entomological boxes evaluated the resistance of *C. annuum* genotypes collected in south-eastern Mexico, to *B. tabaci* (Ballina-Gomez et al. 2013, Chan et al. 2014). Of the twelve genotypes evaluated by Ballina-Gomez et al. (2013), three (Blanco, Bolita and Pico Paloma) showed low egg hatching and little or no survival of *B. tabaci* nymphs, mentioning that resistance could be associated with antibiosis due to low nutritional quality or toxic secondary metabolites. Chan et al. (2014) assessed 14 genotypes, in which the one collected in a wild habitat (Maax ik), showed the least attraction of adults and low preference for oviposition.

Besides *C. annuum*, resistance to *B. tabaci* has also been examined in genotypes of the other species such as *C. frutescens*, *C. pubescens*, and *C. sinense*. Pantoja et al. (2018) in a *B. tabaci* oviposition preference test found a small number of adults and eggs on some accessions of *C. annuum*, *C. frutescens*, *C. pubescens*, and *C. sinense*, conferring resistance to the infection due to antixenosis. Sripontan et al. (2022) evaluated in entomological boxes resistance to *B. tabaci* of *C. annuum*, *C. frutescens* and *C. sinense* cultivars; small number of adults of *B. tabaci* were found in cultivars of *C. annuum* while those of *C. frutescens* and *C. sinense* presented a higher number of both adults and eggs. Firdaus et al. (2011) evaluated the resistance of forty-four genotypes of *C. annuum*, *C. baccatum*, *C. frutescens* and *C. sinense* species, finding a high negative correlation between the number of adults and eggs of *B. tabaci* and two characteristics of the leaf (the density of glandular trichomes and the thickness of the cuticle). Additionally, *C. annuum* was the species that developed the lowest whitefly populations. Kumar et al. (2020) evaluated the resistance of 125 *Capsicum* genotypes and associated the non-preference of *B. tabaci* to the presence of glandular and non-glandular trichomes, as well as the flavonoids contained in the plants.

The results presented allow to identify three situations among the native *Capsicum* of Ecuador evaluated to the infestation of *B. tabaci*: One, in which a high population density of *B. tabaci* was observed in 76% of the *C. baccatum* genotypes; two, in which most of the evaluated genotypes of *C. annuum* and *C. pubescens* showed low populations; and third, all genotypes of *C. frutescens* and *C. sinense* showed low whitefly infestations.

Genetic variability has been detected in *Capsicum* accessions and hybrids, which present distinct morphological and molecular characteristics (Costa et al. 2016, Cardoso et al. 2018, Tripodi & Kumar 2019). This could explain the different whitefly infestation rates in genotypes of *C. baccatum* and *C. annuum*. Low infestation in *C. pubescens* could be associated with the pubescence of the leaves; however, it is not ruled out that the presence of volatile compounds, high concentrations of capsaicinoids in this species as well as *C. frutescens* and *C. sinense* have affected the colonization of *B. tabaci* populations on the evaluated accessions.

The high attraction of *B. tabaci* for *C. baccatum* genotypes, as well as the low infestation in all the genotypes of *C. frutescens* and *C. sinense* is demonstrated in this study. The non-preference of adults and the scarce oviposition of *B. tabaci* on genotypes of *C. frutescens* and *C. sinense* suggest resistance due to antixenosis that could later have affected the lower number of nymphs. Nevertheless, antibiotic effects of the genotypes on *B. tabaci* nymphs cannot be ruled out. The term antixenosis was proposed by Kogan and Ortman (1978) and defined as the resistance mechanism employed by the plant to deter colonization by an insect and may include morphological changes, such as subtle variations in plant surface colour, waxy or hairy leaves, and flavour, as well as defensive exudations of gums or resins.

Tripodi and Kumar (2019) reported that an important number of accessions of cultivated and wild species are stored in genebanks around the world, which represent a valuable resource for breeding to transfer traits related to resistance to selected cultivars. Certainly, these results can be used as a basis for genetic improvement for the resistance of *Capsicum* species to *B. tabaci*.

This research shows the high attraction of the whitefly *B. tabaci,* towards evaluated genotypes of *C. baccatum*. Likewise, results indicate the non-preference of adults and the scarce oviposition of *B. tabaci* over genotypes of *C. sinense* and *C. frutescens*, suggesting resistance due to antixenosis. These results could guide breeding programs for the resistance to *B. tabaci* infestations of *Capsicum* species.

Literature cited

Al-Aloosi ANS, Al-Anbaki HAM, Kamil SH. 2020. Host plant resistance, chili pepper to whitefly, Bemisia tabaci (Gennadius) (Hemiptera: Aleyrodidae) in field. International Journal of Agricultural and Statistics 16(1): 103–106.

Anjos IV, Silva LP, Silva LR, Araújo KL, Amorim AFS, Barelli MAA, Neves L. 2018. Reação de acessos de Capsicum spp. ao fungo Fusarium solani. Summa Phytopathologica 44: 344–349. https://doi.org/10.1590/0100-5405/189662

Ballina-Gomez H, Ruiz-Sanchez E, Chan-Cupul W, Latournerie-Moreno L, Hernández-Alvarado L, Islas-Flores I, Zuñiga-Aguilar JJ. 2013. Response of Bemisia tabaci Genn. (Hemiptera: Aleyrodidae) Biotype B to genotypes of pepper Capsicum annuum (Solanales: Solanaceae). Neotropical Entomology 42: 205–210. https://doi.org/10.1007/s13744-012-0106-0

Cardoso R, Ruas CF, Giacomin RM, Ruas PM, Ruas EA, Barbieri RL, Rodrigues R, Goncalves LSA. 2018. Genetic variability in Brazilian Capsicum baccatum germplasm collection assessed by morphological fruit traits and AFLP markers. PLOS ONE 13(5):e0196468. https://doi.org/10.1371/journal. pone.0196468

Chan Cupul W, Ruiz Sánchez E, Chan Díaz JR, Latournerie Moreno L, Rosado Calderón AT. 2014. Atracción de adultos y preferencia de oviposición de mosquita blanca (Bemisia tabaci) en genotipos de Capsicum annuum. Revista Mexicana de Ciencias Agrícolas 5(1): 77–86. https://doi.org/10.29312/remexca.v5i1.1011

Chirinos DT, Geraud-Pouey F. 1996. Efectos de algunos insecticidas sobre la entomofauna del tomate, en el noroeste del estado Zulia, Venezuela. Interciencia. 21(1): 31-36.

Costa MPSD, do Rêgo MM, da Silva APG, Barroso PA. 2016. Characterization and genetic diversity of pepper (Capsicum spp) parents and interspecific hybrids. Genetics and Molecular Research 15 (2): gmr.15027652. http://doi.org/10.4238/gmr.15027652

Firdaus S, Van Heusden A, Harpenas A, Supena EDJ, Visser RGF, Vosman B. 2011. Identification of silverleaf whitefly resistance in pepper. Plant Breeding 130(6): 708–714. https://doi.org/10.1111/j.1439-0523.2011.01894.x

Gálvez YA, Cea ME, Lesher Gordillo JM, Latournerie-Moreno L, Martínez-Moreno E, Martínez-Sánchez JL, Castañón-Nájera G. 2021. Comparacion molecular de poblaciones de chile (Capsicum spp.) de Tabasco y Chiapas, México. Bioagro 33(1): 3–12 https://doi.org/10.51372/bioagro331.1

Geraud-Pouey F, Chirinos DT, Vergara JA. 1996. Efectos colaterales de tratamientos con insecticidas sobre la entomofauna del tomate, Lycopersicon esculentum Miller, cv. Peto Seed en la zona del río Limón del estado Zulia, Venezuela. Rev. Fac. Agron. (LUZ). 13(3): 313-325.

Guo Q, Shu Y, Liu C, Chi Y, Liu Y, Wang X-W. 2020. Transovarial transmission of tomato yellow leaf curl virus by seven species of the Bemisia tabaci complex indigenous to China: Not all whiteflies are the same. Virology 531: 240–247. https://doi.org/10.1016/j.virol.2019.03.009

Jeevanandham N, Marimuthu M, Natesan S, Gandhi K, Appachi S. 2018. Plant resistance in chillies Capsicum spp against whitefly, Bemisia tabaci under field and greenhouse condition. Journal of Entomology and Zoology Studies 6(2): 1904–1914.

Kogan M, Ortman EF. 1978. Antixenosis: a new term proposed to define Painter's "nonpreference" modality of resistance. Bulletin of the Entomological Society of America 24(2):175–176. https://doi.org/10.1093/besa/24.2.175

Kumar Yadav R, Kamala Jayanthi PD, Kumar M, Saravan Kumar P, Rao K, Madhavi Reddy K. 2020. Screening chilli genotypes for whitefly (Bemisia tabaci Genn.) resistance: A vector for chilli leaf curl virus. International Journal of Chemical Studies 8(1): 971–979

Latournerie-Moreno L, Ic-Caamal A, Ruiz-Sánchez E, Ballina-Gómez H, Islas-Flores I, Chan-Cupul W, González-Mendoza D. 2015. Survival of Bemisia tabaci and activity of plant defense-related enzymes in genotypes of Capsicum annuum L. Chilean Journal of Agricultural Research 75(1): 71–77. https://doi.org/10.4067/S0718-58392015000100010

Li Y, Mbata GN, Punnuri S, Simmons AM, Shapiro-Ilan DI. 2021. Bemisia tabaci on Vegetables in the Southern United States: Incidence, impact, and management. Insects 12(3): 198, https://doi.org/10.3390/insects12030198

Lorenzo ME, Grille G, Bonato O. 2016. Host preferences and biotic potential of Trialeurodes vaporariorum and Bemisia tabaci (Hemiptera: Aleyrodidae) in tomato and pepper. Arthropod-Plant Interactions 10: 293–301. https://doi.org/10.1007/s11829-016-9434-z

Lucatti AF, van Heusden AW, de Vos RC, Visser RG, Vosman B. 2013. Differences in insect resistance between tomato species endemic to the Galapagos Islands. BMC Evolutionary Biology, 13(1):175. https://doi.org/10.1186/1471-2148-13-175

Monteros-Altamirano A, Tacán M, Peña G, Tapia C, Paredes N, Lima L. 2018. Guía para el manejo y conservación de recursos fitogenéticos en Ecuador. Protocolos. Publicación miscelánea No. 432. Santa Catalina: INIAP-FAO. 104 pp.

Nombela G, Muñiz M. 2010. Host Plant Resistance for the Management of Bemisia tabaci: A Multi-crop Survey with Emphasis on Tomato. In: Bionomics and Management of a Global Pest. [Dordrecht]: Springer; p. 357–383. https://doi.org/10.1007/978-90-481-2460-2

Ortega ES, Veggiani-Aybar CA, Ávila AL, Reguilón C. 2019. Estudio preliminar de la fluctuación de Bemisia tabaci (Hemiptera: Aleyrodidae) en cultivos de tomate y pimiento bajo cubierta, Tucumán, Argentina. Intropica 14(1): 60-64. https://doi.org/10.21676/23897864.2766

Pantoja KFC, Rocha KCG, Melo AMT, Marubayashi JM, Baldin ELL, Bentivenha JPF, Gioria R, Kobori RF, Pavan MA, Krause-Sakate R. 2018. Identification of Capsicum accessions tolerant to Tomato severe rugose virus and resistant to Bemisia tabaci Middle East-Asia Minor 1 (MEAM1). Tropical Plant Pathology 43: 138–145. https://doi.org/10.1007/s40858-018-0212-6

Qin C, Yu C, Shen Y, Fang X, Chen L, Min J, Cheng J, Zhao S, Zu M, Lou Y, et al. 2014. Whole-genome sequencing of cultivated and wild peppers provides insights into Capsicum domestication and specialization. PNAS 111(14): 5135–5140. https://doi.org/10.1073/pnas.1400975111

Di Rienzo JA, Casanoves F, Balzarini MG, Gonzalez L, Tablada M, Robledo CW. 2019. InfoStat versión 2019. Cordoba, Argentina: Centro de Transferencia InfoStat, FCA http://www.infostat.com.ar

Sripontan Y, Chiu C-I, Charoensak K, Sukthongsa N. 2022. Host selection of the tobacco whitefly Bemisia tabaci (Hemiptera: Aleyrodidae) among four pepper cultivars (Capsicum spp.), Thailand. Khon Kaen Agriculture Journal 50(3): 899-909. https://doi.org/10.14456/kaj.2022.77.900

Tripodi P, Kumar S. 2019. The Capsicum Crop: An Introduction. In: The Capsicum Genome, Compendium of Plant Genomes. [Switzerland] Springer Nature; p. 1–8. https://doi.org/10.1007/978-3-319-97217-6_1

Vallejo-Gutiérrez AJ, Mejía-Carranza J, García-Velasco R, Ramírez-Gerardo MG. 2019. Respuesta de genotipos de Capsicum pubescens al daño ocasionado por el complejo fúngico de la marchitez. Revista Mexicana de Fitopatología 37(1): 50–70. https://doi.org/10.18781/r.mex.fit.1809-3

Yánez P, Rivadeneira L, Balseca D, Larenas C. 2015. Características morfológicas y de concentración de capsaicina en cinco especies nativas del género Capsicum cultivadas en Ecuador. La Granja: Revista de Ciencias de la Vida 22(2): 12–32. https://doi.org/10.17163/lgr.n22.2015.02

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