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Screening Cultivated Eggplant and Wild Relatives for Resistance to Sweetpotato Whitefly (*Bemisia tabaci*) and to Two-Spotted Spider Mite (*Tetranychus urticae*)

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Abstract

Whiteflies and spider mites are amongst the most harmful eggplant (*Solanum melongena*) pests. Considering the need for reduction of chemical applications for whitefly and spider mite control, the exploitation of wild relatives of eggplant as sources of pest resistances represents an important strategy in order to improve cultivated eggplant. The objectives of this study were to evaluate 15 accessions from 11 species of eggplant wild relatives together with seven *S. melongena* accessions for resistance to sweet potato whitefly (*Bemisia tabaci*) and to two-spotted spider mite (*Tetranychus urticae*). Resistance to whitefly was evaluated based on number of eggs, nymph, puparium and whitefly adults in a choice bioassay, while for two-spotted spider mite it was based on leaf damage scores in the choice and no-choice bioassays. The results revealed significantly (*P*<0.05) different levels of resistance to the two pests among the accessions evaluated. Considering all screening parameters in the whitefly choice bioassay, the highest levels of resistance in wild eggplant relatives were detected in *Solanum dasyphyllum* (DAS1) and *S. pyracanthos* (PYR1), although one of the cultivated *S. melongena* (MEL2) accessions also displayed similar resistance levels. In addition, *S. campylacanthum* (CAM8) and *S. tomentosum* TOM1 were also resistant to whitefly based on numbers of puparium and adult whiteflies. Two accessions of *S. sisymbriifolium* (SIS1 and SIS2) exhibited strong resistance to two-spotted spider mite based on the choice and no-choice bioassays. High levels of spider mite resistance were also detected in the no-choice assay in *S. dasyphyllum* (DAS1) and *S. torvum* (TOR2) accessions. These resistant accessions can be used in pre-breeding program aiming to breed pest-resistant cultivars in cultivated eggplant. Moreover, to our knowledge, this study represents the first report on potential sources of resistance to whitefly and two-spotted spider mite in wild relatives of eggplant.

Keywords. antibiosis, antixenosis, *Solanum melongena*, two-spotted spider mite resistance, wild relatives, whitefly resistance

Introduction

Eggplant (*Solanum melongena* L., 2n=2x= 24) is a member of the nightshade (Solanaceae) family, and is one of the most widely grown and consumed vegetable crops around the world. Unlike other solanaceous crops, eggplant is native to the Old World and was first domesticated over 4000 years ago in South East Asia (Meyer et al. 2012). Eggplant contributes to a healthy diet of low-income consumers, as it has high amounts of vitamins, dietary minerals, and bioactive phenolic compounds (Plazas et al. 2014b; Taher et al. 2017). Besides its nutritional importance, eggplant has also been used in traditional medicine to treat many diseases (Meyer et al. 2015; Im et al. 2016). China is the largest producer of eggplant (28.4 million tons; 57% of world's total), followed by India, Egypt, Turkey, and Iran. Additionally, eggplant is a high-value vegetable commodity and provides opportunities for smallholder farmers to raise their income, with an approximate global production of 50 million tons annually and the cultivated area extending over 1.8 million hectares (FAO, 2017).

In most eggplant cultivation areas, its production is hampered by pests, particularly during the warm seasons. Hence, eggplant is exposed to a broad range of pests such as mites, whiteflies, aphids, eggplant fruit and shoot borer, leafhopper, thrips, spotted beetles, leaf roller, stem borer, and blister beetle (Rotino et al. 1997; Medakker and Vijayaraghavan 2007; Srinivasan 2009; Taher et al. 2017). Two of the most widespread and destructive pests are the sweet potato whitefly (*Bemisia tabaci* Gennadius) and the two-spotted spider mite (*Tetranychus urticae* Koch.), which can cause considerable damage on leaves and fruits that result in reduced leaf photosynthetic efficiency and fruit quality, and increases the number of unmarketable fruit (Schuster et al. 1996; Ghidiu et al. 2006; Rakha et al. 2017a). Most importantly, more than 200 species of plant viruses are transmitted by whitefly (Hogenhout et al. 2008; Wang et al. 2017). Uncontrollable infestations of these pests in eggplant can cause 100 % yield loss as a result of direct feeding damage (Srinivasan 2009). The control of these two pests is notoriously difficult because of their high reproductive capacity and they can quickly damage crops (Khanamani et al. 2014). Eggplant farmers, particularly in developing countries, rely mainly on chemical pesticides for pest control; for instance, eggplant farmers in the Philippines sprayed around of 20–72 times with mixtures of pesticides per crop season (5–6 months/season) for pest control (Medakker and Vijayaraghavan 2007; Choudhary and Gaur 2013; Hautea et al. 2016). Pest management by chemical pesticides is often costly, especially in open cultivation systems and presents high risks to human health, environment and non-target organisms such as beneficial insects (Abudulai et al. 2001; Del Prado-Lu 2015). Furthermore, a long-term application of insecticides results in the development of pest-resistant insects (Helps et al. 2017). Biological Control by natural enemies presents an environmentally friendly method of controlling pests but it is not sufficient in the open field conditions (Bostanian et al. 2003; Khanamani et al. 2014). Considering these aspects, the availability of pest-resistant eggplant cultivars provides new possibilities for crop protection against pests, and would reduce pesticide applications and associated input costs. To date, no eggplant cultivars are resistant to whitefly or to two-spotted spider mite.

Eggplant wild relatives provide an invaluable source of variation for improving cultivated eggplant (Rotino et al. 2014). These wild relatives of eggplant may carry genes for traits that have not been identified in cultivated eggplant, and have also been recognized for their remarkable ability to withstand pests, diseases and various abiotic stresses (Bubici and Cirulli 2008; Frary et al. 2003; Daunay and Hazra 2012; Naegele et al. 2014). More than 50 species closely related to eggplant exist, mostly in tropical Eastern Africa and the Middle East (Syfert et al. 2016). Resistance to pests and diseases has been found in some wild eggplant species, for instance, resistance to shoot and fruit borer (*Leucinodes orbonalis*) in *S. sisymbrifolium, S. xanthocarpon* and *S. aculeatissimum* (Khan et al. 1978; Chelliah and Srinivasan 1983; Rotino et al. 1997), as well as resistance to carmine spider mite (*Tetranychus cinnabarinus*) and cotton aphid (*Aphis gossypii*) in *S. mammosum* and *S. sisymbrifolium* (Schalk et al. 1975; Sambandam and Chelliah 1983; Rotino et al. 1997). The wild relatives of eggplant have been defined into primary, secondary and tertiary genepools according to the ease of crossability with the cultivated eggplant for use by plant breeders (Harlan and de Wet 1971; Plazas et al. 2016; Syfert et al., 2016; Gramazio et al. 2017).

Compared to other crops in the Solanaceae, the exploration of plant natural defenses that are present in wild relatives of eggplant and its use in backcross breeding programs have been limited (Daunay 2008; Díez and Nuez 2008). In the last years, eggplant breeding program objectives have mostly focused on improving fruit yield and quality and , and more recently nutritional and bioactive properties (Kashyap et al. 2003; Frary et al. 2006; Toppino et al. 2016), but did not focus on improving pest resistance. However, increased interest by farmers in pest-resistant eggplant cultivars has brought as a new priority objective of plant breeders the identification of pest resistant source in eggplant wild relatives as the first step in breeding for a pest-resistant crop.

The aim of this work was to evaluate a collection of accessions of wild eggplant relatives from different gene pools using choice and no-choice bioassays in order to identify sources of resistance against the whitefly and the two-spotted spider mite. The information presented in this study may open a way to eggplant breeders for developing eggplant varieties exhibiting resistance to these two pests, which would help farmers to reduce the use of pesticides.

Materials and methods

Plant materials and growth conditions

Plant materials consisted of seven accessions of cultivated eggplant and 15 wild accessions including *S. insanum* (1), *S. anguivi* (2), *S. campylacanthum* (2), *S. dasyphyllum* (1), *S. incanum* (1), *S. lichtensteinii* (1), *S. linnaeanum* (2), *S. pyracanthos* (1), *S. tomentosum* (1), *S. sisymbriifolium* (2), *S. torvum* (1). *Solanum melongena* (MEL3) was used as pest-susceptible check for this experiment based on preliminary experiments (Table 1). Experiments were conducted at the World Vegetable Center (WorldVeg) in Taiwan. Seeds of cultivated and wild accessions were obtained from the Universitat Politècnica de València (UPV, Valencia, Spain). Seeds were sown in 14 cm pots (in diameter) with potting soil in a WorldVeg greenhouse (26 ± 4 ºC, 16/8 h day/night). Plants were watered daily and fertilized weekly with a NPK 15-15-15 fertilizer. Five weeks after sowing, seedlings of accession and check were transplanted into 12 cm^2 pots (in diameter) with potting soil and moved from the plastic greenhouse to growth rooms at 27 ± 2°C temperature, 65 ± 5% relative humidity (RH) and a photoperiod of 16/8 h day/night. Accessions and check were first evaluated for all whitefly resistance parameters in the choice, and later for two-spotted spider mite leaf damage in the choice and no choice bioassay. Due to low germination, two wild accessions (INS1, SIS2) were discarded in whitefly choice bioassay, and cultivated accession MEL2 in the spider mite choice and no-choice bioassays.

Whitefly choice bioassay

The initial population of whitefly (*B. tabaci*, biotype B) used in choice assays was originally collected from WorldVeg field. Laboratory colonies of whitefly were reared and maintained on cabbage plants (*Brassica oleracea* L.) in muslin-covered cages in a growth chamber at 23–30 ˚C as described in Rakha et al. (2017 a).

Four plants per accession and the susceptible check were included for the whitefly choice bioassay. Six-week-old plants were transferred to cages (50 × 160 × 40 cm) and arranged according to a completely randomized design. Plant spacing was 20 cm and 15 cm between and within accessions, respectively. Four cages (blocks) were used and each cage contained one plant of each of the twenty accessions and the check. For each cage, 210 pairs of non-viruliferous whitefly were collected with a hand-held aspirator, and were released at once in each cage. The number of whiteflies that had settled on each plant was recorded three days after introduction by gently turning the plants and noting the number of adults on the abaxial side of the leaves. Adult whiteflies were removed from the plants by a handmade vacuum aspirator after counting. Numbers of eggs, nymphs and puparium were counted under a stereo microscope (10×) at 3, 11 and 18 days, respectively, after infestation. Numbers of adults were counted again 23 days after introduction. Log transformation was used to normalize adult-whitefly data before analysis; egg, nymph and puparium data were transformed by natural logarithm (ln) before analysis.

Two-spotted spider mite choice and no choice bioassays

The two-spotted spider mite (*T. urticae*) colony used in choice and no-choice bioassays was reared and maintained on 2-3-week-old bean (*Phaseolus vulgaris* L.) plants in a growth room at 23–30°C as described in Rakha et al. (2017b). Bean plants were replaced every 12 days by cutting an infested plant and placing it on top of a new plant for several days to allow spider mites to move onto the new plants. Bean leaves with a very high density of spider mites, eggs and nymphs were used for choice and no-choice bioassays.

For choice bioassays, six-week-old plants were evaluated for two-spotted spider mite damage in seedling trays. The plants were arranged according to a randomized complete block design in 35-plug seedling trays (5 rows x 7 columns) with one plant per accession and check in each experimental unit, so that there were 22 plants per tray. The trays were moved on stainless steel benches in growth rooms with the temperature 26 ± 2°C and conditions (70% RH, 16/8 h day/night) as described above. The plants were covered by a net (60 mesh) and mass infested with a very high density of spider mites from bean leaves. Each tray was infested by two bean plants highly infested with about 3300 spider mite adults, eggs and nymphs. When the bean leaves wilted the net was removed from the plants, because the spider mites had moved onto the eggplant plants. Leaf damage was scored 10 days after spider mite infestation using a 0-5 visual scale based on the percentage of the leaf area damaged, where 0 indicates no symptoms (complete resistant); 1 indicates <5% leaf area affected (highly resistant); 2 indicates 6–20% leaf area affected (resistant); 3 indicates 21–50% leaf area affected and light webbing (moderate resistant); 4 indicates 51–90% leaf area affected and intense webbing (susceptible); 5 indicates 91–100% of leaf area affected, intense webbing, or a dead plant (highly susceptible).

In no-choice bioassays, each accession and the susceptible check were represented by six plants. Six-week-old plants were moved in small pots (7 cm) with sterilized potting soil and arranged according to a completely randomized design, with a spacing 20 cm between plants on stainless steel benches in growth rooms. One day after moving to growth rooms, the plants were mass infested with a very high density of spider mites from bean leaves. Each plant was inoculated with about 50 to 75 spider mite adults, eggs and nymphs. The bean leaves were removed from the eggplant plants when they wilted because the spider mites had moved onto the eggplant plants. After 6 weeks of spider mite infestation, the leaf damage was scored as described above.

Statistical analysis

Statistical procedures were performed using the statistical software SAS (version 9.1; SAS Institute, Cary, NC). Data of whitefly resistance parameters in choice bioassay and spider mite damage in both choice and no-choice bioassays were subjected to one-way analysis of variance (ANOVA) and mean comparisons were made using Duncan's multiple range test ($P = 0.05$).

Results

Whitefly resistance in choice bioassay

A total of 20 accessions corresponding to 6 *S. melongena* and 14 wild relatives along with susceptible check (MEL3) were assessed for all whitefly resistance parameters in the choice bioassay between 3 and 23 days after whitefly infestation (Table 2). Highly significant differences among accessions and the susceptible check (*S. melongena* accession MEL3) for all whitefly resistance parameters were detected ($P < 0.001$). Very high numbers of adults, eggs, nymphs and puparium survived on the susceptible check, cultivated accession ANS26 and wild accessions *S. sisymbriifolium* SIS1 and *S. incanum* MM577. Conversely, numbers of adults, eggs, nymphs and puparium were significantly lower (by 6- to 11-fold) on wild accessions *S. pyracanthos* PYR1 and *S. dasyphyllum* DAS1 compared to other tested entries. Though *S. campylacanthum* accessions CAM8 and *S. tomentosum* TOM1 harbored high number of eggs (106.7), most of them were not developed into puparium stage. Interestingly, few numbers of eggs, nymph, puparium and whitefly adults were also found on cultivated accession MEL2.

Two-spotted spider mite resistance in choice and no-choice bioassays

In choice bioassays, a total of 21 cultivated and wild eggplant accessions and susceptible check (MEL3) were evaluated for spider mite damage 10 days after infestation in choice bioassay (Fig. 1). The analysis of variance revealed highly significant differences ($P < 0.0001$) between the wild accessions and the check for spider mite damage. The susceptible check accession (MEL3) had severe damages, with a mean rating of 5. The two accessions of *S. sisymbriifolium* showed very less damage to spider mite with a mean rating of 0.5. Moderate resistance was observed in *S. torvum* (TOR2) and *S. melongena* (ANS26), with a mean rating of 3. Furthermore, the accessions of *S. dasyphyllum* DAS1, *S. incanum* MM577, *S. lichtensteinii* LIC2 sustained significantly less damage than MEL3. The remaining accessions were highly susceptible, with a mean rating of 5.

In spider mite no-choice bioassays, symptoms started to occur two weeks after infestation, and damage scores were recorded six weeks after infestation. Results from the no-choice bioassay (Fig 2) indicated highly significant differences ($P < 0.0001$) between the cultivated and wild eggplant accessions and the susceptible check for spider mite damage. Eggplant check MEL3 and *S.*

campylacanthum accession CAM5 were highly susceptible compared to other tested entries. Interestingly, no damage was found on the accessions of *S. sisymbriifolium*. High levels of resistance were also observed in *S. dasyphyllum* (DAS1) and *S. torvum* (TOR2) accessions, with a mean rating of 0.25. Furthermore, the accessions of *S. lichtensteinii* and *S. tomentosum* showed moderate resistance, with a mean rating of 3. The remaining accessions were susceptible or highly susceptible to two-spotted spider mites.

DISSCUSION

Insect pests are a major limiting factor in crop cultivation and production throughout the world. Crop losses due to pests have been estimated at 18–26% of the annual crop production worldwide (Culliney 2014). On commercial eggplant, whiteflies and spider mites are major pests because their feeding behavior causes yield losses in both quality and quantity, particularly in the tropics and sub-tropics where temperatures are high. Current management strategies are not effective due to a high reproduction rate, dispersion, and rapid development of resistance to a wide array of insecticides. The best approach to prevent the pest problems from occurring in eggplant is the development of resistant cultivars. However, the narrow genetic base of cultivated eggplant (Barchi et al., 2019) is considered a major bottleneck for eggplant improvement; therefore, the use of crop wild relatives is a promising strategy to enhance the genetic diversity of cultivated eggplant. In spite of the successful crossing made between cultivated eggplant and many wild relatives from different gene pools (Daunay and Hazra 2012; Liu et al. 2015; Plazas et al. 2016; García-Fortea et al. 2019), few reports are available on the identification of insect resistant eggplant wild relatives and to introduce these into modern eggplant varieties.

In the present study, cultivated eggplant and wild species were evaluated for resistance to whitefly and two-spotted spider mite through choice and no-choice bioassays in order to identify potential sources of resistance that can be used as valuable resources for future pest resistance breeding program. The whitefly choice bioassays showed high levels of resistance in *S. pyracanthos* (PYR1) and *S. dasyphyllum* (DAS1) based on screening parameters in the choice bioassays number of eggs, nymphs, puparium and adults, indicating the occurrence of antixenosis and/or antibiosis. This resistance mechanism commonly affects insect behavior during host plant selection, as well as may directly or indirectly impact the insect's reproduction (Smith 2005; Smith and Clement 2012). Furthermore, cultivated accession MEL2 and two wild accessions *S. campylacanthum* (CAM8) and *S. tomentosum* (TOM1) were resistant based on low numbers of puparium and adult whiteflies, indicating the occurrence of antibiosis in these accessions. Antixenosis and antibiosis studies in pests have been tested in tomato (*S. lycopersicum*), cotton (*Gossypium hirsutum* L.), bean (*P. vulgaris*), and cucurbits (Soria et al. 1999; Jindal et al. 2008; Firdaus et al. 2012). So far, there have been no studies on the mechanisms of host plant resistance to pests in eggplant species. The presence of antixenosis and antibiosis resistance mechanisms can be tested in choice bioassay (van Emden, 2002). Several resistance parameters can be tested in the choice bioassays such as density of eggs, nymphs, puparium and whitefly adults (Muigai et al. 2003; Oriani and Vendramim 2010; Oriani et al. 2011; Firdaus et al. 2012; Rakha et al. 2017a). Furthermore, the no-choice bioassay assesses presence of antibiosis resistance mechanisms (Baldin and Beneduzzi 2010). Pest preference and performance are influenced by the quality of the host plants (Leimu et al. 2005). There are several biophysical and biochemical factors involved in host plant selection by insects, which include leaf color (Sippell et al. 1987, van Lenteren and Noldus 1990), leaf wax accumulation and trichomes (McAuslane 1996; Snyder et al. 1998; Smith 2005, Rakha et al.

2017a), leaf age (Bentz et al. 1995, Cardoza et al. 2000, Liu and Stansly 1995), pH (Berlinger et al. 1983), semiochemicals (Bleeker et al. 2009; Bleeker et al. 2012), nitrogen availability (Bentz et al. 1995) and amino acid composition (Blackmer and Byrne 1999).

Our results in whitefly choice bioassays showed significant differences in numbers of eggs, nymphs, puparium and adults on the various wild and cultivated eggplant species. Similar results were found in cultivated and wild accessions of tomato (*Solanum lycopersicum*) in choice bioassays (Firdaus et al. 2012; Rakha et al. 2017), demonstrating the viability of this test. Unlike tomato (*Solanum lycopersicum*) on which whitefly stay for a few hours after landing, whitefly seldom stay on eggplant plants for several days (van Lenteren and Noldus 1990).

Resistant accessions identified in the present study (*S. pyracanthos* and *S. dasyphyllum*) belong to the secondary genepool of cultivated eggplant (Syfert et al. 2016) and its hybrids and backcrosses with common eggplant are partially fertile (Kouassi et al. 2016; Plazas et al. 2016). In addition, *S. dasyphyllum* is the putative progenitor of *S. macrocarpon* (African eggplant), and hybrids between *S. macrocarpon* and *S. dasyphyllum* are fully fertile (Bukenya and Carasco 1994).

In this study, resistance to spider mite was identified based on damage scores in the choice and no choice bioassays. The choice and no-choice bioassays revealed overall differences among wild and cultivated accessions in spider mite resistance. *Solanum sisymbriifolium* accessions exhibited high resistance in the choice and no-choice bioassays suggesting the expression of high levels of antixenosis and antibiosis for spider mite. Moreover, *S. torvum* accession showed moderate resistance in the choice bioassay and exhibited high resistance in the no-choice bioassay. However, both species belong to the tertiary genepool of eggplant (Syfert et al., 2016) and development of introgression populations with these two species has proved unsuccessful so far (Plazas et al., 2016). On the other hand, the *S. dasyphyllum* accession was susceptible in the choice bioassay, but it was resistant in the no-choice bioassay. Variation for resistance in this accession indicates that resistance factors affecting spider mite damage in the choice bioassay may be different from those involved in no-choice bioassays in *S. dasyphyllum*. Most previous research has demonstrated that secondary metabolites such as terpenes, terpenoids and acylsugar stored in glandular trichomes play a relevant role in plant defenses against this mite in several Solanaceae crops (Agut et al., 2014, 2018). Taher et al. (2018) reported that the spider mite resistance was highly correlated with high densities of glandular trichomes in African eggplant. In tomato wild relatives, Rakha et al. (2017b) also showed that glandular trichomes and acyl sugars provide physical and chemical defense against spider mite. Further studies are required to identify mechanisms of resistance in resistant sources identified in the present study.

Overall the results of our study indicate that *S. dasyphyllum* (DAS1) was resistant to both of whitefly and spider mite, indicating that resistance in this accession might be a valuable source for future eggplant improvement programs. In addition, *S. pyracanthos* appears to be another promising resistant source for whitefly resistance, and *S. sisymbriifolium* and *S. torvum* for spider mite resistance. Crosses between cultivated eggplant and wild relatives (*S. dasyphyllum* and *S. pyracanthos*) were successfully made by Spanish research group at Universitat Politècnica de València and introgression lines with *S. dasyphyllum* are being developed. These useful pre-breeding materials will enable us to confirm resistance in these resistant sources and map pest resistance genes. Development of new pest-resistant varieties will reduce pesticide use and contribute to more sustainable agriculture.

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Conflicts of Interest

The authors declare no conflict of interests

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Table 1. Species, genepool, country origin and previously known resistance traits in cultivated and wild relatives of eggplant tested for insect resistance in the present study

Species	Genepool	Country of origin	Resistance traits	Reference
Solanum insanum	GP1		Adaptation to drought and other abiotic environmental stresses.	Ranil et al. 2017
INS2		Sri Lanka	No information	
S. anguivi	GP2		Resistance to *Ralstonia solanacearum*	Schippers 2000
ANG1		Ivory Coast	No information	
ANG2		Ivory Coast	No information	
S. campylacanthum	GP2	Unknown	No information	
CAM5		Tanzania	No information	
CAM7		Unknown	No information	
S. dasyphyllum	GP2	Uganda	High content in bioactive phenolic acids	Plazas et al. 2016
DAS1			No information	
S. lichtensteinii	GP2	Iran	Tolerance to drought	Vorontsova and Knapp 2012
LIC2			No information	
S. linnaeanum	GP2		Tolerance to salinity and resistance to verticillium wilt (*Verticillium dahliae*)	Liu et al. 2015
LIN1		Spain	No information	
LIN3		Spain	No information	
S. pyracanthos	GP2		Tolerance to verticillium wilt (*Verticillium dahliae*)	Bletsos and Olympios 2008
PYR1		Unknown	No information	
S. tomentosum	GP2		It potential for antimicrobial activities	Aliero and Afolayan 2006
TOM1		South Africa	No information	

S. sisymbriifolium	GP3		Resistance to nematodes and verticillium wilt	Bletsos et al. 2003
SIS1		Unknown	No information	
S. torvum	GP3		Resistance to verticillium wilt, bacteria,and *Fusarium oxysporum*, nematodes and high tolerance to salinity	Bletsos et al. 2003
TOR2		Unknown	No information	
Solanum incanum	GP2		Resistance to *Pseudomonas solanacearum*, *Leucinodes orbonalis*, *Phomopsis rexans* and tolerance to drought	Bletsos and Olympios, 2008
MM577		Israel	No information	
Solanum melongena	GP1		Some accession resistance to *Phytophthora capsici* L. and *Ralstonia solanacearum*	Naegele et al. 2014; AVRDC 1999
ANS26		Ivory Coast	No information	
MEL1		Ivory Coast	No information	
MEL2		Ivory Coast	No information	
MEL3		Ivory Coast	No information	
MEL4		Sri Lanka	No information	
MEL5		Sri Lanka	No information	
MEL6		Sri Lanka	No information	

Table 2: Means of sweetpotato whitefly resistance parameters in cultivated eggplant and wild relatives based on choice bioassays

Taxa and accessions code	Adult whitefly (3WF) (no)^z		Eggs (no.)^y		Nymph (no.)		Puparium (no.)		Adult whitefly (23WF) (no.)	
Solanum insanum										
INS2	1.3	bc	200.0	abcd	75.8	a	51.3	bcd	95.0	bc
Solanum anguivi										
ANG1	4.3	bc	127.5	bcd	9.8	b	11.8	d	56.3	bc
ANG2	2.7	bc	143.8	abcd	27.3	b	35.0	bcd	58.0	bc
Solanum campylacanthum										
CAM5	9.3	bc	106.3	bcd	11.5	b	31.8	bcd	38.0	bc
CAM8	2.5	bc	106.7	bcd	42.0	ab	4.3	d	26.0	c
Solanum dasyphyllum										
DAS1	2.3	bc	37.5	d	6.5	b	4.3	d	11.5	c
Solanum lichtensteinii										
LIC2	3.3	bc	132.5	bcd	26.0	b	75.5	abcd	82.0	bc
Solanum linnaeanum										
LIN1	8.3	bc	136.3	abcd	10.8	b	20.5	bcd	44.3	bc
LIN3	1.7	bc	66.3	cd	8.0	b	19.0	bcd	42.0	bc
Solanum pyracanthos										
PYR1	0.3	c	28.8	d	0.5	b	12.0	d	13.8	c
Solanum tomentosum										
TOM1	4.0	bc	70.0	cd	8.0	b	6.0	d	22.5	c
Solanum sisymbriifolium										
SIS1	16.3	ab	320.0	a	25.5	b	82.5	ab	128.8	bc
Solanum torvum										
TOR2	28.0	a	261.3	ab	6.5	b	77.3	abcd	118.8	bc

Solanum incanum										
MM577	8.3	bc	180.0	abcd	22.8	b	44.5	bcd	143.3	ab
Solanum melongena										
MEL1	2.3	bc	112.5	bcd	16.5	b	28.8	bcd	54.8	bc
MEL2	3.5	bc	51.7	d	3.3	b	5.7	d	13.0	c
MEL4	5.0	bc	155.0	abcd	25.3	b	29.0	bcd	62.8	bc
MEL5	7.3	bc	88.8	bcd	6.8	b	19.3	bcd	32.8	bc
MEL6	4.7	bc	140.0	abcd	14.5	b	15.8	cd	32.8	bc
ANS26	8.3	bc	246.3	abc	44.8	ab	138.0	a	234.3	a
MEL3 (Susceptible check)	12.0	bc	188.8	abcd	29.0	b	89.0	abc	126.3	bc

1. [z] Whitefly adults were counted 3 (3WF) and 23 (23WF) days after whitefly infestation

2. [y] Means followed by different letters within columns are different by Duncan’s multiple range test in 0.05 *P*-significance

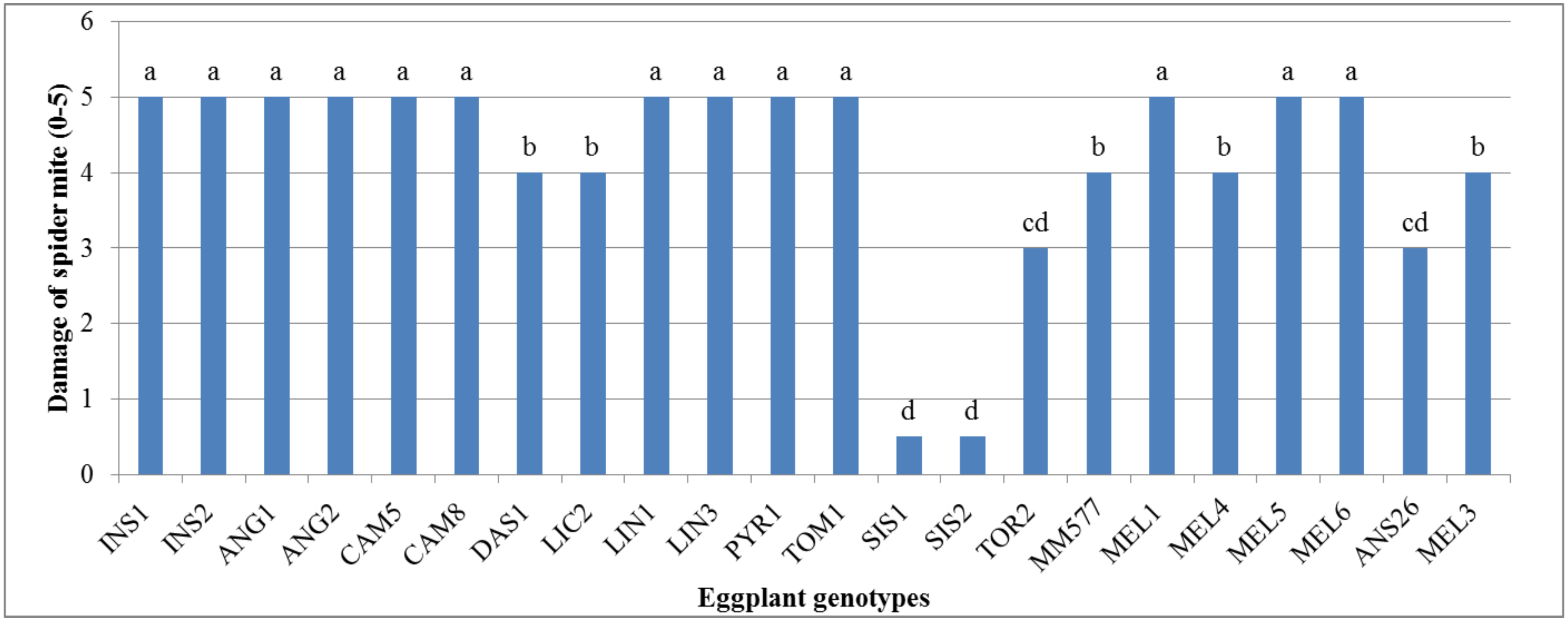

Fig. 1 Spider mite damage in the choice assays in cultivated and wild relatives of eggplant accessions 10 days after spider mite infestation in the growth room (26 ± 2°C; 70% H; 16/8 h day/night). Ratings assessed visually based on the leaf damage in the choice assays using a 0 to 5 scale, where 0 indicates no symptoms (complete resistant); 1 indicates <5% leaf area affected (highly resistant); 2 indicates 6–20% leaf area affected (resistant); 3 indicates 21–50% leaf area affected and light webbing (moderate resistant); 4

indicates 51–90% leaf area affected and intense webbing (susceptible); 5 indicates 91–100% of leaf area affected, intense webbing, or a dead plant (highly susceptible). Means (n=4) followed by different letters are significantly different according to according to Duncan’s multiple range test at $p < 0.05$.

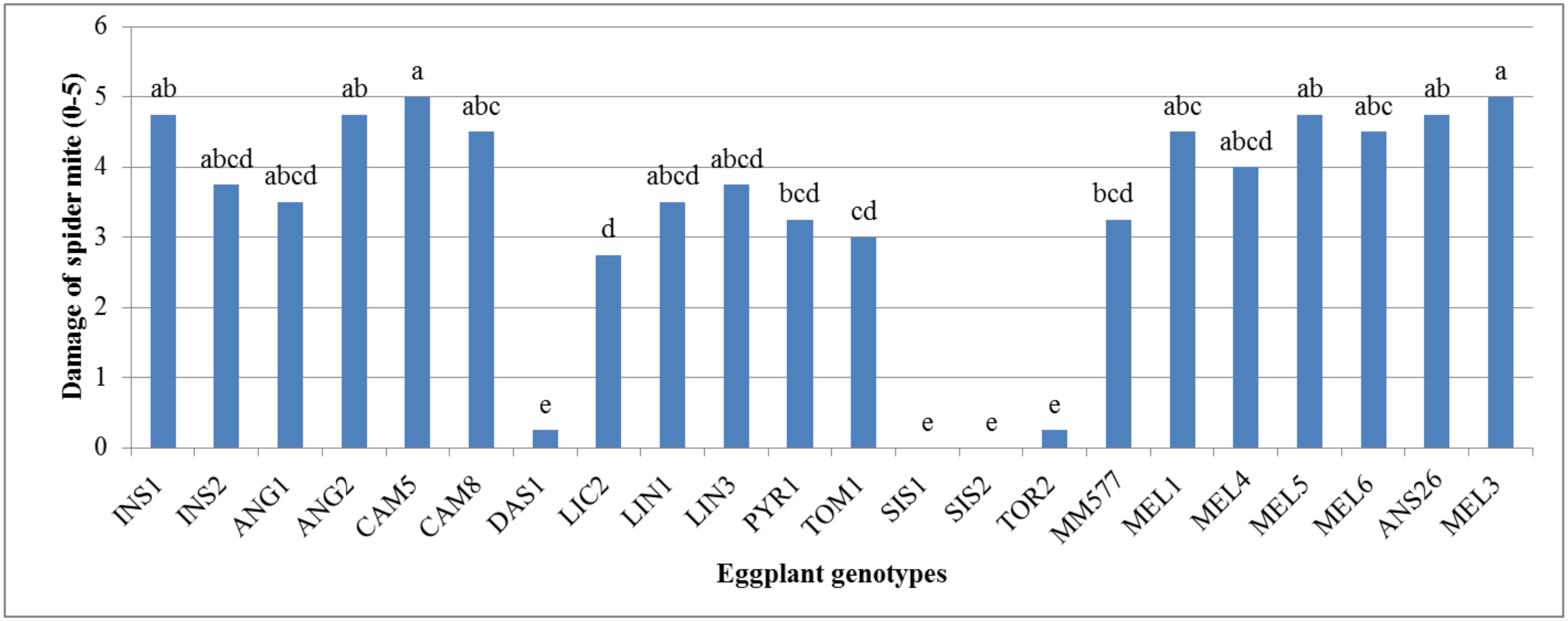

Fig. 2 Spider mite damage in the no-choice assays in cultivated and wild relatives of eggplant accessions six weeks after spider mite infestation in the growth rooms (26 ± 2°C; 70% H; 16/8 h day/night). Ratings assessed visually based on the leaf damage in the no-choice assays using a 0 to 5 scale, where 0 indicates no symptoms (complete resistant); 1 indicates <5% leaf area affected (highly resistant); 2 indicates 6–20% leaf area affected (resistant); 3 indicates 21–50% leaf area affected and light webbing (moderate

resistant); 4 indicates 51–90% leaf area affected and intense webbing (susceptible); 5 indicates 91–100% of leaf area affected, intense webbing, or a dead plant (highly susceptible). Means (n=4) followed by different letters are significantly different according to according to Duncan's multiple range test at $p < 0.05$.