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UMH1400 and UMH1401: New Cherry Tomato Breeding Lines Resistant to Virus

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Cherry tomato (*Solanum lycopersicum* var. *cerasiforme*) is a commercial type including cultivars with several growth habits (determinate, semideterminate, and indeterminate), with long clusters and fruits weighting between 10 and 30 g. In the last years, cherry tomato has shown an increasing market share. Like all tomato landraces, cherry cultivars are susceptible to several viruses, such as *Tomato mosaic virus* (ToMV), *Tomato spotted wilt virus* (TSWV), *Tomato yellow curl virus* (TYLCV) (Cebolla-Cornejo et al., 2007), PepMV (Gómez al., 2012), ToTV (Verbeek et al., 2007), or ToLCNDV (Juárez et al., 2019). A breeding program for introgressing of resistance to ToMV, TSWV, and TYLCV into several tomato landraces has been carried out over the last 20 years at Miguel Hernández University (Spain) (Carbonell et al., 2018). The breeding line UMH1400 (homozygous for *Tm-2a*, *Ty-1*, and *Sw-5* genes) and UMH1401 (homozygous for *Tm-2a* and *Sw-5* genes) are the first releases obtained within the cherry tomato type in the EPSO-UMH tomato breeding program. These breeding lines enable farmers to obtain acceptable harvests despite intense virus incidence conditions. Nevertheless, important decreases in yield have been reported for the breeding line UMH1400 (with TYLCV resistance), ranging between 35% and 48%. Previous work indicates that the introgression of TYLCV resistance has been responsible for most of the decrease in yield obtained in fresh tomatoes (Rubio et al., 2012). For this reason, breeding line UMH1401 (without TYLCV resistance) was developed. This line has shown better marketable yield than traditional cherry cultivar and similar titratable acidity (TA) and soluble solid content (SSC).

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Origin

The breeding lines UMH1400 and UMH1401 were obtained by crossing a cherry cultivar [accession cherry pera, previously selected for fruit morphological characteristics, uniformity, and high quality (Ruiz and García-Martínez, 2009)] with the commercial cultivar Anastasia F_1 (Seminis Vegetable Seeds, Saint Louis, MO). 'Anastasia F_1' was used as the donor parent of the *Tm-2a*, *Sw-5*, and *Ty-1* genes (Pérez de Castro et al., 2007), conferring resistance to ToMV, TSWV, and TYLCV, respectively. Twelve generations of backcrossing were performed to the cultivar cherry pera using Cleaved Amplified Polymorfhic Sequences (CAPS) markers for assisted selection for the virus resistance genes (García-Martínez et al., 2016). Several trials were carried out under different infection conditions (mechanical inoculation for ToMV and natural infection for TSWV) to check for the presence of resistance alleles in the first backcross (BC) generations and to assess the effectiveness of the molecular markers. Progenies for each backcross generation were screened with molecular markers for *Tm-2a*, *Sw-5*, and *Ty-1* genes, described in García-Martínez et al. (2016). In each BC progenie, only plants containing the three resistance genes (usually between 5 and 10 plants) were transplanted and then crossed with the recurrent parent cherry pera. Only the best plants per progenie (usually between two and four) were selected for further backcrossing. This selection was based on desirable cherry characteristics (fruit shape and size, low sensitivity to blossom-end rot), good agronomic behavior (proper fruit set, sufficient uniformity among fruits and yields), and high quality (soluble solid content and titratable acidity). After the selfing of one BC_{12} triple heterozygous plant, followed by two generations of selfing and selection, the pure-breeding line UMH1400 (homozygous for *Tm-2a*, *Sw-5*, and *Ty-1*) and UMH1401 (homozygous for *Tm-2a* and *Sw-5*) (Table 1) were selected using molecular markers. These lines were then multiplied by self-pollination in a greenhouse under controlled conditions.

Description and Performance

UMH1400 and UMH1401 breeding lines have an indeterminate growth habit with intermediate foliage density and small-sized fruits (8–16 g) in a bell shape. UMH1400 is homozygous for the *Tm-2a*, *Sw-5,* and *Ty-1* resistance genes, while UMH1401 is homozygous for the *Tm-2a* and *Sw-5* resistance genes only (Table 1). Between 2013 and 2015 we cultivated UMH1400 and UMH1401 breeding lines together with the cultivar cherry pera in a mesh-covered net house in the spring–summer crop cycle, the most widely used cycle in the traditional area of cultivation for tomato in southeastern Spain. UMH1400 shows significant decreases with respect to cultivar cherry pera in marketable yield (ranging between 35% and 48%), average fruit weight (except year 2013) (about 15%), and fruit number per plant (ranging between 18% and 40%), as well as in titratable acidity (TA) (ranging between 17% and 35%) and soluble solid content (SSC) (about 15%) (Table 2). These decreases are due to the introgressed genes themselves and/or to the linkage drag associated with the *Ty-1* gene, which confers resistance to TYLCV (Rubio et al., 2016). The negative effect of resistance gene introduction from wild relatives has been previously described in tomatoes for industrial use (Tanksley et al., 1998) and for fresh consumption (Brouwer and St. Clair, 2004) and in tobacco (Lewis et al., 2007). UMH1401 shows a significant increment with respect to the cultivar cherry pera in marketable yield (ranging between 15% and 35%) and average fruit weight (ranging between 18% and 39%). No significant differences have been found for the average fruit weight, TA and SSC. In previous works, breeding lines without TYLCV resistance had higher TA and SSC (ranging between 5% and 15%) than recurrent parentals in some crop cycles, both 'Muchamiel' (García-Martínez et al., 2015) and 'De la pera' types (García-Martínez et al., 2016). Comparing the breeding lines, UMH1400 shows significant decreases with respect to UMH1401 in marketable yield (ranging between 48% and 65%), average fruit weight (ranging between 15% and 33%), fruit number per plant (ranging between 35% and 63%), TA (ranging between 19% and 26%) and SSC (ranging between 10% and 17%)

Table 1. Genotype for each resistance gene [resistant homozygous (RR) and susceptible homozygous(ss)] for the two new breeding lines. Cultivar cherry pera is included as reference.

	Genotype		
Breeding line/cultivar	*Tm-2*[a]	*Ty-1*	*Sw-5*
UMH1400	RR	RR	RR
UMH1401	RR	ss	RR
Cherry pera	ss	ss	ss

Table 2. Yield traits, titratable acidity (TA), and soluble solids content (SSC) of the two new breeding lines. Cultivar cherry pera is included as reference. All the accessions were grown in the spring–summer crop cycle during 3 years, under the typical growing conditions of the region.[w]

Year	Marketable yield (kg/plant)[z]	Avg fruit wt (g)[z]	Fruit number per plant[z]	TA (g/100 g)[y]	SSC (°Brix)[y]
2013					
UMH1400	0.84[x] a	11.0 a	76.8 a	0.71 a	5.50 a
UMH1401	1.93 c	16.4 b	117.7 c	0.93 b	6.63 b
Cherry pera	1.25 b	13.4 ab	93.2 b	0.90 b	6.52 b
2014					
UMH1400	1.11 a	10.6 a	102.9 a	0.52 a	5.40 a
UMH1401	3.28 c	13.5 b	277.5 c	0.70 b	6.03 b
Cherry pera	2.29 b	12.6 b	170.5 b	0.80 b	6.38 b
2015					
UMH1400	1.02 a	7.8 a	129.8 a	0.48 a	5.68 a
UMH1401	1.95 c	9.2 b	213.2 c	0.59 b	6.54 b
Cherry pera	1.66 b	9.2 b	174.5 b	0.58 b	6.61 b

[z]Mean of six to eight plants per plot for two replicates. The experiments were completely randomized designs.

[y]Mean of 10 fruits in the same stage of ripening (with >50% of the surface showing red color) per plot for two replicates.

[x]Mean values in a column followed by a different letter are significantly different according to the Newman–Keuls's multiple range test ($P < 0.05$).

[w]Plants were grown vertically with a single stem, with black plastic mulch to reduce the incidence of weeds, with 2.5 plants/m^2 in a mesh-covered net house.

(Table 2). As previously mentioned, these decreases are due to the TYLCV resistance introgression.

Use

UMH1400 and UMH1401 breeding lines have genetic resistance to ToMV and TSWV, which often infect tomato landrace crops in southeastern Spain, especially in open field conditions (Cebolla-Cornejo et al., 2007). The two new breeding lines are available for cropping in the spring–summer production cycle, which is the most important cycle in the traditional area of cultivation for the tomato in southeastern Spain, when the level of TYLCV incidence is less intense due to the low population levels of the whitefly vector *Bemisia tabaci* (Genn.). Cultivation of these breeding lines is also feasible in the summer–autumn cycle (when the level of TYLCV incidence is higher), either in greenhouses or mesh-covered net houses with an enclosure in good condition, making it possible to effectively control the vector. The UMH1400 breeding line, with TYLCV resistance, is available also for open-air cropping, where the viruses' incidence is especially intense, allowing farmers to obtain an acceptable yield. These breeding lines may be used to develop F_1 hybrids by crossing them with other cherry landraces to increase yield by using genetic resistance to ToMV, TSWV, and TYLCV in a heterozygous state.

Availability

Small trial seed samples of the breeding lines are available for research purposes (please contact authors).

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