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UMH1209 and UMH1155: New 'Moruno Pera' Tomato Breeding Lines Resistant to Virus

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In recent years, consumers' demand for fresh tomato fruits from local varieties is increasing considerably worldwide, mainly for their high sensory value and attractive appearance (Casals et al., 2011). One of the most cultivated tomato landraces in different montane areas in Spain is the 'Moruno' type, a savory fruit much appreciated by consumers for its dark color and organoleptic attributes, but with a short postharvest storage, or low yield in some locations (Moreno et al., 2019). Like many tomato landraces, 'Moruno' cultivars are highly susceptible to several viruses, such as *Tomato mosaic virus* (ToMV), *Tomato spotted wilt virus* (TSWV), and *Tomato yellow leaf curl virus* (TYLCV) (Cebolla-Cornejo et al., 2007), *Pepino mosaic virus* (PepMV) (Gómez et al., 2012), *Tomato torrado virus* (ToTV) (Verbeek et al., 2007) or *Tomato leaf curl New Delhi virus* (ToLCNDV) (Juárez et al., 2019). A breeding program for introgressing resistance to ToMV, TSWV, and TYLCV into several tomato landraces has been carried out over the past 20 years at Miguel Hernández University (Orihuela, Spain) (Carbonell et al., 2018). The breeding line UMH1209, homozygous for *Tm-2a*, *Ty-1,* and *Sw-5* genes, and UMH1155, homozygous for *Tm-2a* and *Sw-5* genes, are the first releases obtained within the 'Moruno' tomato type in the Escuela Politécnica Superior Orihuela-Universidad Miguel Hernández breeding program.

Origin

The breeding lines UMH1209 and UMH1155 were obtained by crossing 'Pera294' [accession De la 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). 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. Six generations of backcrosses were performed to the 'Pera294' cultivar using Cleaved Amplified Polymorfhic Sequences (CAPS) markers described in (García-Martínez et al., 2016) for assisted selection for the virus resistance genes. In each BC progeny, only plants containing the three resistance genes (usually between five and 10 plants) were transplanted and then crossed with the recurrent parent 'Pera294'. Only the best plants per progeny (usually between two and four) were selected for further backcrosses. This selection was based on desirable 'De la pera' characteristics (bell-shaped fruits, similar size to the recurrent parent, low sensitivity to blossom-end rot), good agronomic behavior (proper fruit set, sufficient uniformity among fruits and yields) and high quality [soluble solid content (SSC) and titratable acidity].

In the BC6 generation, a plant with all red-brown–colored mature fruits was selected. After four generations of selfing, during which no segregation was observed for the color of the fruits, the pure-breeding lines UMH1209 (homozygous for *Tm-2a*, *Sw-5*, and *Ty-1*) and UMH1155 (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.

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Description and Performance

UMH1209 and UMH1155 breeding lines have indeterminate growth habit with intermediate foliage density. Like other 'De la pera' cultivars, fruits of both lines have a juicy and medium-firm texture and a high proportion of seeds and mucilage. Fruits weigh in ranges between 40 and 100 g, and are bell-shaped with dark green shoulders and without ribs. Ripe fruits have brown-red color, and separate easily from pedicels during harvest, like 'Pera294'. UMH1209 is homozygous for the *Tm-2a*, *Sw-5*, and *Ty-1* resistance genes, whereas UMH1155 is homozygous for the *Tm-2a* and *Sw-5* resistance genes only (Table 1). Between 2013 and 2015, we cultivated UMH1209 and UMH1155 breeding lines together with the cultivar Pera294 in a mesh-covered net house in the spring-summer crop cycle, the most widely used cycle in the traditional area of cultivation for 'De la pera' tomato in southeastern Spain. 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. UMH1209, with resistance to ToMV, TYLCV, and TSWV, shows a decrease with respect to 'Pera294' in marketable yield (ranging between 24% and 33%), average fruit weight (ranging between 18% and 24%), and fruit number per plant (11%, only in 2015) (Table 2). However, the UMH1209 breeding line shows an increase with respect to 'Pera294' in SSC (ranging between 4% and 17%). For titratable acidity (TA), the differences depend on the year: in 2014 in favor of UMH1209 and in 2015 in favor of 'Pera294' (4% and 17%, respectively) (Table 2). Similar results have been obtained previously with 'Muchamiel' (García-Martínez et al., 2011), 'De la pera' (García-Martínez et al., 2012), and cherry (García-Martínez et al., 2020) breeding lines with homozygous TYLCV resistance, obtained in the School of Engineering of Orihuela, Miguel Hernández University tomato breeding program. 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 introgression 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). The UMH1155 breeding line, without resistance to TYLCV, shows an increment of ≈15% to 20% with respect to 'Pera294' in marketable yield and average fruit weight. Regarding quality traits, significant differences were obtained only for SSC, in favor of UMH1155, ranging between 5% and 22% (Table 2). Comparing both breeding lines, UMH1155 surpasses UMH1209 in all productive and quality traits, except for SSC in

Table 1. Genotype for each resistance gene (RR = resistant homozygous, ss = susceptible homozygous) for the two new breeding lines. 'Pera294' is included as reference.

Breeding line/ cultivar	Genotype		
	Tm-2[a]	*Ty-1*	*Sw-5*
UMH1209	RR	RR	RR
UMH1155	RR	ss	RR
Pera294	ss	ss	ss

Table 2. Yield traits, titratable acidity (TA) and soluble solids content (SSC) of the two new breeding lines. 'Pera294' 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.

	Marketable yield (kg/plant)[z]	Avg fruit wt (g)[z]	Fruit number per plant[z]	TA (g/100 g)[y]	SSC (°Brix)[y]
2013					
UMH1209	2.22[x] a	58.2	38.4 a	0.32 a	4.7 a
UMH1155	3.14 b	67.2	50.0 b	0.40 b	5.2 b
Pera294	–	–	–	–	–
2014					
UMH1209	2.67 a	53.4 a	49.8 a	0.44 a	5.5 b
UMH1155	4.47 c	61.4 b	73.1 b	0.60 b	5.6 b
Pera294	3.51 b	64.9 b	53.7 a	0.63 b	5.3 a
2015					
UMH1209	2.75 a	58.7 a	50.1 a	0.39	5.2 b
UMH1155	4.83 b	72.7 b	66.4 b	0.36	5.5 c
Pera294	4.13 a	76.9 b	56.2 a	0.36	4.3 a

[z]Mean of six to eight plants per plot for two replicates. The experiments were completely randomized design.
[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 multiple range test ($P < 0.05$).

2014 and TA in 2015, for which no significant differences were found (Table 2).

Use

UMH1209 and UMH1155 breeding lines have genetic resistance to ToMV and TSWV, viruses that 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.). The UMH1209 breeding line, with TYLCV resistance, is available for the summer-autumn cycle, when the level of TYLCV incidence is higher. In this case, the breeding line UMH1155, without TYLCV resistance, is recommended only in greenhouses or mesh-covered net houses with an enclosure in good condition, making it possible to effectively control the TYLCV vector. These breeding lines may be used to develop F_1 hybrids by crossing them with other 'Moruno' or 'De la pera' 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 the authors).

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