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'Mini PS': A new mini melon breeding line exploiting the "Dudaim" variability – Short Communication

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Abstract: 'Piel de Sapo' is one of the most consumed market class of melons in the Mediterranean area and it represents an important economic crop in Spain. The 'Mini PS' melon breeding line, which bears two main introgressions from the dudaim 'Queen's pocket' melon in the Piel de Sapo genetic background, was evaluated for its fruit quality traits in three environments. Some interesting commercial characteristics were detected, such as a notable decrease in the fruit weight and a rounder shape, compared with Piel de Sapo, while the other quality traits were not altered. Thus, this mini melon line, ideal as a personal melon, may be useful in the development of new melon cultivars.

Keywords: quality traits; *Cucumis melo*; breeding; fruit shape; fruit weight

The melon, *Cucumis melo* L., is one of the most important crops worldwide. Apart from the high level of extant diversity (Pitrat 2017; Esteras et al. 2018), the rapid development of molecular tools has allowed important advances in melon breeding programmes. Most of these strategies modify the expression of specific traits, usually controlled by several genes (quantitative trait locus, QTL), to improve fruit quality (Gur et al. 2017) by developing new varieties. One of them is the development of introgression lines (ILs). ILs are usually generated by backcrossing and marker assisted selection, introgressing pieces of an exotic genome on an elite genetic background (Zamir 2001; Perpiñá et al. 2016; Pereira 2018). Ideally, each IL carries one or a few selected introgressions with exotic alleles that leads to favourable phenotypes in some specific traits, but that does not alter the other features of the elite genotype.

'Piel de Sapo' (PS) melons (subsp. *melo*, group ibericus; Pitrat 2017), the most important class in the Spanish market and very popular in the Mediterranean area, are large, elongated, without ribs and vein tracts, and with either no netting or slight netting. They are characterised by having a thick rind, which is green with yellow speckles and dark-green spots, a thick white juicy flesh with a high sugar content and a low aroma, and a late non-climacteric ripening behaviour associated with a long shelf life (Pitrat 2017).

In this work, we present a breeding line derived from IL DUD_4-2 (Castro et al. 2019), a BC3S3 generation developed using the Spanish cv. Piñonet, a PS melon, as the recurrent parent, and the Asian ac-

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cession PI 273438, known as the 'Queen's pocket' melon (DUD) (subsp. *melo*, group dudaim), as donor parent. This exotic group of melons is mainly characterised by its round and small, white-fleshed climacteric fruits, with a characteristic thin rind, yellow to orange with ochre stripes, and its strong external aroma. For their differential and exotic features, dudaim melons are interesting genetic resources to diversify melon cultivars. The DUD introgressions in this PS breeding line caused a significant decrease in the fruit size and changed its shape in comparison to the PS melon, so it has been denominated a 'Mini PS'.

MATERIAL AND METHODS

The 'Mini PS' was obtained after three selfing cycles from IL DUD_4-2. The selection was based on the phenotype, searching for uniformity and interesting fruit quality traits. This IL has 84.6% of the PS genetic background with two major homozygous DUD introgressions in chromosomes 4 and 12, and several minor introgressions (based on genotyping-by-sequencing (GBS) data; Castro et al. 2019).

Three characterisation assays for the 'Mini PS' were carried out under greenhouse conditions at the Cajamar Foundation (Paiporta, Spain) over 3 years (2017, 2018 and 2019, corresponding to BC3S4, BC3S5, BC3S6). Twelve plants were characterised for each 'Mini PS' assay, as well as for the PS and DUD parentals. The greenhouse conditions were as follows: a growing season from March to July with a temperature range of 25 to 35°C, for the three trials. Two fruits per plant were set and characterised at full maturity based on the methodology described by Perpiñá et al. (2016) for the fruit weight, fruit shape index, cavity width, flesh and rind thickness and firmness, flesh colour (FCHl, FCa, FCb; HL, a and b coordinates), soluble solids content, and also for the presence of the typical DUD external aroma (by olfaction), as well as for the abscission layer and netting on the rind (scale 0 – absence, 1 – presence).

An ANOVA (analysis of variance) analysis was used to identify significant differences between the 'Mini PS' fruits and those of the recurrent PS parent (P-value > 0.05) within a year. Significant differences among the years were also estimated by the Least Square Differences (LSD) method 95%. A t-test was employed in the case of the qualitative traits scaled 0–1 with no variances.

RESULTS AND DISCUSSION

Differences in the vine development and flowering time between the 'Mini PS' plants and PS ones were not noticed in the greenhouse assays. The phenotypic data for the 'Mini PS' fruit traits assessed in comparison to the PS ones are shown in Table 1. Despite the clear differences between the parents, DUD and PS, the 'Mini PS' fruits did not differ from the PS ones in most flesh features (flesh colour, rind and flesh firmness) and ripening behaviour (absence of an abscission layer and external aroma).

The main new and interesting characteristics in this cultivar were related to the fruit size and shape, which were significantly different from the PS ones in the three assays (Figure 1, Table 1). The 'Mini PS' presented a significant reduction in weight (–41.3%, –52.2%, and –37.0% in 2017, 2018 and 2019, respectively). The fruit shape parameter also was significantly lower, and the fruits were consequently rounder than the PS one (–35.1% and –27.5%, and –21.4% in 2017, 2018, and 2019, respectively). Additionally, the seed cavity width, also related to the shape, was somewhat higher than the PS ones in all the environments (22.7%, average trials), and associated to a slight reduction in the flesh thickness (–29.6%, average trials). The 'Mini PS' fruits displayed a rind slightly thinner than that of the PS melons in two trials, but much thicker than that of the DUD melons (Table 1), a positive aspect for marketing and storing. Although these 'Mini PS' melons were as sweet as the PS ones in 2017, they showed a significant decrease in the soluble solids content in 2018 and 2019 (Table 1). This trait needs to be further studied due to the environmental influence.

Nowadays, improving the quality traits is one of the main objectives in breeding programmes, and market preferences must guide the breeding efforts. For instance, the large size of the PS melon is a negative aspect for its commercialisation since individual consumption is a current tendency, and families tend to be smaller than before. Therefore, a decrease in the reported weight in the 'Mini PS' breeding line (750 g to 1 kg) might be of great interest to some markets. This line also presents a rounder shape, which might be singular for consumers that are used to associate the round shape to honeydew or cantaloupe melons, but not to the PS types. Moreover, although DUD melons are less sweet (5 to 8 Brix degrees), the 'Mini PS' reaches 10–12 Brix degrees, which is in the range of commercial sweet melons.

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Table 1. The mean value and standard deviation, along with the statistical results for the means comparison between both parents, PS and DUD, and the 'Mini PS' for each trait assessed in the three trials

Trait	Trial	PS		DUD		'Mini PS'		
		mean	SD[1]	mean	SD	mean	SD	phenotype effect (%)[2]
Abscission layer	2017	0.00	0.00	1.00^{+}	0.00	0.00	0.00	–
	2018	0.00	0.00	1.00^{+}	0.00	0.00	0.00	–
	2019	0.00	0.00	1.00^{+}	0.00	0.00	0.00	–
External aroma	2017	0.00	0.00	1.00^{+}	0.00	0.00	0.00	–
	2018	0.00	0.00	1.00^{+}	0.00	0.00	0.00	–
	2019	0.00	0.00	1.00^{+}	0.00	0.00	0.00	–
Rind firmness (kg/cm^2)	2017	13.00^{c}	0.00	7.23^{b*}	3.21	13.00^{c}	0.00	–
	2018	13.00^{c}	0.00	4.78^{a*}	1.90	13.00^{c}	0.00	–
	2019	13.00^{c}	0.00	8.70^{b*}	4.11	13.00^{c}	0.00	–
Flesh firmness (kg/cm^2)	2017	1.73^{b}	0.57	0.75^{a*}	0.34	2.18^{c}	0.65	–
	2018	4.28^{e}	1.05	1.46^{b*}	0.50	3.90^{e}	0.75	–
	2019	1.93^{bc}	1.18	2.00^{bc}	0.62	3.00^{d}	1.21	–
Fruit weight (g)	2017	1 739.50^{c}	425.39	257.10^{a*}	62.07	1 020.87^{b*}	375.88	–41.31
	2018	1 741.00^{c}	147.56	186.80^{a*}	40.90	832.71^{b*}	277.23	–52.17
	2019	1 621.00^{c}	31.24	173.33^{a*}	52.94	1 021.33^{b*}	203.18	–36.99
Fruit shape index	2017	1.77^{e}	0.18	1.02^{a*}	0.08	1.15^{bc*}	0.11	–35.13
	2018	1.68^{de}	0.13	1.08^{ab*}	0.12	1.22^{c*}	0.09	–27.45
	2019	1.55^{d}	0.26	1.07^{abc*}	0.14	1.22^{bc*}	0.04	–21.43
Cavity width	2017	0.37^{a}	0.02	0.52^{e*}	0.05	0.45^{c*}	0.05	21.37
	2018	0.37^{a}	0.10	0.57^{e*}	0.05	0.48^{cd*}	0.05	29.68
	2019	0.38^{ab}	0.03	0.51^{de*}	0.02	0.45^{bcd*}	0.02	17.03
Flesh thickness (mm)	2017	29.53^{c}	4.08	11.64^{a*}	2.46	23.57^{b*}	4.03	–20.18
	2018	33.28^{c}	5.62	10.60^{a*}	0.98	21.58^{b*}	4.56	–35.15
	2019	33.90^{c}	2.03	11.84^{a*}	2.47	22.51^{b*}	4.96	–33.60
Rind thickness (mm)	2017	3.17^{d}	0.46	1.90^{a*}	0.21	2.58^{bc*}	0.34	–18.50
	2018	4.08^{e}	0.25	1.42^{a*}	0.39	3.11^{d*}	0.66	–23.77
	2019	3.63^{de}	0.92	1.99^{ab}	0.97	3.05^{cd}	0.93	-
Netting	2017	0.30^{bcd}	0.47	0.00^{a+}	0.00	0.25^{abc}	0.68	-
	2018	0.75^{de}	0.50	0.00^{ab+}	0.00	0.57^{cde}	0.50	-
	2019	1.00^{e}	0.00	0.00^{ab+}	0.00	0.75^{de}	0.00	-
FCHl	2017	62.19^{cd}	6.20	70.76^{e*}	4.15	62.30^{cd}	2.79	-
	2018	51.83^{ab}	4.38	67.42^{de*}	2.07	55.64^{b}	5.88	-
	2019	56.15^{abc}	5.89	47.43^{a}	16.37	53.60^{ab}	8.72	
FCa	2017	–2.03^{b}	0.45	–0.97^{d*}	0.50	–2.01^{b}	0.48	-
	2018	–2.28^{ab}	0.66	–0.91^{d*}	0.25	–2.60^{a}	1.07	-
	2019	–1.94^{abc}	0.24	–1.01^{cd*}	0.67	–2.28^{ab}	0.25	
FCb	2017	9.54^{a}	1.76	9.55^{a}	1.60	11.28^{b}	1.38	-
	2018	10.99^{ab}	1.24	9.96^{ab}	1.19	10.13^{ab}	1.67	-
	2019	10.63^{ab}	1.67	9.02^{a}	2.80	9.68^{ab}	2.08	-
Soluble solids content (Brix degrees)	2017	11.91^{de}	1.15	8.18^{b*}	0.73	12.23^{e}	1.44	-
	2018	12.00^{de}	0.56	5.08^{a*}	0.38	10.06^{c*}	0.65	–26.15
	2019	11.47^{de}	0.65	8.00^{b*}	0.30	10.80^{cd*}	0.36	–5.81

[1]SD – standard deviation; [2]phenotype effect in the 'Mini PS' is indicated when significant difference in this line regarding the PS control has been detected; *indicates a significant difference (P-value > 0.05) with respect to the PS (ANOVA test). The homogeneous groups among the years are indicated with letters (LSD method 95%); (+) indicates a significant difference (P-value > 0.05) with respect to the PS (t-student); PS – 'Piel de Sapo' melon; DUD – 'Queen's pocket' melon

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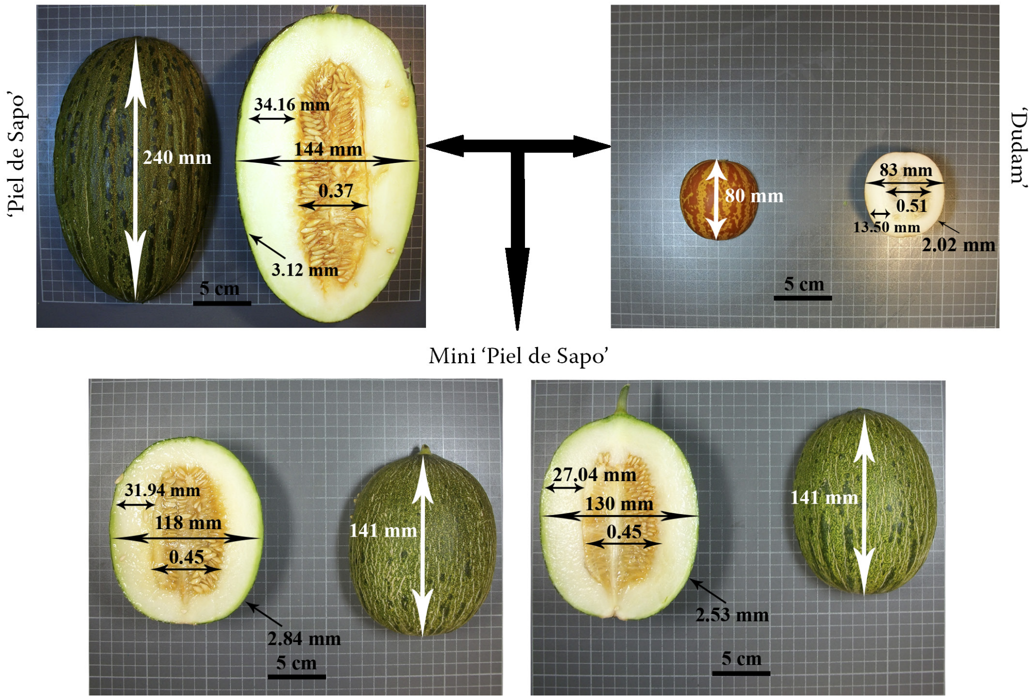

Figure 1. Variation in the fruit morphology in the 'Mini PS' regarding the PS affecting the fruit weight, shape, cavity width, rind and flesh thickness.

From a breeding point of view, this line provides information about the genomic regions from the DUD line that controls the fruit weight, shape, rind and flesh thickness. Our results not only support the QTLs for the shape and rind thickness reported by Castro et al. (2019) (*fs.4, rth.4*), but also demonstrates the existence of the effects on the fruit weight and flesh thickness not previously detected in the IL.

In conclusion, this breeding line provides fruits with a smaller size than the PS ones, suitable for individual consumption based on current market preferences, and a more spherical shape, which may generate new interest among consumers, but retains the specific organoleptic properties of the PS melons. These new characteristics make the 'Mini PS' an ideal candidate for future breeding programmes aimed at obtaining new commercial cultivars.

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