HortScience 58(7):804–807. 2023. https://doi.org/10.21273/HORTSCI17116-23

‘Supermelon’ and ‘Flavorific’: Two New Hybrid Muskmelon Cultivars with Resistance to *Monosporascus cannonballus* from Texas A&M AgriLife Research

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Keywords. cantaloupe, flavor, sweet, vine decline

The genus *Cucumis* (family Cucurbitaceae) includes a large number of economically important crops, such as melon (*Cucumis melo*) and cucumber (*Cucumis sativus*), that are widely cultivated. Muskmelons, called cantaloupes in Texas, are popular among consumers for their taste, flavor, and health benefits. These nutritious fruits are a rich source of provitamin A, vitamin C, folate, minerals, fiber, and polyphenols with antioxidant and anti-inflammatory properties. Once considered ‘seasonal delights’ because of their relatively short domestic production season, intense breeding efforts, horticultural advances, and imports have enabled year-round availability. Major domestic commercial production regions are in the southern parts of the United States, including California, Arizona, Texas, Georgia, and Florida, with ideal growing conditions (long, warm, frost-free growing seasons) and harvest windows ranging from April through December depending on location. According to US Department of Agriculture’s (USDA’s) 2021 Vegetable Summary, the value of US cantaloupe production was $277.5 million in 2021, up from $237.7 million in 2019 but slightly down from $291.9 million in 2020 (USDA 2022). The western shipper type of cantaloupe melons is popular for long-haul shipping. Their heavy net, absence of suturing, and small seed cavities all contribute to superior handling during shipping and longer shelf life at retail outlets. Unfortunately, the vines and fruits are susceptible to many biotic and abiotic stresses, which result in inconsistent fruit quality and shelf life. When consumers encounter low-quality melons, they are unlikely to make repeat purchases.

Therefore, the goal of the breeding efforts that resulted in these two new cultivars was to combine traits that optimize disease resistance and yield and enhance retail and sensory quality parameters. This was accomplished by selecting for healthy vines and vigorous root systems in disease-prone environments. Healthy vines are known to support higher photosynthetic carbon dioxide assimilation rates, the source of sugars for fruit quality (Mitchell et al. 1992). Similarly, a vigorous root system is vital for tolerating soilborne diseases and abiotic stresses (water/nutrient deficits). Under the “Table to Farm: A Sustainable, Systems-Based Approach for a Safer and Healthier Melon Supply Chain in the U.S.” project (USDA-NIFA-SCRI-2017-51181-26834), breeding efforts focused on combining enhanced levels of beneficial phytochemicals, such as beta-carotene, aromatic volatiles, and total sugars, with good field performance. The results are new inbred lines with resistance to Monosporascus root rot and vine decline (MRRVD), enhanced powdery mildew resistance, and improved fruit quality with preferred 9 to 12 sizes (Suslow et al. 1997).

Origin

‘Supermelon’ is an F_1 hybrid derived from a cross of two elite inbred lines, 2012-52 and 2012-136. ‘Flavorific’ is an F_1 hybrid cross of 2012-52 and 2012-96. Line 52 was derived from a cross of ‘TAM Dulce’ and Plant Introduction (PI) 124104. ‘TAM Dulce’ is highly resistant to powdery mildew (PM) and *Fusarium* wilt races 0 and 2 and has high-quality orange flesh (Zink et al. 1983). The PI is highly resistant to vine decline (*Monosporascus cannonballus*) and has a vigorous root system (Marquez et al. 2022). In 2005, F_2 and F_3 progeny plants were evaluated for resistance to PM (*Podosphaera xanthii*) and vine decline and for fruit quality during the spring and fall seasons at Weslaco, Texas. During the first three selection cycles, seeds were planted with 2 mL of *M. cannonballus* inoculum derived from liquified agar plates to avoid any possibility of individual plants escaping infection. Additionally, the soil in the field plot was highly infested with *M. cannonballus* after continuous melon crops for more than 30 years. Single-plant selections were made with high-level resistance to both diseases, and high Brix, compared with susceptible checks. This process was continued until the F_{11} generation in 2012. Line 136 was derived from a cross of Ames 20608 and TAM Dulce. Ames 20608 is an accession of *Cucumis melo* var *agrestis* from India with a high level of resistance to *M. cannonballus*. The same process of single plant selection was carried out until the F_{10}

Table 1. Fruit quality traits and yield of hybrid muskmelons grown at Weslaco in a sandy loam, pH 8.0. Randomized complete block design with three reps.

Entry	Brix (°)	Acid (%)	β-carotene (μg/g)	Yield (kg/ha)
TH5	10.6 ab[1] (0.38)	2.8 ab (0.8)	20.3 b (1.58)	46,429 e
Supermelon	11.2 a (0.33)	0.6 b (0.1)	26.0 ab (1.43)	53,144 cd
Flavorific	10.4 ab (0.53)	1.3 ab (0.2)	28.9 a (1.5)	59,099 bc
TH14	11.6 a (0.84)	1.5 ab (0.3)	26.8 ab (1.5)	45,148 e
Chujuc	7.3 b (0.77)	3.3 a (0.7)	11.9 c (1.58)	49,569 de
Cruiser	7.8 b (0.35)	1.3 ab (0.2)	15.2 c (1.4)	63,508 ab
Davinci	9.8 ab (1.27)	1.9 a (0.7)	23.4 ab (1.5)	53,000 cd
Infinite Gold	10.1 ab (0.59)	0.6 b (0.2)	21.8 b (1.5)	66,982 a

[1] Means followed by same letter are not significantly different.
Mean separations by least significant difference, $P < 0.05$.

Received for publication 13 Feb 2023. Accepted for publication 28 Apr 2023.
Published online 26 Jun 2023.
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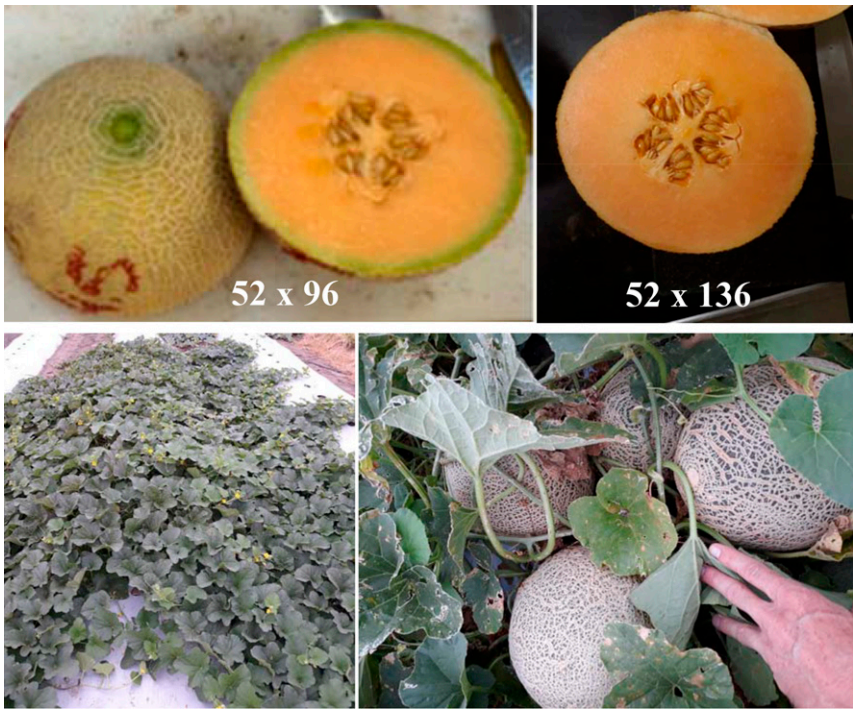

Fig. 1. 'Flavorific' (52 × 96, left) and 'Supermelon' (52 × 136, right) fruits and 'Supermelon' fruits and vine (bottom) showing great vigor, health, and yield at Weslaco, TX.

generation. Line 96 is an F_{10} inbred line derived from single plant selections of the cross, 'TAM Uvalde' × 1409. 'TAM Uvalde' was released in 1970 by Texas A&M breeder Mayo Correa. It is a high-quality cantaloupe with thick, sweet flesh, small (size 15) fruit and resistance to powdery and downy mildews. Line 1409 was derived from a cross of 'Deltex', an ananas-type melon, with 'Caravelle' and has intermediate resistance to MRRVD. The vines are extremely vigorous and produce large (size 9) cantaloupes with high Brix and deep orange flesh. Line 96 has strong vines with intermediate resistance to MRRVD and good PM resistance. It produces high-quality cantaloupe fruit of size 9 to 12 with high Brix and thick, orange flesh.

Adaptation

'Supermelon' and 'Flavorific' have been grown in replicated field plots at Weslaco, College Station, and Uvalde, TX, as well as Yuma, AZ, and North Carolina. Vines have demonstrated exceptional vigor at all locations compared with standard commercial cultivars Infinite Gold and Da Vinci. No PM or vine decline was observed on plants at these locations. Fruit size was smaller and more variable in North Carolina than in Texas and Arizona. It is recommended that growers first plant small test plots to determine if their soils or local growing conditions have any negative effects on fruit size or flavor. Yields at Weslaco were equal to commercial check cultivars of similar fruit type (Table 1; Fig. 1). 'Supermelon' appears to be well suited to production in both semitropical south Texas and desert regions such as Yuma.

Performance and Fruit Quality

The fruit of 'Supermelon' is round to blocky oval and ranges in size between 6 and 9 with a relatively dense netting, and a small abscission scar. The rind turns a classic tan color when allowed to reach full slip, and the thick flesh is extremely sweet and orange in color (L = 71.7, a = 17.7, b = 42.4). These coordinates are based on the CIE L*a*b* color measurement system and commonly used for fruits (Itle and Kabelka, 2009). Total soluble solids (measured as °Brix) have been consistently higher than other cultivars at Weslaco over three seasons, ranging between 12 and 14 °Brix. Fruit firmness of cut flesh was measured with a standard, digital penetrometer, and three readings in Newtons (N) were taken per fruit. One N is equal to ~0.102 kg of force. 'Supermelon' firmness was equivalent to 'TAM Dulce' (48 N) but lower than the long shelf life 'Infinite Gold' (85 N) or Tuscan type 'Da Vinci' (78 N). Yields are similar to the commercial cultivar Primo, but plants exhibit superior disease resistance. In trials at Weslaco, 'Supermelon' was one of the few entries with high level resistance to both MRRVD and PM (presumably race 2). It also resists alternaria, downy mildew and *Fusarium* wilt, and the vigorous vine has relatively early fruit maturity (80 d).

The fruit of 'Flavorific' is round to blocky oval and consistently size 12 in Texas trials. It has a fine, low, dense netting; small abscission scar; and an attractive, straw-colored rind at maturity (Fig. 1). The seed cavity is small and closed (no airspace), and the flesh color is deep orange (L = 66.8, a = 17.4, b = 42.1). Brix levels ranged from 10.3° at

Table 3. Fruit quality of 'Supermelon' (52 × 136) and 'Flavorific' (52 × 96) compared with other hybrids at College Station, 2020.

Hybrid	Brix (°)	Firmness (N)	Size[i]
37 × 109	11.3 ± 1.6[ii]	65.6 ± 7.7	12
40 × 65	12.2 ± 1.6	54.4 ± 6.8	9–12
52 × 136	12.6 ± 1.4	35.2 ± 9.2	9–12
110 × 109	11.8 ± 0.7	59.6 ± 14.9	9
19 × 65	11.7 ± 0.6	66.0 ± 18.9	12
52 × 70	11.9 ± 0.8	75.8 ± 19.9	9–12
52 × 96	12.9 ± 1.3	94.8 ± 31.7	9–12
26 × 96	12.0 ± 0.5	91.8 ± 17.6	12
Davinci	11.9 ± 1.3	71.6 ± 12.3	15
Infinite Gold	11.9 ± 1.5	63.4 ± 14.4	9

[i] Melon size based on the number of fruits that fit in a 40-lb melon box.
[ii] Means ± SDs.

Table 2. Quality attributes of 'Supermelon' and 'Flavorific' compared with commercial melon cultivars grown at Yuma, AZ.

	TH-5	Supermelon	Flavorific	F-39	TT-DV[ii]	HT-IG[iii]
Brix (°)	11.9 ± 0.6 a[i]	11.0 ± 0.7 a	11.3 ± 0.7 a	7.3 ± 0.7 b	9.8 ± 0.7 ab	10.1 ± 0.7 ab
β-carotene (μg/g)	25.8 ± 1.6 ab	30.8 ± 1.9 a	24.8 ± 1.0 ab	11.4 ± 1.8 c	23.4 ± 1.8 ab	21.8 ± 1.8 b
Esters (%)	5.0 ± 1.0 a	2.2 ± 0.4 a	4.7 ± 0.4 a	4.0 ± 1.1 a	2.7 ± 1.1 a	2.3 ± 1.0 a
Alcohols (%)	28.6 ± 2.4 bc	27.4 ± 4 bc	32.3 ± 3.1 b	14.6 ± 2.5 c	14.8 ± 3.5 c	52.8 ± 3.3 a
Aldehydes (%)	46.9 ± 1.6 a	41.8 ± 3.0 a	32.2 ± 3.6 ab	48.7 ± 7.0 a	42.2 ± 2.9 a	23.2 ± 0.8 b
Hydrocarbons (%)	0.9 ± 0.1 b	1.4 ± 0.2 ab	1.9 ± 0.1 a	1.0 ± 0.1 ab	1.2 ± 0.1 ab	1.1 ± 0.1 ab
Ketones (%)	15.7 ± 1.9 b	24.5 ± 3.5 ab	21.4 ± 2.2 ab	27 ± 6.4 ab	35.5 ± 4.2 a	18.7 ± 3.9 ab
Sulfur (%)	1.1 ± 0.2 a	0.6 ± 0.1 ab	1.5 ± 0.1 a	0.1 ± 0	0.4 ± 0.4 ab	1.0 ± 0.4 a
Acids (%)	1.4 ± 0.4 a	1.5 ± 0.9 a	5.3 ± 2.1 a	3.3 ± 0.7 a	1.9 ± 0.7 a	0.6 ± 0.1 a
Furans (%)	0.5 ± 0.1 a	0.7 ± 0.2 a	0.6 ± 0.1 a	0.9 ± 0.3 a	1.0 ± 0.1 a	0.2 ± 0 a

[i] Mean separations within rows by least significant difference ($P \leq 0.05$). Means followed by the same letter are not significantly different within a given variety.
[ii] TT-DV = Tuscan type 'Da Vinci'.
[iii] HT-IG = Harper type 'Infinite Gold'.

Fig. 2. Roots of resistant inbred line 52-TAM Dulce × 124104-F4 (left), and 'Cruiser' (right) after inoculation with *Monosporascus cannonballus*.

Weslaco to 12.9° at College Station. The flesh was consistently firmer (56–94 N), than 'Supermelon' or 'Primo'. The flavor is fruity-floral, with a less musky aftertaste than 'Primo' or 'Cruiser'. Yields are similar to 'Cruiser', which is considered a high-yielding cultivar in south Texas. The vines are superior in vigor to 'Cruiser' due to much better resistance to MRRVD and PM. Fruit maturity is early (76 d).

Replicated field trials were planted at Weslaco and College Station (Tables 1–3) during 2019–20 to compare fruit quality and yield to commercial check cultivars. Four replications of 20-plant plots were direct seeded into black plastic mulch, with subsurface drip irrigation at 30-cm spacing within rows and 100-cm spacing between rows. All fertilizer and pesticide applications followed standard commercial practices. 'Supermelon' (TH6) and 'Flavorific' (TH13) had high Brix levels at both locations, exceeding that of similar cultivars Cruiser and Chujuc. Beta-carotene content was also higher for these new hybrids than for commercial cultivars (Table 2). Resistance to MRRVD was significantly better than for commercial cultivars at fruit maturity, which clearly decreased fruit quality in susceptible cultivars such as DaVinci, Cruiser, and Chujuc. Despite declining vines at maturity, 'Infinite Gold' still produced the greatest yields and acceptable sugars at Weslaco but with much lower Brix than in locations such as College Station and Uvalde where MRRVD was not a problem. However, this is a long shelf-life melon that lacks true cantaloupe flavor.

Table 4. Mean vine vigor, root disease and powdery mildew ratings for six melon cultivars grown in *Monosporascus* infested soils at Weslaco, TX, Jun 2021. Randomized complete block design with three reps, six plants per rep.

Cultivar	Vine vigor[i]	Root rating[ii]	Powdery mildew rating[iii]	Fruit size
Supermelon (TH6)	1.0 a	1.4 a	1.0 a	6–9
Flavorific (TH13)	1.6 a	1.8 a	1.0 a	12
Chujuc	2.8 b	3.2 b	1.0 a	9
Da Vinci	4.2 c	4.5 c	1.8 b	12–15
Cruiser	3.0 b	4.0 bc	2.8 c	9
Primo	4.4 c	4.8 c	1.0 a	9

[i] Vine vigor rated on 1 to 5 scale at 60 d post planting. 1 = healthy vine growth exceeding 25 ft^2, 2 = healthy vine growth 20–25 ft^2, 3 = healthy vine growth 16–20 ft^2, 4 = healthy vine growth 12–16 ft^2, 5 = healthy vine growth 9–12 ft^2.

[ii] Root rating on 1 to 5 scale at fruit maturity. 1 = no symptoms, 2 = few tan lesions, 3 = extensive tan lesions and necrosis of smallest roots, 4 = extensive tan lesions, perithecia, necrosis of small and medium roots, 5 = completely withered, necrotic, dead roots.

[iii] Powdery mildew rating on scale of 1 to 5. 1 = no leaves with any symptoms, 2 = less than 10% of leaves with small lesions <2 cm, 3 = up to 50% of leaves with sporulating lesions, 4 = up to 90% of leaves with sporulating lesions and some necrosis, 5 = all leaves covered in lesions and necrotic, defoliation.

Mean separations by least significant difference, $P < 0.05$. Means followed by same letter are not significantly different.

Fig. 3. Healthy roots of 'Supermelon' at maturity from Weslaco field plot infested with *Monosporascus cannonballus*, 2021 compared with diseased roots of 'Primo'.

Monosporascus Resistance

The virulent *M. cannonballus* strain, TX 90-25, was maintained on V8 agar in plastic petri plates (Mertely et al. 1993). A sand/oat hull mixture (500 g) was placed into plastic storage boxes and autoclaved four times for 20 min. Each box of sterilized media was then inoculated under a laminar flow hood with ten 1-cm diameter plugs of the V8 agar containing *M. cannonballus* mycelia. The inoculum was shaken once a week for 4 weeks while the fungus developed, after which, colony-forming unit (CFU) counts were determined by a standard thousandfold dilution on petri plates of potato dextrose agar with no streptomycin (Mertely et al. 1993).

Before sowing the seed, the sand was pasteurized at 72 °C for 10 h to kill other potential pathogens. The pH of the sand was 8.5 to 9.0, which was favorable for *M. cannonballus* growth (Mertely et al. 1993). The sand/oat hull inoculum was added to the pasteurized sand in a rotating cement mixer, using 60 CFU of *M. cannonballus* per gram of sand.

Black plastic seedling trays were filled with the inoculated sand within 2.5 cm of the top. An additional 2.5 cm of pasteurized sand was then added to provide a buffer zone for germination to prevent immediate inoculation and death of the seedlings. Control pots were filled with pasteurized sand. Each experiment was arranged in a randomized complete block design with four replications (blocks). Three plants per line were grown in each rep. Seedling emergence was examined each day and at the start of the growth period noted. Plants were hand-watered with tap water every 3 or 4 d based on temperature and moisture content of the sand. In addition, each plant received a soluble solution of Peters 9.1 N–8.7 P–16.6 K (400 $mg \cdot L^{-1}$), plus micronutrients every 7 d throughout the growth period.

After 35 d, all plants were harvested in a 24 h period. After cutting the vine and removing the pot, each root system was carefully placed in a fine mesh cage and submerged in a 200-L drum of water. This allowed all sand to flow out, leaving only the roots. Entire root systems were photographed and rated on a 1 to 4 scale: 1 = no symptoms, 2 = slight necrosis of fine roots and few tan lesions, 3 = slight necrosis of all roots and moderate tan lesions, and 4 = severe necrosis of all roots and reduced root mass.

All plants with root ratings of 1 or 2 were transplanted immediately into 12-L plastic pots with peat and perlite mix. These plants were then grown to maturity and self-pollinated or backcrossed to the high-quality, recurrent parents. Subsequent cycles of selection were conducted in the infested field plots at the Texas A&M AgiLife Research center at Weslaco, rating both vine decline and root rot.

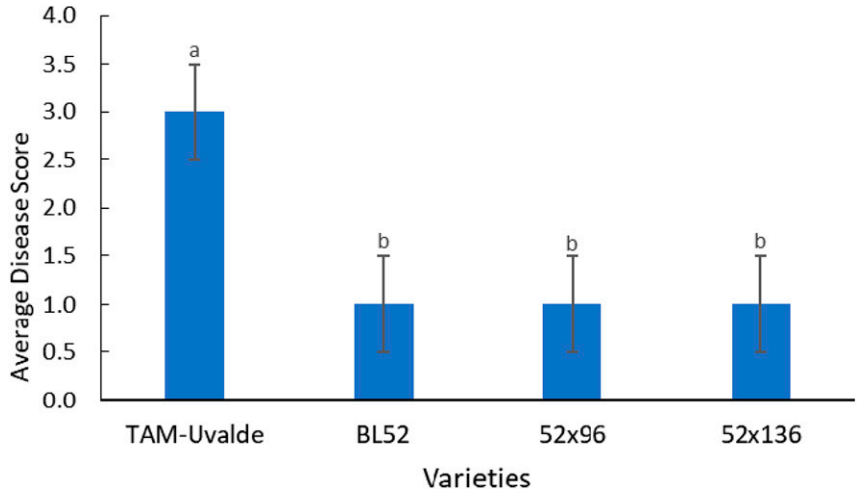

Fig. 4. Average disease ratings for *Monosporascus* root rot resistance in the lines: 'TAM-Uvalde', 'BL52', 'Flavorific' (52 × 96), and 'Supermelon' (52 × 136). Root rating scale 1–4: 1 = no symptoms, 4 = severe discoloration and necrosis. Mean separations by least significant difference, $P < 0.05$. Means followed by same letter are not significantly different.

Among the resistant lines, PI 124104 had the largest fruit, similar to a honeydew type. This accession also had a vigorous root system in the field plots and apparent drought and heat tolerance. Ames 20608 also exhibited high level resistance to *M. cannonballus* but had small fruits. F_1 hybrids derived from these parents crossed with western shipper lines exhibited MRRVD resistance in the field and root ratings similar to the resistant PIs. The dominant resistance of PI 124104 was successfully introgressed into a western shipper inbred line 2012-52 using the high-quality cultivar TAM Dulce as the muskmelon parent, using a pedigree system-Fig. 2 (Marquez et al. 2022).

'Supermelon' and 'Flavorific' were both screened by controlled inoculation in sand culture and in Weslaco field plots for 3 years to verify resistance to *M. cannonballus*–induced root rot and vine decline (Table 4; Figs. 3 and 4). The commercial cultivars Tam Uvalde, Primo, and Cruiser served as susceptible checks with similar quality, western shipper fruits. Root ratings of both new hybrids ranged from 1 to 1.8, corresponding to high resistance equivalent to the resistant parent, PI 124104.

Seed Production and Availability

Trial seed has been produced in Thailand and is available in small quantities (500) for interested seed companies and growers. Parent stock seed has been increased in the greenhouse and is available for larger production of F_1 seed from K.M. Crosby.

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