HortScience 56(2):293–295. 2021. https://doi.org/10.21273/HORTSCI15574-20

‘Ground Jewel’ and ‘Ground Dew’: Two Tomato Breeding Lines for Growers in the Northern and Short-season Locations

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Additional index words. dwarf, ‘Micro-Tom’, ‘Zac-Heart’

Tomato, *Solanum lycopersicum*, is native to South and Central America, and it is now extensively cultivated throughout the world. Tomatoes are a rich source of vitamins and antioxidants valuable to human diets (Beecher, 1998; George et al., 2004). Each American consumes an average of nearly 80 pounds of tomatoes every year (Jones, 2008), which makes tomato the second most consumed vegetable crop. In 2007, the world produced 285.8 billion pounds of tomatoes, including 27.7 billion pounds produced in the United States (annual crop value: ≈$25 billion; USDA tomato statistics, 2010). There are more than 7000 tomato cultivars available for use by home and commercial gardeners worldwide (Jabr, 2012). However, most cultivars are adapted to high tropical and subtropical temperatures. These varieties take from 60 d to more than 95 d to mature. Only a few cultivars have been introduced for use in high latitudes, such as states in the upper midwest region of the United States, especially between the USDA growing zones 2b and 5a. These northern cultivars can reach maturity within 45 d, making tomato production feasible in areas with a short growing season. One drawback to many northern cultivars is that yield is often lower than desired. This characteristic limits the choices of economically valuable cultivars for short-season farms and home gardens (Jones, 2008). To provide for the tomato demands of northern states, costly long-distance transportation from the south or greenhouse crops are required to meet the commercial year-round demand. Researchers at the University of Minnesota aimed to fill this gap by breeding and selecting for cultivars adapted to short-season requirements. ‘Ground Jewel’ and ‘Ground Dew’ are the first new cultivars released by the University of Minnesota to meet this demand.

‘Ground Jewel’ and ‘Ground Dew’ are two new dwarf tomato cultivars with determinate growth habits. Fruit yield of both cultivars is high, relative to the mass of mature plants (87% for ‘Ground Jewel’ and 84% for ‘Ground Dew’). Both cultivars are the result of an initial cross between ‘Zac-Heart’ and ‘Micro-Tom’ in 2007. Successive generations were selected for high fruit yield, short time to maturity, dwarf plant structure, and stable phenotype. ‘Ground Jewel’ and ‘Ground Dew’ are attractive varieties for both commercial producers and home gardeners, especially those residing in regions with a short growing season.

Origin

Since 2007, the tomato breeding program at the University of Minnesota has been working on the development of dwarf tomato cultivars through sexual crosses followed by phenotypic selection. ‘Ground Jewel’ and ‘Ground Dew’ were obtained by crossing ‘Zac-Heart’ to ‘Micro-Tom’, and they were initially named MTX097 and MTX104, respectively. One of the parental lines, ‘Zac-Heart’, was selected from an F3 population of the ‘Big-Zac’ hybrid with very stable ‘Brandywine’-like large heart-shaped fruits for four more generations (F7). ‘Big-Zac’ was bred by Minnie Zaccaria of New Jersey, and the hybrid seeds were purchased from Totally Tomatoes (www.totallytomato.com, cat. #00087). The female parental plant line we used for the initial cross was ‘Micro-Tom’, which was bred by the researchers at the University of Florida (Scott and Harbaugu, 1989). The miniature dwarf characteristics make ‘Micro-Tom’ one of the most used model systems for plant research. In the F2 population developed from a cross between ‘Zac-Heart’ to ‘Micro-Tom’, we observed more than 20 unique phenotypes that were subjected to selection for dwarfness and short-season growth habit (Fig. 1A). ‘Ground Jewel’ and ‘Ground Dew’ are the result of 8 years of field selections from this initial pool of phenotypic variation and are the first two official releases from the University of Minnesota Tomato Breeding Program since 1965, when ‘Early Fireball’ was introduced.

Both ‘Ground Jewel’ and ‘Ground Dew’ were tested for large-scale field production in two Minnesota locations since 2014 (Fig. 2). In 2014, plants were grown in Isanti, MN. Rows ≈750 ft long were planted with each of the lines successively over five different rows (Fig. 2C). Seedlings were transplanted to the field or directly seeded every 12 inches and offset from the neighboring row (Fig. 2A). Rows were covered with black plastic mulch for weed control and moisture retention. Drip line irrigation was placed underneath plastic mulch in the middle of each row at the time of installation (Fig. 2). The soil type was sand to loamy sand, characteristic of the Anoka Sand Plain that is located throughout much of east central Minnesota. Soluble fertilizer was injected to the irrigation lines several times during the growing season.

From 2015 onward, plants were grown at the Minnesota Agricultural Experiment Station (MAES) on the St. Paul Campus of the University of Minnesota. Soil at the MAES contains a higher percentage of organic matter relative to the soil at the growing site in Isanti, MN. Each year, seeds were collected from four to five of the highest-yielding plants of each cultivar to be used as seed source for the next year.

Description and Performance

Both cultivars have similar determinate growth habits. Mature plants have a small, bushy appearance, spreading ≈1 ft^2 and growing to no more than 1 ft in height. The fruit set is very dense and eventually accounts for the majority of the aboveground biomass (Fig. 1B–D).

Weights were determined for the whole plant, fruit set, and aboveground vegetative growth for both cultivars. We report the total average fruit weight per plant, average number of fruits per plant, average weight per fruit, as well as Brix and pH for fruits when available. Brix readings were performed using the HI96811 0% to 50% Brix Portable Meter (Hanna Instruments, Woonsocket, RI). The pH readings were performed using the

Received for publication 13 Nov. 2020. Accepted for publication 14 Dec. 2020.
Published online 14 January 2021.
The University of Minnesota tomato breeding program is sponsored by the Minnesota Agricultural Experimental Station (AES 00021031, AES 0002095), Minnesota Department of Agriculture Specialty Crop Block Grant, and by gift funds from the Fink family. We thank Judith Lacy for her name suggestion of ‘Ground Jewel’. During the past 10 years of selection, many students, visiting scholars, and volunteers have been working on this project, especially Ben Fink, Bo Dai, Kenneth Jombwe, Eric Berry, John Hiebel, Tao Li, Noah Reimer, Anthony Harris, Marshall Thomas, Aidan Shaughessy, John Romens, Thomas Lake, Noah Hendricks, Clemon Dabney, Vincenzo Averello, Penny Kianian, and Shahzad Shah. We are also grateful for the support from local farms and gardens, especially Donny Sparks and his Green Barn Farm, and Randall Hagen and his Hagen specialty growers. We thank the reviewers for their valuable comments that improved the manuscript.
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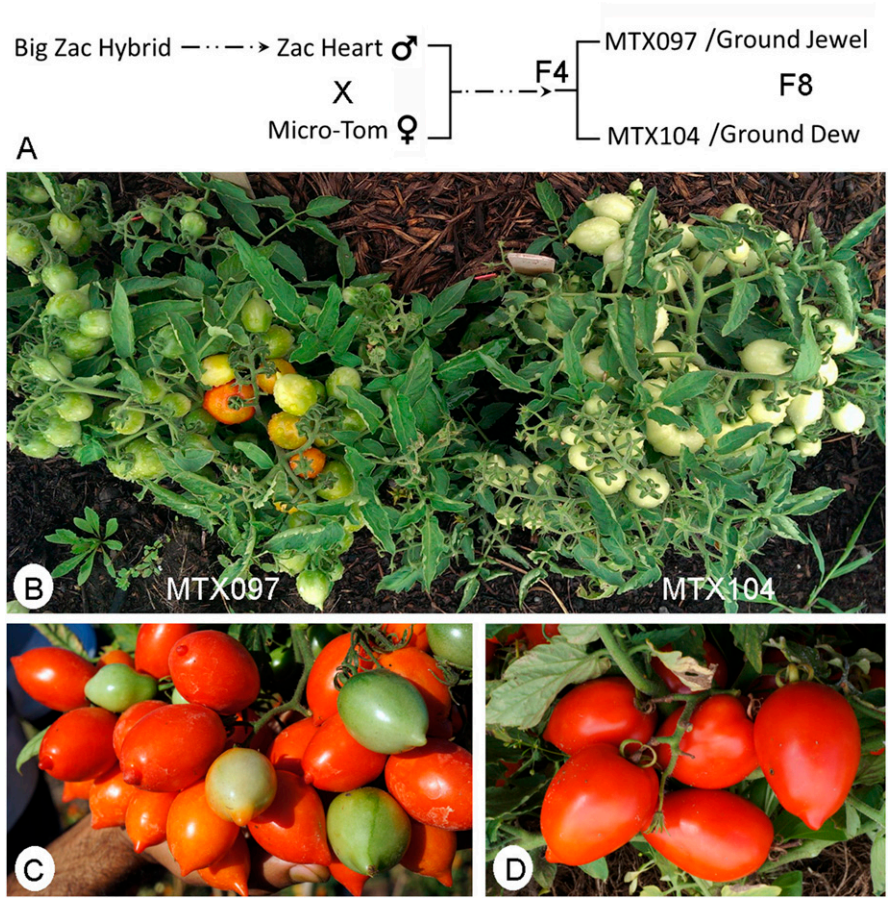

Fig. 1. Origin, plant, and fruit forms of 'Ground Jewel' and 'Ground Dew'. (**A**) Pedigree of 'Ground Jewel' and 'Ground Dew'. Both cultivars were selected from a cross between 'Zac-Heart' and 'Micro-Tom'. MTX97 and MTX104 were selected from the F4 population; both MTX97 and MTX104 continued selfing for four more generations with stable phenotypes and named 'Ground Jewel' and 'Ground Dew', respectively. (**B**) Side-by-side growth and comparison of 'Ground Jewel' (MTX097) and 'Ground Dew' (MTX104). Both lines develop oval-shape fruits with a pointer/nib on each fruit. The main difference between these two lines is observed in the young fruits: young fruits of 'Ground Jewel' develop green shoulders and 'Ground Dew' have white young fruits. (**C**) A mature fruit cluster of 'Ground Jewel'. (**D**) A mature fruit cluster of 'Ground Dew'.

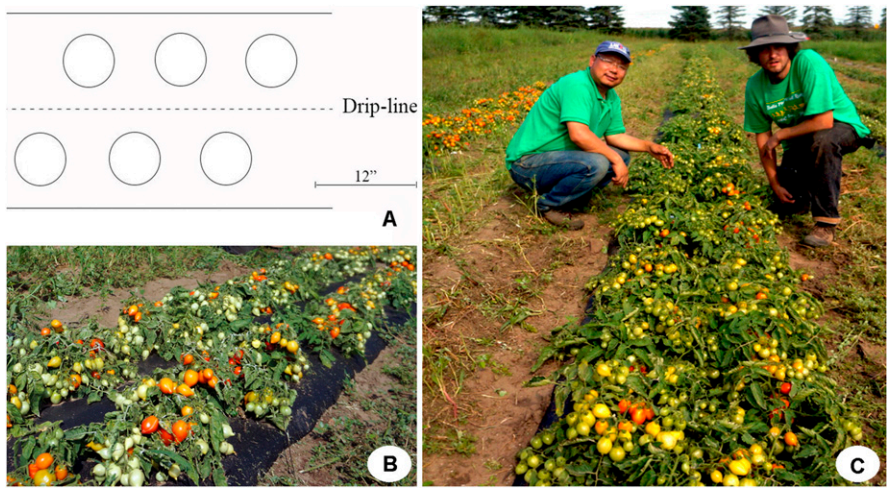

Fig. 2. Large-scale farm field trial of 'Ground Jewel' and 'Ground Dew'. (**A**) Planting row layout. Plants were spaced 12 inches apart and offset from the adjoining row. A drip line was run down the middle of the row to supply water and nutrients. (**B**) 'Ground Dew' trial at the Green Barn farm. Young fruits are white. (**C**) 'Ground Jewel' trial at the Green Barn farm. Young fruits develop green shoulders. Different starting times were also tested: from left to right, each row has a 12-d difference in the starting date. For example, the central row plants are 12 d younger than the left row.

SCT-pH-PEN-5 pH meter (SciChemTech, Malden, MA). Results are detailed in the Table 1.

Differences were found between cultivars grown at different locations, especially 'Ground Dew'. 'Ground Jewel' produced a nearly identical average number of fruits in 2014 and 2015; however, the average yield per plant increased ≈300 g in the 2015 crop grown at MAES. Compared with the 2014 trial, 'Ground Dew' produced nearly three-times as many fruits per plant on average in 2015, and the average weight of fruit per plant almost doubled. Fruits of both cultivars had similar Brix and pH values. For both cultivars growing at the MAES, 2019 was a rather exceptional year compared with previous years. The significant yield increase in 2019 might have been due to the climate or nonirrigation; the field preparation in 2019 was performed in the same manner as previous years, except for the drip line.

Qualitative observations indicate that 'Ground Jewel' might have slightly better resistance to later season foliar diseases than 'Ground Dew'. More research is needed to determine the susceptibilities of these two new cultivars to specific tomato pathogens.

Discussion

Tomato plants are easily damaged by frost or chilling at temperatures above freezing. Short-season areas with a high latitude and/or altitude pose a challenge for commercial producers and gardeners growing most available tomato cultivars. Even if the plants survive, their fruit quality may be poor due to failure to ripen or low yield. In an attempt to maximize fruit quality, tomato cages or other systems are used to support growing branches. The installation and maintenance of tomato support systems require additional labor and production costs for commercial growers, especially for those who live in regions with a very short growing season. The obstacles of the environment, available cultivars, and maintenance costs have discouraged home gardeners and commercial growers alike from pursuing tomato production.

Our breeding program aims to fill the gap and focuses on the development of dwarf, high-yield, cage-free, short-season tomatoes for home gardens and large-scale vegetable farms with the potential for machine harvesting. Using sexual crosses, we have been breeding for cultivars adapted to northern climates.

Although our selection interests are mainly for dwarf and short-season phenotypes, the cross between 'Zac-Heart' and 'Micro-Tom' offers tomato breeders a diverse set of phenotypes from which to choose. Furthermore, this cross may be of special interest to other breeders interested in developing cultivars suited to cool climates.

Table 1. Characteristics of 'Ground Jewel' and 'Ground Dew' at the large-scale farm field.[z]

	Avg wt of fruit per plant (g)	Avg no. of fruit per plant	Avg wt per fruit (g)	Avg Brix	Avg pH	No.
Ground Jewel						
Isanti, MN (2014)	1591.7	103.0	15.5	NA	NA	25
MAES (2015)	1836.7	105.0	17.5	3.5	4.3	40
MAES (2016)	2066.0	166.0	12.4	3.6	4.0	10
MAES (2017)	2098.3	167.4	12.5	3.8	4.2	20
MAES (2018)	1882.6	102.2	18.4	3.8	NA	20
MAES (2019)	3483.0	210.0	16.6	3.3	NA	20
Duluth, MN (2018)	579.7	68.3	8.5	NA	NA	8
Ground Dew						
Isanti, MN (2014)	1007.7	51.0	19.8	NA	NA	12
MAES (2015)	2294.9	144.0	15.9	3.3	4.1	40
MAES (2016)	1828.5	126.0	14.5	3.4	4.1	10
MAES (2017)	1942.6	154.9	12.5	3.7	4.1	20
MAES (2018)	1717.5	81.7	21.0	3.1	NA	10
MAES (2019)	2488.7	141.0	17.7	3.3	NA	20
Duluth, MN (2018)	529.3	46.5	11.4	NA	NA	12

[z]Fruit yield characteristics of 'Ground Jewel' and 'Ground Dew' grown in the field at Green Barn Farm in Isanti, MN, and the Minnesota Agriculture Experiment Station (MAES) at the University of Minnesota, St. Paul campus.

Availability

Small trial seed samples of 'Ground Jewel' and 'Ground Dew' are available for research purposes (contact the authors or the Office of Technology Commercialization, University of Minnesota). We welcome inquiries from the seed industry and garden centers for further seed distribution.

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