Watermelon Germplasm Lines USVL246-FR2 and USVL252-FR2 Tolerant to *Fusarium oxysporum* f. sp. *niveum* Race 2

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Additional index words. *Citrullus citroides*, inbred line, host plant resistance

Two improved germplasm lines of wild watermelon (*Citrullus lanatus* var. *citroides*) designated USVL246-FR2 and USVL252-FR2 were released in 2012 by the Agricultural Research Service of the U.S. Department of Agriculture (Wechter et al., 2012). These lines are each highly uniform for growth characteristics, fruit size, and fruit shape. In both greenhouse and field tests, these lines also exhibit high levels of tolerance to the phytopathogen *Fusarium oxysporum* f. sp. *niveum* race 2 (*Fon*-R2) when compared with the watermelon cultivars Charleston Gray, Allsweet, Calhoun Gray, and Sugar Baby (all *C. lanatus* var. *lanatus*). In addition, they have shown higher vigor and equal or higher tolerance levels to *Fon*-R2 than PI 296341-FR, an improved *C. lanatus* var. *citroides* germplasm line derived from U.S. PI 296341, which has been reported previously as resistant to *Fon*-R2 (Martyn and Netzer, 1991).

Fusarium wilt [caused by *F. oxysporum* Schlechtend.:Fr. f. sp. *niveum* (E.F. Sm.) W.C. Snyder & H.N. Hans (*Fon*)] is one of the most serious soilborne diseases of watermelon (Martyn, 1985, 1987; Netzer, 1976). There are four pathogenic races, 0, 1, 2, and 3 (Martyn and Netzer, 1991; Netzer, 1976; Netzer and Martyn, 1989; Zhou et al., 2010). Various commercial cultivars have been introgressed with resistance to *Fon* race 0 and 1, but not to race 2 or 3. *Fon*-R2 has been reported throughout the United States (Bruton and Damicone, 1999; Bruton et al., 1988, 2008; Egel et al., 2005; Keinath and DuBose, 2009; Martyn, 1985; Martyn and Bruton, 1989; Zhou and Everts, 2001, 2003). *Fusarium* wilt can reduce yield of susceptible watermelon by 40% (Keinath et al., 2010).

USVL246-FR2 and USVL252-FR2 were developed at the U.S. Vegetable Laboratory, Charleston, SC. The PIs from which the released lines were developed, PI 482246

and PI 482252, were initially reported as resistant to *Fon*-R2 based on standard *Fusarium* assay definitions (Wechter et al., 2012). The term tolerance is now being used instead of resistance to characterize these two PIs and the lines described here. This decision is based on subsequent studies (data not shown) showing that after root or seed inoculation, the plants grow normally through fruit harvest without showing symptoms of wilt; however, the pathogen can be isolated from parts of the plant not directly associated with the site of inoculation.

Origin

Each of these lines is derived from a U.S. PIs of the wild type watermelon *C. lanatus* var. *citroides* collected in Zimbabwe and

maintained at the USDA, ARS, Plant Genetic Resources and Conservation Unit, Griffin, GA. USVL246-FR2 and USVL252-FR2 are derived from PIs 482246 and 482252, respectively. In each case, tolerant individuals were selected from a greenhouse-based disease assay using a South Carolina *Fon*-R2 isolate. In our original greenhouse experiments, tolerance to *Fon*-R2 was significantly higher in these two PIs than in the watermelon cultivars Charleston Gray (moderately susceptible), Calhoun Gray (susceptible), and Sugar Baby (susceptible) that were used as the susceptible control lines, as well as in PI 296341-FR that was used as a *Fon*-R2-resistant control (Wechter et al., 2012). In the original disease trials, several plants in each of the resistant PIs exhibited a lower level of tolerance to *Fon*-R2. Thus, we selected and self-pollinated the most tolerant plants from each PI in seven consecutive generations in the greenhouse, selecting for tolerance using a seed inoculation *Fusarium* assay described by Wechter et al. (2012) in each subsequent selfed population to produce S₇ lines designated here as USVL246-FR2 and USVL252-FR2.

Description and Performance

USVL246-FR2 has a runner growth habit with an intermediate leaf blade type. Flowers are hermaphroditic. The fruits are round to slightly flattened (oblate), ≈25 cm in diameter and 20 cm in length (Fig. 1). The median fruit weight in field trials (five replications, six plants per plot) conducted in 2012

Fig. 1. A mature fruit of USVL246-FR2.

Table 1. Weights in kilograms of fruit raised to maturity in field trials during the summers of 2012 and 2013 at U.S. Vegetable Laboratory, Charleston, SC. Weights are averages and medians of all fruit from all plots in a six replication complete block trial with six plants per plot. Plants were grown on plastic mulch with under-plastic drip irrigation.

	USVL246-FR2		USVL252-FR2	
	2012	2013	2012	2013
Average	8.59	4.86	1.07	1.08
SD	2.22	2.32	0.56	0.61
Median	8.66	5.20	1.00	0.94

Received for publication 29 Sept. 2015. Accepted for publication 23 Dec. 2015.

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and 2013 was 8.7 and 5.2 kg, respectively (Table 1). The predominant fruit rind color is light green, with a striped secondary skin color pattern. The stripes are dark green. Fruit flesh is firm and salmon yellow at maturity. The pericarp averages 4 cm thick and fruit bitterness is absent. Seeds are moderately large and red/orange in color. In Charleston, SC, the fruit matures in ≈ 90 -d postanthesis. USVL246-FR2 seedlings are sturdy with large cotyledons and exhibit faster growth than the watermelon cultivars Charleston Gray, Allsweet, and Sugar Baby in our field trials. Fusarium wilt symptoms are noted in $\approx 15\%$ of the S₇ lines in greenhouse assays (Table 2), but are usually seen as a single wilted cotyledon (Fig. 2), with the plants often growing to maturity and producing fruit with no other symptoms. Greenhouse inoculation studies indicate USVL246-FR2 exhibits levels of tolerance to *Fon*-R2 similar to or higher than that exhibited by PI 296341-FR, yet USVL246-FR2 exhibits more vigorous growth than PI 296341-FR. USVL246-FR2 crosses readily with the *C. lanatus* var. *lanatus* cultivars Charleston Grey, Calhoun Grey, and Sugar Baby.

USVL252-FR2 has a runner growth habit with an intermediate leaf blade type. Flowers are andromonoecious. The fruits are round to slightly broad, being ≈ 15 cm in diameter and 13–15 cm in length (Fig. 3). The median fruit weight in field trials (five replications, six plants per plot) conducted in 2012 and 2013 was 1.0 and 0.94 kg, respectively (Table 1). The predominant fruit color is medium green, with a striped secondary skin color pattern. The stripes are light green. Fruit flesh is firm and white to salmon yellow at maturity. The pericarp averages 1.5 cm thick and fruit bitterness is absent. Seeds are pale red/orange in color. In Charleston, SC, fruits mature in ≈ 75 -d postanthesis. USVL252-FR2 seedlings are smaller than USVL246-FR2. Size and growth characteristics of USVL252-FR2 plants are similar to that of ‘Charleston Gray’, ‘Allsweet’, and ‘Sugar Baby’. Fusarium wilt is noted in $\approx 10\%$ of the S₇ plants of this line in greenhouse assays (Table 2), but it is usually seen as a single wilted cotyledon, with the plants often growing to maturity and producing fruit with no other symptom. Greenhouse inoculation studies indicate USVL252-FR2 has levels of tolerance to *Fon*-R2 similar to or higher than that found in PI 296341-FR, yet USVL252-FR exhibits more vigorous growth than PI 296341-FR. USVL252-FR2 crosses readily with the *C. lanatus* var. *lanatus* cultivars Charleston Grey, Calhoun Grey, and Sugar Baby.

Availability

Small quantities of seed of USVL246-FR2 and USVL252-FR2 are available for distribution to interested research personnel and plant breeders who make written request to Dr. Patrick Wechter, U.S. Vegetable Laboratory, 2700 Savannah Highway, Charleston, SC 29414-5334 (Pat.Wechter@ars.usda.gov). Seed of USVL246-FR2 and USVL252-FR2

Table 2. Results of two separate Fusarium wilt assays (data combines as there was no statistical difference between tests) rated at 28-d post inoculation with *Fusarium oxysporum* f. sp. *niveum* race 2. Statistical analysis was performed using the Waller–Duncan K-ratio *t* test ($P \leq 0.0001$).

Germplasm	Generation	Mean healthy ^a	Waller grouping
USVL252-FR2	S ₇	0.948	A
USVL246-FR2	S ₇	0.861	A
296341-FR	S ₁₀	0.676	B
Charleston Grey	NA	0.306	C
Allsweet	NA	0.269	C
Sugar Baby	NA	0.167	C

^aMeans are derived from three independent replications. Number of plants tested: USVL252-FR2 (n = 170), USVL246-FR2 (n = 131), 296341-FR (n = 165), Charleston Grey (n = 60), Allsweet (n = 60), and Sugar Baby (n = 60).

Fig. 2. Two 21-day-old USVL246-FR2 plants that were inoculated at the seed stage with 1×10^6 conidia/mL *Fusarium oxysporum* f. sp. *niveum* race 2 spore suspension. Plant on right shows a chlorotic/necrotic cotyledon but otherwise healthy plant. Symptomatic plant grew to maturity and produced fruit with no further symptoms.

Fig. 3. A mature fruit of USVL252-FR2.

will also be submitted to the National Plant Germplasm System where it will be available for research purposes, including the development and commercialization of new, Fusarium wilt race 2-tolerant watermelon

cultivars. It is requested that appropriate recognition of the source be given when this germplasm contributes to research or development of a new breeding line or cultivar.

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