Fusarium Wilt in Watermelon Cultivars Grown in a 4-Year Monoculture

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ABSTRACT

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The year-to-year increase of Fusarium wilt in 10 watermelon cultivars grown in a 4-yr monoculture was inversely related to the resistance rankings of the cultivars. Crimson Sweet, rated as moderately resistant, was the exception. The mean rate of increase of Fusarium wilt was less in Crimson Sweet than in any other cultivar. In the fourth year, Crimson Sweet had the least wilt and the highest yield of all cultivars. Greenhouse bioassays for *Fusarium oxysporum* f. sp. *niveum* demonstrated a slower rate of increase of soil propagules with Crimson Sweet than with any other cultivar. Crimson Sweet appeared to have a unique type of resistance to Fusarium wilt that was somewhat more stable in a monoculture than that of other cultivars.

Fusarium wilt of watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai) caused by *Fusarium oxysporum* f. sp. *niveum* (E. F. Sm.) Snyd. & Hans. occurs throughout watermelon-growing regions of the world. Because of the severity of Fusarium wilt in Florida, watermelons are grown either on new land or in a rotation of at least 6 yr (preferably 8–10 yr) between watermelon crops. Long rotations with resistant cultivars is currently the best control used by growers.

Watermelon cultivars are usually described as either "resistant" or "susceptible" to Fusarium wilt; however, there is a continuum in the resistance from very susceptible to highly resistant (1,2,4,5). Four groups have been used to categorize cultivars (2,4). Cultivars rated as highly resistant to Fusarium wilt have not been readily accepted by commercial growers because of certain other undesirable characteristics (2). Perhaps, rotation intervals could be shortened if highly resistant cultivars were used.

The purpose of this study was to determine the influence of a monoculture of watermelon cultivars with different levels of resistance to Fusarium wilt. The test was done from 1979 through 1982 in naturally infested field soil at the Agricultural Research Center at Leesburg, FL.

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MATERIALS AND METHODS

In February 1979, 10 watermelon cultivars (Table 1) were planted in a test replicated four times in a field naturally infested with *F. oxysporum* f. sp. *niveum*. The soil was an Apopka fine sand, which is low in organic matter (<1%) and has very low available water capacity. Fusarium wilt was observed in Charleston Gray grown in this field in 1973. From 1973 through 1978, Pensacola bahiagrass (*Paspalum notatum* Flugg) was grown in the field. Test plots consisted of 40 hills in four rows with 1.5 m between hills and 3 m between rows.

Ten watermelon cultivars representing all four categories of Fusarium wilt resistance (2) were tested. The cultivars were: Calhoun Gray and Smokylee (highly resistant); Dixielee, Crimson Sweet, Charleston Gray, and Sugarlee (moderately resistant); Jubilee (slightly resistant); and Sugar Baby, Florida Giant (Black Diamond), and Congo (susceptible). Seed sources were constant throughout the test. Permanent posts were set to mark the corners of the test area. Measuring from these permanent posts, plots could be placed precisely in the same location each year of the test. Each year, from 1979 through 1982, six to eight seeds per hill were planted the last 2 wk of February. Each cultivar was monocropped in the same plots during the 4 yr of the study.

Watermelon seedlings that died of Fusarium wilt were counted three times each week during the first 5 wk after emergence and wilt percentages were calculated. At maturity, fruit were harvested and total yields of marketable fruit determined. Soil samples were taken from the field plots and brought to the laboratory for assay. Soil samples from the plots were about 100 g and resulted from mixing six subsamples taken from the top 20 cm of soil in each plot. *F. oxysporum* propagules per gram of airdry soil were determined using soil dilutions on Komada's selective medium (3). Five-gram subsamples of soil were diluted and plated on five petri plates. The average of the five plates was used as the propagule population. Greenhouse bioassays for Fusarium wilt were conducted by planting seeds of wilt-susceptible Garrisonian in pots containing field soil and determining the percentage of wilt after 5 wk. Two 4-in. pots were used for each field plot and 10 seeds were planted in each pot.

RESULTS

During the first season (1979), there was only 0–6% seedling wilt observed in any of the cultivars (Table 1); some late-season wilt symptoms were observed in Sugar Baby, Florida Giant, Jubilee, Congo, and Sugarlee. Yields of all 10 cultivars were at commercially acceptable levels. During the second year, seedling wilt was severe (62–82%) in the susceptible cultivars Congo, Florida Giant, and Sugar Baby. Highly resistant cultivars Calhoun Gray and Smokylee had the least wilt (12%). In 1980, yields of Calhoun Gray, Crimson Sweet, and Smokylee were significantly higher than those of the other cultivars. Florida Giant did not yield any marketable melons in the second year. In the third year (1981), seedling wilt was lowest (8–15%) in Crimson Sweet, Smokylee, and Calhoun Gray and highest (57–78%) in Florida Giant, Congo, and Charleston Gray. There were no yields obtained from any cultivars in 1981; the field was abandoned because of excessive weeds. During the last year of the 4-yr monoculture, seedling wilt was significantly lower in Crimson Sweet than in all other cultivars. Yields from all cultivars were low except for Crimson Sweet, the only one yielding close to commercially acceptable levels.

Seedling wilt and yields during the 4-yr monoculture could be used to distinguish the highly resistant, moderately resistant, and susceptible cultivars. Typical examples are Calhoun Gray, Charleston Gray, and Florida Giant, respectively (Table 1). The exception was Crimson Sweet. Categorized as moderately resistant, it had less wilt and higher yields than the highly resistant cultivars in the fourth year of the test.

At the beginning of the test in March 1979, *F. oxysporum* f. sp. *niveum* as determined by greenhouse bioassay was low in all plots (Table 2). By the end of the second season (September 1980), the percentage of wilt in the bioassay was high with soil from all plots, but the least wilt was found in soil from Crimson Sweet plots. At the end of the 4-yr monoculture, the percentage of wilt in the bioassay was high in soil from all plots. The major increases in wilt occurred during the first 2 yr of the test.

Concentrations of *F. oxysporum* propagules recovered from soil were not a useful indicator of Fusarium wilt severity in watermelon because clear trends did not develop (Table 3).

Table 1. Wilt incidence and yield of 10 watermelon cultivars grown in a 4-yr monoculture

	Percentage of seedling wilt[y,z]				Yield (t/ha)[y]		
Cultivar	**1979**	**1980**	**1981**	**1982**	**1979**	**1980**	**1982**
Crimson Sweet	3 bc	19 ab	8 a	13 a	31.1 b	24.0 a	16.6 a
Smokylee	1 ab	12 a	13 a	29 b	30.1 b	21.3 a	11.4 b
Calhoun Gray	0 a	12 a	15 a	47 bcd	40.5 a	22.0 a	11.4 b
Charleston Gray	2 b	41 bc	57 d	63 def	39.9 a	11.2 b	5.8 c
Jubilee	6 c	44 bc	22 ab	43 bcd	30.0 b	7.8 b	3.8 cd
Dixielee	3 bc	26 ab	34 bc	35 bc	26.7 b	7.8 b	1.4 cd
Congo	5 bc	66 cd	74 e	67 ef	32.7 ab	7.2 b	1.6 cd
Sugarlee	0 a	34 ab	42 bcd	49 cde	29.1 b	6.3 b	0.2 d
Sugar Baby	2 bc	62 cd	49 cd	59 def	15.5 c	1.6 c	0.0 d
Florida Giant	3 bc	82 d	78 e	76 f	26.2 b	0.0 c	0.0 d

[y] Means in columns followed by the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test; percentage wilt data were analyzed after transformation to arc sine $\sqrt{X}$. There were no yield data obtained in 1981 because of excessive weed growth in the plots.
[z] Mean percentage of plants that died of Fusarium wilt between emergence and thinning 5 wk later.

Table 2. Percentage of wilt of Garrisonian watermelon in greenhouse bioassays of soils from the cultivar monoculture plots

	Percentage of wilt[y,z]				
Cultivar	**March 1979**	**Sept. 1979**	**Sept. 1980**	**Oct. 1981**	**Sept. 1982**
Crimson Sweet	1	8 a	40 a	39	61 ab
Smokylee	5	13 ab	76 abc	26	49 a
Calhoun Gray	0	13 ab	72 abc	56	80 b
Charleston Gray	4	43 ab	65 ab	54	75 ab
Dixielee	5	14 ab	96 c	27	76 ab
Sugarlee	6	9 a	77 bc	54	63 ab
Jubilee	1	57 b	77 bc	24	77 ab
Sugar Baby	1	19 ab	57 ab	37	83 b
Florida Giant	3	38 ab	58 ab	59	66 ab
Congo	3	39 ab	77 bc	40	69 ab

[y] Means in columns followed by the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range tests; percentage wilt data were analyzed after transformation to arc sine $\sqrt{X}$. Data of March 1979 and October 1981 had no significant differences.
[z] Average percentage of Garrisonian plants that died of Fusarium wilt within 5 wk of planting in the greenhouse.

Table 3. Populations of *Fusarium oxysporum* propagules recovered from the soil during a 4-yr monoculture of 10 watermelon cultivars

	Propagules per gram of soil[z]				
Cultivar	**Feb. 1979**	**Sept. 1979**	**Sept. 1980**	**Sept. 1981**	**Sept. 1982**
Sugarlee	1,660	1,905	1,862	1,175 a	1,380 ab
Crimson Sweet	1,549	2,042	1,778	1,549 ab	813 ab
Dixielee	1,445	1,862	1,778	1,778 ab	1,202 ab
Sugar Baby	1,175	1,445	1,349	1,778 ab	724 a
Florida Giant	1,175	1,585	1,318	2,089 bc	1,288 ab
Jubilee	1,318	1,549	1,738	2,239 bc	1,445 b
Smokylee	1,479	1,660	1,622	2,291 bc	1,047 ab
Congo	1,479	1,413	1,950	2,344 bc	1,479 b
Calhoun Gray	1,202	1,862	1,698	3,020 c	1,585 b
Charleston Gray	1,413	1,549	1,995	3,388 c	1,047 ab

[z] Means in columns followed by the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test; data were analyzed after logarithmic transformation. There were no significant differences in propagules in February 1979, September 1979, and September 1980.

DISCUSSION

During the first 2 yr of this test, Fusarium wilt incidence was in agreement with earlier rankings of cultivar resistance (2,4,5). This was also supported by yield data, although Crimson Sweet performed slightly better than other moderately resistant cultivars. Surprisingly, Crimson Sweet had less Fusarium wilt and higher yield in 1982 than the highly resistant Smokylee and Calhoun Gray. The wilt resistance of Calhoun Gray and Smokylee appeared to break down during the fourth year of the monoculture, whereas it was more stable with Crimson Sweet. Crimson Sweet may have unique resistance genes that result in a mechanism of resistance more stable in a monoculture than that of other highly resistant or moderately resistant cultivars.

Apparently, in a monoculture of highly resistant cultivars, Fusarium wilt increases more rapidly than in a monoculture of the moderately resistant

Crimson Sweet. This could result from either an accumulation of *F. oxysporum* f. sp. *niveum* propagules to a very high concentration in the soil or development of strains of the fungus that are more aggressive to highly resistant cultivars. Large differences in *F. oxysporum* propagules were not observed in this test; however, we did not conduct pathogenicity tests necessary to determine *F. oxysporum* f. sp. *niveum* populations.

As expected, the increase in Fusarium wilt was most rapid on susceptible cultivars. Generally, this increase had an inverse relationship with previous rankings of cultivar resistance to Fusarium wilt (2,4,5). Crimson Sweet was an exception to the general trend.

Before this study, it was proposed that use of highly resistant cultivars would be a necessary component of any shorter watermelon rotation scheme for disease control (2). We found, however, that Crimson Sweet may be better suited for short-interval rotations than the highly resistant cultivars. Perhaps, the long-term answer might be to combine the high-type resistance of Calhoun Gray or Smokylee with the more stable resistance of Crimson Sweet into a cultivar that could be grown in a 2- or 3-yr rotation or even in a monoculture.

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