Inheritance of Resistance in Watermelon to Race 1 of *Fusarium oxysporum* f. sp. *niveum*

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ABSTRACT

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The mode of inheritance of resistance to Fusarium wilt in watermelon was determined by analyzing the segregation of F_1, F_2, F_3 progenies of crosses involving one susceptible (Mallali) and two resistant (Calhoun Gray, Summit) watermelon cultivars and backcross progenies to the susceptible parental cultivar. The ratios obtained indicate that resistance to race 1 of *Fusarium oxysporum* f. sp. *niveum* is controlled by a dominant gene.

Fusarium wilt, caused by *Fusarium oxysporum* (Schlecht) f. sp. *niveum* (E.F.S.) Snyd. & Hans., presents serious problems in growing watermelon in many parts of the world. In Israel, the commercial cultivars as well as those bred recently and introduced during the last decade are susceptible to the local isolates of the Fusarium wilt organism (6).

Differences in aggressiveness (sensu van der Plank) of isolates of f. sp. *niveum*, without a clear indication of a race situation, have been reported (5). However, Crall (3) reported two races of the fungus in Florida in 1963. Cirulli proved the existence of two races in Italy (2), designated by him as races 0 and 1, differentiated on the basis of a gene-for-gene relationship. Of the three cultivars used by Cirulli, Calhoun Gray was resistant to both races. Paulus et al (8) found this cultivar to provide the highest level of resistance in both field and greenhouse trials. The resistance of Calhoun Gray and Summit to the two races (sensu Cirulli) has been corroborated (6). These two cultivars apparently derive their resistance to Fusarium wilt from the same source (2).

During a breeding program, we studied the inheritance of resistance in Calhoun Gray and Summit to race 1 of Fusarium wilt.

MATERIALS AND METHODS

The inoculum was derived from a culture of *F. oxysporum* f. sp. *niveum* isolated from a wilted watermelon plant in California. This isolate previously (6) was defined as race 1 (sensu Cirulli). Details of inoculum preparation and method of inoculation are given elsewhere (7).

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Inoculated plants were transplanted into Jiffy pots filled with heat-sterilized sandy loam soil and maintained in a greenhouse with 28 C air and 26 C soil. Calhoun Gray (CG) and Summit (S), both resistant, and the local cultivar Mallali (M), susceptible to the isolate, were used in this study.

Final assessment of wilt symptoms was made on the 15th day after inoculation. After an additional 6 days, the nonwilted plants were transplanted and grown to maturity for either self- or cross-pollinations.

RESULTS

Progenies from self-pollinated M plants were 100% susceptible, whereas progenies from CG or S plants did not show wilt symptoms. These two latter cultivars were crossed with the susceptible M; none of the F_1 progenies wilted. The segregation observed in the F_2 generation (Table 1) of the crosses M × CG, as well as M × S, suggested simple inheritance (3:1) of the disease reaction, resistance being controlled by one dominant gene. In order to verify this pattern of resistance, the F_1 plants of the crosses CG × M and S × M were backcrossed to the susceptible M. The BC_1 progenies of these crosses gave a 1:1 ratio of resistant to susceptible plants (Table 1).

The mode of inheritance was tested further in F_3 progenies of CG × M, derived from resistant and noninoculated F_2 plants. Fourteen and 10 progenies of such plants, respectively, were obtained (Table 2). Five progenies of the 14 resistant F_2 plants contained resistant plants only, and the nine segregating progenies consisted of a total of 92 resistant and 32 susceptible plants. Of the 10 F_3 progenies of noninoculated F_2 plants, five contained susceptible plants only; two segregating progenies consisted of 34:12 (resistant/susceptible) plants, and three progenies of resistant plants only (Table 2).

Table 1. Segregation in progenies from crosses between resistant (R) cultivars Calhoun Gray and Summit and the susceptible (S) cultivar Mallali after inoculation with race 1[a] of *Fusarium oxysporum* f. sp. *niveum*

Parents and crosses	Plants tested (no.)	Expected ratio	Seedlings (no.)		X^2	P
			Resistant	Susceptible		
M	30	all S	0	30	...	...
CG	25	all R	25	0	...	...
S	15	all R	15	0	...	...
F_1 M × CG	30	all R	30	0	...	...
M × S	15	all R	15	0	...	...
F_2 M × CG						
1[b]	256	3:1	188	68	0.33	0.50–0.70
2[c]	90	3:1	64	26	0.72	0.30–0.50
Total	346	3:1	252	94	0.86	0.30–0.50
M × S	47	3:1	37	10	0.34	0.50–0.70
BC_1 (M × CG) × M						
1[b]	94	1:1	53	41	1.53	0.20–0.30
2[d]	180	1:1	82	98	1.42	0.20–0.30
Total	274	1:1	135	139	0.05	0.80–0.90
(M × S) × M	26	1:1	15	11	0.61	0.80–0.90

[a] *sensu* Cirulli (2).
[b] With Mallali as female parent.
[c] With Calhoun Gray as female parent.
[d] With F_1 plant as female parent.

Table 2. Segregation in F_3 progenies derived from either inoculated resistant or noninoculated F_2 plants of the cross Mallali × Calhoun Gray[a]

F_2 parental plants	With R plants only	With both R and S plants	With S plants only	Total progenies tested (no.)
Resistant	5 (49)	9 (92:32)	0	14
Noninoculated	3 (33)	2 (34:12)	5 (55)	10

[a] Figures in parentheses are total numbers of resistant (R) and susceptible (S) plants in the respective F_3 progenies.

DISCUSSION

Except for the report by Henderson et al (4), who suggested that in cv. Summit Fusarium wilt resistance is controlled by a single dominant gene, the available information on this subject is rather contradictory (1,9,10). In the present study, race identification of *F. oxysporum* f. sp. *niveum* was based on the differentiation suggested by Cirulli (2). Segregation ratios obtained in F_1, F_2, and backcross progenies suggest a single dominant gene pattern of resistance to race 1 of the watermelon Fusarium wilt. Furthermore, in our study of resistant F_2 progenies (of CG × M) carried to the F_3 generation, five of 14 progenies were homozygous resistant, clearly supporting the one-gene hypothesis.

The suggestion that the resistance factor to Fusarium wilt in cultivars Calhoun Gray and Summit derives from Florida Seedling 124 (2) is strengthened by the results of the present study. The importance of this source of resistance should not be ignored in any future breeding program. Unfortunately, in Israel this source is of no practical value, because the local isolates were pathogenic to all lines and cultivars tested so far, including Calhoun Gray and Summit. Their susceptibility to the local isolates indicates the existence of a third race (6), in addition to the two races suggested by Cirulli (2).

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