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New Sources of Resistance to Watermelon Anthracnose[1]

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Abstract. **Watermelons Plant Introductions (PI) 189225, PI 271775, PI 271778, and PI 299379 were resistant to a population of *Colletotrichum langenarium* (Pass.) Ell. & Halst. in 3 states. Entries PI 203551, PI 270550, and PI 271779 were resistant in some field and greenhouse tests.**

According to Winstead et al (12), the first anthracnose-resistant cultivars of watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai) to find wide acceptance were 'Congo', 'Fairfax', and 'Charleston Gray' released by Andrus. In 1954 and 1955 Goode (2) observed severe anthracnose on 'Charleston Gray' watermelons at 4 locations in North Carolina. Later (3), he described the race pathogenic on 'Charleston Gray' as race 2. He reported some resistance to race 2 in 20 plant introductions of a total of 354 screened for resistance. Winstead et al. (12) failed to confirm the resistance reported by Goode but found that an African citron line W-695 segregated for resistance to race 2. Hall et al. (4) screened newer commercial cultivars for relative resistance to the pathogen and found that 'Congo', 'Charleston Gray', and 'Fairfax' were resistant to 2 isolates of the pathogen. Dutta et al. (1) reported the resistance of the cultivars and 'Hope Diamond' to races 1 and 3, but they found no resistance to race 2. Today, 20 years after resistance was reported in W-695, anthracnose still causes severe damage in some fields of 'Congo' and 'Charleston Gray', and watermelon breeders are still seeking an effective source of resistance.

Since the work of Winstead et al. (12), the Southern Regional Plant Introduction Station, Experiment, Ga., has received about 450 new plant introductions of watermelon. The purpose of our research was to screen this germplasm for resistance to populations of *Colletotrichum lagenarium* pathogenic on 'Charleston Gray'.

Materials and Methods

Twenty-five seeds of each PI were enclosed in a cheesecloth bag, treated for 5 min in 0.5% sodium hypochlorite, and rinsed in running tap water for about 30 min. This treatment reduced the seedborne bacterial disease described by Webb and Goth (11) and by Schaad et al. (10) to a low level, so that it did not interfere with the results. The seeds were dried, treated with 50% thiram (bis(dimethylthiocarbamoyl)disulfide) dust, and planted in a row in a soil-vermiculite-peat moss mixture (pH 5.5 – 6.5). Four PIs were planted in each 38- x 54-cm greenhouse flat.

Colletotrichum lagenarium was isolated from a leafspot on a PI growing in the field at Experiment, Ga. This isolate, designated "883," was grown on sterilized, frozen green beans for 4-7 days, and the conidia were suspended in deionized water and adjusted to a concentration of about 2×10^4/ml. The concentration of conidia was determined with a hemacytometer. When the watermelon seedlings were 3 weeks old, they were sprayed with the inoculum and incubated without light for 48 hr at 100% relative humidity and 25°C. This technique is similar to that recommended by Littrell and Epps (6). One week later, the severity of the disease was recorded as a disease index on a 0-5 scale of increasing severity (7). After an analysis of variance was done for each test, the means were compared for differences at the 5% level by Duncan's multiple range test.

The PIs that had a disease index of 2.0 or less in the preliminary screening tests were included in a replicated test. In the greenhouse test 25 seeds were planted per row and each PI was replicated 4 times in a randomized block design. This experiment was repeated in 1977 in the field. In all field tests, 2 hills, each with 4 plants, comprised a plot. In the 1977 field test, the plants were inoculated with about 10^5 conidia per ml when the runners were about 30 cm long. Ten days later, the percentage of the foliage with one or more spots per leaf was estimated and converted to the disease index. Seven weeks after inoculation, the % plant area made nectotic by the pathogen was estimated and converted to the disease index.

A second replicated greenhouse test was conducted in 1978. The seven PIs included in field tests and 'Charleston Gray' were grown in 10 cm pots. When the plants were 32 days old, they were thinned to 2 per pot and inoculated with a suspension containing 2×10^4 conidia per ml and incubated as in previous greenhouse tests. Isolate ClBR was used in this test and in all subsequent resistance tests. When the plants were removed from the moist chamber, they were arranged in a completely random design. The disease index was determined 9 days later.

The seven PIs tested in the 1978 greenhouse test were also tested in the field at Experiment, Ga., Blackville, S.C., and E. V. Smith Research Center, Ala., in 1978. 'Allsweet' was included at all 3 locations and 'Charleston Gray', at 2 locations. A randomized block design with 4 replications was used. The seed was treated with a 16-hr soak in streptomycin at 1000 μg/ml, dried, and planted in peat pellets, and the seedlings were transplanted at about 2 weeks of age. The plants were inoculated with suspensions containing $5 \times 10^4 - 5 \times 10^5$ conidia per ml at 5 weeks (Ga.) at 8 weeks (S.C.), and at 4 weeks (Ala.) after transplanting. In Alabama, the disease index was determined 3 weeks after inoculation and in Ga. and S.C. it was determined both at 17 days and at 7 weeks after incoulation. The disease index was determined on 6 dates in S.C., beginning 9 days after inoculation, and the lesions on each of 20 fruits from each plot were counted 53 days after inoculation. Nine fruits were measured and flesh and rind color were recorded in the plots at Experiment, Ga.

The pathogenicity of isolates 883 and ClBR were tested on

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the following hosts: *Cucumis sativus* L. 'Marketer', 'Poinsett', and PI 163213; *Cucurbita moschata* (Duch.) Duch. ex Poir. 'Butternut'; and *Citrullus lanatus* 'Charleston Gray'.

Results and Discussion

Fifteen PIs had a disease index of 2.0 or less in the preliminary screening tests. In the 1977 replicated greenhouse test, only 4 of these had a significantly lower disease index than did 'Charleston Gray' (Table 1). In the 1977 field test, seven PIs were significantly superior to the susceptible cultivar, 'Florida Giant', in July. Nine PIs were significantly superior to 'Florida Giant' in August.

In the 1978 greenhouse test, four PIs were superior to 'Charleston Gray' in resistance (Table 1). The mean disease indices of 'Charleston Gray' and PI 271778 and 203551 were significantly lower than that of PI 270550.

In the 1978 field test, five PIs were significantly superior to 'Allsweet' in Georgia in July, whereas only three PIs were significantly superior to this susceptible cultivar in August (Fig. 1 and Table 2). In Alabama all seven PIs were superior to 'Charleston Gray' and 6 of them were superior to 'Allsweet'. In South Carolina there were no significant differences between any of the PIs and the susceptible cultivars early in the season. Late in the season, however, five PIs were significantly superior to 'Charleston Gray' and four PIs were significantly superior to 'Allsweet'. Most of the PIs had very low fruit lesion counts, ranging from 0 to 9.5 lesions per fruit (Table 2). 'Charleston Gray', with a mean of 28.7 lesions per fruit, and all of the PIs were significantly superior to 'Allsweet'. The mean fruit size, flesh color and rind color at Experiment Ga. are listed in Table 3.

Isolate 883 from Georgia and isolate ClBR from South Carolina were pathogenic on 'Marketer' cucumber and 'Charleston Gray' watermelon. Neither isolate was pathogenic on PI 163213, 'Poinsett' cucumber, or 'Butternut' squash.

Populations of *C. langenerium* which can be separated into race 2 and race 5 as defined by Jenkins et al. (5), function as a single pathotype on watermelon at present, since they

Table 1. Severity (disease index[z]) of anthracnose on watermelon PIs inoculated with *Colletotrichum lagenarium*.

	1977 tests			1978 test
		Field		
Entry	Greenhouse	July	August	Greenhouse
PI 271779	3.5 b[y]	2.0 ab	4.0 de	1.2 a
PI 299379	5.0 d	2.2 abc	4.0 de	2.0 a
PI 271775	4.2 bcd	2.5 bcd	2.2 ab	1.0 a
PI 189225		2.8 cde	2.8 abc	1.2 a
PI 271778	5.0 d	2.2 abc	2.2 ab	3.8 b
Charleston Gray	5.0 d			3.0 b
PI 203551	5.0 d	1.8 a	2.0 a	3.5 b
PI 270550	5.0 d	2.8 cde	3.0 abcd	5.0 c
Florida Giant		3.5 fg	5.0 e	
PI 381752	4.2 bcd	3.0 def	2.5 abc	
PI 364460	4.8 cd	3.2 efg	5.0 e	
PI 346787	5.0 d	3.2 efg	5.0 e	
PI 271773	4.0 bcd	3.5 fg	3.5 cd	
PI 271363	3.8 bc	3.8 g	5.0 e	
PI 381751	3.5 b	3.8 g	3.5 cd	
PI 381742	4.0 bcd	3.8 g	3.2 bcd	
PI 271769	2.2 a	4.0 g	5.0 e	

[z]Disease index on a 0–5 scale, in which 0 = no infection and 5 = 81–100% plant area infected.

[y]Mean separation in columns by Duncan's multiple range test, 5% level.

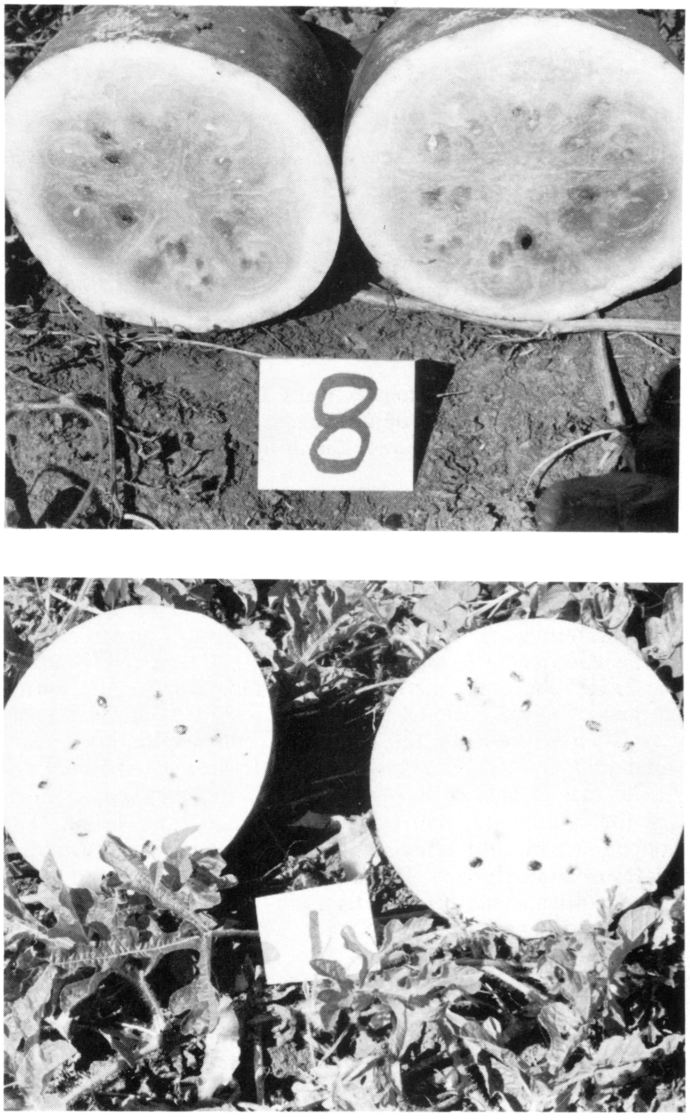

Fig. 1. Fruits and foliage of 'Allsweet' (#8) and PI 189225 (#1) in 1978 field test at Experiment, Ga. Note severe defoliation of 'Allsweet'. Dimensions of white card = 64 × 76 mm.

Table 2. Severity of anthracnose on watermelon plant introductions at three locations in 1978.

	Disease index[z]					
	Georgia			S. Carolina		Fruit
Entry	July	August	Alabama	May	July	lesions[y]
PI 189225	1.5 a[x]	1.0 a	0.0 a	1.9 a	3.1 cd	0.0 a
PI 271775	2.0 a	1.2 ab	3.0 c	1.5 a	2.0 a	0.2 a
PI 271779	1.5 a	1.2 ab	0.5 b	1.6 a	1.8 a	0.1 a
PI 299379	1.5 a	2.0 bc	3.5 d	2.1 ab	2.1 ab	0.0 a
PI 271778	2.2 b	2.5 c	0.5 b	2.4 ab	3.8 de	5.0 a
Allsweet	3.0 c	2.8 c	4.0 e	1.9 a	3.2 d	65.8 b
PI 203551	3.0 c	4.2 d	3.0 c	3.1 bc	2.6 bc	9.5 a
PI 270550	3.0 c	5.0 d	4.0 e	3.5 c	3.4 de	21.1 a
Charleston Gray			5.0 f	2.1 ab	3.9 e	28.7 a

[z]Disease index on a 0–5 scale, in which 0 = no infection and 5 = 81–100% plant area infected.

[y]Mean number of lesions on 8 fruits in S. Carolina.

[x]Mean separation in columns by Duncan's multiple range test, 5% level.

Table 3. Characteristics of watermelon PIs which are highly resistant to anthracnose.

PI number	Length (cm)	Width (cm)	Flesh color	Rind color	Maturity in days from planting
189225	18	16	white	dark green	85–95
271775	30	28	white	yellow	85–95
271778	19	18	yellow	dark green stripes on medium green	85–95
299379	28	26	white	light green	85–95

cannot be differentiated on available watermelon cultivars. The fact that both isolates of the pathogen tested, one from South Carolina and one from Georgia, represent race 5 as defined by Jenkins et al. (5) indicates that this race may be common in the Southeastern U.S.A.

Four PIs (189225, 271775, 271779, and 299379) showed the most consistent resistance to this pathotype. These were superior to the susceptible cultivar, 'Florida Giant', by a significant amount in the 1977 field test in July, and to 'Charleston Gray' in the 1978 greenhouse test; and, except for PI 299379 in Ga., they were superior to 'Allsweet' in all field locations in 1978. Entry PI 271778 was less consistent in its reaction but may still serve as an adequate source of resistance for breeders. Entries PI 271778 and 189225 have the additional advantage of carrying genes for resistance to gummy stem blight (8, 9).

If the level of resistance of the highly resistant PIs can be transferred to commercial-quality watermelons, economic losses due to anthracnose should be reduced significantly. If one considers that under extremely high inoculum levels (up to 10^5 conidia per ml) the resistant PIs have retained from 50 to more than 80% of their foliage while 'Charleston Gray' or another susceptible entry was 100% defoliated, the PI's have high potential as useful sources of resistance. The potential of the PI's also is enhanced by the fact that very few to no lesions were found on the fruit. We believe that the disease pressure in field tests with inoculum of $2 - 10 \times 10^4$ conidia per ml under favorable conditions for infection is much higher than one would expect in commercial fields. Therefore, it is likely that cultivars with the same level of resistance to anthracnose as that of the resistant PIs would have lower levels of plant and fruit infection in commercial fields than these have shown in our tests.

Literature Cited

1. Dutta, S. K., C. V. Hall, and E. G. Heyne. 1960. Observations on the physiological races of *Colletotrichum lagenarium*. *Bot. Gaz.* 121:163-166.
2. Goode, M. J. 1956. Physiologic specialization in *Colletotrichum lagenarium*. *Plant Dis. Rptr.* 40:741.
3. _____. 1958. Physiological specialization in *Colletotrichum lagenarium*. *Phytopathology* 48:79-83.
4. Hall, C. V., S. K. Dutta, H. R. Kalia, and C. T. Rogerson. 1960. Inheritance of resistance to the fungus *Colletotrichum lagenarium* (Pass.) Ell. and Halst. in watermelons. *Proc. Amer. Soc. Hort. Sci.* 75:638-643.
5. Jenkins, S. F., N. N. Winstead, and C. L. McCombs. 1964. Pathogenic comparison of three new and four previously described races of *Glomerella angulata* var. *orbiculare*. *Plant Dis. Rptr.* 48:619-623.
6. Littrell, R. H. and W. M. Epps. 1965. Standardization of a procedure for artificial inoculation of cucumbers with *Colletotrichum lagenarium*. *Plant Dis. Rptr.* 49:649-659.
7. Sowell, G., Jr. and W. L. Corley. 1974. Severity of race 2 of *Sphaerotheca fuliginea* (Schlecht.) Poll. on muskmelon introductions reported resistant to powdery mildew. *HortScience* 9:398-399.
8. _____. 1975. An additional source of resistance to gummy stem blight in watermelon. *Plant Dis. Rptr.* 59:413-415.
9. _____and G. R. Pointer. 1962. Gummy stem blight resistance of introduced watermelons. *Plant Dis. Rptr.* 46:883-885.
10. Schaad, N. W., G. Sowell, Jr., R. W. Goth, R. R. Colwell, and R. E. Webb. 1977. *Pseudomonas pseudoalcaligenes* subsp. *cucurbitae* subsp. nov. *Intern. J. Syst. Bact.* 28:117-125.
11. Webb, R. E. and R. W. Goth. 1965. A seed-borne bacterium isolated from watermelon. *Plant Dis. Rptr.* 49:818-821.
12. Winstead, N. N., M. J. Goode, and W. S. Barham. 1959. Resistance in watermelon to *Colletotrichum lagenarium* races 1, 2, and 3. *Plant Dis. Rptr.* 43:570-577.

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Salinity Effects on Yield and Fruit Quality of 'Valencia' Orange[1]

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Additional index words. Citrus sinensis, sand culture

Abstract. **Salinity effects on yield and fruit quality of 'Valencia' orange (*Citrus sinensis* (L.) Osbeck) were determined in sand cultures artificially salinized with irrigation water applied twice daily. Yield reduction with increasing salinity during the 10-year study was attributed to a reduction in fruit number, not size. Salinity decreased rind thickness and delayed maturation but did not influence other fruit quality measures.**

Salinity in soil and irrigation water is a major consideration in citrus production in the arid southwestern United States. Salt tolerance of orange trees is well established (1, 4, 13, 14, 19), but information on the long-term effects of salinity on fruit yield and quality is limited. Bingham et al. reported that both quantity and quality of oranges, in an 8-year trial, declined with accumulation of soluble salts within the rootzone (4). The only other fruit quality information is from studies on fertilizer and management practices (10, 11, 16, 18).

This paper reports the results of an experiment designed to determine the long-term effects of salinity, with low specific ion toxicity (8, 15), on yield and fruit quality of 'Valencia' oranges.

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