Reaction of Cotyledons of Safflower Cultivars to Phytophthora drechsleri: Effect of Temperature and Inheritance

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ABSTRACT

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Cotyledons of 7-day-old safflower (*Carthamus tinctorius*) seedlings were wound-inoculated with a virulent isolate of *Phytophthora drechsleri*. Inoculated plants were held in a controlled environment with continuous light (13,988 lux) at 22, 26, 28, and 30 C for 10 days. Cotyledons of the cultivars Nebraska 10, both root and hypocotyl tissues susceptible to *P. drechsleri*, and Gila and US 10, roots resistant and hypocotyls susceptible, were susceptible at all temperatures. Cotyledons of VFR 1, root tissue resistant and hypocotyl tissue susceptible, and USB, both root and hypocotyl tissues resistant, were resistant at 22 and 26 C, showed intermediate symptoms at 28 C, and were susceptible at 30 C. The cotyledon reactions of the F_1, F_2, and BC_1 progenies derived from a VFR 1 × Nebraska 10 cross indicate that resistance at 22 C is conditioned by a single dominant factor.

Root and stem rot incited by *Phytophthora drechsleri* Tucker is an important disease of irrigated safflower *(Carthamus tinctorius* L.) in several parts of the world (4, 7). The use of resistant cultivars is the most practical means of control. Cultivars with root resistance only are suitable for production on infested soil if they are grown either with subirrigation or on beds with furrow irrigation (1). Both lower-stem and root resistance appear necessary for successful production on infested soils that are flood-irrigated (5, 7). In developing new cultivars, the screening of segregating or heterogeneous populations can be time-consuming, particularly if a stem inoculation technique is employed (2, 6).

Pratt et al. (3) reported that the reaction of cotyledons of young alfalfa seedlings to *P. megasperma* Drechsler parallel the tap- and lateral-root reactions of older plants. We have found distinct differences among some safflower cultivars in cotyledon reaction to *P. drechsleri*. Our objectives in this work were to evaluate the cotyledon resistance of cultivars that differ in root and hypocotyl resistance, to study the effect of temperature on the cotyledon reaction, and to determine the inheritance of resistance.

MATERIALS AND METHODS

Tests were run in a controlled-environment room with continuous light at 13,988 lux (cool-white fluorescent, supplemented by incandescent light). Plants were grown in steamed soil in porous 15.2-cm diameter clay pots, five plants per pot. Plants were grown at 22 C prior to inoculation. The inoculum of *P. drechsleri* [our isolate 201 (7)] consisted of circular plugs, 3 mm in diameter, cut from lima-bean-agar plate cultures incubated 8 days at 27 C. Seven-day-old plants were inoculated by smearing the inoculum into a pin-hole wound in the center of the cotyledon. Cotyledons of control plants were wounded and smeared with a plug of sterile lima-bean agar. Inoculated and control plants were sprayed with sterile distilled water and then the pots of moist, inoculated plants were covered for 16 hr with a moist inverted pot and a plastic bag.

In cultivar evaluation tests, Nebraska 10, root and hypocotyl tissues both susceptible to *P. drechsleri* (7), was compared with Gila, US 10, and VFR 1, roots resistant and hypocotyls susceptible (5), and with USB, roots and hypocotyls both resistant (5). Plants were held at 22, 26, 28, and 30 C following inoculation.

In the inheritance study, VFR 1 was used as the female parent in crosses with Nebraska 10. Parents, F_1 and F_2 generations, and progenies from backcrosses of the F_1 hybrids to both parents were tested at 22 C. All evaluations were made at least three times with a minimum of 50 seedlings of each cultivar or progeny. Symptoms were observed daily for 10 days following inoculation.

RESULTS AND DISCUSSION

Cotyledons of Nebraska 10, Gila, and US 10 were susceptible at 22, 26, 28, and 30 C. Necrosis of cells immediately adjacent to the pin-hole wound was observed 24 hr after inoculation. The necrosis expanded rapidly in the next 72 hr and the entire cotyledons were completely necrotic and collapsed after 96 hr. The affected area subsequently included the hypocotyl tissue. Rate of symptom development at 22 C was slightly slower than at 30 C.

Cotyledons of VFR 1 and USB were resistant at 22 and 26 C. Although the symptoms 24 hr after inoculation were similar to those of susceptible cotyledons, the necrotic area expanded only slightly during the next 72 hr. The average diameter of the necrotic area 96 hr after inoculation was 3.4 mm. No enlargement of the lesion

TABLE 1. Reaction to *Phytophthora drechsleri* of the cotyledons of the resistant VFR 1 safflower, the susceptible Nebraska 10, the F_1 hybrid, F_2, and backcross populations

Parent or Cross	Number of plants[a]		*P* value
	Resistant	Susceptible	
VFR 1	150	0	
Nebraska 10	0	150	
VFR 1 × Nebraska 10 F_1	150	0	
VFR 1 × Nebraska 10 F_2	317	99	>0.50[b]
F_1 × VFR 1 F_1	150	0	
F_1 × Nebraska 10 F_1	83	77	>0.50[c]

[a]At 22 C, 10 days after inoculation.
[b]Goodness of fit to a 3:1 ratio.
[c]Goodness of fit to a 1:1 ratio.

occurred during the next several days. At 28 C, the necrosis covered one-half to three-fourths of the cotyledon 96 hr after inoculation, but there was little enlargement thereafter. At 30 C, the cotyledons were killed almost as rapidly as those of Nebraska 10, Gila, and US 10.

The F_1 plants of the cross VFR 1 × Nebraska 10 were as resistant as the resistant parent. Segregation for resistance and susceptibility in the F_2 progeny was in good agreement with a 3:1 ratio (Table 1). Data from the BC_1 progenies (in good agreement with a 1:1 ratio) substantiated the F_2 results that resistance is conditioned primarily by a single factor exhibiting complete dominance.

The resistant reaction of VFR 1 cotyledons to *P. drechslieri* appeared to be indicative of its root resistance, that also is conditioned by a single dominant factor (5). The cotyledon reactions of Gila and US 10 were not indicative of their root resistance which appears to be conditioned by a dominant factor (7). Since both VFR 1 and USB have a higher level of root resistance than either Gila or US 10 (5), it is probable that different dominant factors are involved.

Inasmuch as hypocotyls of VFR 1 are susceptible to *P. drechsleri* (5), the cotyledon reaction is not indicative of hypocotyl reaction. Hypocotyl resistance of USB is conditioned by a recessive factor (7).

The cotyledon reaction of safflower to *P. drechsleri* may have limited use in screening germplasm for resistance. Temperature is an important factor and its effect on the resistant reaction could be utilized in studies on the nature of resistance. Breeding safflower for resistance to *P. drechsleri* is complicated by the existence of different factors conditioning resistance in either the root, the hypocotyl, or the cotyledons.

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