

## Pathogenic Races of *Fusarium oxysporum* f. sp. *carthami*

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### ABSTRACT

Two pathogenic races of *Fusarium oxysporum* f. sp. *carthami* are distinguished among 13 isolates which are highly virulent on three susceptible safflower varieties. The races are established on the

basis of reactions of variety Nebraska 6. Some safflower introductions and the breeding line Nebraska 4051 are highly resistant to the two races. *Phytopathology* 60:83-84.

*Fusarium* wilt of safflower (*Carthamus tinctorius* L.) was discovered in California in 1962 (4) in two widely separated safflower-growing areas of the Sacramento Valley. The disease has subsequently occurred in production areas along the Sacramento River and parts of the river Delta. A majority of the acreage where the wilt fungus *Fusarium oxysporum* Schlecht. f. sp. *carthami* Klis. & Hous. persists in the soil is subject to winter flooding. Floods have contributed to spread of the pathogen to noninfested fields. Wilt has also spread to safflower fields not subject to flooding. Here the fungus was probably introduced by infected seed (3).

Most commercial safflower varieties are not resistant to *Fusarium* wilt. However, variety Nebraska 6 (N6) has shown some resistance in field tests. A field test conducted in 1967 (5) demonstrated that several safflower introductions are highly resistant to the *Fusarium* wilt fungus, while many others carry resistance. Transfer of high resistance from plant introductions to desirable breeding and agronomic lines of safflower is of major concern in developing resistant varieties.

The success of breeding for resistance to safflower wilt may largely depend on our knowledge of *F. oxysporum* f. sp. *carthami*. In field tests (5), certain safflower materials varied in their disease reactions. These variances indicated the presence of distinct pathogenic races of *F. oxysporum* f. sp. *carthami*, and provided an objective for this study.

Pathogenic races of several other wilt-inciting formae speciales have been identified. Recently, Gordon (2) and Armstrong & Armstrong (1) compiled lists of

formae speciales and races of *Fusarium oxysporum* and their hosts.

**MATERIALS AND METHODS.**—The safflower varieties, breeding lines, and introductions used to differentiate races of this pathogen were selected on the basis of performance in a field test (5).

All isolates of *F. oxysporum* f. sp. *carthami* were obtained from diseased safflower plants. The initial isolate obtained in 1962 (4) and 12 other isolates came from the same or different areas of the Sacramento Valley. All isolates were cultured on potato-dextrose agar (PDA), and subcultured at 7- to 10-day intervals. Infected stems from safflower plants inoculated with each isolate are stored at room temperature. New cultures are initiated from this material at least twice each year. These isolates were used in tests in the greenhouse in the spring, summer, and fall under high natural light and an ambient temperature range of 20-30 C.

Inoculum consisted of wheat grain infested with each isolate. Grain steeped for 16 hr in tap water was placed in 1-quart Mason jars, autoclaved at 15 psi for 30 min, cooled, and inoculated with the various *Fusarium* isolates from PDA cultures. Following incubation for 1 week at room temperature, the inoculum was mixed with autoclaved soil at a rate of 1.5 g inoculum/100 g soil. One g of infested grain consisted of approximately 20 kernels. Inoculum rate was determined on the basis of results from initial trials in which 1-, 2-, and 3-g rates were used with a susceptible safflower variety. Seed were planted on inoculum-free soil covering the

TABLE 1. Reaction of selected safflower varieties, plant introductions, and a breeding line to different isolates of *Fusarium oxysporum* f. sp. *carthami*

Isolate	Pacific 1	Nebraska 6	PI 250,822	PI 251,267	Nebraska 4051	Race designation
FYBy	6.0 <sup>a</sup>	0.0	0.0	0.0	0.0	I
N6-3	6.0	0.1	0.0	0.0	0.0	I
FGI	6.0	0.8	0.0	0.0	0.0	I
FSBy	6.0	0.8	0.0	0.0	0.0	I
F-1	6.0	1.0	0.1	0.0	0.1	I
FM	6.0	1.1	0.0	0.0	0.0	I
F-3	6.0	4.0	0.3	0.5	0.0	II
FDr	6.0	4.3	0.6	0.5	0.0	II
N6-2	6.0	5.3	0.3	0.0	0.0	II
FDeI	6.0	5.5	0.1	0.0	0.5	II
FAr	6.0	5.6	0.5	0.1	0.6	II
N6-64	6.0	6.0	0.5	0.0	0.0	II
N6-1	6.0	6.0	0.0	0.0	0.0	II

<sup>a</sup> Disease rating = dead and diseased plants of 36 plants/combination. 6.0 = All plants dead or diseased.

infested soil, and covered with vermiculite. All treatments were replicated twice in each of three experiments.

RESULTS AND DISCUSSION.—Safflower varieties Pacific (P1), Gila, and US10 were susceptible to all 13 isolates of *f. sp. carthami* in greenhouse tests. Variation in pathogenicity among isolates could not be demonstrated with these varieties. The reaction of variety N6 in our tests separates the isolates into two pathogenic groups designated as race 1 and 2 (Table 1). It is resistant to race 1 and susceptible to race 2. Disease rating and percentage of wilt ranged from 0.0-1.1, and 0.0-18, respectively, for the six isolates in race

TABLE 2. Relative resistance of certain safflower varieties, introductions, and a breeding line based on their reactions to two races of *Fusarium oxysporum f. sp. carthami*

Variety, PI or line	Race 1		Race 2	
	Disease rating <sup>a</sup>	% Diseased plants	Disease rating <sup>b</sup>	% Diseased plants
Pacific 1	6.0	100	6.0	100
N6	0.6	10.0	5.4	90.0
PI 209,280	0.1	1.6	0.7	11.6
250,007	0.0	0.0	0.6	10.0
250,822	<0.1	0.2	0.3	5.0
251,267	0.0	0.0	0.2	3.0
251,288	<0.1	0.3	0.4	6.6
253,893	<0.1	0.8	1.2	20.0
306,831	0.8	13.3	1.9	31.6
N4051	<0.1	0.2	0.2	3.0

<sup>a</sup> Average of 6 isolates.

Dead and diseased plants of 216 plants/variety, PI or line  
36

<sup>b</sup> Average of 7 isolates.

Dead and diseased plants of 252 plants/variety, PI or line  
42

1, and 4.0-6.0, and 66-100, respectively, for the seven isolates in race 2. Safflower breeding line Nebraska 4051, PI 250,822, and PI 251,267 are highly resistant to all isolates of the two races established by our tests (Table 1). The low percentage of diseased plants obtained in these tests with resistant safflower can be expected among plants originating from open-pollinated seed.

Safflower introductions which were highly resistant in a field test showed moderate to high resistance to the two pathogenic races in greenhouse tests (Table 2). Some isolates in race 2 were more virulent on certain introductions than on others. The increased virulence may indicate another pathogenic race. More extensive tests with these and other isolates and a wider selection of safflower PI's may reveal the presence of other pathogenic races.

Isolation of the two races from the same field and conformity of isolates from widely scattered fields to each race supports the view that the different races are widely distributed and established in soils of safflower acreage affected by *Fusarium* wilt.

#### LITERATURE CITED

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