

# Wilt of *Chrysanthemum* Caused by *Fusarium oxysporum* f. sp. *chrysanthemi*, forma specialis nov.

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## ABSTRACT

A new forma specialis, *Fusarium oxysporum* f. sp. *chrysanthemi* Litt., Armst. & Armst., was obtained from wilting plants of Yellow Delaware chrysan-

themum. Its relationships to other f. sp. of *F. oxysporum* are given. *Phytopathology* 60:496-498.

The first substantiated report of a typical *Fusarium* wilt of chrysanthemum (*Chrysanthemum morifolium* [Ramat.] Hemsl.), was by Toop (8), who designated *Fusarium oxysporum* f. sp. *callistephi* (Beach) Snyder & Hans. as the causal agent of wilt of Encore chrysanthemum. Cross-inoculations with this *Fusarium* showed it to be *F. oxysporum* f. sp. *tracheiphilum* (E. F. Sm.) Snyder & Hans. race 1 Armst. & Armst. (2, 4). In 1966, Littrell (5) reported a wilt of chrysanthemum that was caused by a different *Fusarium*. It caused wilt of Encore and Yellow Delaware chrysanthemum, but not of Climax cowpea (*Vigna sinensis* [Torner] Savi), which, like Encore, is susceptible to f. sp. *tracheiphilum* race 1; moreover, race 1 was nonpathogenic on Yellow Delaware. A *Fusarium oxysporum* was isolated from wilting plants of Yellow Delaware collected by the senior authors at Delray, Florida. Inoculations of chrysanthemum confirmed the results of Littrell (5), whereupon inoculations with several other wilt fusaria were made to determine the host relationships of the apparently new forma specialis.

Since *F. oxysporum* f. sp. *cassiae* Armst. & Armst. was moderately virulent on Encore, and this f. sp. and f. sp. *tracheiphilum* race 1 were moderately virulent on varieties of yellow lupine (*Lupinus luteus* L.) and white lupine (*L. albus* L.) (3), lupines and *F. oxysporum* f. sp. *lupini* races 1, 2, and 3 (Richter) Armst. & Armst. were included in the inoculations. The relationship of the new f. sp. to *F. oxysporum* f. sp. *callistephi* races 1 and 2 Hoffman was also investigated by the inoculation of several varieties of China aster (*Callistephus chinensis* Cass.) and African marigold (*Tagetes erecta* L.). These results and the proposal for a new f. sp. of *F. oxysporum* are presented.

**MATERIALS AND METHODS.**—Rooted cuttings of chrysanthemum were supplied by Yoder Brothers, Barberton, Ohio. Aster plants were from seed in trays of vermiculite in the greenhouse. Transplants of chrysanthemum or aster, 7-13 cm tall and 5/pot, respectively, were grown in steam-sterilized sand in 8-liter glazed pots to which a nutrient solution was added. When they were well established, the roots on one side of

each plant were cut by pressing a large inverted test tube into the sand, and 500 ml of a 3-day-old liquid culture of the fungus was poured around them. The roots of other plants, grown directly from seed sown in a circle about 2.5 cm from the wall of the pot, were cut on one side by pressing an inverted Büchner funnel into the sand in the center of the pot, then inoculated as described above. Noninoculated plants were included; none showed symptoms of disease upon examination at the termination of each experiment. The usual precautions were taken to prevent contaminations. Further details of the method have been presented elsewhere (1).

Monoconidial, chiefly microconidial, isolates of most of the forms were used, although mass isolates of some, especially the new one, were also included. All isolates were maintained on potato-dextrose agar.

**RESULTS.**—*Inoculation of chrysanthemum, aster, lupine, and marigold with several wilt fusaria.*—Some of the differences between the new f. sp. from Yellow Delaware and the one first described (f. sp. *tracheiphilum* race 1) as causing wilt of Encore are indicated in Table 1. The *Fusarium* from Encore and f. sp. *cassiae* caused wilt of Encore, but neither caused wilt of Yellow Delaware, whereas the *Fusarium* from Yellow Delaware was pathogenic on both varieties and on Delaware. F. sp. *callistephi* races 1 and 2 were nonpathogenic on chrysanthemum in these experiments as well as in those reported previously for Encore (race 1 only) (4).

In the first inoculation of King Lavender aster with the new f. sp., several plants showed wilt, whereupon other varieties of aster (Table 1) were included in the tests. Except for Crego, there were very few wilted plants. After using numerous lots of seed in other experiments, it was evident that some carried the aster-wilt *Fusarium*; but in our experiments, when seed was sown in trays and the seedlings transplanted to pots of sand, the noninoculated checks were apparently free of disease. The low percentages of wilted plants indicate, therefore, that the new f. sp. is weakly pathogenic on some varieties of aster. Sixty-two per cent of

TABLE 1. Number of plants inoculated with several wilt fusaria and percentage of wilted (external symptoms only) aster, chrysanthemum, lupine, and marigold plants

Plants	<i>Fusarium oxysporum</i> from																	
	Chrysanthemum				Cowpea		<i>Cassia</i>		Aster				Lupine					
	Yellow Delaware f. sp. nov.		Encore f. sp. <i>trachei-philum</i> Race 1		f. sp. <i>trachei-philum</i> Race 1		f. sp. <i>cassiae</i>		f. sp. <i>callistephi</i> Race 1		Race 2		Race 1		f. sp. <i>lupini</i> Race 2		Race 3	
	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%
Chrysanthemum																		
Delaware	36	92											4	0	4	0	4	0
Yellow Delaware	28	100	20	0	10	0	10	0	5	0	5	0	7	0	7	0	4	0
Encore	84	100	8	100	9	100	17	53	15	0	5	0	7	0	7	0	8	0
Aster <sup>a</sup>																		
Azure	9	0																
Bellablanca	41	5																
Crego	19	26																
King Lavender	41	12																
Queen of Market	9	0																
Rosenknopse	23	0																
Sonnenstrahl	61	3																
Marigold																		
Mission Giant Mixture	26	62																
Tall African Double Orange	39	21																
Lupine																		
Blue bitter	18	6			142	0 <sup>b</sup>	92	0 <sup>b</sup>					17	0 <sup>b</sup>	49	0 <sup>b</sup>	57	100 <sup>b</sup>
Blue sweet	4	0																
Neven	59	53			30	47 <sup>b</sup>	57	86 <sup>b</sup>					29	69 <sup>b</sup>	92	99 <sup>b</sup>	31	6 <sup>b</sup>
Sweet Yellow	11	64																
Weiko 111	80	55	16	88	56	29 <sup>b</sup>	38	61 <sup>b</sup>					11	91 <sup>b</sup>	17	100 <sup>b</sup>	68	68 <sup>b</sup>

<sup>a</sup> These varieties are susceptible to f. sp. *callistephi* race 1 (*unpublished data*).

<sup>b</sup> Data from reference (3).

the plants of Mission Giant marigold wilted after inoculation with the new f. sp., also indicating a relationship of the new f. sp. to f. sp. *callistephi*. F. sp. *lupini* races 1, 2, and 3 were nonpathogenic on the three varieties of chrysanthemum, but the new f. sp., like f. sp. *tracheiphilum* race 1, was pathogenic on Weiko 111 yellow lupine and nonpathogenic on two varieties of blue lupine (*Lupinus angustifolius* L.). It was less virulent on Weiko 111 than f. sp. *tracheiphilum* race 1, and the rate of wilting was much slower than with the lupine-wilt fusaria.

Reisolates of the new f. sp. from wilting aster, lupine, and marigold caused 100% wilting of Encore and Delaware. Some formae speciales of *F. oxysporum* that cause wilt of plants grown in the area of Florida, where the wilted chrysanthemums were found, were nonpathogenic on Yellow Delaware chrysanthemum; viz., *apii*, *batatas* race 1, *cucumerinum*, *lycopersici* races 1 and 2, *niveum*, *perniciosum* race 1, and *vasinfectum* race 1.

*Inoculation of other plants with the new forma specialis from Yellow Delaware chrysanthemum.*—None of the plants listed below showed external symptoms of wilt when inoculated with the new f. sp. There were 10 or more plants/pot of each kind, except five or six plants/pot for cabbage, daffodil, sweetpotato, and tobacco. The plants were alfalfa (*Medicago sativa* L. 'Grimm'); bean (*Phaseolus vulgaris* L. 'Mexican Pink'); sugar beet (*Beta vulgaris* L. 'G. W. A.-1140-52'); cabbage (*Brassica oleracea* var. *capitata* L. 'Copenhagen Market'); *Cassia tora* L.; cotton (*Gossypium arboreum* L. 'K-1'), (*G. barbadense* L. 'Coastland'), and (*G. hirsutum* L. 'Hurley Special Rowden'); cowpea (*Vigna sinensis* [Torner] Savi 'Chinese Red', 'Climax', 'Brown Sugar Crowder', 'Running Acre', and 'Snapea'); cucumber (*Cucumis sativus* L. 'Ashley'); daffodil (*Narcissus pseudonarcissus* L. 'Golden Harvest'); eggplant (*Solanum melongena* L. 'Black Beauty'); mimosa (*Albizzia julibrissin* Durazz.); garden pea (*Pisum sativum* L. 'Little Marvel'); radish (*Raphanus sativus* L. 'White Icicle'); safflower (*Carthamus tinctorius* L. 'Gila'); sesame (*Sesamum indicum* L. 'Criollo'); spinach (*Spinacia oleracea* L. 'Bloomsdale Savoy Leaved'); staghorn sumac (*Rhus typhina* L.); sweetpotato (*Ipomoea batatas* [L.] Lam. 'Porto Rico'); tobacco (*Nicotiana tabacum* L. 'Ky Burley 5'); tomato (*Lycopersicon esculentum* Mill. 'Bonny Best'); and watermelon (*Citrullus lunatus* [Thunb.] Mansf. 'Sugar Baby').

**DISCUSSION.**—More than one f. sp. of *F. oxysporum* may cause wilt of a single host; for example, with alfalfa, garden pea, soybean, and tobacco, respectively, several ff. sp. are involved. It was not surprising, therefore, to discover a wilt of chrysanthemum caused by a *Fusarium* different from *F. oxysporum* f. sp. *tracheiphilum* race 1. Encore was inoculated with most of the ff. sp. in our collection (4), but this was not possible with Yellow Delaware. However, the inoculation of 28 varieties or species of plants with the *Fusarium*

from Yellow Delaware provides information as to some probable relationships of the fungus, and indicates a new f. sp. as suggested by Littrell (5).

Certain varieties of *L. albus* and *L. luteus* are common hosts for ff. sp. *cassiae*; *lupini* races 1, 2, and 3; *medicaginis*, *phaseoli*, *tracheiphilum* race 1; and *vasinfectum* races 1 and 2 (3). The new f. sp. was nonpathogenic on alfalfa, bean, *Cassia*, five varieties of cowpea, and three varieties of cotton, but caused a slowly developing wilt of 53 to 64% of plants of three varieties of yellow lupine (Table 1). The small percentages of wilt of aster caused by the new f. sp. indicate that it is a weak pathogen for at least a few varieties of aster, but 63% wilt of marigold (*Tagetes*) is more indicative of some relationship with *F. oxysporum* f. sp. *callistephi*, since a race of this f. sp. has been described on *Tagetes erecta* (6).

Since the new chrysanthemum-wilt *Fusarium* is different from the one reported on this host (4, 8), and since it does not cause wilt of 28 varieties or species of plants known to be susceptible to some wilt fusaria, a new f. sp. is proposed: *Fusarium oxysporum* Schlecht. emend. Snyder & Hans., f. sp. *chrysanthemii* Litt., Armst., & Armst., f. sp. nov., a *Fusarium* of the section *Elegans* (9) or *Fusarium oxysporum* sensu Snyder & Hans. (7) pathogenic in the vascular tissues and causing a severe wilt of some varieties of chrysanthemum (*Chrysanthemum morifolium* [Ramat.] Hemsl.) and a slowly developing wilt of some varieties of yellow lupine (*Lupinus luteus* L.). It is nonpathogenic on varieties of cowpea (*Vigna sinensis* [Torner] Savi) that serve to differentiate pathogenic races of *F. oxysporum* f. sp. *tracheiphilum*; therefore, it is not race 1 of this f. sp. that causes wilt of Encore chrysanthemum.

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