A New Race of *Fusarium oxysporum* f. sp. *conglutinans* That Attacks Cabbage with Type A Resistance

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ABSTRACT

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An isolate of *Fusarium oxysporum* f. sp. *conglutinans* from cabbage (*Brassica oleracea* var. *capitata* cv. Headstart), grown in California, was determined to be a new pathotype on the basis of pathogenicity to a series of differential hosts. The new pathotype, designated race 5, was determined capable of overcoming the monogenic dominant type A resistance commonly found in resistant cabbage cultivars.

For more than 50 yr, the monogenic type A resistance derived by Walker (1) from open-pollinated cultivars has effectively controlled Fusarium yellows of cabbage (*Brassica oleracea* var. *capitata* L.), caused by *Fusarium oxysporum* Schlecht. f. sp. *conglutinans* (Wr.) Snyd. & Hans. race 1. Data are presented to support the conclusion that a new pathotype of the fungus, designated race 5, has appeared and is capable of causing disease in cabbage with type A monogenic resistance.

MATERIALS AND METHODS

The new race was isolated from an infected plant of the yellows-susceptible cultivar Headstart, grown at Camarillo, CA. Isolates of races 1, 2, 3, and 4 used in these studies correspond to American Type Culture Collection numbers 52557, 58110, 11602, and 16603, respectively. Race 5 has been accessioned by the American Type Culture Collection as ATCC 58385. Except for the cabbage cultivar Golden Acre, the Wisconsin-named cabbage cultivars, and the radish cultivar Red Prince, the cultivars of Cruciferae evaluated for their reaction to the new race at Riverside and Madison differed as to their seed lot and seed source.

Inoculum preparation and inoculation of host plants performed at University of Wisconsin, Madison, has been described by Williams (3). At the University of California, Riverside, inoculum preparations and inoculation of host plants were similar to those by Williams except for the following changes: Conidia were harvested by pouring the contents of the flask onto a double layer of cheesecloth and washing the mat with 50 ml of sterile distilled water, then the washing and filtrate were combined and centrifuged at 1,000 rpm for 10 min. The spores in the pellet were resuspended in sterile distilled water and the concentration of conidia was adjusted to 1×10^6/ml. After roots of plants were dipped in the suspension of conidia, the plants were transplanted into steamed U.C. soil in stainless steel containers. The plants were grown for 14 days at a soil temperature of 24 ± 0.5 C in Wisconsin Soil Temperature Tanks, then evaluated for yellows.

The diseased plants were rated for severity of disease on a scale of 0–9 (3), where 0 = no symptoms in tops or roots; 1 = darkening of roots, no stunting or symptoms in tops; 3 = darkening of roots, slight top stunting, no chlorosis; 5 = dark stunted roots, tops stunted, slight chlorosis; 7 = severe stunting of roots and tops, severe chlorosis; and 9 = death. The disease index (DI) was calculated using the formula: $DI = \Sigma\, i \times j/n$, where n = total number of plants, i = the severity class of each plant, and j = number of plants in each class. A DI value of 2.00 or less was considered a

Table 1. Disease indices[a] of various crucifers inoculated with *Fusarium oxysporum* f. sp. *conglutinans* races 1–5 determined in tests at the University of California, Riverside

	Race									
	1		2		3		4		5	
Host	DI	SD	DI	SD	DI	SD	DI	SD	DI	SD
Cabbage										
Express	1.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	9.0	0.0
Wisconsin Golden Acre	1.5	1.7	0.0	0.0	0.0	0.0	0.0	0.0	8.4	1.5
Marion Market	0.5	1.8	0.0	0.0	0.0	0.0	0.0	0.0	7.6	2.6
Early Jersey Wakefield	0.6	2.8	0.0	0.0	0.0	0.0	0.0	0.0	7.4	2.8
Golden Acre	8.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	9.0	0.0
Earliana	9.0	0.0	0.0	0.0	0.0	0.0	0.9	0.2	9.0	0.0
Rio Verde	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	0.0
Wisconsin All Season	0.8	0.3	0.0	0.0	0.0	0.0	0.0	0.0	1.5	2.4
Radish										
Summer Cross	0.4	0.2	7.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0
Red Prince	0.8	0.5	4.0	2.4	0.0	0.0	0.0	0.0	0.6	0.7
Scarlet Knight	0.0	0.0	4.9	2.5	0.0	0.0	0.0	0.0	1.0	0.0
White Icicle	4.0	3.2	9.0	0.0	0.0	0.0	2.5	2.2	8.5	1.9
Matthiola										
Pacific Pink	0.9	0.2	2.5	2.6	2.2	3.0	9.0	0.0	0.0	0.0
Dark Purple	0.0	0.0	5.2	2.7	6.0	2.2	0.0	0.0	0.0	0.0
Mustard										
Southern Giant Curled	8.6	2.8	7.5	2.9	8.0	2.9	8.7	2.5	8.8	2.8

[a] Disease indices (DI) and standard deviations (SD) were calculated with two replicates of 70 plants.

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resistant reaction, whereas any value greater than 2.00 was considered a susceptible reaction. In the field, any cultivar that expressed a DI greater than 2.00 had a reduction in yield (P. H. Williams, *unpublished*).

RESULTS AND DISCUSSION

The results presented are from independent experiments at both the University of California, Riverside, and University of Wisconsin, Madison. The disease indices listed in Tables 1 and 2 illustrate the pathogenicity of the new pathotype. Cultivars of crucifers that were resistant to race 1 were susceptible to race 5, with the exception of the radish cultivars Red Prince, Scarlet Knight, and Summer Cross and the stock cultivars Pacific Pink and Dark Purple, which were resistant to both races 1 and 5. In 1958, Walker (2) alluded to the eventual breakdown of monogenic resistance in cabbage and believed that the open-pollinated cultivars would be the source of resistance in the future. That the open-pollinated cabbage cultivars may be the source of resistance to the new race, as suggested by Walker, appears to be verified by the variable reaction of the open-pollinated cultivar Wisconsin All Seasons against race 5 (Tables 1 and 2). Screening 175 plants of Wisconsin All Seasons against race 5 at Riverside and Madison produced 31 plants that had a DI rating of 0 and 42 plants that had a DI rating of 1, indicating the presence of additional genes for resistance in this cultivar.

Table 2. Disease indices[a] of various crucifers inoculated with *Fusarium oxysporum* f. sp. *conglutinans* races 1–5 determined in tests at the University of Wisconsin, Madison

	Race									
	1		2		3		4		5	
Host	**DI**	**SD**	**DI**	**SD**	**DI**	**SD**	**DI**	**SD**	**DI**	**SD**
Cabbage										
Golden Acre	8.4	1.7	1.0	0.0	0.1	0.1	0.0	0.0	8.9	0.4
Wisconsin Hollander #8	4.1	2.3	1.0	0.0	0.1	0.1	0.0	0.0	7.3	2.5
Wisconsin Golden Acre	1.8	2.5	1.0	0.0	0.2	0.1	0.0	0.0	7.6	2.3
Wisconsin All Season	1.3	1.6	0.0	0.0	0.0	0.0	0.0	0.0	4.2	2.2
Broccoli										
Green Sprouting	1.0	1.6	1.0	0.0	0.0	0.0	0.0	0.0	6.2	2.9
Cauliflower										
Super Snowball	2.5	2.8	1.0	0.0	0.2	0.1	0.0	0.0	8.6	1.2
Radish										
Red Prince	1.7	1.0	1.0	0.0	0.1	0.1	0.0	0.0	1.4	1.7
White Icicle	5.6	3.6	9.0	0.0	2.6	2.4	0.0	0.0	8.2	2.3
Matthiola										
Giant Imperial Mix	2.1	2.8	1.9	2.5	3.9	2.8	2.8	1.2	6.0	3.5
Ten Weeks Mix	1.8	2.6	2.5	2.3	3.8	2.7	3.8	2.6	4.5	3.3
Miracle Gold	1.1	0.7	2.0	2.9	1.8	2.2	1.0	2.2	4.6	3.3

[a] Disease indices (DI) and standard deviations (SD) were calculated with two replicates of 50 plants.

It is interesting that the new race appeared in southern California, where cabbage is rarely if ever attacked by the yellows fungus, and that the disease appeared in a field where no previous occurrence of Fusarium yellows of crucifers had been reported. Because race 1 has never been reported in California, growers in California commonly grow cultivars that do not possess resistance to yellows. Resistance to race 5 in cultivars of various subspecies of *Brassica oleracea* from Europe, Asia, North America, and South America is currently being examined at Madison.

LITERATURE CITED

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