Root-Infecting Species of Fusarium in Soil and in the Roots, Rhizospheres, and Residues of Oats

H. L. Warren and Thor Kommedahl

Department of Plant Pathology, University of Minnesota, St. Paul 55101. Present address of first author is Department of Botany and Plant Pathology, Purdue University, West Lafayette, Indiana 47907.

Paper No. 8271, Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul.
Accepted for publication 8 May 1973.

ABSTRACT

Fusarium oxysporum, F. solani, and *F. roseum* were the principal *Fusarium* spp. isolated from oat roots, rhizosphere, plant residues, and soil in a field plot cropped annually to oats for a decade. Of *Fusarium* spp. isolated, *F. oxysporum* made up 72% in roots, 63% in the rhizosphere, and 58% in soil; *F. solani* comprised 19% in roots, rhizosphere, and soil; and *F. roseum* made up 7% in roots, 12% in the rhizosphere, and 16% in soil. *Fusarium tricinctum, F. moniliforme*, and *F. episphaeria* never exceeded 5% in prevalence for any substrate. Presence or absence of fertilizer or plant residues did not change these percentages appreciably during the 2-year test period. On oat residues, *F. roseum* was the most prevalent (54%), followed by *F. oxysporum* (33%) and *F. solani* (11%), and the percentages were lower in spring than in the preceding fall only when fertilizer was not applied. The rhizosphere to soil ratio was about 1:1 except for *F. roseum*, where it was 0.4 when plant residues were retained on the plot and 2.6 when residues were removed but fertilizer was applied.

Phytopathology 63:1401-1403

Additional key word: soil-borne fungi.

We previously reported the prevalence of *Fusarium* spp. in wheat (4) and corn (5) soils grown annually to these crops for 10 years in Minnesota. Of different *Fusarium* spp. in soil, rhizosphere, and on the roots and residues of wheat (4) and corn (3, 5), *Fusarium oxysporum, F. solani*, and *F. roseum* were judged to be the most abundant. Those results suggested that the addition of fertilizer or retention of residue did not markedly influence the prevalence of *Fusarium* spp. in the four substrates. The work here reported was undertaken to determine the predominant species of *Fusarium* present on oat roots, in the plant residues, rhizosphere, and soil in which oats had been grown annually for 10 years and to determine the effect of fertilizer and residues on the prevalence of these fungi.

MATERIALS AND METHODS.—At Rosemount, Minnesota, oats (*Avena sativa* L. 'Minhafer') was grown in plots that had been planted with oats annually for 10 consecutive years, during which time crop residues were either retained or removed, with and without fertilizer (5:20:20 of NPK at 243 kg/hectare). This arrangement gave four treatments: no fertilizer nor residue; no fertilizer with residue; fertilizer without residue; and fertilizer with residue.

Root surface flora was determined by shaking 5.0 g root samples in water on a rotary shaker for 20 min to remove rhizosphere soil. The roots were surface treated for 2 min in 70% ethanol, kept 2 min in 5% NaOCl, and then placed on PCNB (pentachloronitrobenzene)-peptone agar adjusted to pH 5.2.

Soil samples were taken by combining three 5.0 g samples (3-15 cm deep) per treatment. Soil was passed through a 2-mm sieve; then successively diluted in water to give a dilution of 1:10,000. The soil dilutions were mixed in a shaker for 30 sec and 1-ml aliquots were pipetted into petri dishes to which 15 ml of cool PCNB agar was added.

Colonies isolated initially on PCNB agar were transferred to homemade potato-dextrose agar (PDA) for identification to species and cultivar. The cultures were incubated at about 24 C under fluorescent lamps for 16 hr/day.

TABLE 1. Relative prevalence of *Fusarium* spp. isolated from oat roots, residues, rhizosphere, and soil in a field plot cropped annually to oats for a decade but in which residues were either removed or retained or where fertilizers were either added or withheld

Fusarium source	Relative prevalence of each *Fusarium* sp.[a]		
	F. oxysporum (%)	*F. solani* (%)	*F. roseum* (%)
Oat roots[b]	72 (67-77)	19 (16-22)	7 (5-8)
Oat residues[c]	33 (10-66)	11 (4-18)	54 (10-76)
Rhizosphere[d]	63 (58-71)	19 (13-24)	12 (9-16)
Oat soil[e]	58 (53-60)	19 (17-24)	16 (12-18)

[a] Avg and range in field plots with and without residues and with and without fertilizer (NPK, 5:20:20, at 243 kg/hectare).

[b] Based on 180 plants (30 roots, three times/year, 2 years).

[c] Based on 800 oat residue sections (400 in fall and 400 the next spring).

[d] Avg of 36 petri dishes for each of 2 years of sampling.

[e] Avg of 24 samples (four times/year, three samples each time, 2 years); *F. tricinctum* = 5% and *F. episphaeria* = 4% of total *Fusarium* spp.

Unless stated otherwise, plant residues were removed by raking them from the soil. All of the residue was not removed by this method, so we checked to determine how much was left after raking by screening 2.8×10^4 cc of soil over a 2-cm screen. The residue obtained was dried for 24 hr at 110 C and weighed. The results of removing residue by raking from the oat plots showed that 71% of the residue had been removed from the plots where residue ostensibly had been removed and 90% removed where residue ostensibly had been removed and fertilizer applied. In plots where residues had not been removed but fertilizer had been applied, only 66% of the initial residue was present.

RESULTS AND DISCUSSION.—*Fusarium substrates in soil.*—The prevalence of *Fusarium* spp. in the soil and in the roots, rhizospheres, and residues of oats was not affected significantly by the four soil treatments. Accordingly the results from the four plots are combined in Table 1.

Fusarium oxysporum, F. solani, and *F. roseum* comprised the main *Fusarium* species isolated. *Fusarium oxysporum* made up 72% of the *Fusarium* spp. on roots, 63% in the oat rhizosphere, and 58% in oat soil. *Fusarium solani* comprised 19% of the *Fusarium* species in oat roots, rhizosphere, and soil, whereas *F. roseum* constituted 7% of *Fusarium* spp. on roots, 12% in rhizosphere, and in 16% in soil. *Fusarium tricinctum, F. moniliforme*, and *F. episphaeria* never exceeded 5% in prevalence of *Fusarium* spp. on any substrate.

Thus relative prevalence of *Fusarium* spp. on roots, rhizosphere, or soil was not altered by season, fertilizer, or plant residue, a pattern consistent with previous results for wheat (4) and corn (5), at the same station. However the results for *Fusarium* spp. from oat residues, shown in Table 1, indicate considerable variation in range of values among the three species, and Table 2 is presented to show possible causes for variation.

Residue effect from fall to spring.—Table 2 shows that regardless of treatment, *F. oxysporum* was more prevalent in the spring than in the fall but *F. roseum* was more prevalent in the fall than in the spring. The apparent effect of seasons on *F. solani* was inconsistent. No essential difference was found for *F. moniliforme* or *F. tricinctum*, except in the first treatment where residues were removed (Table 2); the prevalence of these two species increased from 0 to 12% from fall to spring. This latter increase is attributed either to sampling error in the fall, or colonization of residue from soil-borne inoculum. The latter explanation is doubtful, based on work with wheat (2).

The most striking difference of treatment appeared with *F. oxysporum* in the fall and *F. roseum* in the spring (Table 2). The removal of oat residues lowered the relative prevalence to half without fertilizer application and to a third with fertilizer application. By spring, however, the relative prevalence had increased for all treatments but more so where residues were removed than retained. Subsequent measure of removal indicated only 27%

TABLE 2. The relative prevalence of *Fusarium* spp. isolated fall and spring from oat residues in field plots cropped to oats for 10 years, but with different crop residue and fertilizer treatments

Treatment		Prevalence of *Fusarium* spp. per season[a]					
		F. oxysporum		*F. roseum*[d]		*F. solani*	
Fertilizer[b]	Crop residue[c]	Fall (%)	Spring (%)	Fall (%)	Spring (%)	Fall (%)	Spring (%)
None	Removed	16	67	76	10	8	8
None	Retained	30	46	61	40	8	14
Applied	Removed	10	23	74	70	13	4
Applied	Retained	28	42	53	46	18	12

[a] *Fusarium moniliforme* and *F. tricinctum* together increased from 2 to 4% in prevalence from fall to spring, with negligible effect of fertilizer or residue. In the first treatment, these species increased from 0 to 12% from fall to spring.

[b] NPK (5:20:20) at 243 kg/hectare.

[c] Although residue was ostensibly removed by raking, organic matter was still present and was found to be 4.5%, 6.0%, 4.8%, and 5.6%, respectively, for the four treatments, based on sampling soil at depths from 5-35 cm (12 samples/treatment).

[d] Relative prevalence of *F. roseum* cultivars: Avenaceum 44%, Graminearum 23%, Equiseti 22%, and Culmorum 11% among four treatments from fall and spring.

removal of residue by hand raking obtained in the first treatment and 11% in the third, so residue removal was not complete.

Residue vs. fertilizer effect.—The prevalence of *Fusarium roseum* in the fall was the inverse of *F. oxysporum* in that the removal of residues had the opposite effect in the absence of fertilizer (Table 2). With fertilizer application there was a higher percentage of *F. roseum* where residues were removed than where retained, and this effect persisted to spring. Because most of the *F. roseum* cultivars were potentially pathogenic (Avenaceum, Graminearum, and Culmorum) these results become more significant. *Fusarium roseum* apparently can maintain its competitive saprophytic ability as long as fertilizer (probably nitrogen) is present, a point made also by Garrett (1). Also, the application of fertilizer where residues were retained could favor more nonpathogenic species such as *F. oxysporum* and *F. solani* and thereby reduce inoculum potential of pathogenic cultivars of *F. roseum* on oats. Without fertilizer, Culmorum is not a good saprophyte (2).

Rhizosphere to soil ratio.—Another aspect of ecological relationships in soil is the rhizosphere to soil ratio (R:S). The propagules of *F. oxysporum* in the rhizosphere and soil nearby were about equal in number whereas propagules of *F. solani* were more

TABLE 3. The rhizosphere to soil ratio (R:S) of three species of *Fusarium* in field plots of oats with fertilizer and residue treatments

Treatment[a]		R:S of *Fusarium* spp.		
Fertilizer	Crop residue	*F. oxysporum*	*F. roseum*	*F. solani*
			Ratio	
None	Removed	1.1	1.5	1.7
None	Retained	1.1	0.4	1.8
Applied	Removed	0.8	2.6	1.6
Applied	Retained	1.2	1.1	1.2

[a] See Table 2, footnotes b and c.

numerous in the rhizosphere than in nearby soil (Table 3). Presumably *F. solani* survived on oat roots without being pathogenic and in this way utilized oats as a nonhost. None of the treatments affected the R:S of *F. oxysporum* or *F. solani*.

Where neither fertilizer nor residues were present, or where both were present, there was a slightly higher number of *F. roseum* propagules in the rhizosphere than in nearby soil (Table 3). However, where residues were retained (and no fertilizer applied), propagules of *F. roseum* were more numerous in soil; where residues were removed and fertilizer applied, propagules were 2.6 times more numerous in the rhizosphere. Probably the removal of residues removed inoculum also, because oat stems and roots probably became infected when alive. The removal of residues (at least the coarser fragments) and application of fertilizer probably hastened deterioration of remaining residues and thereby destroyed inoculum of *F. roseum*.

LITERATURE CITED

1. GARRETT, S. D. 1972. Factors affecting saprophytic survival of six species of cereal root-rot fungi. Brit. Mycol. Soc. Trans. 59:445-452.
2. NYVALL, R. F., & T. KOMMEDAHL. 1973. Competitive saprophytic ability of Fusarium roseum f. sp. cerealis 'Culmorum' in soil. Phytopathology 63:590-597.
3. PALMER, L. T., & T. KOMMEDAHL. 1969. Root-infecting Fusarium species in relation to rootworm infestations in corn. Phytopathology 59:1613-1617.
4. WARREN, H. L., & T. KOMMEDAHL. 1973. Fertilization and wheat refuse effects on Fusarium species associated with wheat roots in Minnesota. Phytopathology 63:103-108.
5. WARREN, H. L., & T. KOMMEDAHL. 1973. Prevalence in and pathogenicity to corn of Fusarium spp. from corn roots, residues, and soil. Phytopathology 63: 1288-1290.