Sporulation of *Cochliobolus sativus* on Residues of Winter Crops and Its Relationship to the Increase of Inoculum Density in Soil

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ABSTRACT

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The inoculum density of *Cochliobolus sativus* in the soil was related to the amount of fungal sporulation occurring on crop residues. Spore counts were higher from residues of Gramineae than from broadleaf plants. The fungus produced the highest number of conidia on the residue of rye, and this corresponded to the highest propagule counts in the soil 1 yr later.

Additional key words: common root rot, *Triticum aestivum*, wheat

Common root rot and take-all are the two principal soilborne diseases of wheat in Southern Brazil. *Cochliobolus sativus* (Ito & Kurib.) Drechs. ex Dastur (anamorph: *Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem.; syn. *Helminthosporium sativum* Pamm., King, & Bakke.) is the main pathogen involved in common root rot (6). The disease has been reported in the main wheat-growing regions of the country (6,7,9,10). In Rio Grande do Sul, the estimated average loss from 1979 through 1981 was 18.7% (8).

Conidia of this pathogen are the main structures for infection and survival, and according to Duczek (12) and Ledingham et al (13), spores may survive in the soil for more than 2 yr. Chinn (4) reported that sporulation occurs on infected basal stems, lower leaves, and subcrown internodes of host plants during the growing season. Chinn (2) observed that sporulation of *C. sativus* increased in wheat fields in Saskatchewan when the crops were nearly ripe. The intensity of disease in wheat seedlings but not in mature plants was found to be associated with the viable spore population in soil (5). Chinn (3) reported that some crops contributed more than others to the populations of *C. sativus* conidia in soil.

This work was conducted to determine the population of *C. sativus* propagules in soil after some of the winter crops that are grown in southern Brazil and the contribution these crops made to inoculum density.

MATERIALS AND METHODS

Various winter crops were grown in a field test conducted in 1980 and 1981 on the same site at the National Wheat Research Center-EMBRAPA, Passo Fundo, Brazil. The soil was previously cultivated with wheat and soybeans. The crops were Gramineae—rye (*Secale cereale* L.), wheat (*Triticum aestivum* L.), oats (*Avena sativa* L.), and ryegrass (*Lolium multiflorum* L.); broad-leaved crops—alfalfa (*Medicago sativa* L.), vetch (*Vicia villosa* Roth), flax (*Linum usitatissimum* L.), rapeseed (*Brassica campestris* L.), turnip (*Raphanus sativus* L.), white lupine (*Lupinus albus* L.), blue lupine (*L. angustifolius* L.), yellow lupine (*L. luteus* L.), clover (*Trifolium vesiculosum* Savi), and red clover (*T. pratense* L.); and mixed crops—vetch plus sand oat (*Avena strigosa* Schreb.) and clover plus ryegrass. The experimental design was a randomized complete block with three replicates. Individual plots were 10 × 10 m. The test was sown on 9 July 1980 and 10 July 1981. Soybeans were grown on the land during the summer of 1980–1981, and the area was left fallow after the 1981 test. No volunteer plants existed in the summer soybean crop.

The number of propagules of *C. sativus* in soil was determined by selective plating using the method described by Reis (14). Soil samples were collected from the plot areas on 2 July 1981 and 23 March 1982; one sample consisting of 15–20 intermixed subsamples was taken from a depth of 0–5 cm in each plot on each of the two dates.

Sporulation on the residues of the winter crops was determined in a manner similar to that of Boosalis et al (1) and Stedman (16). Residue of a crop was collected randomly within a plot in March 1982 and chopped into pieces 2–3 cm long. A 5-g sample in 100 ml water in a stoppered flask was shaken vigorously for 5 min. A 1-ml aliquot of the suspension was distributed on the surface of selective medium (14) in each of four plates, and after incubation, the colonies of *C. sativus* that developed were counted under a dissecting microscope. Where colonies of *C. sativus* were numerous, the suspension that had been stored at 5 C was diluted and replated.

Throughout this study, each colony of *C. sativus* in the plates was considered to have originated from one propagule and the propagules were assumed to be conidia, these being the primary survival and infecting structure of the fungus. Values were transformed to $\sqrt{x + 0.5}$, and statistical analysis was performed individually for each year and for the general mean.

RESULTS AND DISCUSSION

Propagule counts of *C. sativus* per gram of soil averaged 132, 64, and 26 following gramineous, mixed, and broad-leaved crops (Table 1). Almost invariably, the number of propagules was lower after the second than after the first winter crop. The highest number of propagules occurred in plots cropped to rye, then ryegrass, wheat, vetch plus sand oats, oats, and clover plus ryegrass; relatively low numbers were present in plots where the broad-leaved crops were grown.

Major differences occurred in the number of propagules obtained from the crop residues (Table 1). The overall mean numbers of conidia per gram of crop residue was 521 for Gramineae, 125 for mixed crops, and 58 for broad-leaved crops. Sporulation was most profuse on rye, followed by wheat, oats, vetch plus sand oats, and alfalfa. Relatively low numbers were associated with ryegrass and most broad-leaved crops. No propagules were recovered from white or yellow lupine, clover, or rapeseed residue. Renfro (15) showed that *C. sativus* can infect and cause black stem in alfalfa and red clover, but it apparently is an unimportant pathogen of these crops. Possibly, the other broad-leaved crops from which residue *C. sativus* was isolated are supportive but not highly compatible hosts of the fungus. An alternate explanation for the presence of *C. sativus* on the residue of some may be that the fungus developed saprophytically or occurred simply as a contaminant on the plants from wind and water dispersal of conidia.

Propagule numbers in the soil generally were related (r = 0.936) to numbers found on the crop residue (Table 1). Largest populations in soil were associated with residues on which

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Table 1. Effect of some winter crop residues on sporulation and inoculum density of *Cochliobolus sativus* in the soil and on crop residues

Crops	Propagules per gram of: Soil[x] A	B	Mean	Residue[x]
Gramineae				
Rye (*Secale cereale*)	321 a[y]	226 a	274 a	1,250
Wheat (*Triticum aestivum*)	100 b	77 bc	89 bc	417
Oats (*Avena sativa*)	55 cd	64 bc	60 cde	333
Ryegrass (*Lolium multiflorum*)	100 b	104 b	102 b	83
Mean	144	118	132	521
Crop mixture				
Vetch (*Vicia sativa* L.) + sand oats (*Avena strigosa*)	100 b	45 cd	73 bcd	250
Clover (*Trifolium vesiculosum*) + ryegrass (*L. multiflorum*)	67 bc	41 cde	54 def	...[z]
Mean	84	43	65	125
Broad-leaved crops				
Alfalfa (*Medicago sativa*)	46 cde	10 f	28 ghij	167
Vetch (*V. villosa*)	30 cdef	23 def	27 fghi	83
Flax (*Linum usitatissimum*)	46 cdef	37 cde	42 efg	83
Turnip (*Raphanus sativus*)	46 cdef	14 def	30 fghi	83
White lupine (*Lupinus albus*)	17 ef	4 f	11 j	...
Blue lupine (*L. angustifolius*)	38 cdef	18 def	28 fghi	83
Yellow lupine (*L. luteus*)	33 cdef	10 ef	22 ghij	...
Clover (*Trifolium vesiculosum*)	50 cd	18 def	34 fgh	...
Red clover (*T. pratense*)	17 f	10 f	14 ij	83
Rapeseed (*Brassica campestris*)	29 def	9 f	19 hij	...
Mean	3.5	1.5	26	58
C.V.%	18.28	28.57		

[x] Mean of three replicates. A = Crops planted 9 July 1980, soil sampled 2 July 1981; B = crops planted 10 July 1981, soil sampled 3 March 1982. Residue collected in March 1982.
[y] Values followed by the same letter are not statistically different at $P = 0.05$ according to Duncan's multiple range test.
[z] Not detected.

the fungus was most abundant, and smallest populations occurred where crop residues were devoid of the pathogen. Chinn (4) found that conidial numbers in row soil occurred, in descending order, where barley, wheat, rye, and oats were grown. He noted some spore population differences between cultivars of the same kind of crop. Thus, the differences in the results of this study for some Gramineae may be due to cultivar differences.

Currently, a 3-yr rotation between wheat crops is recommended for control of common root rot in Brazil (11). On the basis of these results, some reduction in inoculum level may be expected when broad-leaved winter crops are used in the rotation. However, it is not known how long the fungus may remain viable on crop residues, and the threshold level of inoculum for disease is not known. Apparently, some of the broad-leaved crops may harbor the fungus and ensure its survival over a rotation cycle, whereas others such as white and yellow lupine, clover, and rapeseed may not. Further studies are needed to elucidate the epidemiology of *C. sativus* in the soil and develop residue management practices to reduce the disease to noneconomic levels.

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