Effect of Tillage and Wheat Residue Management on the Vertical Distribution and Inoculum Density of *Cochliobolus sativus* in Soil

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ABSTRACT

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Propagules of *Cochliobolus sativus* in soil were significantly more numerous in plots where wheat following soybean was seeded conventionally than where direct drilling was practiced. Burning wheat residue significantly reduced the population of the pathogen in soil compared with plots where the residue was retained. Propagule numbers decreased with soil depth; 90% of the propagules ocurred in the top 0–10 cm of soil. Propagules were most generally distributed in soil when conventional seeding practices were used.

Common root rot of small grains occurs throughout the cereal-growing areas of Brazil (6–8), with losses estimated as high as 20% (9). The principal pathogen involved in the disease is *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur (imperfect stage: *Helminthosporium sativum* Pamm., King, & Bakke). The main survival structures of the pathogen are conidia in the soil (2–4,14). Chinn (3) indicated that conidia are formed on crowns and subcrown internodes of infected plants and are dispersed by soil cultivation and wind movement. Ledingham (11) and Ledingham et al (13) suggested that infected plant debris left on the soil surface may allow sporulation for a longer period than if the debris had been buried.

Effects of soil cultivation methods on the epidemiology of several diseases have been reviewed by Sumner et al (16). Ledingham (12) reported from Canada that incorporating wheat residues into soil decreased the intensity of common root rot, but he did not compare this with zero tillage and he did not present data on the fungal population in soil.

This work was undertaken to study the effects of tillage and management of wheat residues on the vertical distribution and inoculum density of *C. sativus* in soil.

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MATERIALS AND METHODS

Populations of *C. sativus* propagules in soil were determined in a field test conducted at Centro de Experimentação e Pesquisa-CEP/FECOTRIGO in Cruz Alta County in the state of Rio Grande do Sul, Brazil. The test on latosol Santo Angelo soil was initiated in 1975. Wheat was grown in winter (June–November) and soybeans in summer (November–May). Official recommendations for seeding time, cultivars, seed density, fertilization, and pest control were followed for both crops. The experimental design was a split-split plot with four replicates. Main plot treatments were 1) conventional seeding with a disk drill after disk-plowing to a depth of 15–20 cm and 2) seeding directly into soybean stubble with a disk drill. Subplot treatments were 1) burning wheat residue in situ after harvest and 2) not burning wheat residue. About 5–10% of wheat stubble in the burned plots did not burn.

Subplots were established in 1982 for sampling soil at four different depths, namely 0–5, 5–10, 10–15, and 15–20 cm. Each sub-subplot measured 20 × 4.8 m. Continuous double-cropping was practiced, with main and secondary treatments applied annually until May 1982, when soil in the plots was sampled after the soybeans were harvested. One sample consisting of two subsamples represented each plot.

Soil samples were air-dried and sieved in the laboratory. Soil was diluted in 0.1% water agar (1:50) for plating. The soil suspension was shaken vigorously for 20 min and 1-ml aliquots were pipetted into plastic petri dishes containing 5 ml of 0.8% water agar and uniformly spread by gently shaking and tilting the plate. The suspension was allowed to dry, and finally, 15 ml of molten (≤50 C) selective medium (16) at pH 5.0 was poured on the soil. Five petri plates were prepared per soil sample. *C. sativus* colonies were identified and counted under a dissecting microscope after incubation for 12 days at 25 ± 2 C under continuous light from two fluorescent light bulbs (Philips TL 40W/54RS daylight) 50 cm from the plates. Statistical analyses were used for comparisons of means.

RESULTS AND DISCUSSION

Effect of tillage systems. In conventionally seeded plots, the inoculum density of *C. sativus* had an overall mean of 67 propagules per gram of soil, significantly more than in plots seeded directly, which had a population of 31 propagules per gram. Under conventional drilling, wheat residues left on the soil surface, or partially buried, would probably have enough moisture to ensure higher sporulation than under direct drilling, where residues would dry out faster. Competition and antibiosis caused by different microflora (1,5) under the systems could also at least partially explain the lower multiplication of *C. sativus* under zero tillage.

Effect of burning wheat residues. The inoculum of *C. sativus* in the soil was significantly reduced by destruction of wheat residues by fire (Table 1). The overall mean number after burning wheat straw was 27 propagules per gram of soil compared with 70 where the wheat residues remained. This sanitizing effect of fire supports the hypothesis that fungal sporulation occurs mainly on the residues left on the soil surface rather than on the crowns and subcrown internodes buried in the soil. According to Chinn (2,3), fungal multiplication occurs principally on subterranean wheat tissues. Data from our experiment presented in Table 1 partially support that statement. Buried tissues were protected from fire and may have contributed to some multiplication of inoculum. On the other hand, Ledingham et al (14) raised the hypothesis that sporulation of *C. sativus*

Table 1. Effects of management of wheat residues and of tillage systems on the vertical distribution and inoculum density of *Cochliobolus sativus* in soil

Soil depths (cm)	Burning[x] Direct drilling (no.)	Burning[x] Conventional drilling (no.)	No Burning Direct drilling (no.)	No Burning Conventional drilling (no.)	Means Number	Means Percent
0–5	90[y]	74	137	209	128	67
5–10	4	27	7	126	41	23
10–15	0	13	2	68	21	8
15–20	0	5	0	13	5	2
Means	24 A[z]	30 A	37 B	104 C		
Overall mean for residue management	27 A		70 B			
Overall mean for tillage systems:						
Direct drilling		31 a				
Conventional drilling		67 b				

[x]Wheat residues destroyed by fire soon after harvest.
[y]Number of propagules per gram of air-dried sieved soil counted in four aliquots of 1 ml. Soil dilution 1:50 in 0.1% water agar in selective medium.
[z]Numbers followed by the same lowercase letter within columns, or by the same capital letter within rows, are not significantly different ($P = 0.05$) according to F test. C.V. = 34.75% for residue management and 47.92% for tillage systems.

may occur on straw at the soil surface. Data in Table 1 confirm this.

Vertical distribution of *C. sativus* propagules in soil. The number of *C. sativus* propagules in soil declined with the vertical depth of soil (Table 1); 90% of all propagules were found in samples taken at depths of 0–10 cm. Duczek (10) reported a similar distribution of conidia of *C. sativus* in field soil in Saskatchewan, Canada. The concentration of propagules near the soil surface was significantly higher in our directly seeded than in our conventionally seeded plots; 95% of the propagules in the former and 53% of the propagules in the latter were contained in the top 0–5 cm of soil. It is likely that preseeding cultivation to 15–20 cm is responsible for the wide distribution of spores through the soil in conventionally seeded plots.

In summary, we concluded that 1) inoculum density of *C. sativus* in soil was reduced by burning wheat residues soon after harvesting, 2) the soil population of *C. sativus* was larger under conventional soil cultivation than under direct drilling, 3) propagules were more concentrated in the upper layer of soil (0–10 cm), and 4) propagules were found deeper in the soil under conventional drilling than under direct drilling where they were concentrated close to the soil surface.

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