Effects of Tillage on Common Root Rot of Wheat in Texas

J. T. MATHIESON, Research Associate, C. M. RUSH, Associate Professor, D. BORDOVSKY, Research Scientist, and L. E. CLARK, Professor, Texas Agricultural Experiment Station; and O. R. JONES, Soil Scientist, Agricultural Research Service, U.S. Department of Agriculture, Bushland, TX 79012

ABSTRACT

Mathieson, J. T., Rush, C. M., Bordovsky, D., Clark, L. E., and Jones, O. R. 1990. Effects of tillage on common root rot of wheat in Texas. Plant Dis. 74:1006-1008.

Effects of tillage on the incidence and severity of common root rot caused by *Bipolaris sorokiniana* and on spore distribution were studied in continuous wheat culture at three locations in Texas. Spore populations were determined to a depth of 40 cm in 10-cm increments. The majority of spores were found in the top 10 cm of soil regardless of tillage method. Although significantly more spores were found with conventional tillage than in the no-till system, the distribution of spores in the soil profile was not significantly affected by tillage. Disease incidence and severity were evaluated by rating the amount of discoloration of the subcrown internode. Disease severity and incidence were usually significantly higher in conventional-till plots than in no-till plots, indicating that cultural practices can reduce common root rot in northern Texas.

The high plains and rolling plains regions of Texas are the state's major production areas for hard red winter wheat (*Triticum aestivum* L.). Approximately 1.6 million hectares of wheat are planted annually in the two regions, which account for about 54% of all wheat harvested in the state (1). The climate is semiarid, with average rainfall of 48–61 cm/yr. Average annual grain yields for continuous dryland wheat range from 1,000 to 1,680 kg/ha (1). The high evaporative demand and erratic rainfall encourage producers to conserve water and to seek improved methods of tillage and crop production to increase yields. In recent years, there has been considerable interest in the use of conservation tillage and no-till systems that increase crop residue on the soil surface to conserve moisture and control soil erosion. Such systems reduce soil compaction, increase soil moisture, and may increase yields in the high plains (9). Among the risks involved in using such systems, however, is the potential for increased disease (7).

In 1987, Specht and Rush (6) conducted a disease survey of wheat in the Texas Panhandle. They found that the major root disease of dryland wheat was common root rot, caused by the soilborne fungus *Bipolaris sorokiniana* (Sacc.) Shoemaker (syns. *Helminthosporium sativum* Pammel, C. M. King, & Bakke, *H. sorokinianum* Sacc. in Sorokin) (6). Reported yield losses due to common root rot range from 3 to 6% throughout North America (4). The disease is usually most severe when plants experience some type of stress, such as lack of soil moisture (10). Because common root rot can be a problem in wheat production in northern Texas, we studied the effects of tillage on the distribution of *B. sorokiniana* within the soil profile and on the incidence and severity of common root rot in winter wheat.

Accepted for publication 8 June 1990 (submitted for electronic processing).

MATERIALS AND METHODS

We studied two continuous wheat tillage systems, conventional and no-till. Conventional-till plots were usually chiseled 10 cm deep after harvest and disk- or sweep-plowed during the summer months to control weeds. In the no-till plots, herbicides were used to control weeds and volunteer wheat.

Tests were conducted at Bushland, Chillicothe, and Munday, TX. Plot size varied among the sites because of land availability, but tillage practices were similar. Plots measured 8.5 × 15.2, 9.1 × 15.2, and 16.2 × 79.2 m at Chillicothe, Bushland, and Munday, respectively. Cultivars used were Siouxland in 1988 and TAM 200 in 1989 at Chillicothe and Bushland and TAM 105 in both years at Munday. A randomized complete block design was used at each site, with four replications at Chillicothe and Munday and three at Bushland. Wheat was sown around 1 October at Bushland each year and in mid-October at Munday and Chillicothe. Planting depth was in the range of 2.5–3.8 cm. Soil types and duration of tillage studies were as follows: Pullman clay loam, 7 yr (Bushland); Abilene clay loam, 5 yr (Chillicothe); and Miles fine sandy loam, 10 yr (Munday).

The effect of tillage on spore distribution within the soil profile was studied in the spring of 1988. Five soil cores (2.5 cm in diameter) were taken to a depth of 40 cm in 10-cm increments at random locations within each replicate plot at each location. The five samples from each depth within each replication were bulked and diluted 1:25 with 0.2% water agar. One milliliter of the dilution was spread on a selective medium to enumerate the conidial populations of *B. sorokiniana* (6). Five plates were prepared for each depth from each replication. Plates were incubated on the lab bench under natural light at 22 ± 2 C for 10 days. Colonies of *B. sorokiniana* were counted with the aid of a dissecting microscope at ×64.

A second study was conducted to evaluate the effects of tillage on populations of *B. sorokiniana* in the top 10 cm of the soil profile over a period of time. Soil for the study was collected at the same time as in the first study, and populations of *B. sorokiniana* were determined in the same way.

To assess the incidence and severity of common root rot of wheat in the test plots, 15–20 subsamples, each consisting of plants from 50 cm of row, were taken at random from each replication in each tillage treatment, yielding about 40–50 good subcrown internodes. Fields were sampled about 2 mo after planting (Feekes scale 3–4) and again during March (Feekes scale 6–7). The roots of the plant samples were washed free of soil. Disease severity on the subcrown internodes was rated on a 0–3 scale as described by Ledingham and co-workers (3,8). Disease incidence was also determined by calculating the percentage of plants exhibiting symptoms of common root rot (brown to dark brown lesions) on the subcrown internode. All data were analyzed by analysis of variance. Data recorded as percentages were arcsine-transformed before analysis, and mean separation was achieved with Duncan's multiple range test ($P=0.05$).

RESULTS

Propagule distribution. Propagules of *B. sorokiniana* were recovered to a depth of 40 cm. The propagule distribution pattern in each tillage system was similar at all three sites; the top 10 cm of soil had more spores than the other three layers (Table 1). When data from all locations were combined and counts of total colony-forming units (cfus) at various depths were compared, we found that the conventional-till plots contained significantly more propagules in the first layer (0–10 cm) than in all other layers in both tillage systems (Table 1). However, when we expressed the cfu counts at each level as a percentage of the total count in the profile, we found that the distribution was the same in the two treatments, indicating that tillage had no effect on spore distribution (Table 1).

Soil populations. Tillage method had definite effects on total populations of *B. sorokiniana*. Conventional-till plots had higher populations than no-till plots at every location on all sampling dates, with the exception of Chillicothe in the fall of 1988; however, only at Munday were the differences consistently significant (Table 2). Pooling the data over time indicated differences between tillage treatments at Munday and Bushland (Table 2), and combining data over all dates and locations indicated significantly higher populations in conventional-till than in no-till treatments (Table 3).

Disease incidence and severity. Conventional-till plots had significantly higher disease incidence and more severe disease than no-till plots at Munday and Bushland on all sampling dates except one (Tables 4 and 5). Differences were not significant at Chillicothe except with regard to disease incidence in the spring of 1989. When the data were combined over all dates and locations, the conventional-till system had significantly higher disease incidence and more severe disease than the no-till system (Table 3).

DISCUSSION

Our study found that most of the propagules of *B. sorokiniana* were contained in the top 10 cm of the soil profile. This result is similar to findings in other studies (5). Several factors may account for this result. First, depending on the amount of soil moisture present, 59–80% of the root weight of winter wheat is in the top 10 cm of soil (2). It is logical to expect that the most spores would be produced where most of the roots are located. Second, when fields are tilled, the soil is usually disturbed to a depth of about 10 cm. Therefore, the area in which most of the roots are located is also the area plowed, and most of the spores remain in the plow layer. Third, the deeper layers of soil may not be biologically favorable for *B. sorokiniana*.

We noted that the distribution pattern of spores within the soil profile was the same for both tillage systems, even though the total spore population was higher in the conventional-till plots. The conventional-till system may have more spores because the greater number of tillage operations incorporates any inoculum present on plant tissue into the soil. Increased tillage also places more straw into the soil, giving the fungus more substrate on which to grow and reproduce.

Moisture and temperature may also have influenced the population of *B. sorokiniana*. In general, soil moisture is higher and temperatures are cooler in no-till systems than in conventional-till systems (9,11). Both variables may have contributed to some difference in the microflora that may have suppressed the

Table 1. Number and distribution of spores of *Bipolaris sorokiniana* in the soil profile at three locations in the spring of 1988

Tillage and depth	Location[x] Munday	Chillicothe	Bushland	Mean distribution cfus/g of soil[y]	Percentage of total[z]
Conventional-till					
0–10 cm	140.0 a	40.0 a	63.3 a	82.7 a	74 a
10–20 cm	27.5 b	12.5 b	11.7 b	17.9 b	16 b
20–30 cm	2.5 b	13.8 b	3.3 b	6.8 b	6 b
30–40 cm	5.0 b	3.8 b	5.0 b	4.6 b	4 b
No-till					
0–10 cm	26.3 a	21.3 a	23.3 a	23.6 b	63 a
10–20 cm	1.3 b	6.3 b	8.3 a	5.0 b	13 b
20–30 cm	0.0 b	5.0 b	6.7 a	3.6 b	10 b
30–40 cm	2.5 b	3.8 b	10.0 a	5.0 b	13 b

[x] Data are colony-forming units (cfus) per gram of soil and are the means of three or four replications. Means within each column followed by different letters are significantly different ($P = 0.05$) according to Duncan's multiple range test.
[y] Data analyzed among depths and between the two tillage methods.
[z] Percentage of total spores found at the various depths within each tillage treatment.

Table 2. Populations of *Bipolaris sorokiniana* in the upper 10 cm of soil at three sites on three sampling dates

Site	Tillage[y]	Date[z] Spring 1988	Fall 1988	Spring 1989	Average
Munday	CT	101.3 a	68.8 a	48.8 a	85.8 a
	NT	26.3 b	13.8 b	15.0 b	18.3 b
Chillicothe	CT	86.3 a	25.0 a	61.0 a	41.3 a
	NT	73.8 a	31.3 a	32.0 a	29.2 a
Bushland	CT	63.3 a	26.7 a	21.7 a	37.2 a
	NT	23.3 a	8.3 a	15.0 a	15.5 b

[y] CT = conventional-till; NT = no-till.
[z] Data are colony-forming units per gram of soil and are mean spore counts from three or four replications. Tillage treatments were compared separately for each location. Means within each column followed by different letters are significantly different ($P = 0.05$) according to Duncan's multiple range test.

Table 3. Population and disease data combined over all dates and locations[y]

Tillage	Spore population (cfus/g of soil)	Disease incidence (%)	Disease index[z]
Conventional-till	56.4 a	63.7 a	1.5 a
No-till	21.5 b	35.4 b	0.7 b

[y] Means within each column followed by different letters are significantly different ($P = 0.05$) according to Duncan's multiple range test.
[z] On a scale of 0–3, where 0 = clean, 1 = 1–25%, 2 = 26–50%, and 3 = 51–100% discoloration of the subcrown internode.

Table 4. Percentage of plants with symptoms of common root rot at three sites on three sampling dates

Site	Tillage[y]	Sampling date[z] Spring 1988	Fall 1988	Spring 1989	Average
Munday	CT	86.2 a	53.8 a	77.1 a	72.4 a
	NT	8.3 b	25.0 b	24.5 b	19.3 b
Chillicothe	CT	40.6 a	50.6 a	95.5 a	62.2 a
	NT	32.1 a	54.3 a	86.8 b	57.7 a
Bushland	CT	36.8 a	44.3 a	88.4 a	56.5 a
	NT	7.8 b	22.0 a	58.1 b	29.3 b

[y] CT = conventional-till; NT = no-till.
[z] Tillage treatments were compared separately for each location. Means within each column followed by different letters are significantly different ($P = 0.05$) according to Duncan's multiple range test. Data are the means of three or four replications consisting of about 40–50 subcrown internodes.

Table 5. Disease index for common root rot of wheat at three sites on three sampling dates

Site	Tillage[y]	Sampling date[z] Spring 1988	Fall 1988	Spring 1989	Average
Munday	CT	2.5 a	1.0 a	1.7 a	1.7 a
	NT	0.2 b	0.3 b	0.4 b	0.3 b
Chillicothe	CT	0.8 a	0.9 a	2.4 a	1.4 a
	NT	0.6 a	1.0 a	2.3 a	1.3 a
Bushland	CT	0.9 a	0.6 a	2.2 a	1.3 a
	NT	0.1 b	0.3 b	1.4 b	0.6 b

[y] CT = conventional-till; NT = no-till.

[z] Values are mean disease ratings on a scale of 0–3, where 0 = clean, 1 = 1–25%, 2 = 26–50%, and 3 = 51–100% discoloration of the subcrown internode. Tillage treatments were compared separately for each location. Means within each column followed by different letters are significantly different ($P = 0.05$) according to Duncan's multiple range test.

population of *B. sorokiniana*. Lower temperatures and higher soil moisture in the no-till system may also have reduced stress in wheat, resulting in lower disease severity. These variables may also have reduced disease incidence in the no-till system because the disease is favored by conditions that stress the wheat plant. The reduced-till plots in our study did have lower disease incidence, severity, and spore populations than the conventional-till plots.

Spore populations and disease varied on each sampling date (Tables 2, 4, and 5). Although the same plots were sampled each time, samples were taken at random within the plots, and the population of the fungus may not have been uniformly distributed throughout the soil. Climatic conditions may also have contributed to the differences among sampling dates. The spring of 1988 was unusually moist compared to both the fall of 1988 and the spring of 1989, which were quite dry. The lack of moisture favored the development of common root rot, as reflected in the increase in both disease incidence and severity in the spring of 1989 compared to the spring of 1988, when moisture was more favorable for wheat production (Tables 4 and 5).

Although we found that tillage system affected disease severity and incidence, we did not determine the effect of the disease on wheat yield. It is possible that during years when climatic conditions favor disease development, the disease could have a significant economic impact on wheat production. Additional work is needed to determine the overall impact of the no-till system on fungal populations, disease incidence, and disease severity relative to the conventional system.

LITERATURE CITED

1. Anonymous. 1986. Texas Small Grains Statistics, 1986. Texas Department of Agriculture and U.S.D.A. National Agricultural Statistics Service, Austin, TX.
2. Chaudhary, T. N., and Bhatnagar, V. K. 1980. Wheat root distribution, water extraction pattern and grain yield as influenced by time and rate of irrigation. Agric. Water Manage. 3:115-124.
3. Ledingham, R. J. 1970. Crop loss assessment methods. Special method no. 29 in: FAO Manual on the Evaluation and Prevention of Losses by Pests, Diseases, and Weeds. Food and Agriculture Organization of the United Nations, Rome.
4. Ledingham, R. J., Atkinson, T. G., Horricks, J. S., Mills, J. T., Piening, L. J., and Tinline, R. D. 1973. Wheat losses due to common root rot in the prairie provinces of Canada, 1969–71. Can. Plant Dis. Surv. 53:113-122.
5. Reis, E. M., and Abrão, J. J. R. 1983. Effect of tillage and wheat residue management on the vertical distribution and inoculum density of *Cochliobolus sativus* in soil. Plant Dis. 67:1088-1089.
6. Specht, L. P., and Rush, C. M. 1988. Fungi associated with root and foot rot of winter wheat and populations of *Cochliobolus sativus* in the Texas Panhandle. Plant Dis. 72:959-963.
7. Sumner, D. R., Doupnik, B., Jr., and Boosalis, M. G. 1981. Effects of reduced tillage and multiple cropping on plant diseases. Annu. Rev. Phytopathol. 19:167-187.
8. Tinline, R. D., Ledingham, R. J., and Sallans, B. J. 1975. Appraisal of loss from common root rot in wheat. Pages 22-26 in: Biology and Control of Soil-Borne Plant Pathogens. G. W. Bruehl, ed. American Phytopathological Society, St. Paul, MN.
9. Unger, P. W. 1984. Tillage and residue effects on soil water and crop factors in a winter wheat-sorghum-sunflower rotation. Soil Sci. Soc. Am. J. 48:885-891.
10. Wiese, M. V. 1987. Compendium of Wheat Diseases, 2nd ed. APS Press, St. Paul, MN. 112 pp.
11. Willis, W. O., and Amemiya, M. 1973. Tillage management principles: Soil temperature effects. Pages 22-42 in: Proc. Natl. Conf. Conservation Tillage, Des Moines, IA, 28–30 Mar. M. Schnepf, ed. Soil Conservation Society of America, Ankeny, IA.