Effects of Common Root Rot on Winter Wheat Forage Production

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ABSTRACT

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A 2-yr field study was conducted to evaluate the effects of common root rot, caused by *Bipolaris sorokiniana*, on winter wheat forage production. Treatments were established that resulted in different levels of disease severity. Disease severity was evaluated on seven cultivars by using three seed treatments including imazalil fungicide, conidial inoculation with *B. sorokiniana*, and noninoculated, nontreated controls. Forage samples were taken in November and March each year, and plants were evaluated at the same time for disease incidence and severity. At all sampling dates, significant differences ($P = 0.05$) in disease incidence and severity existed among cultivars and seed treatments. Seed treatment effects were similar on all cultivars as indicated by the lack of any cultivar × seed treatment interaction. The imazalil treatment had a significantly lower disease index (DI) than the other two treatments at each sampling date, and the DI of the treatment with *B. sorokiniana* was significantly higher than the control at three of four dates. Cultivar TAM 200 consistently had a high DI, and the DI of cultivars Scout 66 and Siouxland were consistently low. However, the correlation coefficient between DI and forage production was always low and nonsignificant. Although significant differences in forage production existed among cultivars, they were not related to the disease measured, indicating that control of common root rot is not important when forage production is the primary concern. However, because grain yields may be reduced by common root rot, management practices that reduce disease severity are still highly recommended.

Wheat (*Triticum aestivum* L.) is one of the major agricultural crops produced in Texas, with over 3 million ha planted annually (17). The majority is hard red winter wheat, normally planted from September through October. Because of warm temperatures at this time, plants with adequate soil moisture develop rapidly and produce extensive vegetative growth. Cattle are overwintered in many fields, making wheat an important source of winter forage. In 1988, the value of wheat as a forage crop was estimated to exceed $100 million (Steve Amosson, agricultural economist, *personal communication*). When cattle prices are up and those of wheat are down, as in recent years, wheat becomes even more valuable as a forage crop. Wheat as a forage crop is planted earlier than when grain is the main consideration (6,24), and earlier planting often exposes seedlings to hot, dry conditions. Although early planting is necessary for maximum forage production, associated stresses can predispose seedlings to numerous disease problems, especially those of soilborne origin (15).

During 1986–1987, a disease survey was conducted to identify the predominant soilborne pathogens of dryland wheat grown in the Texas Panhandle (17). *Bipolaris sorokiniana* (Sacc.) Shoemaker, the cause of common root rot, was the most frequently isolated pathogen from diseased wheat seedlings. It is almost ubiquitous in Panhandle wheat field soils. Common root rot is known to be a disease associated with plant stress (5,15,19), and seedling infections result in greater grain yield loss than later infections (3,21,22). Although researchers have reported reductions in grain yield attributable to common root rot, little is known about how this disease affects wheat grown as a forage crop. Because wheat forage is such an important crop in the Texas Panhandle and common root rot is so prevalent, research was initiated to determine how this disease affects forage production. The primary objective was to determine whether reduced disease incidence and severity, achieved through the use of varietal resistance or seed treatment fungicides, would result in increased forage production. A preliminary report has been published (7).

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MATERIALS AND METHODS

All research was conducted in field plots at the Texas Agricultural Experiment Station in Bushland, Texas, during the 1987–1988 and 1988–1989 wheat growing seasons. Seven cultivars of hard red winter wheat were used in the study: TAM 200, Collin, TAM 107, TAM 201, Siouxland, Hawk, and Scout 66. Five hundred grams of seed from each cultivar were treated with 0.017 g a.i. imazalil (Flo-Pro IMZ 10%), conidia of *B. sorokiniana* (suspended in 2% methyl cellulose) from 15 plates of potato-dextrose agar (PDA), or left untreated. Seed was planted 1 September 1987 and 8 September 1988 in a Pullman clay loam naturally infested with approximately 150 colony-forming units (cfu) of *B. sorokiniana* per gram of soil. Soil inoculum densities were determined by dilution plating on a semiselective medium (17). Seeding rate was 45 g per plot, with each plot six rows wide (25-cm row spacing) and 4 m in length. There were six replications for each cultivar × seed treatment combination, all arranged in a randomized complete block. Following planting, plots were irrigated for emergence. No fertilizer was added either year, but insecticides were applied as needed to reduce insect damage.

Forage production and disease incidence and severity were measured in November and March each year. Forage samples were taken with a rotary lawn mower from the center two rows of each plot, oven dried for 2 days, and dry weights were recorded.

For disease determinations, approximately 50 plants were randomly harvested from each plot. Plants were assigned a disease severity rating of 0–3, similar to that described by Tinline et al with 0 = clean and 3 ≥ 50% of the subcrown internode exhibiting disease symptoms (19). These were used to derive a disease index (DI) value. Disease incidence was expressed as the percentage of plants in each sample exhibiting symptoms of common root rot. All data were subjected to ANOVA and treatment means were compared with Duncan's procedure ($P = 0.05$). Additionally, the relationship between DI and forage production was evaluated with correlation analysis.

RESULTS

Environmental conditions were favorable for disease development in both years of the study. Immediately following planting in 1987, heavy rains washed loose soil over seed rows burying the seed approximately 5–7 cm deep. The deep seed placement resulted in greater overall disease severity in the fall of 1987 than fall 1988, regardless of cultivar or seed treatment. Forage production was also much higher in the 1987–1988 growing season than in the second year of the study when drought conditions prevailed from planting through March.

Seed treatments significantly affected disease incidence and severity both years of the study (Table 1). There was no sig-

Table 1. Effects of seed treatment on common root rot disease incidence and severity in two crops of winter wheat sampled in fall and spring[w]

Seed treatment[x]	Fall 1987		Spring 1988		Fall 1988		Spring 1989	
	Incidence[y] (%)	Index[z]	Incidence (%)	Index	Incidence (%)	Index	Incidence (%)	Index
Bipolaris sorokiniana	94 a	2.3 a	78 a	1.9 a	58 a	1.3 a	92 a	2.3 a
Control	96 a	2.3 a	72 a	1.7 b	45 b	1.0 b	86 b	2.0 b
Imazalil	89 b	1.8 b	55 b	1.2 c	30 c	0.6 c	80 c	1.8 c

[w] Means in each column are inclusive of seven cultivars with six replications, and those followed by the same letter are not significantly different according to Duncan's test ($P = 0.05$).
[x] Five hundred grams of seed were treated with conidia of *B. sorokiniana* (suspended in 2% methyl cellulose) from 15 PDA plates, 0.017 g a.i. imazalil (Flo-Pro IMZ 10%), or left untreated.
[y] Disease incidence was based on the number of plants in a sample of approximately 50 that exhibited symptoms of common root rot.
[z] Disease index was based on a disease severity rating system ranging from 0 to 3 with 0 = clean and 3 = ≥ 50% of the subcrown internode exhibiting disease symptoms.

Table 2. Common root rot disease incidence and severity in winter wheat cultivars sampled in fall and spring in each of 2 yr[x]

Cultivar	Fall 1987		Spring 1988		Fall 1988		Spring 1989	
	Incidence[y] (%)	Index[z]	Incidence (%)	Index	Incidence (%)	Index	Incidence (%)	Index
TAM 200	97 a	2.5 a	85 a	2.1 a	54 a	1.3 a	90 a	2.2 a
Collin	93 ab	2.3 ab	68 b	1.6 b	55 ab	1.1 ab	85 ab	1.9 bc
TAM 107	94 ab	2.2 b	71 b	1.8 ab	50 ab	1.2 ab	90 a	2.0 ab
TAM 201	94 ab	2.2 b	71 b	1.8 ab	49 ab	1.1 ab	85 ab	2.0 ab
Siouxland	90 b	1.6 c	50 c	0.9 d	42 bc	0.8 cd	87 ab	2.0 abc
Hawk	93 ab	2.3 ab	77 ab	1.9 a	40 bc	0.9 bc	85 ab	1.9 abc
Scout 66	89 b	1.8 c	58 c	1.2 c	36 c	0.7 d	82 b	1.7 c

[x] Means in each column are of six replications and are inclusive of all three seed treatments. Those followed by the same letter are not significantly different according to Duncan's test ($P = 0.05$).
[y] Disease incidence was based on the number of plants in a sample of 50 that exhibited symptoms of comon root rot.
[z] Disease index was based on a disease severity rating system ranging from 0 to 3 with 0 = clear and 3 = ≥50% of the subcrown internode exhibiting disease symptoms.

nificant cultivar × seed treatment interaction with any of the recorded variables, therefore results are presented as seed treatment effect inclusive of all cultivars, and cultivar effect inclusive of all seed treatments. At all four sampling dates, imazalil seed treatment significantly reduced incidence of infection and lowered disease index compared to the treatment with *B. sorokiniana* or the untreated control. In the first year of the study, the treatment with *B. sorokiniana* had no significant effect on disease incidence when compared to nontreated seed and had a significantly higher disease index only in the spring. However, in the second year at both sampling dates, the treatment with *B. sorokiniana* had significantly more disease and a higher disease index than either of the other two treatments.

Disease incidence and severity differed among cultivar (Table 2). Scout 66, Siouxland, and TAM 200 were relatively consistent in their rankings, with Scout 66 and Siouxland always having a low disease index and incidence of infection, and TAM 200 always among the highest. Scout 66 had a significantly lower disease index and incidence than TAM 200 at all four sampling dates, and Siouxland had a significantly lower DI and incidence than TAM 200 at three of the four sampling dates. There were no differences in disease index or incidence of infection between the other four cultivars at any sampling date, with the exception of spring 1988, when Hawk had a significantly higher disease index than Collin.

Table 3. Seed treatment effects on winter wheat forage production from two crops sampled in fall and spring[x]

Treatment[y]	Fall 1987 ($g\ m^{-2}$)	Spring 1988 ($g\ m^{-2}$)	Fall 1988 ($g\ m^{-2}$)	Spring 1989 ($g\ m^{-2}$)
Bipolaris sorokiniana	103 a[z]	262 a	37 c	77 a
Control	94 a	278 a	52 a	83 a
Imazalil	104 a	262 a	45 b	79 a

[x] Mean forage production by seven cultivars with six replications as affected by seed treament. Forage was collected from the center two rows, 4 m in length, from each plot, and oven dried.
[y] Five hundred grams of seed were treated with conidia of *B. sorokiniana* (suspended in 2% methyl cellulose) from 15 PDA plates, 0.017 g a.i. imazalil (Flo-Pro IMZ 10%), or left untreated.
[z] Values in each column followed by the same letter are not significantly different according to Duncan's test ($P = 0.05$).

Table 4. Effects of cultivar on winter wheat forage production from two crops sampled in fall and spring[y]

Cultivar	Fall 1987 ($g\ m^{-2}$)	Spring 1988 ($g\ m^{-2}$)	Fall 1988 ($g\ m^{-2}$)	Spring 1989 ($g\ m^{-2}$)
Scout 66	118 a[z]	281 a	57 a	99 a
TAM 200	112 a	267 a	53 ab	89 ab
TAM 201	101 ab	280 a	50 ab	88 ab
Siouxland	106 a	242 a	44 bcd	76 bc
TAM 107	100 ab	279 a	37 cd	78 bc
Collin	78 c	274 a	36 d	71 c
Hawk	83 bc	251 a	34 d	73 c

[y] Mean forage production by seven cultivars inclusive of three seed treatments (imazalil, control, and spores of *B. sorokiniana*). Forage was collected from the center two rows, 4 m in length, of each plot, and oven dried.
[z] Means in each column followed by the same letter are not significantly different according to Duncan's test ($P = 0.05$).

Despite the fact that disease incidence and severity were significantly reduced with certain seed treatment and cultivar selections, no associated increase in forage production was detected (Tables 3 and 4). Correlation coefficients between DI and forage were always low ($r \leq 0.25$) and never significant. When forage production was evaluated in response to seed treatment, the only significant difference occurred in fall 1988 when less forage was produced with the imazalil treatment than with the control. Although imazalil consistently reduced disease incidence and severity, forage production was not increased. The same lack of forage response to reduced disease was observed with the seven cultivars (Table 4). TAM 200, which had significantly more disease than Scout 66 at all four sampling dates and more than Siouxland at three of the four, produced statistically equivalent forage weights at each date.

DISCUSSION

Quantifying wheat's response to infection by *B. sorokiniana* can be an elusive endeavor. In this study, forage production was not correlated to disease severity. Others have reported similar results with regard to grain yield (5,11). Even when yields are increased in response to disease control, the increase is often small (10,18,22). This is particularly disturbing considering the fact that significant disease control can be achieved through chemical, cultural, and genetic means (2,4,8,9,16,20).

There are several possible explanations as to why statistical decreases in disease severity are frequently not associated with increases in plant yields. For instance, the method of assessing disease severity may not be adequate. The most frequently used method of evaluating common root rot severity is one in which individual plants are scored for disease symptoms on the subcrown internode as clean, slight, moderate, or severe (19). Typically, individual plant ratings are bulked and the entire sample is given a disease index to represent a particular treatment. Using this method, it is possible to achieve significant differences in DI that may not be biologically significant. In our study, when evaluating seed treatment effects on disease development, DI values were highest in the inoculated treatment at three of four sampling dates and lowest in the imazalil treatment at all dates. However, these differences never related to forage production (Tables 1 and 3). Although plants in the inoculated plots usually had a significantly higher DI than those in control plots, differences were never greater than 0.3. The maximum difference of 0.7 occurred between the imazalil and inoculated treatment. Similar levels of disease control were achieved with the cultivars, but again there was no associated increase in forage production. It may be that the level of disease control was not adequate to result in a beneficial plant response, especially considering that disease incidence was relatively high at all times.

The use of DI as an indicator of treatment effects on disease development and plant yield in populations may be accurate, but it may also provide misleading information with regard to disease and individual plant response. If plants were grouped and evaluated by disease category, it is likely that significant yield differences would be associated with different categories. This approach was used by Verma et al (22,23). They showed that decreasing dry weight and grain yield of wheat plants was consistently associated with increasing disease severity. Although differences between each individual category were not always significant, differences between clean and severe were significant at every sampling date. Similar results have been obtained with other crops in which selected variables were measured from plants in specific disease categories (12,13).

It may be necessary to study individual plants or categories of plants in order to gain an accurate understanding of host-parasite interactions or to quantitate plant response to disease. However, from an agronomic point of view, in wheat production it is the population that is important and not the individual plant. Often in plant populations, healthy plants compensate in yield for adjacent diseased plants. Also, there have been reports of wheat and barley, infected by *B. sorokiniana* in the seedling stage, recovering from early stunting and yielding more than noninoculated plants. Gray and Mathre (5) planted several barley cultivars in field plots where half were artificially inoculated with barley grains infested with *B. sorokiniana*. Plants in inoculated plots were stunted early, but by the end of stem elongation, there was no difference between plants in inoculated or noninoculated plots. Sallans (14) reported that artificially infested wheat seed produced plants with small first and second leaves, but thereafter, leaves were as large or larger than controls. In our study, there were never any dramatic visual differences between treatments or varieties. Based on 2 yr of data, it appears that in the Texas Panhandle, common root rot has no effect on wheat forage production when plants develop under moderate to good growing conditions, such as those experienced during this study.

Frequently, the primary pathological plant response to root infection is water stress. Apparently, in wheat, extensive root damage must be incurred to reduce or affect forage production. In laboratory studies, Ayling (1) evaluated the effects of root pruning on shoot dry weight and grain production of winter wheat. Removal of either the seminal or nodal root system during tillering reduced shoot dry weight by only 7%, while grain yield was reduced by 25%. Only the most extreme disease pressure and adverse environmental conditions would ever approximate similar damage to wheat root systems. Therefore, the lack of forage response to decreased disease severity and incidence in this study is not surprising.

Many studies of common root rot have focused on how the disease affects grain yield of spring wheat or barley (3,5,9, 10,18). The fact that winter wheat was used in this study may help explain why forage was not affected by disease. Common root rot is most severe in warm soils (15,19). In Texas, winter wheat for forage production is typically planted in late August or September when average temperatures range from 19 to 25 C. These temperatures are optimum for root rot development. In November and March, the months in which forage samples were taken, the average temperature is approximately 7 C. Because wheat can continue active growth to 0 C, there is a considerable period of time when conditions for disease development are poor but still satisfactory for forage production. Therefore, even though typical subcrown internode symptoms of common root rot were present at all sampling dates, plants may not have been stressed for some time because of unfavorable temperatures for disease development. However, as temperatures began to rise and plants approach maturity, maximum demand on the root system and conditions that favor disease development could result in plant stress and reduction in grain yield.

B. sorokiniana is almost ubiquitous in Texas Panhandle wheat fields, therefore, common root rot is essentially a "normal" condition. Results of this study and others indicate that disease incidence and severity can be reduced by cultural, chemical, and genetic means. However, because of the wheat plant's ability to compensate for disease, the extreme amount of root damage required to significantly reduce forage production, and the fact that winter wheat can grow at temperatures unfavorable for disease development, we conclude that common root rot is not a detriment to winter wheat forage production in the Texas Panhandle under the environmental conditions that occurred during this study. Therefore, with regard to forage production, management of common root rot with expensive control measures is not warranted. However, because grain yield reductions may occur, management practices that reduce the incidence and severity of the disease are still highly recommended.

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LITERATURE CITED

1. Ayling, S. M. 1989. The growth, yield and nutrient uptake of winter wheat following root-pruning. Ann. Appl. Biol. 114:567-577.
2. Broscious, S. C., and Frank, J. A. 1986. Effects of crop management practices on common root rot of winter wheat. Plant Dis. 70:857-859.
3. Duczek, L. J. 1989. Relationship between common root rot (*Cochliobolus sativus*) and tillering in spring wheat. Can. J. Plant Pathol. 11:39-44.
4. Duczek, L. J., and Piening, L. J. 1982. Effect of seeding depth, seeding date and seed size on common root rot of spring barley. Can. J. Plant Sci. 62:885-891.
5. Grey, W. E., and Mathre, D. E. 1984. Reaction of spring barley to common root rot and its effect on yield components. Can. J. Plant Sci.

64:245-253.
6. Jones, O. R., and Johnson, W. C. 1983. Cropping practices: Southern great plains. Pages 365-385 in: Dryland Agriculture. H. E. Dregne and W. O. Willis, eds. Agron. Monogr. 23. American Society of Agronomy, Madison, WI.
7. Mathieson, J. T., Rush, C. M., and Porter, K. B. 1988. Relationship between common root rot and winter wheat forage production. (Abstr.) Phytopathology 78:1513-1514.
8. McMullen, M. P., and Stack, R. W. 1987. Improving wheat and durum seedling stands and vigor by fungicide seed treatments. Pages 13-15 in: North Dakota Res. Jan-Feb.
9. Piening, L. J. 1973. Differential yield response of ten barley cultivars to common root rot. Can. J. Plant Sci. 53:763-764.
10. Piening, L. J., Atkinson, T. G., Horricks, J. S., Ledingham, R. J., Mills, J. T., and Tinline, R. D. 1976. Barley losses due to common root rot in the Prairie Provinces of Canada, 1970-72. Can. Plant Dis. Surv. 56:41-45.
11. Piening, L. J., Duczek, L. J., Atkinson, T. G., and Davidson, J. G. N. 1983. Control of common root rot and loose smut and the phytotoxicity of seed treatment fungicides on Gateway barley. Can. J. Plant Pathol. 5:49-53.
12. Rush, C. M. 1987. The relationship between hollow heart of pea and seed electrolyte loss, disease susceptibility, and plant growth. Phytopathology 77:1533-1536.
13. Rush, C. M., Marek, T. H., and Baker, E. H. 1989. Relationship between sugar beet root rot severity and percent reduction in sugar content. (Abstr.) J. Sugar Beet Res. 26:A19.
14. Sallans, B. J. 1959. Recovery in wheat from early infections by *Helminthosporium sativum* and *Fusarium culmorum*. Can. J. Plant Sci. 39:187-193.
15. Sallans, B. J. 1965. Root rots of cereals. III. Bot. Rev. 31(4):505-536.
16. Shefelbine, P. A., Mathre, D. E., and Carlson, G. 1986. Effects of chloride fertilizer and systemic fungicide seed treatments on common root rot of barley. Plant Dis. 70:639-642.
17. 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.
18. Tinline, R. D., and Ledingham, R. J. 1979. Yield losses in wheat and barley cultivars from common root rot in field tests. Can. J. Plant Sci. 59:313-320.
19. Tinline, R. D., Ledingham, R. J., and Sallans, B. J. 1975. Appraisal of loss from common root rot of wheat. Pages 22-26 in: Biology and Control of Soilborne Plant Pathogens. G. W. Bruehl, ed. American Phytopathological Society, St. Paul, MN.
20. Tinline, R. D., Wildermuth, G. B., and Spurr, D. T. 1988. Inoculum density of *Cochliobolus sativus* in soil and common root rot of wheat cultivars in Queensland. Aust. J. Agric. Res. 39:569-577.
21. Verma, P. R., Morrall, R. A. A., and Tinline, R. D. 1974. The epidemiology of common root rot in Manitou wheat: Disease progression during the growing season. Can. J. Bot. 52:1757-1764.
22. Verma, P. R., Morrall, R. A. A., and Tinline, R. D. 1976. The epidemiology of common root rot in Manitou wheat. IV. Appraisal of biomass and grain yield in naturally infected crops. Can. J. Bot. 54:1656-1665.
23. Verma, P. R., Morrall, R. A. A., and Tinline, R. D. 1976. The effect of common root rot on components of grain yield in Manitou wheat. Can. J. Bot. 54:2888-2892.
24. Winter, S. R., and Thompson, E. K. 1987. Grazing duration effects on wheat growth and grain yield. Agron. J. 79:110-114.