Influence of Cultural Practices on Incidence of Foot Rot in Winter Wheat

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ABSTRACT

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Crop rotation, preplant tillage, cultivar selection, nitrogen fertilization, and benomyl application were evaluated for their individual and interactive effects on foot rot (*Pseudocercosporella herpotrichoides*) and seed yield in winter wheat. Preplant tillage had a significant and direct effect on disease incidence. Conventional tillage (plow and disc) consistently supported significantly higher foot rot levels than reduced-tillage and no-till treatments. Cultivars Daws and Stephens supported higher and lower foot rot levels, respectively, than either Luke or Nugaines. The effect of rotation on disease incidence was inconsistent and nitrogen levels between 101 and 135 kg/ha had no significant effect. In 1981, seed yield was influenced significantly by tillage, cultivar, and benomyl treatments. Benomyl application elicited significantly higher yields with all cultivars under reduced tillage but not under no-till. In 1982, benomyl/rotation/tillage, benomyl/tillage/cultivar, and benomyl/rotation/cultivar interactions with yield were significant. Conventional tillage and benomyl application supported the highest yields. Results indicate that reduced-tillage practices can limit both soil erosion and foot rot incidence, but these advantages must be weighed against possible yield reductions.

Yield suppression in winter wheat (*Triticum aestivum* L.) from foot rot caused by *Pseudocercosporella herpotrichoides* (Fron) Deighton may reach 50% in the Palouse region of eastern Washington and northern Idaho (5,12,22). Although such practices as late fall seeding and spring application of fungicide partially control foot rot (4,6,12,13,17,20,22), the associated risk of overwinter soil erosion and the cost of fungicide application are undesirable. In recent years, up to 70% of the wheat acreage in the Palouse receives a foliar application of fungicide in early spring to reduce foot rot development (M. V. Wiese and D. M. Gerten, *unpublished*).

Short periods between successive wheat crops (short rotations) tend to favor foot rot development, whereas long rotations (two or more years between wheat crops) appear to limit inoculum and disease development (10,12,15). Nitrogen, while promoting plant growth, may also promote a favorable microenvironment for foot rot development (5,21).

In an evaluation of tillage in an area with supplemental foot rot inoculum, Cook and Waldher (7) reported that subjecting winter wheat stubble to a chisel plow resulted in less growth and yield in the subsequent wheat crop than when the straw was more completely buried with a moldboard plow. Although foot rot incidence and severity were not measured, Cook and Waldher surmised that resultant foot rot levels were related to plant size rather than to tillage. Brooks and Dawson (3) reported less foot rot in no-till than in conventionally tilled plots. Neither of these studies, however, compared tillage against both foot rot incidence and yield or examined a range of conventional tillage, reduced tillage, and no-till practices.

To date, the possible interaction of fungicide, crop rotation, preplant tillage, cultivar, and nitrogen variables as determinants of foot rot and yield levels has not been evaluated. Such information could be useful to improve wheat management practices and to identify management alternatives that best limit foot rot and soil erosion while sustaining or augmenting yield. The primary objective of this research, therefore, was to measure foot rot incidence in winter wheat as influenced by preplant tillage. This research further compared foot rot incidence and wheat seed yield against other currently employed cultural practices (fungicide use, crop rotation, cultivar selection, and nitrogen application) that are known or suspected to influence foot rot development.

MATERIALS AND METHODS

Field plots of winter wheat were established in 1974 at Moscow, ID, and arranged in a split-block design. Crop rotation and preplant tillage variables served as main plots, and cultivar, nitrogen application, and benomyl sprays were subplots. Foot rot was a natural consequence in the plots each year, and no supplemental inoculum of *P. herpotrichoides* was added.

The three preplant tillage systems evaluated in this study were 1) conventional (moldboard plow, disc, harrow, and John Deere 8250 drill), 2) reduced (chisel planter designed at the University of Idaho [19]), and 3) no-till (John Deere 1500 Power-Till Drill). The three crop rotations evaluated were 1) winter wheat/spring pea, 2) winter wheat/spring wheat/spring pea, and 3) winter wheat/alfalfa + red clover + spring pea/alfalfa + red clover.

Winter wheat cultivars employed in the study were Nugaines (CI 13968), Stephens (CI 17596), Luke (CI 14586), and Daws (CI 17149). Seeding was done during mid-October each year and seeding depth was maintained between 2.5 and 4 cm. Fertilizer (27-12-0-4) was applied at 101 kg of N/ha on all winter wheat plots in autumn. Additional nitrogen (34-0-0) at rates of 17 and 34 kg/ha was applied in spring to create subplots receiving 101, 118, or 135 kg of N/ha. Subplot dimensions were 2.4×8.4 m, and each treatment was replicated four times.

In 1981, foot rot incidence and wheat yield were evaluated under the three rotations; under three nitrogen levels; among the cultivars Daws, Nugaines, and Stephens; and under reduced and no preplant tillage with and without a benomyl spray. Conventional tillage plots were unavailable in 1981 because of equipment malfunction during seeding. In 1982, nitrogen was held constant at 118 kg/ha and cultivars Nugaines, Stephens, Daws, and Luke under the three tillage systems and three rotations with and without benomyl fungicide were evaluated for disease incidence and yield.

In 1981, benomyl was applied to eight of 10 rows of wheat (about 16 m^2) across all nitrogen, cultivar, tillage, and rotation treatments. In 1982, benomyl was similarly applied to half of each subplot (about 10 m^2). In both years, benomyl was applied at a rate of 560 g a.i./280 L of water per hectare at a pressure of 2,068 kilodynes per square centimeter (1/2 lb a.i./acre in 30 gal of water at 30 lb/in.^{2}).

In 1981, benomyl was applied between 10 and 14 April (between growth stages [GS] 2.6 and 3.0 [23]). Foot rot was evaluated on 15 April (GS 2.6–3.0, tillering) and again between late June and early July (GS 6.4–7.0, anthesis).

In 1982, benomyl was applied between 30 April and 5 May (GS 2.7–3.0). Foot

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rot was evaluated between 24 and 26 May (GS 3.2, jointing) and between 5 and 8 July (GS 6.9–7.4, late anthesis).

Foot rot incidence was evaluated by examining a minimum of 50 tillers harvested at random from each subplot. The number of tillers showing severe eyespot lesions (encompassing greater than half of the culm circumference) was expressed as a percentage of all tillers examined.

All plots were harvested when the wheat was mature with an Allis Chalmers Model 100 Self Propelled All Crop Harvester. All harvested samples of grain were moisture-equilibrated and weighed to the nearest gram.

Analysis of disease and yield data were performed using the Statistical Analysis System (SAS) and analysis of variance (ANOVA) procedures (11). Significant ($P = 0.05$) treatment interactions were analyzed using Fisher's least significant difference procedure. Main effects were tested using Duncan's multiple range test.

RESULTS

Effects of cultural practices on disease incidence. Tillage and benomyl treatment had a significant and consistent effect on disease incidence. Foot rot levels were lowest under no-till, intermediate under reduced tillage, and highest under conventional tillage (Fig. 1). Similarly, across all rotations, tillage treatments, and cultivars, benomyl significantly reduced foot rot levels relative to no-benomyl treatments.

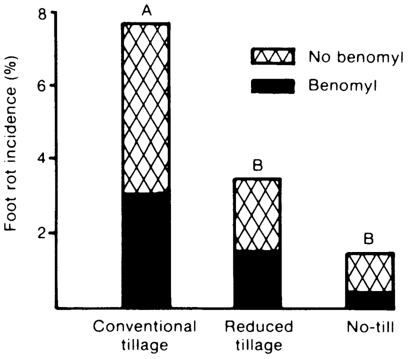

Fig. 1. Foot rot incidence as influenced by tillage and benomyl treatments, May 1982. Different letters indicate significant ($P = 0.05$) differences according to Duncan's multiple range test. Benomyl and no-benomyl treatments were significantly ($P = 0.05$) different (*t* test) within all tillage treatments.

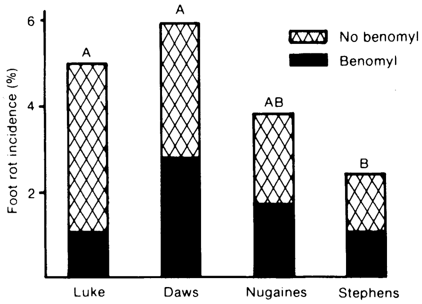

Fig. 2. Foot rot incidence as influenced by cultivar and benomyl spray, May 1982. Different letters indicate significant ($P = 0.05$) differences between cultivars according to Duncan's multiple range test. Benomyl and no-benomyl treatments were significantly ($P = 0.05$) different (*t* test) within all cultivars.

In 1981, analysis of early (GS 3.0) and late (GS 6.7) disease readings uncovered significant cultivar × tillage and rotation × tillage × benomyl interactions, respectively. Early and late foot rot incidence averaged 8% under reduced tillage and 3% under no-till. In 1982, at GS 3.2 (May) and GS 6.9–7.4 (July), conventional tillage supported about two times more foot rot than reduced tillage and about four times more foot rot than no-till (Fig. 1). In early spring (GS 3.2), statistical analyses were not complicated by treatment interactions and a tillage main effect on disease was uncovered. Disease incidence in control (no-benomyl) plots ranged from 7.5% in conventional tillage to 1.7% in no-till (Fig. 1). After heading (GS 6.9–7.4), foot rot incidence showed a significant four-way interaction with tillage, rotation, cultivar, and benomyl treatments.

The effect of rotation on disease incidence was inconsistent. In 1981, rotation 1 supported 2.5% foot rot compared with 5 and 9% in rotations 2 and 3, respectively. In 1982, rotations 2 and 3 supported the lowest levels of foot rot (2.5 and 3%, respectively). These levels were significantly lower than the 6.8% foot rot in rotation 1.

Cultivar selection significantly interacted with preplant tillage to influence disease incidence in 1981. In 1982, a significant cultivar main effect on disease was exhibited (Fig. 2). Daws supported the highest disease incidence in 1981 (10% under reduced tillage) and again in 1982 (5.8%). Stephens, on the other hand, supported the lowest disease incidence in both years (1.8% in 1981 and 2.2% in 1982) (Fig. 2).

Nitrogen had no significant effect on disease incidence in 1981 at either GS 3.0 or 6.7 and was eliminated from the experiment in 1982.

Effects of cultural practices on yield. Significant differences in seed yield occurred between cultivar, tillage, and benomyl treatments in both years. In 1982, an analysis of seed yield among all treatments showed three significant three-way interactions between rotation, preplant tillage, cultivar, and benomyl treatments (Fig. 3). Conventional tillage and benomyl application supported the highest yields, whereas lowest yields occurred in no-till and no-benomyl plots. Stephens under no-till was an exception in that significantly higher yields occurred in no-benomyl plots than in benomyl plots. This phenomenon was observed in 1981 as well.

DISCUSSION

Certain management practices currently employed to control foot rot and soil erosion in the Palouse may be counterproductive. Controlling foot rot by late seeding often contributes to soil erosion. Likewise, application of fungicide is an unnecessary expense when the threat of foot rot is low or nonexistent. Simultaneously reducing foot rot and soil erosion by reduced preplant tillage (Fig. 1) resolves, at least in part, two principal problems associated with Palouse wheat production. This study and previous data (9,19) suggest that a reduction in foot rot by one-half and a threefold decline in erosion may be realized from reduced tillage. Although no-till provides the greatest disease and erosion control, resultant seed yields may be unacceptably low (Fig. 3). Resultant yields, however, must be interpreted in light of reduced tillage costs, reduced foot rot inoculum, and disease development and interactions

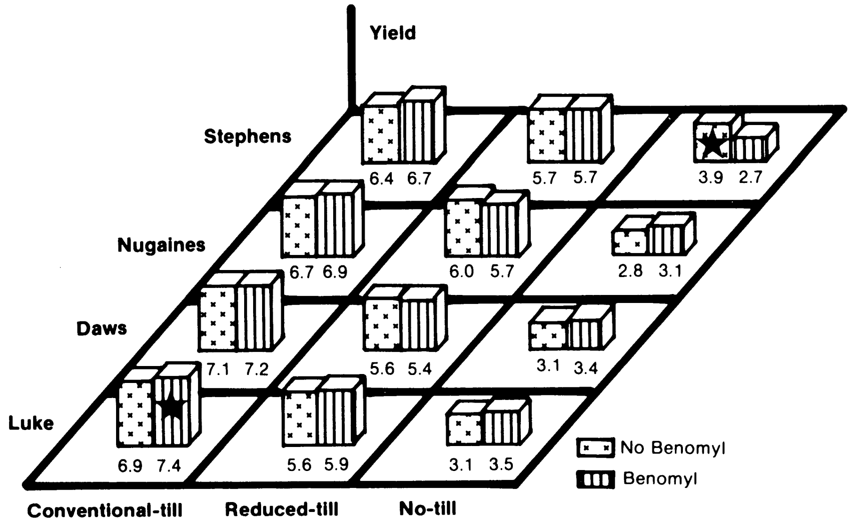

Fig. 3. Seed yield as influenced by cultivar, tillage, and benomyl spray, 1982. Significant ($P = 0.05$) difference between benomyl and no-benomyl treatments designated by a star (Fisher's LSD). Seed yield expressed in t/ha.

with cultivar and rotation choices.

In both years of this study, seed yield was influenced by tillage, cultivar, and benomyl variables. The repeated interaction of these variables (Fig. 3) indicates the importance of each as yield determinants and demonstrates in part the dynamic nature of the local wheat production system.

Greater differences in foot rot incidence between benomyl/no-benomyl treatments have been realized in other tests (6,12,20) and would be expected under conditions of greater disease pressure than were present in this study. Without supplemental inoculation, late seeding of the experimental plots in both 1981 and 1982 is probably responsible for the relatively low disease levels that resulted (6,12). Within both years and all experimental plots in this study, wheat entered winter dormancy at the three-leaf stage (GS 1.3). Therefore, resulting differences in foot rot incidence cannot be attributed to differences in overwintering growth stage.

Heretofore, it was suggested that tillage influenced foot rot by affecting plant growth (3,7). In this study, each of our measurements and statistical analyses confirmed that preplant tillage variables exerted a significant effect on foot rot incidence. Preplant tillage affected foot rot both in interaction with other practice variables and as an independent main effect. In both cases, reduced levels of foot rot were associated with reduced-tillage treatments.

The significant reduction of foot rot associated with reduced tillage and especially no-till practices may be related to straw at the soil line separating the plant's lower stem from the pathogen located below in the soil. Also, differential tillage and straw placement may provoke differential fungistasis and biocontrol mechanisms that act on *P. herpotrichoides* (1,2,8,14).

This study found the cultivar Stephens to support the lowest foot rot levels (Fig. 2). Stephens, relative to Daws, Luke, and Nugaines, has a wider hypodermis and may anatomically resist foot rot infection (18).

The different levels of supplemental nitrogen investigated in this study did not significantly affect disease incidence. However, all nitrogen treatments were relatively high and soil pH between N treatments was not different (16). Differentially lowering soil pH with ammonium-based fertilizers (1,2,16) could alter soil microflora, soilborne pathogens, and foot rot incidence.

The consistent appearance of foot rot in recent years in the Palouse has been attributed to early seeding, cool wet weather, and lush vegetative growth associated with heavy fertilization. Also, the high-yielding susceptible cultivars currently grown tend to develop a dense crop canopy in autumn and create a microenvironment conducive to infection. In recent years, the use of such cultivars in rotation with nonhost legumes or green manure crops has been rare while successive conventionally tilled wheat crops have been commonplace. Until cultivars truly resistant to foot rot are available, use of reduced tillage in conjunction with longer rotations and late seeding of winter wheat may limit foot rot and soil erosion while maintaining yields at or near economic levels.

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