EFFECT OF *RHIZOCTONIA SOLANI* INOCULUM DENSITY AND SUGARBEET VARIETY SUSCEPTIBILITY ON DISEASE ONSET AND DEVELOPMENT

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Rhizoctonia diseases (seedling damping-off and crown and root rot, RCRR), caused by *R. solani* AG 2-2, continue to be among the most common problems on sugarbeet in the Red River Valley and southern Minnesota. Fungicides are available for in-furrow and postemergence applications for control of *Rhizoctonia*, but questions continue to arise about the timing of postemergence applications. Azoxystrobin (Quadris) is effective against RCRR in sugarbeet when applied prior to infection, but is less effective or ineffective after infections have occurred (9). Thus, knowing when infections begin to occur (disease onset) is critical to making timely, effective postemergence fungicide applications.

Rhizoctonia crown and root rot is influenced by soil temperature and moisture. Bolton et al. (1) found 11 growing degree days per day necessary for infection, and disease developed at as little as 25% soil moisture holding capacity and increased with increasing soil moisture. Several studies have evaluated the effect of soil temperature at application of azoxystrobin on control of RCRR (4, 5, 6, and 7). Applications of azoxystrobin at 4-inch soil temperatures ranging from 50 to73°F resulted in statistically equal disease control and recoverable sucrose per acre, but application at 62 to 67°F tended to give best results in 2003 and 2005 (5, 6). This has led to the adoption of a 65°F 4-inch soil temperature threshold for applying postemergence fungicides for control of RCRR. However, this threshold is often reached before sugarbeet seedlings emerge, or shortly after emergence when there is not much foliage present for making a postemergence application. In addition, results have not always been consistent. In 2005, Jacobsen et al. reported significant control with azoxystrobin applications at 4-inch soil temperatures up to 80°F, which was higher than in previous years (4). In Michigan, soil temperature thresholds did not improve efficacy of azoxystrobin applications, and the authors found planting date, seedling development, or leaf stage more reliable indicators of when to apply fungicides (7).

While soil temperature and moisture are clearly important in infection and development of RCRR on sugarbeet, other factors, such as inoculum density and variety resistance also may play an important role. For instance, higher inoculum densities of the soilborne pathogen *Verticillium dahliae* resulted in earlier disease onset in cauliflower compared to lower inoculum densities (10). Similarly, in Fusarium wilt of chickpea, increasing inoculum density of *F. oxysporum* caused an exponential reduction in disease incubation period (8). Also, planting moderately resistant peanut varieties delayed onset of epidemics of Cylindocladium black rot (3).

OBJECTIVES

A field trial was established to evaluate the effect of *R. solani* inoculum density and sugarbeet variety susceptibility on onset and development of Rhizoctonia damping-off and root and crown rot.

MATERIALS AND METHODS

The trial was established at the University of Minnesota, Northwest Research and Outreach Center, Crookston. A factorial set of treatments (*R. solani* inoculum density x variety susceptibility) was set up in a randomized complete block design with four replicates. Inoculum density treatments included 0, 20, 40, and 60 kg ha^{-1} *R. solani*-infested whole barley grain broadcast in plots and worked into the top 4 inches of soil with a Melroe multiweeder prior to planting on May 1. Variety susceptibility treatments included a partially resistant, moderate, and susceptible variety. Seed was sown at a 4.5-inch spacing May 1 into 6-row plots (22-inch row spacing) that were 25 ft long. Counter 20G (6 lb/A) was applied at planting for control of root maggot and glyphosate (4.5 lb product ae/gallon) was applied on May 22, June 4, and June 25 (22 oz/A) for control of weeds. Plots were irrigated with trickle-tape for 6 hours on May 16, 3 hours on May 22, and 3.5 hours on June 4. Cercospora leafspot was controlled by Super Tin

80WP + Topsin M 4.5F (6 oz + 7.6 fl oz product) and Headline (9 oz product) in 20 gallons of water A^{-1} with a tractor-mounted sprayer with TeeJet 8002 flat fan nozzles at 100 psi on July 27 and August 17, respectively.

Soil samples were taken from the top 6 inches 2-3 times weekly from planting until August 10 to calculate percent soil moisture, and 4-inch soil temperature and moisture (kPa) were recorded at 1-hour intervals throughout the growing season. Plots were intensively counted and sampled for RCRR to determine onset of either damping-off (stand counts) or RCRR (root ratings). Stand counts were taken on the center two rows of each plot three times weekly beginning 13 days after planting through 7 wk after planting. Ten plants were arbitrarily sampled from each plot (5 each from rows 2 and 5) of two replicates and rated for RCRR (0-7 scale: 0 = no disease, 7 = root completely rotted, plant dead) weekly from June 25 to August 7.

The center two rows of plots were harvested October 1. Data were collected for number of harvested roots, yield, and quality. Twenty roots per plot also were arbitrarily selected and rated for severity of RCRR using a 0 to 7 scale (0 = healthy root, 7 = root completely rotted and foliage dead). Because many plants had been removed from rows 2 and 5 earlier in the season for RCRR sampling, data for root yield and quality was not analyzed.

Data were subjected to analysis of variance using SAS Proc GLM (SAS Institute, Cary, NC). Means were separated by Fisher's Protected Least Significant Difference ($P = 0.05$).

RESULTS

There were no significant inoculum density x variety interactions, so main effects of inoculum density and variety susceptibility on plant stand and RCRR are discussed separately.

Four-inch soil temperature maxima were consistently above 65 °F beginning May 9 (8 days after planting), dipped below 65 °F from May 26-29, then continued to stay above 65 °F for the rest of the growing season (Fig. 1 & 2). Soil moisture ranged from 23 to 28% from planting to the middle of June, during the period when stand counts were taken and from 15 to 20% for July and early August. Despite favorable soil temperatures, there was very minor disease pressure throughout the growing season, and stand loss due to inoculum of *R. solani* was minimal (Fig. 1). There was no significant effect of inoculum density on stand (Fig. 1). There was, however, a significant effect of variety on plant stand from 2-7 wk after planting (Fig. 2). Stands for the resistant variety were significantly higher than the moderate and susceptible variety from 2-5 wk after planting and higher than the susceptible through 7 wk after planting (Fig. 2).

Root rot ratings were low throughout the growing season including at harvest (Fig. 3 and 4). There was a significant linear response of root rot rating to inoculum density for only 1 of 7 rating dates (July 5, Fig. 3). Even though root rot ratings were very low, there were significant ($P = 0.05$) differences among varieties on 3 out of 7 rating dates (Fig. 4). On July 5, the moderate variety had higher root rot ratings than the resistant and susceptible varieties. The resistant variety had lower root rot ratings than the moderate variety on July 20 and lower ratings than the moderate and susceptible varieties at harvest (October 1).

DISCUSSION

Although soil temperature maxima were greater than 65 °F from the time seedlings were emerging through most of the growing season, there was little disease pressure in plots inoculated with *R. solani*-infested barley at 20, 40, or 60 kg ha^{-1}. In 2010, inoculum density of 35 kg ha^{-1} *R. solani*-infested barley resulted in ~30% stand reduction over 4 wk compared to non-inoculated plots (2). By comparison, in this trial, stand reduction from the non-inoculated plots for the susceptible variety after 4 wk was 0, 13, and 6% for inoculum densities of 20, 40, and 60 kg ha^{-1}, respectively. A major objective of this trial was to determine the onset of disease, but this could not be determined because even plots with the highest inoculum densities did not lose more stand than is typical for sugarbeet under non-disease situations. Mean root rot ratings were below 1.5 for all treatments through August 7, and were still under 2 at harvest. A root rot rating of 2 = shallow rot, dry rot cankers, or active lateral lesions affecting ≤ 5% of root. This rating typically does not have an impact on root yield or quality.

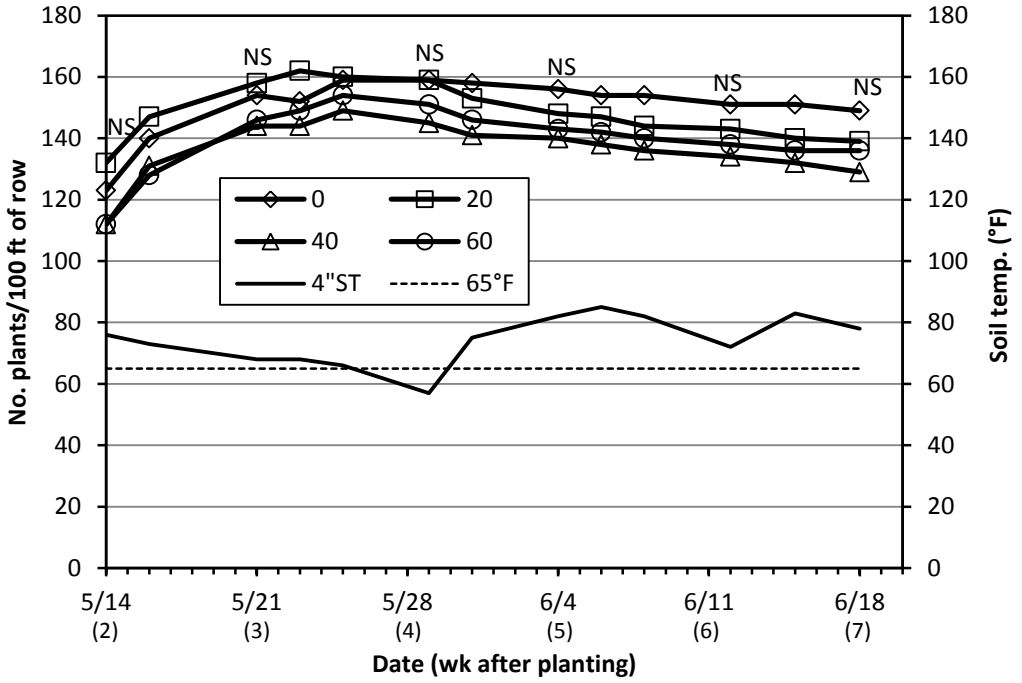

Fig. 1. Plant stand across three sugarbeet varieties sown in plots infested with *Rhizoctonia solani* at various inoculum densities (0, 20, 40, and 60 kg ha^{-1}) and 4-inch soil temperature maxima (4"ST) in a field trial sown May 1. The dotted line shows 65 °F soil temperature threshold for favorability for *R. solani*-infection.

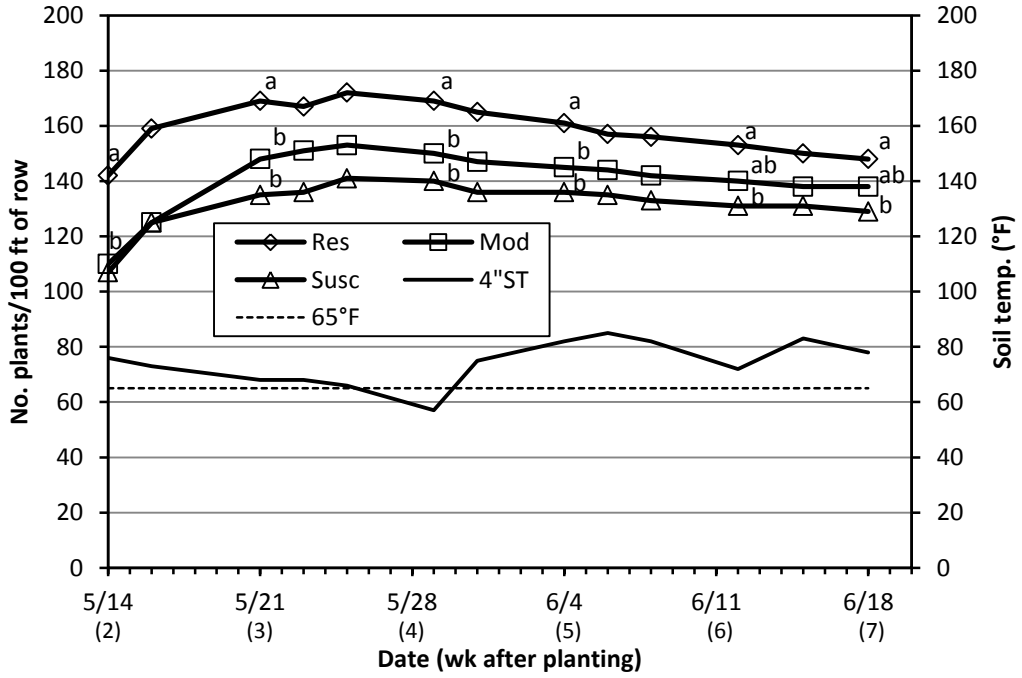

Fig. 2. Plant stand for three sugarbeet varieties sown in plots infested with *Rhizoctonia solani* across four inoculum densities (0, 20, 40, and 60 kg ha^{-1}) and 4-inch soil temperature maxima (4"ST) in a field trial sown May 1. The dotted line shows 65 °F soil temperature threshold for favorability for *R. solani*-infection.

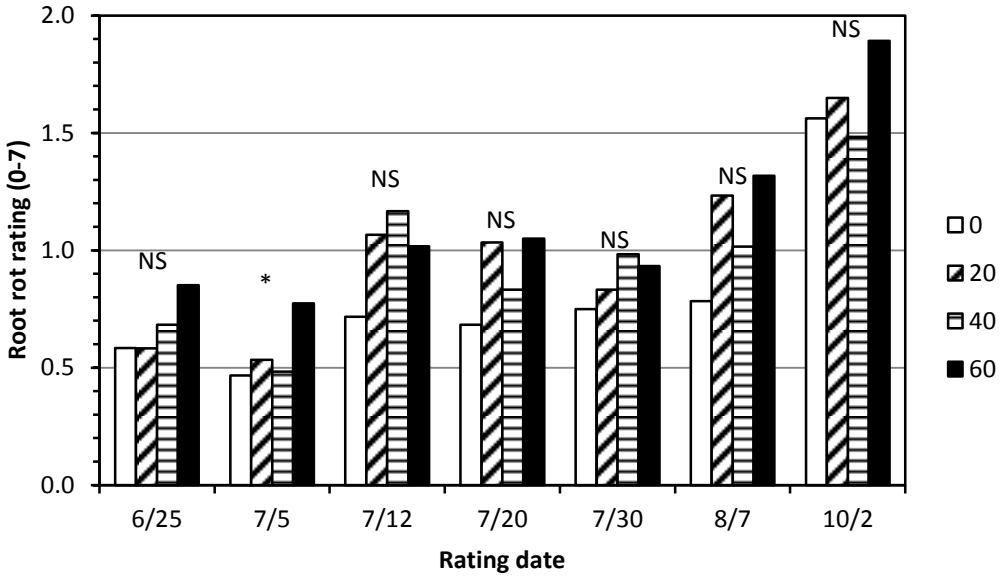

Fig. 3. Root rot ratings (0-7 scale, 0 = no disease, 7 = root completely rotted, plant dead) across three sugarbeet varieties sown in plots infested with *Rhizoctonia solani* at four inoculum densities (0, 20, 40, and 60 kg ha^{-1} in a field trial sown May 1. Bars represent mean of 60 rated roots (10 roots/plot x 3 varieties x 2 replicate plots rated at each timing). For each rating date, * = significant (P = 0.05) linear response of root rot rating to inoculum density; NS = not significantly different.

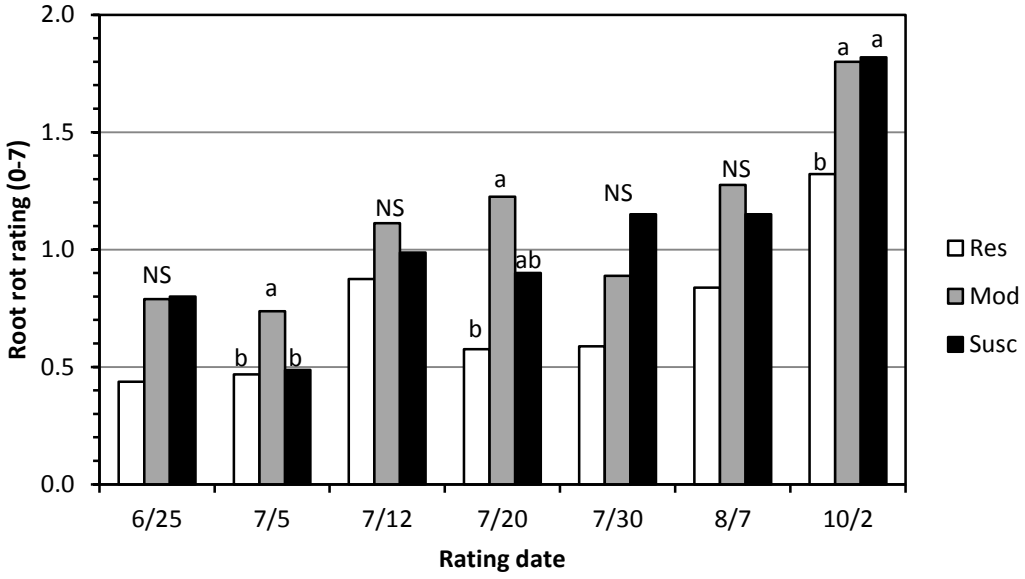

Fig. 4. Root rot ratings (0-7 scale, 0 = no disease, 7 = root completely rotted, plant dead) for three sugarbeet varieties sown in plots infested with *Rhizoctonia solani* across four inoculum densities (0, 20, 40, and 60 kg ha^{-1} in a field trial sown May 1. Bars represent mean of 80 rated roots (10 roots/plot x 4 inoculum densities x 2 replicate plots rated at each timing). For each rating date, bars sharing a letter are not significantly different (P = 0.05); NS = not significantly different.

The lack of disease pressure in this trial in the presence of favorable soil temperatures, high inoculum densities, and a susceptible sugarbeet variety illustrates the importance of soil moisture as another environmental factor influencing disease onset and development. Soil moisture from May 1 to August 10 ranged from 15 to 28%, which may have been too low for *R. solani* to infect many roots or for the pathogen to develop within infected roots. Further research should incorporate soil moisture as a factor.

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