New York's Most Prevalent Beet Root Pathogen, *Rhizoctonia solani*

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Background

Rhizoctonia root rot, caused by the fungal pathogen *Rhizoctonia solani*, continues to reduce table beet yields and economic returns for New York Beet growers. This disease is a concern for several reasons:

1) *R. solani* can reduce stand establishment via damping off
2) Developing and mature roots can be infected, limiting growth and harvest quality
3) Fungal material can persist in soil for several years, fueling future outbreaks
4) Many crops and weeds are susceptible, causing crop rotation to non-hosts to be difficult

Symptoms of this disease on mature roots include black lesions, growth cracks with dark tissue, and dark lesions inside the beet with brown spongy tissue. The fungus itself can occasionally be seen inside the infected beet as white mycelium. Under a microscope, *R. solani* produces distinct hyphae with right-angle branching pattern and dark septa. Thicker, tougher fungal structures called sclerotia can be produced. Sclerotia are long-lived in soil and allow the fungus to survive through harsh winter conditions.

The species *Rhizoctonia solani* contains a relatively large amount of genetic diversity. *R. solani* is divided into 21 different anastomosis groups (AG). These groupings are determined by which isolates fuse mycelium with one another. Only a few AG groups are pathogenic to table beets. AG 2-2 IIIB and AG 2-2 IV are the most virulent table beet pathogens and have both been found in New York infecting seedlings and mature beets. *R. solani* AG 4 is sometimes found to be a problem in beets, but AG 4 tends to cause damping off rather than root rot in mature beets.

Disease Cycle and Epidemiology

During the growing season, *R. solani* germinates from sclerotia that have survived in the soil through the winter. Some sclerotia can remain viable for 3-4 years. The fungus grows and infects host roots, first by colonizing root surfaces. Infection of mature roots leads to symptoms like black lesions, growth cracks, and spongy brown and black rot inside the beet.

There are three requirements for epidemics to occur, commonly known as the disease triangle

1) The pathogen in a viable and infectious form: In this case, either sclerotia or fungal mycelium. *R. solani* does not form spores.
2) A susceptible host: Beets, corn, legumes, or other vegetable crops.
3) Environmental conditions that promote disease: *R. solani* AG 2-2 prefers 55°F to 95°F soils temperatures, with fastest growth occurring above 70°F. Poorly drained soils encourage disease development. However, wet conditions are not required. *R. solani* can grow and infect beets in dry soils as well.

Rhizoctonia disease control and management

Chemical controls (fungicides) emphasize early-season protection against *R. solani*, when young plants are most vulnerable. Azoxystrobin (FRAC 11, tradename: Quadris) is typically applied in-furrow. New York beet growers have moved away from a second application of azoxystrobin, which may or may not offer improved control compared to a single application. *Rhizoctonia* isolates from other regions and cropping systems have been found to be resistant to azoxystrobin, but azoxystrobin resistance has not been detected in New York populations of *R. solani* AG 2-2. The reliance on a single mode of action (QoI inhibitor) for *Rhizoctonia* disease management presents a high risk of resistance development. Fungicide seed treatments have also become standard in the NY beet industry, including fludioxonil (FRAC 12), which has some efficacy against *R. solani*.

Cultural controls for *R. solani* center around removing susceptible hosts from the system and allowing built-up inoculum to degrade over time. Beets are typically grown on a five-year rotation. More non-host crops (e.g. small grains) included in the rotation mean greater reduction in inoculum and better disease management. Common rotation crops include corn, soybeans, small grains, snap beans, and peas. Importantly, corn, legumes, and vegetable crops can all host *Rhizoctonia*, maintaining or even increasing inoculum in the soil.

Cornell AgriTech's ongoing beet research

Current plant pathology research at Cornell AgriTech seeks to provide growers with tools to optimize table beet crop stand and ensure high quality roots. Early season disease management and informed risk-based decision making are priorities. Quantifying pre-season inoculum from *R. solani* DNA in the soil can help to predict risk of disease during the upcoming season. This information can help growers make decisions on prophylactic fungicides, post-emergent applications, or extended crop rotations. The Pethybridge lab has previously developed a novel technique for extracting DNA from 100-gram soil samples, which can reduce variability and improve accuracy compared to conventional methods.

Besides inoculum, other fungi and bacteria living in the soil can also affect disease development. Interactions between this microbiome and *R. solani* could mitigate disease risk and possibly provide new avenues of disease management.

In the summer of 2019, an early season root disease trial was conducted at Cornell AgriTech in Geneva, NY. Beets were planted according to industry and research standards. Plots were inoculated with an isolate of *R. solani* AG 2-2 from a western NY beet field, confirmed to be pathogenic on beets. Treatments consisted of one or two applications (in-furrow and/or post-emergent) of the products listed below (Table 1). Data on crop stand, root quality, and disease incidence and severity were collected and analyzed. The low incidence of disease caused by *R. solani* across the trial compromised the ability to differentiate between treatments. While stand counts decreased as the season progressed, differences between treatments were not significant. A replication is planned for the summer of 2020 with changes to the inoculation procedure that will ensure higher levels of disease development and minimize variation.

Products	Active Ingredient (s)	Mode of action	FRAC Group
Quadris (0.8 oz/1000 ft)	Azoxystrobin	QoI	11
Elatus (0.5 oz/1000 ft)	Benzovindiflupyr + azoxystrobin	SDHI + QoI	7 + 11
Solatenol (0.57 oz/1000 ft)	Benzovindiflupyr	SDHI	7
Orondis Gold (0.18 oz/1000 ft)	Oxathiapiprolin + mefenoxam	OSBPI + PA	49 (U15) + 4
Uniform (0.34 oz/1000 ft)	Azoxystrobin + mefenoxam	QoI + PA	11 + 4
Cannonball (0.5 oz/1000 ft)	Fludioxonil	PP	12

Table 1. Products used for the 2019 Early Season Disease Trial. Both Quadris and Elatus were applied at three different levels (in-furrow, post-emergent, in-furrow + post-emergent). Orondis Gold was applied in-furrow only. Uniform, Cannonball, and Solatenol were applied in-furrow + post-emergent.