UNDERGROUND Ally

Natural fungal protection against sugarbeet cyst nematodes

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Harvested sugarbeets on their way into the processing facility in Brawley, Calif. © 2020 Paul Ruegger

The sugarbeet cyst nematode Heterodera schachtii is a significant pathogen of sugarbeets worldwide. It infects more than 200 different plants, including many important cole crop vegetables, often causing considerable economic loss.

California's only remaining sugarbeet factory is located in the town of Brawley in the Imperial Valley, close to the Mexican border. The area's low desert climate is characterized by hot summers and mild, sunny winters. When the Holly Sugar Corporation opened its factory in 1947, the surrounding farmland was free of H. schachtii. However, the nematode was quickly introduced, most likely with contaminated seed or machinery from other sugarbeet-growing areas along the California coast, where beets had been grown the late 1870s. Today, sugarbeet production in California is limited to about 25,000 acres in the Imperial Valley. The crop is seeded in fall and harvested from April to early August, and, despite the nematode's widespread presence, the growers produce the highest gross sugar yields per acre in the U.S.

Young, white female Heterodera schachtii on host roots. © 2017 J. Ole Becker

Since the 1960s, the primary strategy Imperial Valley growers have employed to mitigate yield reduction due to H. schachtii has involved monitoring the level of cyst infestation at harvest. When the number of H. schachtii cysts exceeds an economically damaging threshold, growers are contractually required by the local sugar factory to either crop that field for three to five years with plants that do not support the nematode's reproduction or to leave it fallow. The natural population decline is approximately 50 percent per year, mainly due to the nematodes hatching when no host plant is present and microbial parasitism.

One of the microorganisms responsible for the population reduction is a soil fungus that consumes nematode females and eggs. This fungus, Hyalorbilia aff. multiguttulata (formerly Dactylella oviparasitica) was initially shown by nematologists and plant pathologists from the University of California, Riverside (UCR) to cause long-term suppression of sugarbeet cyst nematode populations in a field at the university's agricultural operations near Riverside. Other scientists detected closely related fungal species in Arkansas

Hyalorbilia fungus destroying a young sugarbeet cyst nematode egg. © 2017 J. Ole Becker

and California's Central Valley, which parasitized and destroyed soybean cyst and root-knot nematodes, respectively.

The feature that all these nematode species have in common is that the femaile remains stationary for her whole life in a host root. While the head is embedded next to root cells that serve as her feeding sites, the body's back end enlarges during maturation and breaks through the root surface. After mating with motile H. schachtii males, the females produce several hundred eggs, mostly contained within her body. This life stage is visible as a diagnostic symptom when roots are dug up and carefully examined. The females are detectable as tiny, lemon-shaped white bodies on host roots. This is the most vulnerable phase for an attack by Hyalorbilia species, which utilize the nematode and young eggs as a food source. The destruction of the female and her undifferentiated eggs by the fungus prevents the development of hundreds of infective juveniles, leading to a dramatic nematode population suppression.

In recent studies, researchers at UCR determined that Hyalorbilia fungi were often associated with H. schachtii females in Imperial Valley sugarbeet fields. They were found in representative samples from 21 of 25 fields. More importantly, the presence of young H. schachtii females parasitizing their plant hosts led to an approximately 10,000-fold increase in the population densities of these cyst nematode-destroying fungi during one nematode generation. As H. schachtii goes through up to five generations per cropping season in the Imperial Valley, this suggests that the populations of these natural antagonistic fungi may continue to expand with each nematode life cycle throughout the sugarbeet-growing period. The practical consequence of this discovery could be a considerable increase in the frequency of sugarbeet plantings. When the population densities of both the cyst nematode and the Hyalorbilia fungi are above their threshold values, confirmed by laboratory analysis, the research suggests that cropping sugarbeets would lead to the development of an H. schachtii-suppressive soil by the time the sugarbeets are harvested.

To avoid an early-damaging impact of H. schachtii on sugarbeets, it is suggested that this first planting use a cultivar that can endure parasitism by the nematode with reasonably little impact on beet growth. As the reproduction of H. schachtii on such tolerant cultivars is still abundant, it would provide a sufficient number of young females and eggs to enable a substantial Hyalorbilia population expansion, thereby creating a nematode-suppressive soil. Growers should be able to maintain this nematode suppressiveness by following the study's cropping guidelines. This will give growers considerable cropping flexibility and be based on prior research showing the relationships between the type of crop planted and the stability of the nematode suppressiveness.

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