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Take-All Disease of Wheat in Idaho

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Introduction

TAKE-ALL, A FUNGAL DISEASE OF cereals caused by *Gaeumannomyces graminis* var. *tritici* (Ggt), has a wide host range in the grass family. Of our agriculturally important crops, it mainly infects wheat, barley, rye, and occasionally oats. Ggt is the most economically important take-all pathogen of the three common subspecies. The other two (var. *avenae* and var. *graminis*) are more commonly associated with severe disease in oats, rice, and turfgrass and are much less aggressive to wheat. The disease was named "take-all" due to the pathogen's ability to infect multiple parts of the plant, mainly the roots, crown, and stem base, at times resulting in the crop's complete destruction. It is one of the most economically important root diseases of wheat worldwide, wherever small grains are cultivated, since it is a common natural inhabitant of the roots of wild grasses.

Take-all commonly reduces wheat yields by 10%–25% and is most serious in the northern and eastern parts of Idaho and throughout the irrigated Snake River Plain where crop rotations are limited. In a survey of 270 wheat fields in the Pacific Northwest that had been planted to winter or spring wheat the previous year (high risk) or two years earlier (medium risk), 75% had enough take-all to reduce production. Take-all disease becomes challenging when fields are used for small grain production for two or more years or following other crops, like alfalfa. This is also the case in which grasses or cereal volunteers are not controlled, in areas of higher rainfall or excessive irrigation.

Symptoms

Aboveground

When wheat is infected with take-all, the plant has fewer tillers, matures early, and may be stunted. Foliar symptoms reflect damaged roots, resulting in symptoms of nutrient deficiencies and rapidly senescing yellow leaves. Take-all disease is often evident on the blackened crowns and white heads, where the most visible symptom is the formation of empty white heads on prematurely ripe tillers (Figure 1). Black fungal growth wraps the wheat stem base under leaf sheaths, resulting in shiny, streaky black, or completely black "stockings." The pattern of occurrence in the field could be circular patches or uniformly scattered white heads throughout the field. Affected circular patches are usually observed in low areas where soil moisture is highest and where the aboveground symptoms are more prevalent. Severe infections result in reduced tillering, stunting, and the rapid development of white heads in hot, dry conditions during grain fill.

Figure 1. Healthy (left) and diseased (right) wheat plants infected with the wheat take-all pathogen. Stunted plants have fewer tillers, yellowed leaves, poorly developed roots, and prematurely dry down, resulting in empty white heads.

Figure 2. Shiny, black wheat stem bases and roots are typical symptoms of take-all disease.

Figure 3. Blackening of the wheat stem base with black fungal growth. Courtesy of the Plant Diagnostic Laboratory, Parma Research and Extension Center.

Belowground

A diagnostic characteristic for take-all is when wheat roots turn black and become brittle. Stems have a shiny black "stocking" at the stem base (Figures 2 and 3). Lesions formed on the roots coalesce and the entire root system becomes weak and remains in the soil when plants are pulled up. The shiny black discoloration on the stem is evident when lower leaf sheaths are removed and are often speckled with the fungal fruiting bodies.

Disease Cycle

In the absence of living hosts, infected residue from the previous season allows Ggt to survive in the form of *mycelium* (fungal threads). As a weakness, Ggt is not competitive as a *saprophyte* (living off dead plant tissue) with other native soil microflora. Ggt infects grassy weeds, volunteer cereals, and cereal crops, remaining active when the availability of host roots and moisture in the soil is high and the fallow period is short.

Roots are infected through infested debris; then the fungi spread plant to plant by fungal threads called runner hyphae (Figure 4) that grow on the surface of roots, infect the cortex, stele, and root endodermis, moving both upward and downward along the root axis until the stem is colonized and the roots die. *Black fruiting bodies* (perithecia) of the fungus form at the base of infected stems toward the end of the growing season.

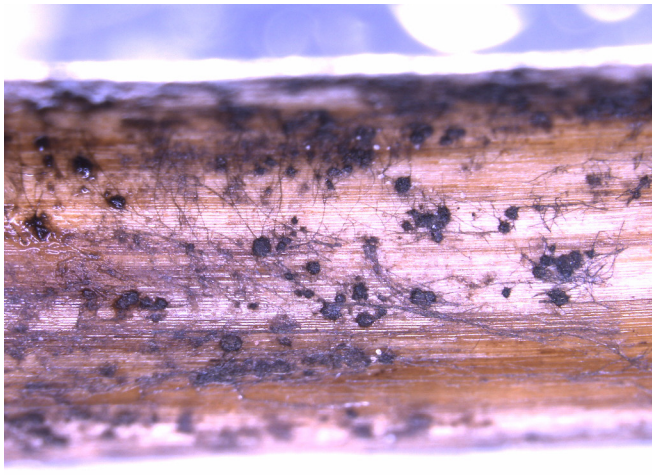

Figure 4. Dark runner hyphae and mycelial mats of the fungus on the root surface. Courtesy of Plant Diagnostic Laboratory, Parma Research and Extension Center.

The dark, flask-shaped perithecia on lower leaf sheaths and stems are the sexual stage of the fungus and contain microscopic sacs called asci. Each individual ascus bears eight elongated spores called ascospores, though these spores do not play an important role in the disease cycle. Spread of Ggt to other plants instead is facilitated by runner *hyphae* growing from plant to plant via root *bridges* (plant contacts formed by the roots of neighboring plants). Ggt then advances toward the crown and eventually kills it.

As a soilborne pathogen, Ggt can be transported by animals and farm machinery with soil and infected plant debris. Soil moisture is considered a key factor in the incidence and severity of the disease. Symptoms may be limited to the roots when moisture is low and may not be detected; crown and stem base infection and stunted plants appear when moisture is high. Short rotations favor Ggt survival and second- to third-year grain production often suffers significant disease damage. A common crop rotation in southern and eastern Idaho of potato–wheat–wheat results in significant soilborne disease populations due to insufficient breakdown of infested residue.

Disease Management

No take-all resistant wheat varieties are available; therefore, cultural practices are the only management strategies that effectively reduce disease.

Cultural Practices

Cultural practices have been widely utilized for the management of take-all disease. Of the cultural practices that are available, crop rotation is considered the most important and the most effective. To reduce the fungal inoculum in the soil, it is best to avoid planting wheat and barley for at least a year and rotate with a broadleaf crop. Manage grassy weeds in rotation crops like perennial alfalfa to reduce the survival of the pathogen. Light-textured soils with low fertility favor disease development as it decreases plant health and creates a loose seedbed in which Ggt can spread from root to root more easily. Continuous wheat cultivation in consecutive years until the third or fourth cropping

season results in the highest risk of take-all. In contrast, disease severity may decrease and yield may increase with the fifth and sixth cropping cycle due to buildup of soil microorganisms antagonistic to Ggt, a condition known as *take-all decline.* The development of suppressive soils against Ggt is due to the buildup of populations of antagonistic bacteria in the genus *Pseudomonas,* which produce antibiotics that accumulate in the rhizosphere. Incorporation of soil with chicken manure may also stimulate antagonistic microorganisms. Good soil drainage and cultivation of nonsusceptible crops can significantly reduce the inoculum level in the soil. Early season infections (either fall or spring) result in the greatest damage, which increases under mild temperatures (50°F–68°F) and moist soil at neutral to alkaline pH. Under acidic conditions, disease severity tends to decline but can increase when soils are limed.

Burning wheat stubble is not effective in disease reduction because the heat generated is not enough to kill infected material belowground. Use of tillage as a cultural practice to manage take-all is inconclusive. For example, some studies have shown that burying residue can reduce take-all severity but other work, including those conducted in the Pacific Northwest, has shown no effect or even lower disease severity with direct seeding in no- or low-tillage cropping systems.

Maintaining crop health with adequate and balanced fertilization is critical to promoting plant and root growth, since healthier plants are less vulnerable to infection and colonization. Rapid increases of the disease can occur in crops with nutrient deficiencies. The use of ammoniacal and slow-release forms of nitrogen generally reduces take-all because it increases the acidity of the soil rhizosphere and thus becomes more conducive for disease suppression by soil microbial antagonists. Application of chloride-containing fertilizers, such as ammonium chloride, potassium chloride, and calcium chloride, prolongs soil nitrogen in the ammonium form into the season. Nitrogen application during critical stages of crop growth, such as at tillering and stem elongation, is crucial to make up for rotted roots and to induce new root growth. For easy access to nutrients by infected roots, it is advisable at planting to place the fertilizer underneath the seeds.

Under irrigated crop production, consistent irrigation metered to crop demand is also important in reducing take-all, especially in winter cereal crops. Take-all often first appears where excessive moisture builds in low areas of the field or where water pools around damaged irrigation pipes. Planting cereal crops in paired rows can extend crop canopy survival into the growing season and promote drying of the soil (especially in heavier soils). A firm seedbed is preferable to a loose one since it decreases fungal spread along the roots.

Chemical Management

Seed treatments or postemergence fungicide applications have provided inconsistent results; furthermore, no effective fungicides are available for take-all disease. Ggt is present in infested fields throughout the growing season, infecting seedlings after the efficacy of fungicides is reduced. Therefore, the disease continues to be an important problem in wheat fields—not only in Idaho, but in wheat-growing areas worldwide.

Further Reading

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