



INTERNAL DISCOLORATION OF HORSERADISH ROOT

Internal discoloration of horseradish roots is a disease complex, caused by the fungi *Verticillium dahliae*, *V. longisporum*, *Fusarium solani*, and *F. commune*. The disease occurs worldwide and can cause up to 100% of root internally discolored and are not marketable or rot. The disease was first reported to be incited by *V. dahliae*, then further investigations revealed that any or combinations of these fungi can cause internal discoloration of horseradish roots. Infection by *F. commune* often results in root rot.

Symptoms

Internal discoloration of the root begins with dark brown to black discoloration of the vascular system and gradually spreads to inward (core) and outward (cortex) areas in the root (Figure 1). Internally discolored horseradish roots are useless for industrial purposes such as preparing horseradish sauce. Depending on the causal agent, and horseradish cultivar, development of discoloration may differ from one field to another. Root rots may occur, which are usually caused by *F. commune* or by colonization of the infected roots by opportunistic fungi and bacteria.

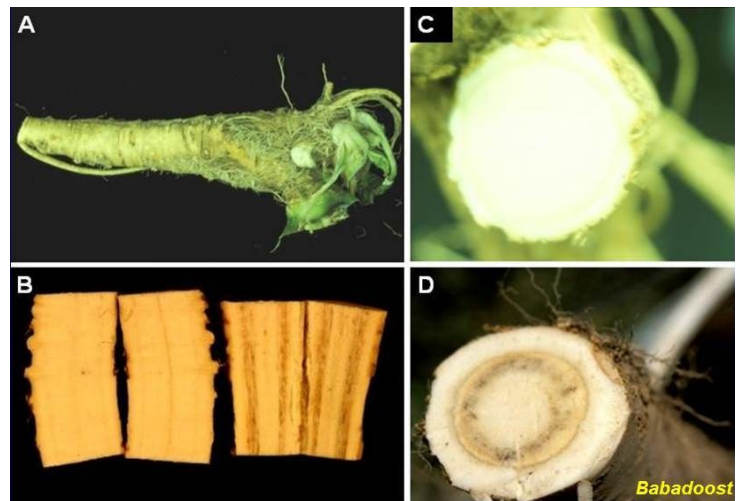


Figure 1. A, Horseradish root; B, longitudinal sections of symptomless (left) and discolored (right) roots; C, cross-section of a symptomless root; and D, cross-section of a discolored root.

Leaf symptoms may also develop when roots are infected by *V. dahliae*. Leaf symptom appears as yellowing tissues near a leaf vein, usually near the leaf margin. The yellowing expands out from the vein and back towards the midrib of the leaf resulting in the formation of a V-shaped lesion. With time, the yellow tissues die and turn light brown.

Disease Cycle

All of the above-mentioned fungal species are soilborne and also setborne (carried in propagative roots). *Verticillium* species overwinter in the soil in the form of small black resting structures called

For further information contact **Mohammad Babadoost**, Extension Specialist in Fruit and Vegetable Pathology, Department of Crop Sciences, University of Illinois at Urbana-Champaign. (Phone: 217-333-1523; email: babadoos@illinois.edu).

microsclerotia. *Fusarium* species survive in soil as chlamydozoospores (thick-walled cells). All of these pathogens are also carried in infected roots. Newly infected roots may be symptomless, but they carry the pathogen from one season to the next. *V. dahliae* and *F. solani* have wide host-range, but host-ranges of *V. longisporum* and *F. commune* are limited to *Brassica* species.

Setborne inoculum results in early-season root discoloration - root discoloration may be observed about four weeks after planting sets. In contrast, root infection and discoloration development caused by the soilborne inoculum may take 12 weeks or longer. By planting infected roots, the pathogens can be introduced to a field with no history of the disease. When the field is infested the pathogen could survive there for a long time.

Disease Management

Once a field is infested, it is very difficult to eradicate the pathogens in the soil. Crop rotation is not a reliable practice for management of the disease because the following reasons: 1) pathogens can survive in the soil for many years, even in the absence of susceptible hosts; 2) once a field is planted to horseradish, small pieces of horseradish roots left in the soil will give rise to plants for several years; and 3) the pathogens have relatively wide host-ranges. However, long-term rotation with grain crops such as corn, wheat, barley may reduce population of the pathogens. Soil fumigation with methyl bromide and/or chloropicrin may also reduce population of the pathogens, but the pathogens inside root pieces will not be affected by fumigation. No horseradish cultivar with adequate resistance to internal discoloration of roots is available.

An integrated strategy was developed to manage internal root discoloration of horseradish roots, which focuses on avoiding severity of root discoloration that makes the roots unmarketable. The procedure is: the sets (propagative roots) saved from previous crop are treated by soaking them in hot-water at 117°F (47°C) for 20 min and then treated either with the fungicide fludioxonil (Maxim 4FS) or biocontrol agent SoilGard 12G (*Trichoderma virens* GL-12). Set

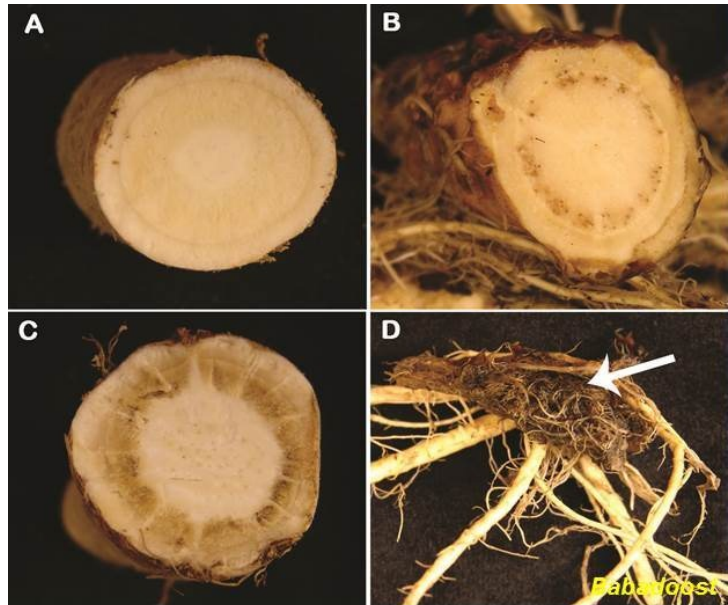


Figure 2. A, Cross-section of an asymptomatic horseradish root; B, cross-section of a horseradish root with internal discoloration caused by *Fusarium oxysporum*; C, cross-section of a horseradish root with internal discoloration caused by *F. commune*; and D, root of main root caused by *F. commune*.



Figure 3. Horseradish sets treated with SoilGard following the hot-water treatment.

treatments can be carried out a few days prior to planting. For treatment with Maxim 4FS, 1 ml of Maxim 4FS is added to 1 liter of water and then hot-water treated sets are placed into the fungicide solution and shaken for 1 min. For treatment with SoilGard, first the sets are soaked with water and then placed in the container (e.g., a plastic bag) with SoilGard and shaken for 10 seconds. The sets will be covered with SoilGard particles (Figure 3). Treated sets can be planted within a week. Hot-water treatment eradicates soilborne inoculum of the fungi. Either Maxim 4FS or SoilGard treatment will protect plant roots against the soilborne inoculum for approximately 12 weeks from planting sets. Then, the roots may become infected by the soilborne inoculum. But if infection takes place, and conditions are conducive for symptom development, it will take about 12 weeks to exhibit internal discoloration of roots to the level that the roots are unmarketable. Horseradish sets are planted in April or May and conditions for root infection by the soilborne inoculum are conducive only from late May through September, thus the time period is not long enough for infection of the roots that can be unmarketable.