Flooding in citrus groves

Trees can be damaged by water standing for days during extended summer rains

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The 2008 hurricane season has already begun. Hurricanes in 2004 and 2005 caused extensive wind and flooding damage in many central and east coast Florida groves. Even without hurricanes, heavy rainfall and inadequate drainage can cause flooding. If water can be removed quickly, flooding injury may be minimal. In some locations, rainfall can be so heavy that it has been impossible to remove the water from the grove rapidly enough to avoid injury.

Research at the University of Florida/IFAS Citrus Research and Education Center showed that there is potential for water damage to citrus trees if water stands over the crown of the tree for four days or more during frequent extended summer rains. Root injury may even occur when the water table remains a few inches below the soil surface and roots are not visibly flooded. When that happens, the grower may not be aware of the potential for root damage. During the cooler months of December through February, citrus trees can tolerate flooded conditions for much longer periods than during the hot summer months.

Water displaces oxygen and allows anaerobic bacteria (which grow only in the absence of oxygen) to develop rapidly in flooded soils. Toxic sulfides produced by anaerobic sulfur-reducing bacteria can build up and kill roots. In a field survey of poorly drained groves, toxic sulfides were formed by anaerobic sulfate-reducing bacteria at more than half the locations.

With experience, flooding injury can be diagnosed during periods when groundwater levels are high. Even before there are visible tree symptoms, auguring and digging in the root zone may give an estimate of future tree condition. Damage can be determined by digging into the soil and smelling root and soil samples. Sour odors or a rotten-egg smell (indicating hydrogen sulfide) is a sign that feeder roots are damaged.

EXCESS WATER SYMPTOMS

Ironically, one of the symptoms of excess water is leaf wilting similar to drought stress. This occurs because flooding and the lack of oxygen increase root resistance to water uptake. Inadequate aeration decreases water absorption. Nevertheless, transpiration, or the loss of water vapor from leaves, continues. Hence, in hot summer weather, tree water loss can be greater than water uptake through the roots and wilting occurs. Because of that, flooding injury occurs sooner in hot weather than in cool weather.

Symptom expression of damage may occur over a period of time depending on the severity of root damage. Symptoms usually start to show up after the water table drops and the soil dries out. Symptoms of root damage include leaf yellowing, chlorosis, wilting, fruit drop, leaf drop and twig dieback. Often, root damage is so severe that trees may go into a wilt even though water furrows are still wet. Because the root system was pruned by the flooding, the full extent of damage may not be known for several months or until drought conditions occur.

More subtle symptoms include reduced growth and thinner foliage. This can occur at field locations only a few inches lower in elevation than the surrounding area. Harvesting operations or other traffic in a grove after recent flooding may further damage surface roots that have been injured by the flooding.

Vegetative material buried during bed formation can provide the energy source for bacteria that reduce sulfates to sulfides. Only a small amount of sulfur (3 ppm) is needed for these bacteria to function. Flood damage is usually less when water is moving than when it is stagnant because anaerobic bacteria cannot multiply if oxygen is present. Good drainage allows air to move into the soil and prevents oxygen-deprived conditions.

In order to understand how citrus trees are damaged by flooding, one needs to understand the soil-water dynamics in a grove. In most flatwoods soils, a clay or organic layer within 20-48 inches of the surface acts as a barrier to downward movement of excess water. As a result, water must move laterally to be drained from saturated soils. The rate at which water moves through soil is expressed in units of distance/time (inches/hr or feet/day) and is called hydraulic conductivity. Sands typically have saturated hydraulic conductivities of 20 inches per hour or more, while the saturated hydraulic conductivity of many flatwoods clay layers is in the range of 0.1-0.2 inch per hour.

Hydraulic conductivity varies tremendously with soil moisture content. Hydraulic conductivity of soil decreases by several orders of magnitude from saturation to permanent wilting point. For example, the saturated hydraulic conductivity of an Oldsmar fine sand soil is about 20 inches per hour when saturated, but drops to less than 0.05 inch per hour when the soil dries to a tension of 85 cbar. Porosity is the volume of pores (air space) divided by the total volume of soil. The quantity of water that can drain out of the soil as the water table is lowered is directly related to soil porosity.

Gravity is the force that moves water in saturated soils. Water in saturated soils moves from a higher to a lower elevation. The difference in elevation between two free water surfaces is called the hydraulic gradient. The steeper the gradient, the faster water will drain from the soil. Excessive rainfall will cause a perched water table to develop above the hardpan in flatwoods soils, and excess water must move laterally toward the water furrow for drainage to occur. Drainage time for aeration to occur may vary from two days in coarse textured soils such as Pineda, Riviera and Immokalee series soils to over a week in heavier textured soils such as Winder.

Under normal conditions, water usually recedes at rates adequate to prevent root damage. Problems develop when rainfall keeps the water table elevated for several weeks. Once the soil is near saturation, it takes only a little rainfall to fill the available pore spaces in the soil and the root zone becomes saturated.

Observation wells are good tools for observing soil-water dynamics. They are the best reliable method for evaluating water-saturated zones in sites subject to chronic flooding injury. Growers can use these wells to measure the rate of water table drawdown. Observation wells constructed with float indicators allow the grower to estimate water table height while driving by the well site. Local offices of the National Resource Conservation Service (formerly SCS) can assist with water table observation well construction and monitoring.

Improper bed formation has been linked to areas with chronic root damage in several groves. Severe sulfide problems have often been found in grove areas that were developed over old swamps that were filled in before planting. Palmetto, cabbage palms and other decomposable organic debris were frequently buried in these areas where land was leveled during preparation. It can take many years for Palmetto roots and stems to decompose in this environment, so they can provide a good source of energy for bacteria that require both energy and sulfates in order to reduce sulfates to toxic sulfides.

Using topography alone as a diagnostic factor to assess potential for flood damage may be misleading. Flooding damage can occur in obvious spots such as poorly drained depressions, but it may also be present where least expected. Flooding injury has been observed on hillsides, on relatively high ground, on isolated areas of flat land, and even on raised beds. Hillsides may have pockets of clay. In flat areas, the problem may be impervious clay, marl or organic layered pockets that hold the water and prevent movement. Even beds in apparently uniform sandy areas can have buried palmetto roots and organic materials. These areas are subject to root damage since the soils are able to support anaerobic bacteria if flooded.

Hot, dry conditions following flooding will hasten the onset of stress and symptom expression. The reduced root system resulting from summer flooding is incapable of supporting the existing tree canopy. When this occurs, irrigation management becomes critical. Irrigation must provide moisture to a depleted (shallow) root system, but excessive water could compound existing problems. Light frequent irrigations will be required until the root zone has become re-established. Subsurface moisture should be maintained to promote root growth into the lower root zone. If root damage is severe, frequent irrigation may even be required throughout the winter months, especially if there are dry winds.

When trying to assess flood damage, Phytophthora problems may also need to be considered. However, if Phytophthora was not a problem before the flooding, excess flooding will not necessarily create one (depending on rootstock tolerance). Therefore, growers should not make costly soil or foliar fungicidal applications for the control of foot rot and feeder root rot unless soil propagule counts reveal such treatments are warranted. Soil and root conditions should be evaluated after the flooding has subsided and the potential for fungal invasion has been determined. If there are high propagule counts, Phytophthora root rot can accentuate the consequences of flooding injury.

In summary, flooding requires that tree management be intensified to minimize the effects of stress on water-damaged trees. Flooding will not always damage tree root systems, but trees should be closely monitored for symptoms. Duration of flooding conditions, rate of water table drawdown, presence of sulfur or organic matter in the soil, nature of the soil, tree age, rootstock and root condition are all factors to be considered when trying to evaluate flooding injury and manage tree recovery. Other cultural practices should be adjusted to minimize stress on water-damaged trees. Fertilization rates and schedules may need to be adjusted for flood-damaged trees. Light fertilizer applications are preferred until the root system becomes re-established. Once the immediate drainage problem has been alleviated, the appropriate course of action is to wait, observe, and let tree response guide the course of action.