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Flooding injury and importance of drainage

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(LEFT): **Figure 1.** Flooded citrus grove after a heavy summer rain event. (RIGHT): **Figure 2.** Flooding damage causing severe leaf wilt.

Almost all citrus trees grown in the Indian River and Southwest Florida production areas are located on high water tables and poorly drained soils. Water management on these soils is difficult and expensive. During heavy rains in the summer, excess water must be removed from the root zone, while periods of limited rainfall require irrigation. On these soils, drainage is as important as or sometimes even more important than irrigation. The concept of total water management must be practiced. If either system — irrigation or drainage — is not designed, operated and maintained properly, then the maximum profit potential of a grove cannot be achieved.

Roots, like the rest of the tree, require oxygen for respiration and growth. Well-aerated soils in Florida typically contain approximately 20 percent to 21 percent oxygen. When flooding occurs, the soil oxygen is replaced by water. This condition causes tremendous changes in the types of organisms present in the soil and in the soil chemistry.

Flooding injury is highly probable if the root zone is saturated for three or more days during the summer when soil temperatures (86°F-95°F) are relatively high (Figure 1). Flooding during the cooler December–March period can be tolerated for several weeks at low soil temperatures (<60°F). The rate of oxygen loss from the soil is much greater at higher than at lower temperatures. The potential for damage to roots is less obvious, but equally serious, when the water table is just below the surface. Flooding stress is much less when water is moving than when water is stagnant. The use of observation wells is an easy and a quick method for evaluating water-saturated zones in sites subject to chronic flooding injury (See "Water table measurement and monitoring," *Citrus Industry*, May 2015).

SIGNS OF STRESS

Short-term estimates of flooding stress can be obtained by digging into the soil and smelling soil and root samples. Sour odors indicate an oxygen-deficient environment. The presence of hydrogen sulfide (a disagreeable rotten egg odor) and sloughing roots indicate that feeder roots are dying.

In flooded conditions, root death is not exclusively associated with oxygen deficiency. Anaerobic bacteria (the kind that can grow only in the absence of oxygen) develop rapidly in flooded soils and contribute to the destruction of citrus roots. Toxic sulfides and nitrites formed by anaerobic sulfate- and nitrate-reducing bacteria are found in poorly drained groves. Sulfate-reducing bacteria require both energy and sulfates to change sulfates to sulfides. The best sources of energy have been found to be certain organic acids contained in citrus roots, grass roots and buried pieces of palmetto. Thus, citrus roots can contribute to their own destruction by being an energy source for these bacteria.

Symptoms of flooding injury may occur within a few days or weeks, but usually show up after the water table has dropped and the soil dries. Leaf wilting appears because the damaged roots cannot take up enough water to meet tree demand. This wilting is followed by leaf drop and twig dieback. Chlorosis patterns may develop, and tree death may occur. Trees subjected to chronic flooding damage are stunted with sparse canopies and dull-colored, small leaves. Trees produce low yields of small fruit. New flushes of growth will have small, pale leaves due to poor nitrogen uptake by restricted root systems.

Usually, the entire grove is not affected, but most likely smaller, more defined areas will exhibit the symptoms. Striking differences in tree condition can appear within short distances associated with only slight changes in rooting depths. Water damage may also be recognized by a marked absence of feeder roots and by root bark that is soft and sloughs easily.

WATER DAMAGE

With acute water damage, foliage wilts and sudden heavy leaf drop follows (Figure 2). Trees may totally defoliate and actually die. More frequently, partial defoliation is followed by some recovery. However, affected trees remain in a state of decline and are susceptible to drought when the dry season arrives because of the shallow, restricted root systems. Moreover, waterlogged soil conditions, besides debilitating the tree, are conducive to the proliferation of soil-borne fungi such as Phytophthora root and foot rot. These organisms cause extensive tree death, especially in poorly drained soils.

Water damage may usually be distinguished from other types of decline by a study of the history of soil water conditions in the affected areas. Areas showing water damage are usually localized and do not increase in size progressively as do areas of spreading decline.

Foot or root rot symptoms include a pronounced chlorosis of the leaf veins caused by root damage and girdling of the trunk. Lesions also appear on the trunk usually near the soil level (foot rot), or roots die and slough-off (root rot). Flood damage does not produce lesions. Trees with blight or citrus tristeza virus are usually randomly distributed within the grove, and diagnostic tests are available to distinguish them from water-damaged trees.

Citrus trees respond physiologically to flooding long before morphological symptoms or yield reductions appear. Photosynthesis and transpiration decrease within 24 hours of flooding and remain low as flooding persists. Water uptake is also reduced. These effects eventually translate to decreased shoot growth and yields.

RECOMMENDATIONS

It is both difficult and costly to improve drainage in existing groves, so drainage problems should be eliminated when the grove area is prepared for planting by including a system of ditches, beds and/or tiling. Growers should not depend on the slight and often unpredictable differences in rootstock tolerance to waterlogging to enable trees to perform satisfactorily in soil-saturated conditions. Trees, irrespective of scion and rootstock cultivars, should be planted using the best drainage conditions possible.

Do not disk a grove when trees were injured by flooding. Irrigation amounts should be reduced, but frequencies should be increased to adequately provide water to the depleted, shallow root systems. Soil and root conditions should be evaluated after the flooding has subsided. Potential for fungal invasion should be determined through soil sampling and propagule counts. If there is a Phytophthora problem, the use of certain fungicides can improve the situation.

Both surface and subsoil drainage is necessary for citrus trees grown in flatwoods areas to obtain adequate root systems. Drainage systems consist of canals, retention/detention areas, open ditches, subsurface drains, beds, water furrows, swales and the pumps required to move the drainage water. These systems require continued good maintenance to minimize the chances of root damage from prolonged exposure to waterlogged soils following high-intensity rains. Rutting in the water furrows that prevents water from efficiently moving into ditches is often a precursor to waterlogging and root damage.

Water furrows and drainage ditches should be kept free of obstruction through a good maintenance program that includes chemical weed control. Drainage systems should generally be designed to allow water table drawdown of 4 to 6 inches per day, which should be adequate to prevent root damage. Good drainage allows air to move into the soil and prevents oxygen-deprived conditions. Tree recovery from temporary flooding is more likely to occur with good drainage structure maintenance conditions.

Recent research work has shown that HLB-infected trees are much more affected by extremes in soil moisture than trees without HLB. This stress intolerance was found to be due to a significant loss of fibrous roots. This finding makes attention to good drainage even more important because flooding could cause additional damage to root systems already weakened by HLB.

Additional information on drainage systems for citrus can be found at http://edis.ifas.ufl.edu/ch165

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