Florida Freezees and the Role of Water in Citrus Cold Protection

Citrus is a major international tree fruit crop. In the United States, citrus production surpasses the combined production of apples, peaches, cherries, pears, nectarines, apricots, plums, avocados, olives, figs, and dates (14). As one of the major industries in Florida, agriculture is the 2nd largest generator of income in the state. Citrus is the primary agricultural industry in Florida, and Florida is the largest producer of citrus in the United States.

In the past 5 years, 4 severe freezees have had a major effect on Florida agriculture and the citrus industry in particular. This series of 4 freezees in such a short time is unprecedented. Prior to 1977, Florida averaged a freeze with minimum temperatures near −5°C every 7 years and a severe freeze of −6°C to −7°C every 10 years (16). As a result, 1984–1985 orange production of 4.24 million metric tons dropped to almost half its 1979–1980 level of 8.44 million metric tons. This drop was due mainly to the loss of trees killed by successive freezees. Over 202,427 acres (81,921 hectares) have been killed. Florida citrus acreage has dropped by nearly 24% to 642,856 acres (260,160 hectares), the lowest level since 1966.

These freezees caused a 97% loss in fruit production in 14 counties in the northern part of the citrus belt. These central upper interior counties dominated Florida citrus production before 1957 and accounted for over 40% of the citrus acreage. Lake County, in this upper interior region, was the 2nd largest producing county until the 1983 freeze. This upper interior area now accounts for less than 7.5% of total Florida citrus acreage. The trend of planting new acreage in the south was accelerated by these freezees, and this move south will reshape the economy of north central Florida (16).

Partially because of these freezees, Brazil has become the major world producer of frozen concentrated orange juice (FCOJ) today. In 1981, Brazil surpassed Florida production and now produces about twice as much orange juice concentrate as Florida. Brazilian juice has stabilized the world supply and moderated price increases.

A major factor that has slowed the replanting of freeze-damaged areas has been the discovery of citrus canker (Xanthomonas campestris pv. citri) in several Florida nurseries since Aug. 1984. At present, the method for eradicating citrus canker is to burn infected or exposed trees. This eradication program has periodically halted the planting of new trees, which will further slow the freeze recovery.

Severe freezees have occurred before, but not in this repeated “back-to-back” manner. Successive freezees occurred in Jan. 1981 and Jan. 1982 and again in Dec. 1983 and Jan. 1985. The Christmas 1983 freeze in Florida also decimated much of the citrus acreage in Texas the day before. The 1983 and 1985 freezees were both advective, or windy, freezees. High monetary losses from the first 2 freezees were exceeded by the 3rd and 4th freezees. Losses were estimated to be more than $2 billion for the 1983 freeze and $472 million for the 1985 freeze (11).

Of these 4 freezees, tree damage was greatest in 1983 and 1985. A major reason for the relatively greater damage in 1983 was the lack of cold-hardening temperatures before the freeze (17). Temperatures below 10°C are necessary for optimal development of citrus cold hardness. For the 12-day period prior to the 1983 freeze, Lake Alfred, located in the central citrus region, had only one day when the minimum temperature was below 10°C. The other freezees had 4 to 12 days during a similar time period with temperatures below 10°C (15). Damage was also greater in 1983 and 1985 because the trees had not fully recovered from the earlier freezees. Additional information regarding these freezees has been published in recent volumes of the Proc. Fl. State Hort. Soc.

Cold protection research

Scientists at the Univ. of Florida Gainesville campus, Citrus Research and Education Center (CREC) at Lake Alfred, and the USDA Horticultural Research Laboratory at Orlando have studied cold protection for a number of years. Before the 1970s, most citrus cold protection involved orchard heaters or wind machines. The increased cost of fuel has eliminated most orchard heating except in traditionally cold locations or for specialty, high-value, fresh-fruit cultivars. While freezees have increased the average value of oranges about 3 fold, the price of fuel for heating has increased approximately 5 fold since the early 1970s. Because of the high cost of fuel, growers have become interested in alternatives to heaters. Wind machines are effective in calm frosts with strong temperature inversions, but are expensive and are often prone to mechanical problems. Though not in common use, fog-generating machines may be beneficial in windless frosts, but even a light wind can blow a fog away.

Irrigation water seems to provide a partial answer to the need for a more cost-effective form of cold protection. Water has been used for a number of years to protect a variety of crops. Much of the research on sprinkler irrigation for citrus cold protection has been carried out in Florida and California (1, 4, 5, 13). However, water cannot be used with overhead sprinklers for cold protection of mature citrus trees in central Florida for several reasons. First, citrus is an evergreen, and the leaf area of a mature tree can accumulate more than one-half a ton of ice during a freeze. The weight of this ice has caused major limb breakage and even tree collapse in the past. Second, most overhead irrigation systems are not designed to produce high

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application rates of water. Hence, evaporative cooling can increase damage or kill trees (5), and this occurred in the windy 1962 freeze when overhead sprinklers were used in some groves.

Overhead irrigations can be used successfully to protect citrus nursery trees and low-growing crops such as strawberries and ferns (5, 12). Initial concerns over evaporative cooling slowed the use of overhead sprinklers by citrus nurserymen. However, observations in 1983 verified sprinkler application rate models (10) and showed that application rates of 9 mm/hr could protect citrus nursery trees successfully in a severe windy freeze (8). The cover photograph shows an example of overhead irrigation in a citrus nursery. While effective, expanded use of this high-volume irrigation for freeze protection may be restricted by water management regulatory agencies as concerns over water supplies increase.

Microsprinkler, or spray jet, irrigation was introduced into Florida around 1973 as a means of conserving irrigation water and pumping energy. In most irrigation designs, microsprinklers typically apply 37–100 liters/hr under each tree. It was suggested that microsprinklers might provide some cold protection, but people were reluctant to use water because of concerns over evaporative cooling. As late as 1980, no one knew how effective this form of irrigation might be with citrus.

Some of the first work on microsprinkler irrigation for cold protection was started in Florida in 1981 (6). Subsequent work has shown that microsprinkler irrigation can indeed provide partial protection to mature trees under radiative frost conditions (2, 7). Even though microsprinkler irrigation only raises air temperature a few degrees, it can enhance tree recovery after a freeze. Microsprinklers can also provide some cold protection, but people were reluctant to use water because of concerns over evaporative cooling. As late as 1980, no one knew how effective this form of irrigation might be with citrus.

Microsprinkler irrigation for cold protection is well-suited to Florida because water is relatively inexpensive, and citrus soils in cold areas are commonly sandy and well-drained. Elsewhere, microsprinklers may not be as feasible for cold protection because of limited water supplies or poorly drained soils. Citrus, which is evergreen, has a leafy canopy that helps hold in heat generated under the tree. Hence, microsprinklers might be more effective for cold protection of citrus than deciduous fruit trees. Like heaters and wind machines, microsprinklers are more effective in protecting mature trees in calm radiation frosts than in advective freezes. Research has shown that if the sprinkler is located downwind or too far from a young tree, evaporative cooling can cause damage in an advective freeze (9).

However, when operated properly, microsprinklers have been very effective in protecting young trees in spite of the windy and low dew point conditions experienced in the 2 recent advective freezes (9). By protecting the scaffold branches of young trees, microsprinkler irrigation can allow for rapid tree recovery after a freeze. Because it has the dual advantage of providing year-round irrigation and some frost protection, microsprinkler irrigation probably will continue to play a major role in Florida citrusiculture.

Future trends

Freezes will continue to occur in Florida. These recent freezes will affect the nature of the Florida citrus industry into the 21st century. Economic conditions and the frequency of future freezes will determine the amount of replanting that occurs in the northern citrus zone. In spite of periodic freezes, this northern area has several notable advantages. The soils are deep, well-drained sands, making them some of the best citrus soils in the state. Yields are commonly better here. In the southern citrus region, land development costs due to drainage and water management problems are greater. Because of these northern-zone advantages, a substantial portion of this area is likely to be replanted to citrus in the next decades. Research in breeding, tree spacing, and orchard management should help improve tree recovery after severe winters. Freezes will always be a threat to Florida citrus, but continued advances in cold-protection methods will help the industry better cope with these natural disasters.

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