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FE950

Citrus Mechanical Harvesting Systems--Trunk Shakers[1]

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Introduction

Mechanization has been the hallmark of American agriculture. Nearly 100 percent of the agronomic crops grown in the United States are plowed, planted, and harvested with mechanical equipment. Mechanical harvesting equipment for sweet oranges has been studied extensively since the 1970s, and during the 2004/05 harvest season, trunk and canopy shakers harvested more than 36,000 acres of Florida citrus. Mechanically harvested citrus acreage, however, has decreased significantly since 2005. During the 2012/13 season, less than 9,000 acres were mechanically harvested (FDOC 2013). Nevertheless, development and adoption of mechanical harvesting technology is important to the long-term economic sustainability of the Florida juice processing industry. This article describes trunk shakers and a companion article (FE951) discusses canopy shakers. Note: Click on hyperlink to watch how a trunk shaker mechanical harvesting system operates in a grove (https://www.youtube.com/watch?v=2sTkpiYbank&feature=youtu.be)

Trunk Shaker Systems

The first tree shakers used to harvest Florida citrus were developed in the 1960s (Figure 1). These early machines were co-designed with fruit catch frames and could harvest up to an average of 12 trees per hour (Coppock and Hedden 1968). By the late 1990s, commercial trunk shakers were

imported from the California nut industries and adapted for orange trees.

The trunk shake and catch (TSC) system uses two self-propelled units that operate on opposite sides of a tree (Figure 5). On one side of the tree, a trunk shaker and a fruit deflector work as a single unit (Figure 2). On the opposite side of the tree, a fruit receiver is positioned to collect and convey harvested fruit to a dump cart (Figure 3). When the cart is full, fruit is off-loaded to a field truck, which in Florida is called a goat (Figure 4).

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Figure 1. Early version of a citrus trunk shaker (Photo courtesy of Dr. Jodie Whitney, UF/IFAS)

Figure 3. Coe-Collier fruit receiver unit (Photo courtesy of Barbara Hyman, UF/IFAS)

Figure 2. Coe-Collier shaker unit (Photo courtesy of Barbara Hyman, UF/IFAS)

Figure 4. Fruit being off-loaded to a field truck, or goat (Photo courtesy of Barbara Hyman, UF/IFAS)

In bedded groves, a shaking unit operates in the swale, or water furrow. The shaker clamps onto the tree trunk above the bud union and below the first scaffold limbs. A specially designed padded clamping pad shakes the tree. A straight-line shaking action is preferred to the multi-direction shaking system because it keeps bark damage to a minimum. Between 2000 and 2004, when field observations on trunk shakers were collected, shake times varied from 5 to 12 seconds depending upon the time of year and the variety of fruit. Early in the season, when fruit pull-force measures were high, shake times typically were between 10 and 12 seconds. As the pull-force measures decreased during the harvest season, shaking times were shortened to 5 seconds. It is important to note that these observations were made when trunk shaking was done without the use of an abscission compound, a chemical agent that when sprayed on the trees causes the fruit to release and drop more easily. As of May 2014, there still is no registered abscission compound for citrus harvesting.

As fruit is shaken out of a tree, it is deflected onto a receiving unit located on the opposite side of the tree. Brushes and blowers on the receiving unit separate leaves and twigs from the fruit. A conveyor moves the fruit into a trailing cart. Each cart holds between 80 to100 boxes worth of fruit. The carts off-load their fruit to a goat.

A TSC system is limited to trees with trunk diameters of less than 10 inches. The TSC system should not be used on trees taller than 16 feet because the falling fruit is likely to split when it hits the catch frame or the ground. For optimum harvesting equipment efficiency, trunk spacing needs to be uniform down the row with clear trunk heights of at least 15 inches above the ground. Skirting low-hanging

Figure 5. A Coe-Collier system harvesting a tree with the two-system shaker and receiver units (Photo courtesy of Barbara Hyman, UF/IFAS)

limbs to at least 30 inches at the drip line improves harvest fruit removal and recovery by allowing the catch frame to easily fit under the tree canopy.

Harvesting Costs

Trunk shakers were used extensively between 1999 and 2005, and more than 90 percent of the equipment was operated through the Coe-Collier Company. During the 2003/04 season, 15 sets of Coe-Collier systems harvested more than 6,000 acres. With an experienced operator, a Coe-Collier unit could harvest 3 trees per minute and between 120 and 150 trees per hour. Between 2000 and 2004, when performance statistics were collected on these units, the Coe-Collier harvesters consistently removed between 94 and 97 percent of the fruit. Not all the fruit shook off the trees were caught by the TSC systems. Some fruit fell between the shaker and receiver units; other fruit was flung beyond the reach of the receiver. Still, between 88 and 95 percent of the available fruit from the tree was recovered by the TSC catch frame.

The cost to hand-harvest juice oranges in 2012 ranged between $1.90 a box for early-season oranges (December/January) to more than $2.20 a box for late-season fruit (May/June) (Muraro 2012). These costs include pick (payments to the harvesters) and roadside (payments to cover a crew leader's salary, harvesting equipment, and employment taxes). Under the grove conditions set up for mechanical harvesting as described above, trunk shaker systems reduced the combined pick and roadside costs by between 20 to 30 cents per box as compared to hand harvesting costs. The cost savings from mechanical harvesting included gleaning services, which involved hand crews following the mechanical harvesters to collect any fruit remaining in the tree canopy and any wholesome fruit that missed the catch frame and fell to the ground (Roka and Hyman 2013).

The costs to hand-harvest citrus will likely increase as the Florida minimum wage rate increases. Effective January 1, 2014, the Florida minimum wage was $7.93 per hour. In 2014, a citrus harvester whose average productivity was 8 boxes per hour had to be paid nearly $1.00 a box simply to cover the minimum wage threshold. Together with roadside charges, costs to hand-harvest citrus were more than $2.25 a box throughout the 2013/14 season.

Tree Health and Late Season Effects

Horticulturalists and agricultural engineers from the University of Florida, the United States Department of Agriculture, and the Florida Department of Citrus conducted several field trials between 1970 and 2005 to investigate whether trunk shakers adversely affected fruit yield and long-term tree health. Except for the case of late-season Valencia oranges, the results of these field trials showed *no* short- or long-term adverse effects. Instead, the research suggested that trees that were well-nourished before and after mechanical harvesting fully recovered from all harvest related stresses (Whitney 2003; Hedden, Churchill, and Whitney 1988). A more recent study analyzed grower yield data between 1998 and 2008 with and without mechanical harvesting and again showed no evidence of shortened tree life or reduced yields (Roka, House, and Mosley 2014).

Valencia oranges present a different and difficult challenge for mechanical harvesting. Valencia trees carry two fruit crops during the entire harvest season (March–June), that is, this year's mature fruit and next year's emerging fruitlets. Once the next year's fruitlets grow to more than one inch (3 cm) in diameter, they can be shaken off the trees along with ripe fruit. In fact, mechanically shaking Valencia trees could cause as much as a 50 percent yield reduction in the next year's crop (Coppock 1972). While growing conditions change each year, fruitlets typically size to a one-inch diameter by mid-May. Consequently, most growers stop harvesting Valencia trees mechanically by early May.

Despite lower harvesting costs and research that indicates no adverse effects from mechanical harvesting, Florida citrus growers have yet to embrace mechanical harvesting. Interest in trunk shakers waned after 2004 and completely stopped after 2006. Even growers who employed the Coe-Collier machines came to believe that a trunk shaker

was too violent for their trees and perceived less damage from canopy shakers. More importantly, however, citrus greening (HLB) became widespread in Florida citrus groves after 2006. Trees infected with HLB absorb nutrients less efficiently and consequently are often not well-nourished. Growers, who were mechanically harvesting fruit before 2006, either stopped or significantly scaled back on their mechanical harvesting efforts as they sought to minimize stress on their HLB-infected trees.

Interest in trunk shakers could be revived if the abscission compound CMNP (5-chlor-3-methyl-4-nitro-1*H*-pyrazole) becomes registered as a harvest aid. Harvesting trials with trunk shakers during the late-season Valencia harvest period produced the best outcomes when used in combination with CMNP. During a late May trial in 2004, CMNP was applied to a group of study trees and a Coe-Collier shaker was operated at various shake frequencies. Fruit removal percentages were measured in 2004, and fruit yields from mechanically harvested trees were compared to hand-picked controls the following year, 2005. The use of CMNP allowed the shaker to completely remove all mature fruit in 2004 with a gentle rocking motion that lasted for at most 5 seconds (that is, no violent shaking). Next year's fruitlets were preserved and, in 2005, no detectable yield differences were recorded between the mechanically harvested trees with CMNP and the hand-picked controls (Burns et, al. 2006).

While citrus growers are rightfully concerned about restoring the health of their HLB-infected trees, more study and consideration should be given to mechanical harvesting. The costs to grow and harvest citrus have been escalating significantly since 2006, and the cost savings potential from mechanical harvesting technologies can help Florida growers remain economically viable.

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