Some visible damage that has been caused by mechanical harvesting including (left) bark scuffing by trunk shakers and (right) limb breakage and bark scuffing by a canopy shaker. Both of these injuries were associated with previously existing damage and are as extreme as we have seen.

Does mechanical harvesting hurt your trees?

By Kuo-Tan Li and Jim Syvertsen

Despite the publication of several long-term studies carried out over periods of eight to 10 years and showing that mechanical harvesting did not reduce yield or increase tree mortality, growers continue to worry about whether mechanical harvesting will hurt their trees. Survey results repeatedly list effects of mechanical harvesting on tree health as a major concern hampering the adoption of mechanical harvesting. Such concerns are understandable, since many people are alarmed the first time they witness the apparently violent manner in which trees are treated during mechanical harvesting with trunk and canopy shakers.

Several types of trunk and canopy shaking systems have been commercially operating in Florida citrus groves for many years. Depending on the type of mechanical harvesting system, the fruit variety and the timing of harvest, visible damage to trees can occur. These injuries often include leaf and twig loss, exposure of shallow fibrous roots, scuffing of the trunk bark, limb breakage, and the removal of flowers and young green fruit. Again, the bottom line is that there is no evidence that mechanical harvesting causes any tree mortality and, except for late season Valencia, mechanical harvesting does not reduce yield. So, if that's true, how important are the

Surface root exposure by trunk shakers.

visible injuries? Does mechanical harvesting really hurt your trees?

Much of the background information for this article was recently published as an EDIS fact sheet dealing with mechanical harvesting and tree health (http://www.lal.ufl.edu/abscission/ Mechanical Harvesting and Tree Health FAQ.html).

Early models of mechanical harvesting machines that were adapted from other tree crops did injure some citrus trees. After 30 years of development, however, the efficiency and safe performance of current tree shaking systems have been greatly improved and mechanical injury to the trees has been reduced. However, even with today's technology and well-trained operators, it appears impossible to completely eliminate all visible damage. Since citrus trees are long-lived evergreen trees, they have built in mechanisms to compensate for leaf and root loss and to recover from short-term injuries.

In 2003, a project supported by the Florida Department of Citrus was initiated to address the effects of mechanical harvesting on tree health. The mission of this ongoing project is to focus mechanical harvesting research on the tree, instead of on the mechanical harvesting machines. Do the visible injuries from trunk and canopy shakers become physiological problems in trees? If so, under what conditions could this happen? And how do trees compensate or recover from such injuries so as not to compromise future yields?

Some early interesting results from this project are providing growers with confidence in the overall safety of mechanical harvesting in maintaining tree health. With an FMC linear-type trunk shaker, 90 to 94 percent of the Hamlin orange crop was removed. In addition, about 12 percent of canopy leaf area was removed. This level of leaf loss during mechanical harvesting is small compared to the leaf area removal by annual hedging and topping that can have no impact on yield. A 12 percent leaf removal rarely causes any reduction in canopy photosynthesis and productivity in any type of fruit tree. In fact, this reduction in leaf area and the removal of dead and weak branches by trunk and canopy shakers can improve sunlight distribution in the canopy and allow the leaves inside the canopy to intercept more light and become more productive. In this way, the tree can compensate for leaf loss. In parallel studies where leaves were manually removed, measurable yield loss did not occur until 50 percent of leaves were removed for three successive years. Two years of removing 50 percent of the tree's leaves had no effect on yield. On trees that were stripped of 50 percent of their leaf area, the regrowth leaves became smaller but the remaining leaves actually increased their rate of photosynthesis, apparently compensating for leaf loss and maintaining yields for two years. Thus, citrus trees have the ability to respond to the growth demands of replacing half of the leaves in a canopy by increasing the physiological activity of individual leaves.

There has been a concern that mechanical harvesting of Valencia trees during peak bloom (March) might shake off too many flowers and young fruitlets and thus reduce next year's crop. By counting flowers and fruitlets before and after

Valencia harvested at full bloom might loose most of the petals but many fruitlets remained on the tree after harvest.

mechanical harvesting at full bloom, we found that about 12 percent of the total flowers and young fruit dropped from Valencia trees harvested by trunk shakers. Surprisingly, we also counted about 12 percent of flowers and young fruitlets that were knocked off by ladders and pick sacks from the control trees that were harvested by hand. Thus, mechanical harvesting at peak bloom does not remove any more flowers than manually harvesting at peak bloom. Since under normal blooming conditions less than two percent of flowers are later harvested as mature fruit, there are more than enough flowers left on the tree after harvest to achieve a good fruit set for the following crop.

There are some data to support the idea that as young Valencia fruit get larger in May and June, late season mechanical harvesting could remove a significant number of green fruit and thus reduce the next year's crop. The severity of this potential problem and whether abscission agents can selectively loosen mature fruit to allow late season mechanical harvesting while avoiding green fruit removal are being examined in several studies currently underway. First year results will be reported later this year.

What about root injury?

Trunk shakers can cause some exposure of fibrous roots at the soil surface. In addition, it is possible that the shaking force could be transferred underground and could disrupt the contact between soil particles and fine root systems. Air-dried roots undoubtedly lose their function and eventually die. Does the loss of exposed fibrous roots and perhaps some underground fine roots have an adverse effect on the tree? Significant root loss may cause drought stress in the tree. In one trial during December 2003, well-irrigated Hamlin trees were shaken for 10 and 20 seconds. For trees shaken only 10 seconds, tree water status was not affected. Excessively shaking trees for 20 seconds did increase drought stress. This stress was the same as withholding irrigation for 10 days prior to hand harvesting. However, drought stress symptoms, either induced by withholding irrigation or by shaking for 20 seconds, disappeared after a third of an inch of rain. These are important results because they underscore the safety margin in which commercial mechanical harvesters are working and explain why mechanically harvested trees do not suffer any long-term yield loss from an upset in tree water relations.

Previous studies on citrus and other fruit crops show that root systems have the ability to compensate for partial root loss by increasing the uptake efficiency of water of remaining roots. After mechanical harvesting, citrus trees maintain the physiological balance between water supply from the root system and the water demand by the canopy.

Bark injury on either trunks or limbs is another concern to growers.

To date, no studies have found any negative effect of bark injury on tree water status. This is not surprising, since bark tissue is not the major vehicle for water transportation. In general, bark injury from winter harvesting in non-active Hamlin trees is not as obvious as spring bark injury in actively growing Valencia trees. Many harvesters and growers believe that bark injury can be minimized by withholding irrigation for several days prior to harvest or by avoiding mechanical harvesting immediately after rainfall. We did not find a direct relationship between soil water availability and bark injury. Therefore, withholding irrigation water prior to harvest might not be advisable especially given that drought stressed trees are more susceptible than well-watered trees to loss of root function from trunk shaking. Although a drier soil surface in bedded groves allows for better movement of harvesting machinery, keep in mind that young fruit and flush growth are very sensitive to water stress. Since bark injury could temporarily reduce the movement of carbohydrates from shoots to roots, current and future studies will be examining root growth underground so that short and long term effects of mechanical harvesting and bark injury can be better defined. Interestingly, there are many published "girdling" studies in citrus trees where rings of bark on the trunk are intentionally removed then allowed to heal, resulting in positive responses of increased flowering, fruit set and yield. Thus, it is possible that 'barking' caused by mechanical harvesting may have a positive effect on the tree.

Will bark injury make the tree more susceptible to diseases or pests?

This concern originates from the tart cherry industry in Michigan where there was increasing plume borer injury in trees as mechanical harvesting became more prevalent. The large bark wounding area in cherry trees provides easy access for the insect to feed on the cambium zone under the bark. Under Florida conditions, there is no evidence of any increases in disease or pest pressure on citrus that can be attributed to mechanical harvesting. Any visible bark wounds from mechanical harvesting should be allowed to dry out and heal naturally. Remedial "pruning scar seal" treatments are not recommended since they can trap pathogens under the seal over the wound.

So far, results from Florida studies have not indicated any major negative effect from mechanical harvesting on physiological or growth responses in Hamlin and early season Valencia (harvesting prior to May 10). Healthy citrus trees in well-managed groves appear to be able to tolerate any visible damage from trunk or canopy shakers. Again, the bottom line – research studies with repeatedly mechanically harvesting trees up to 10 years and current commercial harvesting experience have shown no reductions in yield or tree health for any orange varieties including Hamlin and early-season Valencia. Mechanical harvesting in late Valencia (after May 10th) is more challenging due to the presence of growing immature green fruit. Research is currently underway to address strategies to selectively harvest mature fruit into June.

Mechanical harvesting in late Valencia is more challenging due to the presence of growing immature green fruit.

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