MECHANICAL HARVESTING: The 2006-07 harvest season

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This article summarizes some of the highlights of the IFAS mechanical harvesting research and education program during the 2006-07 season. In this season, 35,600 acres were mechanically harvested, totaling 8.3 million boxes, or about 7 percent of the total Florida orange crop (129 million boxes).

Prior to the 2006-07 harvest campaign, Oxbo International Corp. sold six new units of their continuous travel canopy shake harvester to Florida harvesting contractors and growers. The new units helped to increase the citrus acres mechanically harvested by 23 percent, compared to the 2005-06 season.

MECHANICAL HARVESTING EXTENSION AND EDUCATION

The Citrus Mechanical Harvesting Web site (http://citrusMH.ifas.ufl.edu) was launched on June 1, 2006 and has become the central distribution point of information for the UF/IFAS citrus mechanical harvesting project. The Web site now includes more than 250 mechanical harvesting-related extension and research publications, video clips of harvest equipment in action, a history of mechanical harvesting in Florida and much more. During 2007, monthly articles on mechanical harvesting appeared in trade journals and the "What's Shakin'" monthly feature was introduced to *Citrus Industry* magazine. Two field days demonstrating mechanical harvesting equipment took place in Bartow (Jan. 17, 2007) and Immokalee (April 18, 2007). Each field day began with several presentations by IFAS researchers providing updates on mechanical harvesting and abscission agent research. The presentations and other information from the field days can be found on the mechanical harvesting Web site.

CMNP RESEARCH AND REGISTRATION

Research has continued to test the effect of application volume and sprayer type on the efficacy of the fruit loosening abscission agent CMNP to determine if annually repeated mechanical harvesting plus abscission agent treatments affect yield. The efficacy of CMNP can be significantly affected by weather and other environmental factors. For example, the force required to remove orange fruit from their stems (fruit detachment force, FDF) fluctuates throughout the day, with lowest FDF at 2 p.m and the highest at either 8 a.m. or 5 p.m. Thus, anticipated natural variations in FDF throughout a given day can be used to enhance the efficacy of abscission agents.

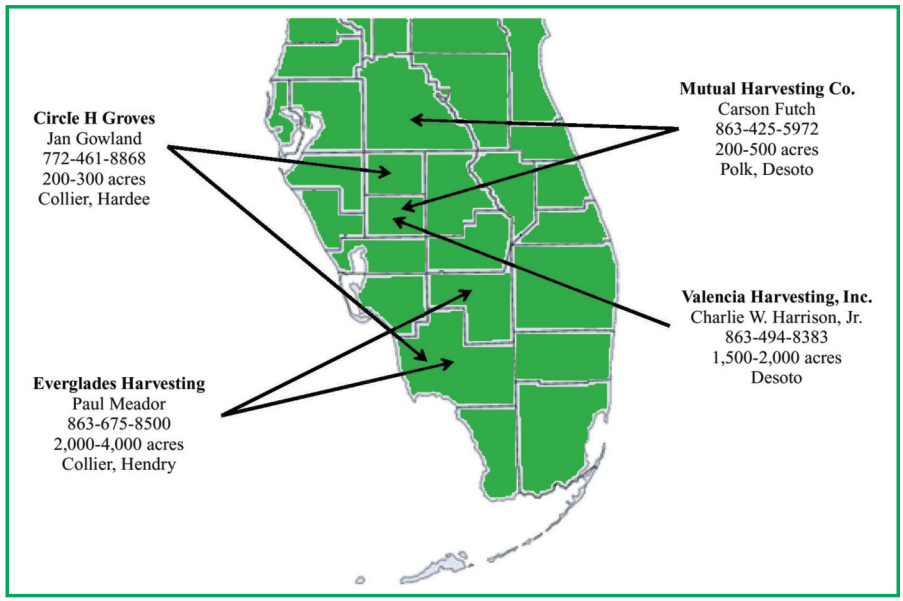
The effect of rootstock on the efficacy of CMNP with various grapefruit, tangelo, tangerine and round orange cultivars revealed that CMNP was somewhat less effective on Swingle rootstock in most combinations tested, whereas Carrizo displayed maximum responsiveness to CMNP.

These research results contribute to an understanding of successful abscission agent management to maximize efficacy and to minimize unwanted post-application fruit drop. Mechanical harvesting with a trunk shaker plus CMNP resulted in no yield reductions or change in tree health the following year. Collec-tively, this research is the basis of developing grower recommendations for optimizing abscission agent response and mechanical harvesting in the field.

The registration effort for CMNP is well under way and is being managed by AgroSource Inc. IFAS researchers are assisting in AgroSource's efforts where needed. This assistance includes testing of newly formulated material (compared with original 'Release' product), receiving, storing and dispensing formulated and technical material to testing agencies as needed, and collecting and shipping soil samples for testing. Registration appears to be on schedule and an Experimental Use Permit is anticipated in 2009, with full registration by the end of 2011.

HARVESTING MACHINE ENHANCEMENTS

Machine enhancements have focused on the development of a yield monitoring system (YMS) for use with citrus mechanical harvesting machines. A YMS can assist the grower by measuring yield and producing a yield variability map, but no such system currently exists for citrus mechanical harvesting machines. The



Some of the harvesting companies operating mechanical harvesters and the counties they operated in during the 2006/07 harvest season.

major component of a yield monitoring system is a Mass Flow Sensing (MFS) system, which measures the citrus fruit mass every second as fruit is conveyed through the citrus harvesting machines. In 2006-07, three methods of mass flow measurement — load cell-based, image-based and optical-based — were compared to select the best method for further yield monitor development. From these comparative tests, the load cell-based system proved to be easy to install and maintain, low-cost, low weight, rugged and durable. For these reasons, the load cell MFS system was selected as the best candidate for further development and the system is now ready to collect a full year of yield data for a pair of citrus mechanical harvesting machines.

Machine improvements also focused on the shaking mechanism and its action on the fruit. Use of small wireless sensors placed on fruit in the canopy showed that the actual force needed to remove fruit is approximately twice that measured by pulling straight down on a fruit with a force gauge and that the forces experienced by fruit vary with canopy position. These findings may be due to the radial formation of the tines and that all of the forces applied to fruit by the machine are not focused in one direction as it is measured by hand with a force gauge. These data are being used to improve machine design to enhance fruit removal, decrease tree stress during harvest and reduce wear and tear on the machines.

During harvest, maximum fruit catching efficiency is achieved when the two machines' travel speeds are synchronized so that gaps in the catch system are prevented. Research has focused on developing a control system using a laser sensor to measure distance and angle between the vehicles, actuators to control vehicle speed and a motor to adjust steering. Currently, the synchronization control system is being evaluated on a pair of test vehicles.

TREE HEALTH

Concern about visible tree injury by mechanical harvesting machines — leaf drop, twig loss, bark scuffing, limb breakage, flower and young fruit removal and exposure of shallow roots — has hampered the adoption of mechanical harvesting. Water use, growth and yield of healthy, well-managed and well-prepared citrus trees are not negatively affected by mechanical harvesting, even when groves are mechanically harvested for several consecutive years. The removal of healthy leaves by mechanical harvesting has no long-term effect on trees and, in some cases, can even be beneficial to light penetration, growth and yield. Any visible root damage after shaking does not measurably affect water and nutrient uptake relative to hand-harvested trees. Thus, there is no meaningful physiological stress caused by mechanical harvesting.

Other physiological studies have shown that mechanical harvesting during peak bloom (March) in Valencia can remove some flowers, but does not diminish fruit set. During late season mechanical harvesting of Valencia, as long as the diameter of young green fruit is less than about 1 inch, mechanical harvesting does not reduce yield the following year. Once the young fruitlets exceed this size, however, aggressive trunk or canopy shaking will likely depress the following year's yield by as much as 25 percent. Studies are under way to determine if drought-induced delayed flowering and fruit set can induce smaller young fruit size through late spring, which would avoid having the fruit affected by mechanical harvesting.

Except for very late-season mechanical harvesting of Valencia with large young green fruit, all research studies in which healthy citrus trees were mechanically harvested — even repeatedly for a number of years — have shown no reductions in yield or tree health.

ECONOMICS

Coordination of grove harvesting schedules and processing plant operations has evolved in the context of hand harvesting. Mechanical harvesting systems can accelerate the speed of harvesting by tenfold over hand crews, and thus afford the citrus industry a chance to rethink optimum harvesting schedules. Mechanical systems offer a possibility to better time harvest with peak pound-solids production, thereby delivering more pound-solids to juice processing plants. With faster harvesting rates, mechanical systems can deliver more daily loads to processing plants and, potentially, shorten the duration of the harvesting season. While a shortened harvest season may allow more efficient utilization of processing equipment, bulk-tank storage facilities would have to be increased. A model incorporating fruit harvesting, juice extraction and storage costs is being developed to analyze the net changes in overall industry returns from possible scenarios made feasible by mechanical harvesting systems.

FRUIT CONTAMINATION AND MICROFLORA

After deficiencies in employee training, contamination of raw materials is listed as the second most serious food safety problem in the food processing industry. In this regard, research has been initiated to evaluate the microbiological aspects of mechanically-harvested fruit with respect to fruit surface and juice microflora. In general, control fruit had fewer microbes on their surface compared to mechanically harvested, dropped on the ground and then picked up either by hand or using an experimental pick-up machine. However, no real trends could be attributed to harvest method for total fruit surface microbial loads. Lower microbial counts are often expected for control fruit as these fruit do not contact the soil — the source of many micro-organisms on agricultural products. However, results to date suggest that dropping fruit to the ground and picking it up does not necessarily result in higher microbial loads.

In all cases to date, juice samples, regardless of fruit harvest or pick-up method, contained significantly less microflora than the peel of the corresponding fruit from which the juice sample was taken. In current studies, there was no indication that juice from fruit which came in contact with the ground had higher contamination. Since all fruit are washed and sanitized and the vast majority (98 percent) of Florida-processed orange juice is pasteurized, wider adoption of mechanical harvest/pick up systems should not contribute to contamination. However, the continued collection of fruit and juice microbiological quality information for any harvest/collection system that promises commercial viability is important. Due to the role that environmental factors may play on all potential contaminants, the inclusion of more sampling sites in widely different groves and weather conditions is also vital.

Many of the projects summarized here are ongoing. Continuing research will result in new information. This article has recapped only some of the highlights of the IFAS mechanical harvesting research and education program during the 2006-07 season. The latest information on all mechanical harvesting projects and contact information for all of the IFAS personnel who contribute to this program is available on the mechanical harvesting Web site (http://citrusMH.ifas.ufl.edu).