Proc. Fla. State Hort. Soc. 118:25-27. 2005.

MECHANICAL HARVESTING WITHOUT ABSCISSION AGENTS—YIELD IMPACTS ON LATE SEASON 'VALENCIA' ORANGES

FRITZ M. ROKA,[1]* JACQUELINE K. BURNS[2]
AND RICHARD S. BUKER[2]
[1]*University of Florida, IFAS*
Food and Resource Economics Department
Southwest Research and Education Center
2686 State Road 29 North
Immokalee, FL 34142-9515

[2]*University of Florida, IFAS*
Department of Horticultural Sciences
Citrus Research and Education Center
700 Experiment Station Road
Lake Alfred, FL 33850

Additional index words. *Citrus sinensis*, canopy shaker, hand harvest, trunk shaker

Abstract. **In Florida, mechanical harvesting of citrus stops around 1 May every year as growers observe inch-diameter green fruitlets being removed by the shaking operations. Previous research by Hedden, Coppick, Whitney, and others found that 'Valencia' [*Citrus sinensis* (L.) Osb.] yields decreased by at least 20% when trees were shaken in early June of the prior year. The question addressed by this study was whether decreasing the duration of a trunk shaker or varying the frequency of a canopy shaker would lessen the yield impacts when 'Valencia' trees were shaken after 15 May. In 2003, an experiment was designed to measure the yield impact on the 2004 'Valencia' orange crop when trees were mechanically shaken at 2-week intervals from the first week in May through mid-June 2003. On four harvest dates, seven mechanical harvesting intensity treatments were replicated four times in a commercial, 15-year-old, 'Valencia' orchard near Immokalee, Florida. Treatments included three durations of a trunk shaker (4, 7, and 10 seconds) and three frequencies of a canopy shaker (215, 230, and 245 cycles per minute) along with hand-picked control plots. The harvest treatments were repeated on the same trees on approximately the same harvest dates, one-year later in 2004. Significant differences in yields were attributable to delayed harvest and to mechanical harvesting treatments. Yield reductions, as compared to the hand-picked controls, ranged from 20 to 50% depending on duration and frequency of shake.**

Late season 'Valencia' oranges [*Citrus sinensis* (L.) Osb.] pose a significant "selectivity" challenge for mechanical harvesting systems. Trunk and canopy shakers must remove a sufficient percentage of the current year's mature crop, but not remove the green immature fruit developing into next year's crop. When 'Valencia' trees were shaken in early June, yields the following year were reduced between 20 and 50% (Hedden and Coppock, 1971; Coppock et al., 1981). As a rule of thumb, growers shut down mechanical harvesting systems when the green fruit reach approximately one-inch diameter usually by about 10 May.

Halting mechanical harvesting during early May is a serious impediment to the development of cost-effective mechanical harvesting systems. Between 25 and 30% of Florida's mature 'Valencia' crop remains on the trees in early May (FASS, 2004). Not only does mechanical harvesting equipment lose access to these acres, but access is also lost to early and mid-season acreage that has to be allocated to hand crews so that their services will continue to be available for hand harvesting the late season 'Valencia' fruit. Attaining the full cost savings potential of existing mechanical systems depends on increasing the acreage over which these systems operate.

In the fall of 2002, the Florida Department of Citrus' Harvesting Research Advisory Council requested a study to re-examine the yield impacts from mechanically shaking trees after 10 May. The Council reasoned that newer equipment technology and less aggressive equipment settings may mitigate green fruit losses. Furthermore, the Council was considering the long-term funding requirements with respect to the research and registration of abscission compounds. Without abscission agents, could mature fruit on 'Valencia' trees be mechanically harvested after 10 May with a sufficient removal percentage but without a significant impact on next year's crop?

Materials and Methods

The study site was located in a commercial grove south of Immokalee, Florida. Standard 'Valencia' on Swingle rootstock was planted in June 1987 at a tree density of 165 trees per acre (12 ft in-row spacing and 22 ft cross-row spacing). Historical production ranged from 450 to 500 ninety lb boxes per acre. Since 2001, the study block had been mechanically harvested by early April with canopy shakers. The study block was divided into four 3-row sections. Each row consisted of 106 trees and each section assigned a specific harvest date.

Seven mechanical harvesting intensity treatments were designed for the study. Treatments for a tractor-drawn canopy shaker were based on the cycles per minute (cpm) or frequency the harvesting tines moved within a tree. The treatment settings were 245, 230, and 215 cpm and harvesting aggressiveness of the canopy shaker decreases with cpm settings. During early May, canopy shakers were running routinely at the 245 cpm setting. At the time the frequency treatments were chosen in 2003, equipment operators believed that 215 cpm was the lowest effective setting that could be achieved and still move through the tree canopy.[1] Tractor ground speed remained constant at one-half mile per hour so that the time each tree received a harvesting treatment was the same. Intensity treatments for a trunk shaker were based on the duration of shake. Shake times decreased from 10 to 4 s per tree. However, the operator varied the frequency of the shaker by changing the throttle intermittently creating a whipping action within the tree during the shake. A whipping action was deemed important for good fruit removal. The sev-

*Corresponding author; e-mail: fmro@ifas.ufl.edu

[1]Subsequent modifications by the manufacturer allowed the cpm setting to be lowered to less than 140 cpm.

enth treatment was a handpicked control. For a given harvest date, each treatment was replicated four times. Each replicated plot included seven contiguous trees with at least two buffer trees at either end. Plots were established with an effort to maintain uniformity among the trees within a plot. Once the plots were identified, the treatments were assigned randomly within the area designated for a given harvest date. The middle two trees in each plot were used to measure tree height, trunk circumference, and canopy volume. Harvests occurred at 2-week intervals. In 2003, harvest dates were 4 May, 18 May, 1 June, and 15 June. In 2004, harvest dates were 6 May, 20 May, 3 June, and 17 June.

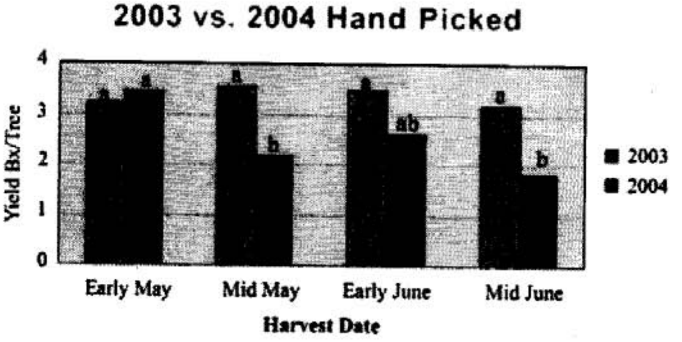
Data were collected in such a way as to account for the entire production from each seven-tree plot. On the day of harvest, a visual count of the sound fruit that had recently dropped was made within each plot and added to the total yield. During the harvesting trial, trunk and canopy shakers shook fruit to the ground using the specified treatment setting. Afterwards, a harvesting crew collected and weighed all the fruit on the ground that had been shaken off the trees during the shaking treatment. A second harvesting crew followed to glean and separately weigh any fruit remaining in the tree after shaking. A second visual count was made to record the number of broken pieces of fruit that were crushed by machines operating in the field.

Data were organized by harvest date within an EXCEL spreadsheet and Statistical Analysis Systems Software for PC (SAS Institute, Inc., Cary, N.C.) was used to run ANOVA. Means were separated by Fisher's LSD at P > 95%.

Results and Discussion

During 2003, average yields were consistent across all harvest dates. Yields in 2003 from handpicked plots averaged between 3.15 and 3.51 boxes per tree (Fig. 1). Analyses did not indicate any statistically significant differences among handpicked plots across harvest dates. Differences were not expected because the fruit crop was set prior to the beginning of the experiment.

Average yields from handpicked plots in 2004, however, were significantly different by harvest date. Yields from the early May harvest averaged 3.43 boxes per tree, slightly higher than what was produced from the same trees in 2003, but not statistically different. Yields from mid-May, early-June, and late-June 2004 dropped by 1.33, 0.51, and 1.40 boxes, respectively, from 2003 levels. Yields from the three later harvests in 2004 were significantly lower than yields in early May (Fig. 1). The reduction in yields from the later harvest dates was attributed to competition between mature and young fruit. Since in 2002, the year prior to when the experiment was initiated, all the trees had been harvested by early April, those trees that were not harvested until 15 June 2003 experienced a harvest delay of more than 2 months.



At the first three dates, trees harvested with the 10-s shake duration in 2003 had significantly lower yields in 2004 as compared to the handpicked controls (Table 1). At least 1.08 to as much as 1.42 boxes per tree was lost as a result of shaking trees for 10 s. Generally, as the shake duration decreased, yields improved but never attained the yield levels of handpicked controls. At a 4-s shake, yield reductions during the May harvests average between 18 and 19%. During the June 2004 harvests, however, yields from a 4-s shake in 2003 were between 48 and 53% of the yields in the handpicked controls.

Results for the canopy shaker treatments were very similar to those for the trunk shaker (Table 2). At the first three harvest dates, shaking trees at 245 cpm in 2003 resulted in significantly lower yields than the handpicked controls in 2004. In general, as the cpm setting decreased, yields improved. During early May, yield losses went from 31% of handpicked yields at 245 cpm to 25% at 215 cpm. During the early June harvest, yields from the 245 setting were 53% of handpicked trees and at the 215 setting, yields were only 21% of the hand-harvested trees.

For both the trunk and canopy shaker treatments, there was an anomaly during the mid June 2004 harvest. The correlation between shake aggressiveness and yield reversed, so that yields were greatest for the 10-s and 245 cpm settings. Although yields were numerically higher, they were not statistically different across the treatments.

Conclusion

Success of mechanical harvesting systems in lowering harvesting costs rests on the ability to mechanically harvest throughout the 'Valencia' season. This requires two objectives to be met. First, the mature crop must be removed at sufficiently high percentages. Second, the negative effect on next year's crop from the excessive removal of immature green fruit must be minimized. For the treatment settings chosen for this experiment, yield losses during the first year after shaking after 10 May were significant. Up to 1.4 boxes per tree were lost as a result of harvesting during early June.

The first year results did offer a hopeful result that less aggressive shaking could lessen yield losses. This result reconfirms the importance of an effective abscission agent. By decreasing the pull-force required to remove mature fruit, the shaking forces of either trunk or canopy shakers could be significantly reduced. This would allow mature fruit to be removed without the excessive removal of immature green fruit.

Table 1. Average yields from trunk shaker treatments and harvest dates in 2004. Means followed by the same letter within a row (i.e., harvest date) were not significantly different, P > 95%.

Harvest date	Hand	4 sec	7 sec	10 sec
	Boxes per tree			
Early May	3.43 (a)	2.81 (ab)	2.76 (ab)	2.19 (b)

Table 2. Average yields from canopy shaker treatments and harvest dates in 2004. Means followed by the same letter within a row (i.e., harvest date) were not significantly different, $P > 95\%$.

Harvest date	Hand	215 cpm	230 cpm	245 cpm
		Boxes per tree		
Early May	3.43 (a)	2.58 (ab)	2.91 (ab)	2.35 (b)
Mid May	2.18 (a)	1.72 (b)	1.64 (b)	1.30 (bc)
Early June	2.61 (a)	1.44 (b)	1.07 (b)	1.22 (b)
Mid June	1.82 (a)	0.75 (b)	0.86 (b)	0.97 (ab)

Literature Cited

Hedden, S. L. and G. E. Coppock. 1971. Comparative harvest trials of foliage and limb shakers in 'Valencia' oranges. Proc. Fla. State Hort. Soc. 84:88-92.

Coppock, G. E., H. R. Summer, D. B. Churchill, and S. L. Hedden. 1981. Shaker methods for Selective removal of oranges. Trans. ASAE 1981:902-904.

Florida Agricultural Station Service (FASS). 2004. Citrus Summary for the 2003-04 Season. Orlando, FL.