# Evaluating Citrus Mechanical Harvesting Systems

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The objective of mechanical harvesting is to decrease harvesting costs and increase "on-tree" revenues. Mechanical systems should increase overall harvest labor productivity, thereby reducing the number of workers needed to harvest citrus. Since 1995, the Florida Dept. of Citrus (FDOC) has lead the effort to research and develop citrus mechanical harvesting systems. The University of Florida has been collecting data to evaluate the performance of commercial systems, impact of grove conditions on harvesting performance, and assessing economic potential of mechanical harvesting.

## 2004-2005 Commercially Available Machines


***Trunk-Shake-Catch (TSC)***

A TSC set includes three machines--a shaker, a receiver, and a field truck (goat). Trunks are shaken between 5 and 10 seconds to remove fruit. Trees have to be "skirted" to allow shaker and receiving units to position underneath the tree canopy. Fruit is caught and conveyed to a cart holding up to 90 boxes of fruit.


***Continuous Canopy Shake & Catch (CCSC)***

One CCSC set includes a minimum of four machines--two harvesting units and two field trucks. Working in parallel, a CCSC system travels between 1 and 2 mph down each side of the tree row. Shaker heads penetrate the canopy to remove fruit. Caught fruit is conveyed to a trailing field truck. CCSC system is well suited for long rows and uniform sized trees. Trees have to be "skirted" to allow optimal fruit collection.


***Tractor Drawn Canopy Shake (T-CS)***

T-CS uses a harvesting mechanism similar to the CCSC. T-CS harvests fruit from one side of the tree canopy at a time, dropping fruit to the ground. A hand crew picks up ground fruit and gleans remaining fruit in the tree. Suited for older, non-uniform trees. Skirting is recommended but not necessary.

## Machine Performance Statistics

| | | TSC | | CCSC | | T-CS | |
|---|---|---|---|---|---|---|---|
| | | Hamlin | Valencia | Hamlin | Valencia | Hamlin | Valencia |
| **Avg. Yield** | Bx/acre | 554 | 371 | 460 | 375 | 377 | 312 |
| **Removal** | % | 95% | 95% | 95% | 95% | 91% | 90% |
| **Recovery** | % | 87% | 88% | 90% | 90% | 99% | 99% |
| **Harvest Speed** | Tree/hr | 190 | 229 | 361 | 466 | 184 | 298 |
| **Labor Productivity** | Bx/man-hr | 96 | 76 | 103 | 122 | 16 | 20 |

The data above represents systems used in a variety of grove conditions **without** abscission chemicals

## Mechanical Harvesting Costs and Benefits Worksheet

| | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **Grower Worksheet Evaluating Costs/Benefits of Any Mechanical Harvesting System** | | | | | | | | | | |
| 2 | | | | | | | | | | | |
| 3 | Prepared by Fritz Roka, University of Florida Revised September 2005 | | | | | | | | | **Grove Preparation Costs** | |
| 4 | | | | | | | | | | | **$/Acre** |
| 5 | | | | | | | | | **Initial skirt** | | **$10 - 20** |
| 6 | **1. Market and grove conditions:** | | | | | | | | **Pruning** | | **$30 - 40** |
| 7 | | Delivered-in price | $/bx | **$5.00** | | | | | **Brush removal** | | **$10 - 40** |
| 8 | | Pick & Roadside costs: | | | | | | | **Micro jet placement** | | **$30 - 40** |
| 9 | | Hand | $/bx | **$1.60** | | | | | **Total** | | **$80 - 140** |
| 10 | | Mechanical | $/bx | **$1.35** | **98%** | Recovery % | | | | | |
| 11 | | Haul cost | $/bx | **$0.40** | 90% | machine % | | | | | |
| 12 | | | | | 8% | gleaning % | | | | | |
| 13 | | Available yield | bx/ac | **500** | | | | | | | |
| 14 | | Tree value | $/tree | **$30.00** | | | | | | | |
| 15 | | | | | | | | | **Explanation of calculations:** | | |
| 16 | **2. Grower costs to mechanically harvest:** | | | | | | | | | | |
| 17 | | **Annual costs:** | | | | | | | **Cell** | | |
| 18 | | skirt (maintenance) | $/ac | **$10.00** | 1 | $10.00 | | | **F21** | E21*D21 | |
| 19 | | tree damage | $/tree | $30.00 | **0** | $0.00 | | | **F22** | E22*D22 | |
| 20 | | non-harvest fruit value | $/bx | $3.00 | 10 | $30.00 | | | **F23** | E23*D23 | |
| 21 | | **Grower costs:** | | | | **$40.00** | | | **F24** | F23+F24+F25 | |
| 22 | | | | | | | | | **D23** | D10-D12-D14 | |
| 23 | | | | | | | | | | | |
| 24 | **3. Benefits to grower from mechanical harvest:** | | | | boxes | | | | | | |
| 25 | | Harvest cost savings | $/ac | $0.25 | 490 | **$122.50** | | | **F29** | E29*D29 | |
| 26 | | | | | | | | | **E29** | E13*D16 | |
| 27 | **4. Benefits - Costs:** | | $/ac | | | **$82.50** | | | **F33** | F31-F26 | |
| 28 | | | | | | | | | | | |
| 29 | | The value in cell F33 represents the change in on-tree revenue from using a mechanical | | | | | | | | | |
| 30 | | system versus the on-tree revenue that would have been earned if the trees had been | | | | | | | | | |
| 31 | | hand harvested. | | | | | | | | | |

Spreadsheet available at the University of Florida, Southwest Florida Research and Education Center's website: ***http://www.imok.ufl.edu/economics***.

## Future Challenges For Mechanical Harvesting Systems

1. **Incorporating abscission agents to extend the harvesting season**
2. **Developing new grove design and tree shapes to enhance machine performance**
3. **Addressing logistics of trailer allocations**
4. **Addressing grower concerns as to tree health, crop yield, and grove aesthetics**