

harvesting/processing routine is followed. In addition, the data indicate that residues from spray applications made at least 3 days prior to CMNP application should not have affect the overall use of CMNP in the abscission/mechanical harvesting system.

Presentations associated with 2009-10 efforts:

Spann, T.M. Citrus Mechanical Harvesting Research Advisory Council Meeting, Bartow, 1 March 2011.

Pozo, L. I. Kostenyuk, J.K. Burns and T.M. Spann. International Society for Horticultural Sciences Congress, Lisbon, Portugal, August 2010.

Publications from 2009-10 efforts:

Spann, T. M., L. V. Pozo, I. Kostenyuk and J. K. Burns. 2011. Application of the abscission agent 5-chloro-3-methyl-4-nitro-1*H*-pyrazole does not affect peel integrity or postharvest decay of mechanically harvested late-season 'Valencia' orange fruit during the normal commercial harvest-to-processing period. *HortScience* *accepted*.

Next steps:

We will complete the 'Valencia' spray residue efficacy trials and analyze the data. Based on the final data analysis further experiments will be designed if warranted; however, we do not anticipate additional work occurring in this area.

We will complete additional early season 'Hamlin' studies on peel quality and storage during the 2011-2012 harvest season and verify the late season 'Hamlin' and all 'Valencia' data by repeating those trials during 2011-2012.

## **IFAS Citrus Initiative MH Annual Progress Report 2010-11**

**Investigator:**

PI – J.P. Syvertsen, J.C. Melgar (postdoc) & A. Kusakabe (MS grad student)

Co-PIs –J.K. Burns, T.M. Spann, K. Morgan, R. Ebel and F.M. Roka

**1. Objectives Pursued: Priority Topics—Horticultural Concerns, Tree Health**

**Objective 1.** Develop methods that extend the mechanical harvesting window by delay of flowering.  $H_0$ : Delaying bloom with drought stress in winter in 'Valencia' can improve late season harvesting in 'Valencia'. If bloom can be delayed 3 weeks, younger fruitlets should be smaller and less susceptible to late season mechanical harvesting losses during May and June.

**Objective 2.** Study physiological mechanisms of drought stress and interactions with mechanical harvesting. Reduce injuries to trees and fruit.  $H_0$ : Partially broken branches not only experience drought stress, but also have decreases in photosynthesis, accumulation of carbohydrates and develop leaf symptoms that also can be confused with mineral deficiencies or greening.

**Objective 3.** Determine interactions with mechanical harvesting, drought stress and ABA in citrus trees on different rootstocks.

**Progress on Objectives:**

Detailed Accomplishments in 2010-11: Objective 1.

--Mechanical vs. hand harvesting were compared during three consecutive years (2007-2009) with and without three winter time (Dec-March) drought treatments to determine any possible carry over effects.

--After resuming normal well-irrigated conditions in the spring, there were little or no measurable physiological effects and no differences in current fruit yield, fruit size, and percentage of juice or juice quality (published: Melgar et al. 2010).

--During three seasons, bloom was successfully delayed for 2-3 weeks by the winter-time drought stress compared to the earlier timing of the bloom in well irrigated trees.

--The young drought-delayed pea-sized fruitlets in June were small enough not to be mechanically harvested along with the mature crop so fruitlet abscission of the next year's fruit in previously drought stressed trees was much less than the larger green fruit that were generally greater than 1 inch in diameter on previously rain plus irrigation trees. --The younger fruitlets matured normally and fruit size caught up with older fruits from the previously winter irrigated trees that flowered earlier.

--Previous drought stress did enhance mature fruit removal efficiency presumably by decreasing fruit detachment force.

#### Areas where progress exceeded expectations:

We have confirmed that interactions with mechanical harvesting and drought stress result in short term tree stress. This is not unlike previous observations of hand harvested drought stress trees, however, where even hand harvesting represented a significant added drought stress after fruit removal. Due to competition between young and old fruit, leaving fruit on 'Valencia' tree late into the season (June) reduces next year's crop regardless of harvesting method.

#### There were no areas where progress did not meet expectations.

#### Impact of accomplishments towards overall goals of funding:

1. This work progressed towards improving safe late season harvesting in previously drought stressed 'Valencia' trees. Mechanical harvesting of well managed healthy trees using a trunk shaker or a canopy shaking machine in the third year, did no long term damage to tree health or had any negative impact on yield relative to hand harvested trees. There were no measurable affects on fruit or juice quality.

2. Mechanical harvesting during peak bloom (~March) in 'Valencia' can remove some flowers but does not diminish total fruit set. During later season mechanical harvesting of 'Valencia', as long as the diameter of young green 'Valencia' fruit is less than about one inch, mechanical harvesting does not reduce yields 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 50%.

3. Winter time drought stress effectively delayed bloom without reducing current yield, percentage of juice or juice quality. Result may allow growers to identify specific blocks for late season harvesting and use winter drought to delay flowering to decrease next season's young fruitlet loss.

#### **2. Objective 2: Injuries to tree branches and fruit.**

Direct injury to fruitlets by canopy shakers can result in oleocellosis in late season mechanical harvested 'Valencia' trees. This can result in cosmetic peel damage or scars which we are monitoring through maturation for a final evaluation during the late harvest, 2009. Leaves on mechanically injured branches can mimic Zn deficiency and symptoms of HLB.

#### Detailed Accomplishments in 2010-11: Objective 2.

--Late season mechanical harvesting (June) of 'Valencia' trees removed only about 20% of fruitlets from previously drought delayed flowering trees but removed up to 50% of fruitlets

from trees that were encouraged to flower normally by keeping them well watered throughout winter.

--Oleocellosis or oil spotting of citrus fruit, is a common injury on the flavedo caused by mechanical damage during harvesting and handling. Physical injury of oil glands of the peel allows the phytotoxic oil to injure the surrounding cells. Using 'Valencia' orange trees, we evaluated the effects of winter time drought stress and late season mechanical harvesting (MH) with a canopy shaker on oleocellosis of green fruitlets of next year's crop. MH removed about 20-50 % of fruitlets depending on previous drought stress treatments and harvesting date. Beginning one week after harvesting (June 13<sup>th</sup>), oleocellosis injury was evaluated on 240 fruitlets based on visual estimations of the percentage of surface injured. Tagged fruit were evaluated about every other month until late season harvest in May. In April, mature fruit quality including fruit size, juice content (%), total soluble solids (°Brix) and acidity, was not affected by previous drought stress treatments. Fruit surface injury decreased as fruit expanded and injuries healed but blemishes did not disappear. Thus, fruitlet oleocellosis in late season mechanical harvested trees did not increase fruitlet drop nor alter fruit quality.

--Citrus leaves on phloem-girdled branches after mechanical harvesting often may develop symptoms similar to Zn deficiency or diseases like Huanglongbing. We studied the changes in secondary metabolites, carbohydrate accumulation and gas exchange parameters after girdling some one cm diameter branches on 13-year-old 'Valencia' sweet orange trees with and without leaves with Zn deficiency symptoms. There were 4 combinations of  $\pm$  Zn deficiency symptoms and  $\pm$  girdling. Overall metabolite profile from leaf extracts were determined using GC-MS metabolomics. Principal components analysis (PCA) showed partial classification of Zn deficient leaves separate from girdled and control leaves. L-proline, simple sugars and sugar alcohols were higher in Zn deficient and girdled samples. Carbohydrate accumulation after girdling caused decreases in CO<sub>2</sub> assimilation and water use efficiency in healthy appearing trees but not in trees with Zn deficiency symptoms. (Publication in progress).

#### Areas where progress exceeded expectations:

Injuries are superficial and are not likely to affect yield or juice quality. We were able to distinguish mechanically injured branches from Zn deficient branches.

#### There are no areas where progress did not meet expectations.

#### Impact of accomplishments towards overall goals of funding:

1. These results have direct implications on the effects of late season mechanical harvesting by canopy shaking on fruit appearance, yield and juice quality. This will be of great interest to growers and the mechanical harvesting industry.

### **3. Objective 3:**, Drought stress, ABA and mechanical harvesting.

#### Detailed Accomplishments in 2009-10: Objective 3. Greenhouse.

The objective of the application of partial root zone drying (PRD) was to evaluate whether this mild drought stress could improve water use efficiency (WUE) at the leaf and whole plant levels in citrus. The feasibility, risks or potential benefits of PRD with saline water or with good quality water were evaluated. Results demonstrated that PRD with saline and with good quality water saved water and restricted plant growth. Roots in wet soil of PRD-treated plants did not enable plants to maintain water status relative to well-watered plants. WUE at the whole plant levels were similar across treatments. The higher plant hormone level in leaves under PRD with saline water may have partly contributed to the stomatal closure and lower water consumption compared with well-watered plants. Rates of photosynthesis were reduced more

than those of leaf transpiration in PRD-treated plants resulting in decreased leaf WUE. Therefore, drought stress saved water but reduced leaf function.

Impact of accomplishments towards overall goals of funding:

1. This work is making progress towards understanding mechanisms for the short-term physiological responses to drought stress, based on ABA signals, which will have implications on the effect of tree water status, rootstocks, time of day as they interact with mechanical stress during mechanical harvesting.
2. Monitoring physiological mechanism underlying drought acclimation will facilitate timing of irrigation management under mild stress.
3. Results will help us understand how water deficits influence physiological processes related to phenological sensitivity to drought stress and interactions with mechanical stress from mechanical harvesting.

Presentations associated with 2010-11 M.H. efforts:

- Melgar, J., Cevallos-cevallos J., Syvertsen J.P. and Reyes-de-corcuera I J. 2010. "Effects of Girdling on Gas Exchange, Carbohydrates and other Secondary Metabolites of Leaves from Low Zn 'Valencia' Orange Trees". 28th International Horticultural Congress, Lisbon-Portugal, 22-27 August 2010. Acta Hort.
- Syvertsen J.P., Li, K., Albrigo L. and J.C. Melgar. 2010. "Mechanical Harvesting and Citrus Tree Stress in Florida". 28th International Horticultural Congress, Lisbon-Portugal, 22-27 August 2010. Acta Hort.
- Syvertsen, J.P. 2010. Intensively managed fertigation in Florida citrus and comments on HLB and citrus nutrition. "XVII International Congress" of the Cuban National Institute of Agricultural Sciences (INCA), 22-26 Nov 2010. Havana, Cuba.
- Syvertsen, J.P. 2011. "Drought Stress and Flowering in Citrus Trees" 1st International Symposium on Citrus Irrigation and Fertigation April 11-19, 2011. Campinas, Brazil.
- Syvertsen, J.P. 2011. "Inflorescence type and fruit set in 'Valencia' orange trees after winter drought stress":25-28 Sept. 2011 ASHS. Hilton Waikoloa Village, Waikoloa, Hawaii.

Publications from 2010-11 efforts:

**Thesis:** Kusakabe, A. 2011. Partial Rootzone Drying In Florida Citrus: Physiological Responses. MS thesis. University of Florida, Gainesville. 56 pp.

**Refereed:** (4)

1. Melgar, J.C, J. Dunlop, L.G. Albrigo and **J.P. Syvertsen**. 2010. Winter drought stress can delay flowering and avoid immature fruit loss during late season mechanical harvesting of 'Valencia' oranges. HortScience 45: 271-276.
2. Melgar, J.C., A.W. Schumann and **J.P. Syvertsen**. 2010. Fertigation frequency affects growth and water and nitrogen use efficiencies of Swingle citrumelo citrus rootstock seedlings. HortScience 45:1255–1259
3. Melgar, J.C., J. Dunlop and **J.P. Syvertsen**. 2010. Growth and Physiological Responses of the Citrus Rootstock Swingle Citrumelo Seedlings to Partial Rootzone Drying and Regulated Deficit Irrigation. J. of Agr. Sci. 148: 593-602.
4. Melgar, J.C, and J.P. Syvertsen. 2011. Oleocellosis Injury of Fruitlets From Late-Season Mechanical Harvesting of 'Valencia' Orange Trees After Different Irrigation Treatments Does Not Affect Internal Fruit Quality. HortSci 46:457-459.

**Non-refereed: (2)**

1. **Syvertsen, J.**, Juan Carlos Melgar and Tim Spann. 2010. Impact of Mechanical Harvesting on Tree Health and Debris. Citrus Industry (Feb) Vol. 91(2):32.
2. Hyman, Barbara, Fritz Roka, **J. Syvertsen**, Bob Ebel, Tim Spann and Reza Ehsani. 2010. Popular Mechanics: Efforts are being made move citrus mechanical harvesting forward. Florida Grower (Feb) Vol 103(2):20-21.

Next steps: 2011-12

We will determine if the winter drought stress increases fruit set in late season ‘Valencia’ orange trees and/or if the relative proportion of vegetative shoots, leafy inflorescences and leafless inflorescences was affected by winter drought. An update report will be published in the Citrus Industry magazine. A manuscript (in preparation) to be sent to a high impact national journal is currently being written.

**Manuscripts in preparation:**

- Melgar, J.C, et al. 2011. Winter drought stress modifies inflorescence type and increases fruit set in ‘Valencia’ orange trees.
- Melgar, J.C, J.M. Cevallos-cevallos, J.P. Syvertsen and J.I.Reyes-de-corcuera. 2011. Metabolomic, carbohydrate and gas exchange changes in girdled branches of Zn deficient Citrus trees

# IFAS Citrus Initiative MH Annual Progress Report 2010-11

## EFFECT OF INITIAL TREE HEALTH and IRRIGATION TIMING ON SHORT AND LONG TERM IMPACTS of MECHANICAL HARVESTING

### Investigator:

PI – Kelly T. Morgan

Co-PIs – Robert C. Ebel

### Objective Pursued (Priority Topics):

Priority topic studied in this project is effect of mechanical harvesting on tree health.

The objectives of this project are to determine the effect of tree condition prior to harvest and harvest method on measures of short-term and long-term tree health. The goal of the research will be the documentation of short-term and long-term impacts of mechanical harvesting on trees of selected levels of initial tree health compared with hand harvested trees over a three year period.

### Detailed Accomplishments in 2010-11:

Trees in the Ranch One grove managed by CPI were selected by tree condition on soils with similar characteristics (Malabar fine sand) and in similar landscape positions. Three tree condition categories (i.e. poor, moderate and excellent) were determined based on general tree appearance, leaf color and size, canopy density and fruit load. Leaf area index (LAI) was used to quantify initial tree condition prior to harvest and to determine effect of harvest method on tree canopy. LAI was significantly different by tree condition prior to harvest. When measured after harvest, LAI was not significantly different by harvest method. Irrigation was either applied the day before harvest or withheld for a period of 5 to 7 days prior to harvest. Pull force (i.e. energy required to detach fruit from the tree) and stem water potential (i.e. water tension of leaf equilibrated to tension in the stem) were determined the day of harvest. Significant differences in pull force was found among the irrigation treatments with a 14% reduction in pull force required to remove fruit of the water stressed trees. Stem water potential of water stressed trees were higher prior to harvest but not significantly greater compared with non-stressed trees. Sap flow flux (i.e. flow of water per unit branches cross-sectional area in response to evapotranspiration) in upper canopy branches was used as a measure of tree health. Differences among tree condition categories were found with poorer trees generally using less water than the excellent trees, but no significant differences in sap flow was found among irrigation treatments within tree condition. After harvesting, half of the six trees in each plot were either irrigated the day after harvest and irrigation was withheld from the other half of the trees for a period of five to eight days after harvest. Average daily sap flow after harvest was significant greater for water stressed trees compared to non-stressed treatments. Short-term yields were not significantly affected by harvest or irrigation treatment.

Areas where progress exceeded expectations:

LAI, stem water potential and sap flow were not significantly affected by harvest method but was significantly different among irrigation treatments. These results support the project hypothesis that mechanical harvesting does not affect short-term tree health or yield, and also supports the hypothesis that water stress from improper irrigation scheduling prior to and after mechanical harvesting may affect tree health.

Areas where progress didn't meet expectations:

None

Impact of accomplishments towards overall goals of funding:

After two years, mechanical harvesting does not appear to affect short term tree health and yield. These data would support previous findings and suggest low impact of mechanical harvest on long-term yields.

Presentations associated with 2010-11 efforts:

Presentation to the CPI board of directors on June 8, 2011

Publications from 2010-11 efforts:

Refereed: None (planned publications after third year)

Non-refereed: None

Next steps:

The study will be continued with the third year of irrigation water stress experiments conducted in the spring of 2012. After this third year of data, adequate data will be compiled to produce a referred journal article with repeated years of data and long-term effects tabulated.

## **IFAS Citrus Initiative MH Annual Progress Report 2010-11**

**Program:** Education and Outreach Program

**Investigator:** Fritz Roka

**Why work is important:** Grower education was given a “high” priority by a southwest Florida grower advisory committee during a meeting on September 2, 2005. If mechanical harvesting is to realize its full economic potential of harvest cost reduction, all aspects of the Florida citrus industry will be affected.

**Objectives:**

- Organize, develop, and deliver multi-media extension materials for convenient and ready use by citrus industry clientele, university personnel, and the general public.
- Organize workshops, field days, and grower meetings for the purpose of direct communication with citrus industry clientele

**Research Gaps:**

*Mechanical Harvesting and Abscission CI Annual Report 2010-11*