IFAS Citrus Initiative
Annual Research and Extension Progress Report 2009-10

Investigator:

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

Objective 1. Determine long-term effects of mechanical harvesting on tree health and yield. Study long-term effects (over 3 years) to assess trees that are drought stressed in winter and mechanically harvested in consecutive years.

1a. Develop drought stress methods that extend the mechanical harvesting window by delay of flowering. H_o: 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 damaged fruit and branches. Reduce injuries to trees and fruit. H_o: 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. Determine the short-term physiological responses to drought (ABA-mediated stomatal closure) of sweet orange grafted on rootstocks with varying drought tolerance.

<u>Detailed Accomplishments in 2009-10</u>: **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 (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.

<u>Areas where progress exceeded expectations</u>:

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.

There were no areas where progress did not meet expectations.

Impact of accomplishments towards overall goals of funding:

1. This work is making progress towards improving safe late season harvesting in previously drought stressed 'Valencia' trees. Mechanical harvesting of well managed healthy trees using a trunk shaker and 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 2009-10: **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 injury was evaluated on 240 tagged fruitlets beginning one week after mechanical harvesting with a canopy shaker in June. Based on visual estimations of the percentage of surface injured, fruit were evaluated about every other month during 2008-2009 until now. Fruit surface injury decreased as fruit expanded and injuries healed but cosmetic peel scars have not disappeared. However, fruitlet oleocellosis did not increase fruitlet drop after the late season harvest so it is not likely to have any additional negative impact on final yield in June. Mature fruit quality including fruit size, juice content (%), total soluble solids (°Brix) and acidity have been evaluated in May (2009) and again at final harvest in June although no alterations are expected as only cosmetic injuries have been observed.

--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_2 assimilation and water use efficiency in healthy appearing trees but not in trees with Zn deficiency symptoms.

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.
2. Determining the effect of drought stress on FDF has implications on the effect of tree water status, rootstock, time of day and the effects of timing of abscission chemical sprays on the FDF. These data will impact the determination of the minimum required machine force for successful and safe mechanical harvesting.

3. Objective 3:, Drought stress, ABA and mechanical harvesting.
Detailed Accomplishments in 2009-10: **Objective 3.** Growth chamber.
--We determine the short-term physiological changes in sweet orange trees under drought stress in a climate controlled growth chamber (14 hr daylight, 30/21 °C day/night temperature). 'Valencia' sweet orange trees on Swingle citrumelo (drought sensitive) or Volk (drought tolerant) rootstocks were compared to examine drought stress responses during a 72 hr period. We observed the highest peak of leaf ABA after only 12 hrs of water stress as levels of leaf ABA after 30 hr of water stress similar to those of leaf ABA after 12 hr of rehydration recovery. High leaf ABA after 12-hr watering suggested that ABA compounds were translocated via the xylem to the shoots due to increased or restored xylem movement. Root ABA started accumulating after 30 hr of drought (perhaps by concentration in xylem fluid), peaked at 36 hr and drastically decreased after 42 hr of drought. The root ABA apparently was not translocated through xylem to the shoots during drought. The ABA reductions after 42 hr of drought stress may be due to higher rates of ABA degradation than local synthesis.
--Field studies. Using bearing sweet orange trees in the field, studies to determine effects of drought status on physiological parameters, vegetative growth and yield have begun. We will use partial root zone drying to try to minimize negative effects of drought by determining if partially wet root zones can lead to long-term acclimation to drought.

In the event there is no drought stress conditions this spring, under tree Tyvek covers will be used as rain-out shelters to compare with well-watered trees

Areas where progress did not meet expectations:

Xylem sap and xylem pH during the water stress and rehydration were not accurately measured. These data will be successfully measured from the drought stressed plants for the next sets of the experiments.

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 from field studies 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 2009-10 efforts: (11)

Syvertsen, J.P. 29 Jan 2009. Understanding how citrus trees grow—a basis for flush management. Indian River Citrus Seminar. Ft Pierce, FL.

Syvertsen, J.P. 8 July 2009. Mechanical Harvesting & Tree Health. Florida Citrus Production Managers Association Meeting. South Florida Community College, Avon Park, FL.

Melgar, J.C. and J.P. Syvertsen. 24 Sept 2009. Mechanical Harvesting & Tree Health. Mechanical harvesting workshop. St Lucie County, IRREC Ft Pierce, FL.

Syvertsen, J.P. 8 Dec 2009. Mechanical Harvesting & Tree Health. In: Mechanical Harvesting Update, Immokalee IFAS Center, FL.

Kusakabe, Ayako, Juan Carlos Melgar, Jill Dunlop, and J.P Syvertsen. 2009. Alternate and fixed partial root zone drying save water in citrus. ASHS Annual Conference, July 25-28, St. Louis, MO. Abst.: HortScience 44(4): 1079.

Melgar, J.C., Dunlop, J. and Syvertsen, J.P. 2009. Oleocellosis damage of fruitlets in late season mechanical harvested 'Valencia' trees does not affect juice quality. ASHS Annual Conference, July 25-28, St. Louis, MO. Abst.: HortScience 44(4): 1084.

Kusakabe, A., J.C. Melgar, Jill Dunlop, and J. P. Syvertsen. 2009. Partial root zone drying affects water use and ABA in Citrus roots and leaves. FSHS Annual Meeting, June 5-7, Jacksonville, FL.

Melgar, J.C., Dunlop, J. and Syvertsen, J.P. 2009. Irrigation regime and exogenous ABA affect freeze tolerance in 'Valencia' trees. FSHS Annual Meeting, June 5-7, Jacksonville, FL.

Melgar, J.C., Schumann, A.W. and Syvertsen, J.P. 2009. Effect of different irrigation and nitrogen application regimes on root/shoot growth in Citrus seedlings. VI International Symposium on Irrigation of Horticultural Crops, November 2-6, Viña del Mar, Chile.

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.

Publications from 2009-10 efforts:

Refereed: (2)

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. Irrigation and nitrogen application frequency affects growth and improves water and N use efficiencies of Swingle citrumelo citrus rootstock seedlings. HortScience (in press)

Non-refereed: (10)

1. Roka, Fritz, Jackie Burns, J. Syvertsen, and Robert Ebel. 2009. Advantages from Registration of an Abscission Product. Citrus Industry (Mar) 90(3): 22-23.
2. Schumann, AW , K. Morgan, W. Castle, **J.P.Syvertsen**. 2009. Advanced Production Systems (APS) for Citrus. Citrus Industry (Aug) 90(8): 14-18.
3. Kusakabe, Ayako, Juan Carlos Melgar, Jill Dunlop, and **J.P. Syvertsen**. 2009. Partial Root Zone Drying With and Without Salinity Affects Water Use Efficiency of Citrus. Proc FSHS 122: 60-62.
4. Melgar, J.C , J. Dunlop and **J.P. Syvertsen**. 2009. Tree Water Status and Exogenous ABA Affect Freeze Tolerance in 'Valencia' Trees. Proc FSHS 122: 78-80.
5. **Syvertsen, J.P.** and J.M. Dunlop. 2009. Imidacloprid Has Little Effect On Growth or Drought Tolerance of Citrus Rootstock Seedlings Without Pests. Proc FSHS 122: 81-84.
6. Schumann, A.W., **J.P. Syvertsen** and K.T. Morgan. 2009. Implementing Advanced Citrus Production Systems in Florida. Proc FSHS 122: 108-113.
7. Spann, Timothy M., Antonios E. Tsagkarakis and **J. P. Syvertsen**. 2009. Managing Citrus Tree Growth With Hedging and Plant Growth Regulators: Strategies For Reducing Psyllid Feeding and Huanglongbing Infection. Proc FSHS 122: 161-165.
8. 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.
9. Melgar, J.C., A.W. Schumann and **J.P. Syvertsen**. 2010. Can fertigation frequency with drip alter Citrus growth and improve water and nitrogen use efficiency? Proceedings VI ISHS International Symp. on Irrigation of Horticultural Crops in Vina del Mar, Chile. 2-6 Nov 2009.
10. **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.

Next steps: 2010-11

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 to be sent to a high impact national journal is currently being written.

A second ABA field study is not completed yet. Leaf ABA and antioxidant enzymes change in response to drought stress and exogenous ABA but all data are not analyzed yet. Only one exogenous ABA concentration was compared to drought stress in the field and we would like to run an experiment with different concentrations of ABA.

The plan for 2010 will be to continue growth chamber evaluations of the short-term physiological responses to drought stress effects to verify physiological acclimation drought stress in sweet orange grown on rootstocks with differing drought tolerances. Under long-term drought stress, the ABA signal may dissipate as changes occur in xylem sap pH, leading to long-term physiological changes that result in reduced growth and water use. The next sets of the short-term drought stress experiments will be set up and evaluated in summer to better elucidate timing.

Manuscripts in preparation:
--Melgar, J.C, et al. 2010 Winter drought stress increases fruit set in late season 'Valencia' orange trees.
--Melgar, J.C, et al. 2010 Oleocellosis damage of fruitlets in late season mechanical harvested 'Valencia' trees does not affect fruit quality.