EFFECT OF TREE HEALTH AND DROUGHT STRESS ON SHORT AND LONG TERM IMPACTS DUE TO MECHANICAL HARVESTING

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Introduction

- Adoption of mechanical harvesting in Florida citrus industry has been very slow due to (Li et al., 2005):
  - loss of leaves and twigs
  - scuffing of the bark on trunk and branches
  - limb breakage
  - removal of flowers and young green fruit
  - exposure of shallow roots at the soil surface
- Well-managed, healthy citrus trees can sustain up to 25% defoliation without reducing the following year crop (Yuan et al., 2005)
- Citrus trees require a properly designed, operated, and maintained water management system to maximize yield and fruit quality (Zekri et al., 2009)
- Advantages of mechanical harvesting
  - reduces harvesting costs by 20 to 40 cents per box (Futch and Roka, 2005)
  - reduces the extreme dependence on seasonal laborers, thereby making the harvesting procedure relatively easier and cost-effective

Objective

To determine the effect of initial tree canopy density and short-term drought stress on health, and productivity of mechanically harvested trees

Material and Methods

- **Study duration –** 3 consecutive years (2010, 2011, and 2012); not complete yet
- **Site** – A commercial citrus orchard located about 20 miles south from the University of Florida, Southwest Florida Research and Education Center (SWFREC), near Immokalee, Florida
- **Cultivar** – Valencia' orange
  - **–** The trees were selected based on canopy density: low, moderate and high
- **Treatments**
  - ***Harvest method*** – four replications of two hand and two machine harvested plots for a total of 16 plots having 8 trees per plot, under each tree category
  - ***Irrigation treatments***
    - Stress: before harvest – no irrigation 10 days prior to harvest
      after harvest – no irrigation 6 days (8 days in 2010) after harvest
    - No stress: before harvest – full irrigation prior to harvest
      after harvest – full irrigation after harvest
- **Data collected**
  - **Leaf area index before and after harvest**
  - **Harvest data**
    - **Fruit yield** (Kg plot^{-1}, harvest and gleaned fruits)
    - **Harvesting debris** (Kg)
    - **Fruit detachment force** (Newton)
  - **Water relations**
    - **Stem water potential** (MPa)
    - **Sap flow flux** (g cm^{-2} h^{-1})
- **Statistical Analysis**: data were analyzed as a split plot design:
  - Main plot: canopy density
  - Sub plot: harvest methods
    - subplots were split into 4 split-plots each with different irrigation treatments
  - Data are discussed based on graphical representation with differences indicated using 2x standard error ($p \leq 0.05$) about each mean

Results

Leaf Area Index

Table 1 Average LAI of HH and MH harvested trees

Year	Tree category	LAI Before harvest			LAI After harvest			% change in LAI from pre- to post-harvest		% change in LAI from 2010(post-harvest) to 2011 (pre-harvest)	
		HH	MH	AVG (by tree category)	HH	MH	AVG (by tree category)	HH	MH	HH	MH
2010	Low	4.6	5.2	*4.9*	4.9	5.8	*5.4*	+6.5	+11.5	+10.2	+0
	Moderate	5.9	5.5	*5.7*	6.3	5.6	*6.0*	+6.8	+1.8	-1.6	+3.6
	High	5.8	6.1	*6.0*	4.6	3.5	*4.1*	-20.7	-42.6	+54.3*	+125.7*
	AVG (by harvest)	*5.4*	*5.6*		*5.3*	*5.0*					
2011	Low	5.4	5.8	*5.6*	5.1	4.9	*5.0*	-5.9	-15.5		
	Moderate	6.2	5.8	*6.0*	5.7	5.6	*5.7*	-8.1	-3.4		
	High	7.1	7.9	*7.5*	6.1	6.3	*6.2*	-14.1	-20.3		
	AVG (by harvest)	*6.2*	*6.5*		*5.6*	*5.6*					

HH: Hand harvested
MH: Machine harvested

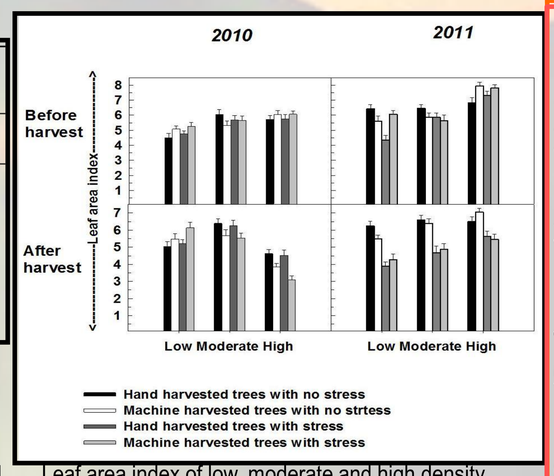

Fig. 1 Leaf area index of low, moderate and high density trees before and after harvest with different treatments of stress and harvest methods

Results (contd.)

Harvest data

Table 2: Harvest data (2011)

Variable	LOW DENSITY (Tree condition 1)						MODERATE DENSITY (Tree condition 2)						HIGH DENSITY (Tree condition 3)					
	FDF (N)	Yield (Kg/plot)	Trash-leaves (g)	Trash-stems (g)	Trash-fruits	Glean Kg)	FDF (N)	Yield (Kg/plot)	Trash-leaves (g)	Trash-stems (g)	Trash-fruits	Glean Kg)	FDF (N)	Yield (Kg/plot)	Trash-leaves (g)	Trash-stems (g)	Trash-fruits	Glean Kg)
Harvest method																		
Hand	79.9	526.5	7.8	10.4	2.4		83.5	662.0	11.6	14.2	2.1		83.3	603.3	14.7	29.1	1.0	
Mechanical	78.6	599.4	21.8	52.8	4.4		80.9	579.0	34.6	48.1	3.8		88.8	656.4	27.4	55.6	6.1	
P-value	*0.68*	*0.42*	*0.01*	*0.003*	*0.28*		*0.61*	*0.21*	*0.02*	*0.01*	*0.25*		*0.17*	*0.39*	*0.05*	*0.83*	*9E-04*	
Irrigation treatments*																		
1	73.2	522.4	12.0	36.0	2.3	45.6	75.7	652.6	16.5	36.3	1.8	34.6	88.7	639.0	27.6	49.1	4.8	32.06
2	85.3	603.5	17.5	27.2	4.5	36.4	88.7	588.5	29.7	25.9	4.1	36.8	83.4	620.7	14.5	35.6	2.3	36.25
3																		
4																		
5																		
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P-value	*0.00*	*0.37*	*0.21*	*0.43*	*0.26*	*0.49*	*0.03*	*0.32*	*0.16*	*0.31*	*0.12*	*0.70*	*0.67*	*0.82*	*0.17*	*0.07*	*0.69*	*0.13*

Table 3: Change in fruit yield

	2010			2011			% change in yield in 2011	
	Total gross yield	Total yield_HH	Total yield_MH	Total gross yield	Total yield_HH	Total yield_MH	HH	MH
Low	6996	3497	3499	9007	4212	4794	+21	+37
Moderate	8636	4767	3869	9928	5295	4632	+11	+20
High	10381	4972	5409	10077	4826	5251	-3	-3

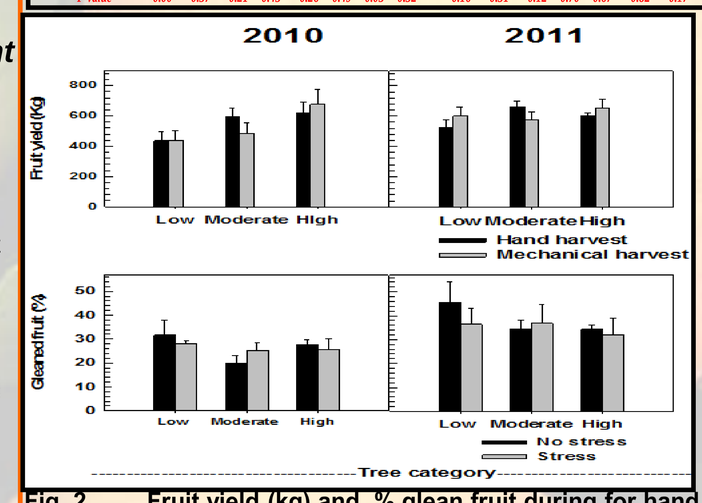

Fig. 2 Fruit yield (kg) and % glean fruit during for hand and machine harvested plots

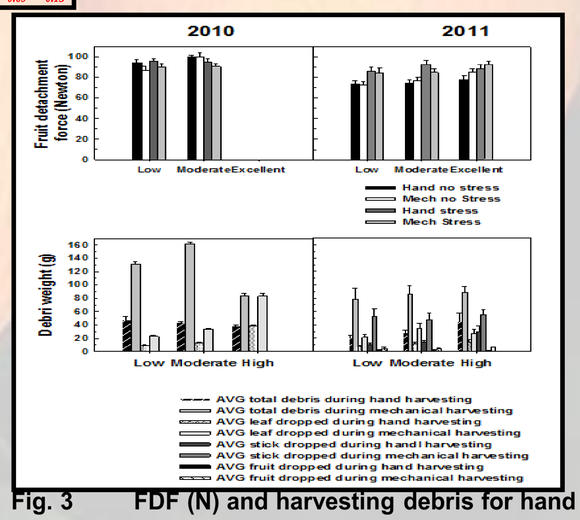

Fig. 3 FDF (N) and harvesting debris for hand and machine harvested plots

Water use data

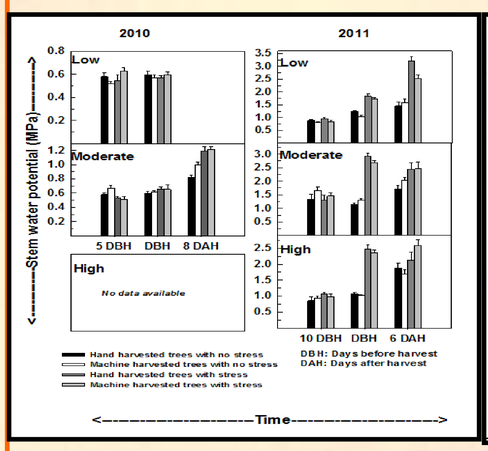

Fig. 4 SWP (Mpa) of drought stressed and non-stressed hand and machine harvested plots during 2010 and 2011

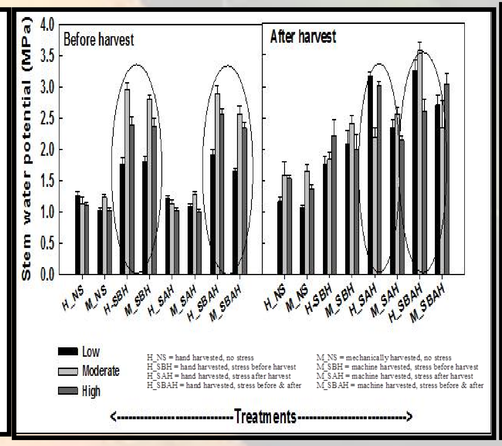

Fig. 5 Comparison of before- and after-harvest SWP in 2011

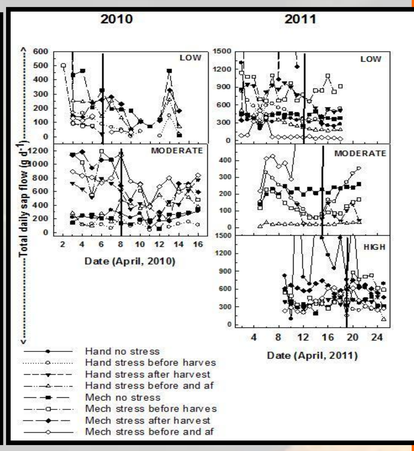

Fig. 6 Total daily sap flow (g/d) during 2010 and 2011

Conclusion

1. No drought treatment effect was seen in 2010 due to unusual rainfall
2. Results from 2011-> drought stress effected citrus growth (LAI) irrespective of harvest method
3. LAI measured before harvest for low, moderate and high density trees increased by 14.3, 5.1 and 26.8%, respectively, during 2011 than 2010
4. Mechanical harvesting had no effect on fruit yield
5. Water use was affected by drought treatments but not by harvest methods
6. Mechanical harvesting does NOT have adverse effects on growth and production of well-watered citrus trees