Mechanized Canopy Management and Timing of Regulated Deficit Irrigation Stress on Syrah

S. Kaan Kurtural
Bronco Wine Company
Viticulture Chair

FRESNO STATE
VITICULTURE & ENOLOGY
CALIFORNIA STATE UNIVERSITY, FRESNO

Introduction

- California accounts for 90% of wine grape production
- The SJV accounts for 70% of wine grapes crushed
- Growers rely on high yields to be profitable
- Out-of-balance vines
- Not able to apply the steps in Canopy Management

Literature Review of CM

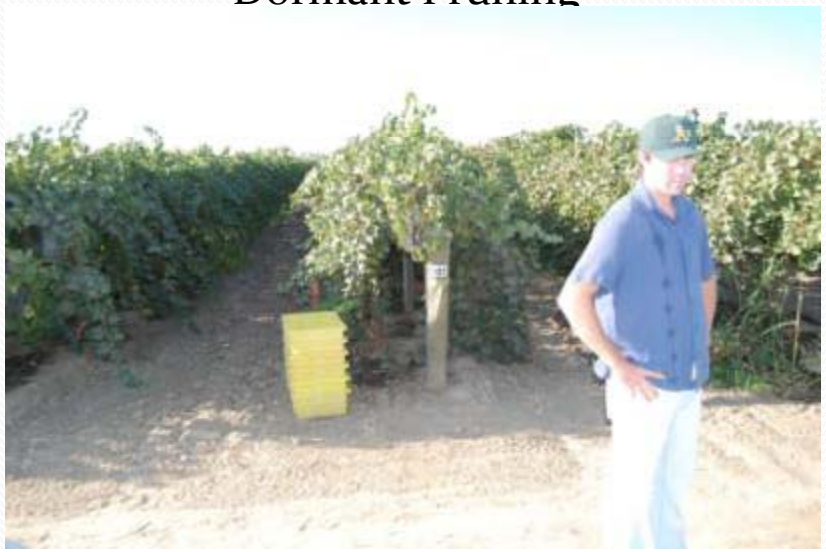
- There seems to be agreement that CM practices slow down vegetative growth (Smart, 1985, 1988),
- Ameliorate light regime in the defined fruit zone (Howell, 2001; Dokoozlian and Kliewer, 1995; Gladstone and Dokoozlian, 2003; Reynolds et al., 1985; Vanden Heuvel et al., 2004),
- Enhance fruit composition (Kliewer and Smart, 1989; Kasimatis, et al., 1982; Kurtural et al., 2006; Petrie and Clingeleffer, 2006; Shaulis et al., 1966; Smart, 1988, Tardaguila et al., 2008),
- Ameliorate evaporative potential in the fruit zone (English et al., 1990; van Zyl and van Huyssteen 1980),
- Mitigate canopy temperature (Becker, 1966; Berqvist et al., 2001; Draganov and Pandeliev 1976; Draganov et al. 1975; Reynolds and Wardle 1993; Smart et al., 1982)
- Brings the vines into balance for sustained commercial production (Howell, 2001; Morris, 2007, Reynolds and Wardle 1993).

Literature Review (RD)

- There seems to be agreement that reduced deficit irrigation:
  - 1) reduces vegetative growth (Pitts, et al., 1995; Pritchard, 2005),
  - 2) enhances ripening by increasing cluster light exposure and berry temperature (Arozarena, 2002; Buttrose et al., 1971; Cohen, 2007; Coombe, 1992; Cortell, 2006; Crippen and Morrison, 1986; Dokoozlian and Kliewer, 1996; Ennhali, 2007; Spayd et al., 2002), and
  - 3) improves fruit and wine quality through an increase of skin/pulp ratio, increased phenolic and aroma precursor compounds (Chalmers, 2007; Coombe and McCarthy, 2000; Escalona et al., 1999; Ferreyra et al., 2002; Jackson, 2000; Kennedy et al., 2002; Matthews and Anderson, 1988; Ojeda et al., 2002; Roby and Matthews; 2004; Roby et al., 2004; Williams, 2005.)

Objectives

- Goal
  - Identify sustainable mechanized canopy management techniques with timing and severity of reduced deficit irrigation
  - Mechanize the following CM
    - Dormant Pruning



- Determine interactive effects on canopy
- Evaluate cluster architecture
- Evaluate yield components and fruit composition
- Evaluate wine making potential potential of the fruit
- Develop science based mechanized CM and RDI techniques to maintain vine capacity and longevitiy

Hypothesis

- Hypothesis: Can we ripen a larger crop of Syrah using mechanical canopy management and inducing water stress at key phenological stages without adversely affecting
  - Canopy microclimate
  - Yield
  - Fruit composition
  - Wine quality
  - Production efficiency?

Plant Materials and Vineyard Management

- Time frame 2009-2012
- Shiraz06/1103P
- 7' x 11' N-S orientation
- Bi-lateral cordon at 54"
  - Foliage support at 66"
  - 12" T-Top
- Drip-irrigated
  - 0.62 gal/h/vine
  - @ 42" spacing
- Split-Plot with 4 Blocks
- Sampling based on a grid of three adjacent rows

Experimental Design (4 Blocks)

- **Main Plot**
- *Canopy Management*
  - Hand pruned (42 spurs/vine)
  - Crop load low
    - 4" hedge then 5 shoots/ft
  - Crop load mid
    - 4" hedge then 7 shoots/ft
  - Crop load High
    - 4" hedge 15 shoots/ft (no thinning)

- **Sub-Plot**
- *RDI Stress*
  - RDI control
    - (70% of Daily ET at -12 bars)
  - RDI early
    - (50% of Daily ET between fruit set and veraison @ -14 bars)
  - RDI late
    - (50% Daily ET between veraison and harvest @-14 bars)

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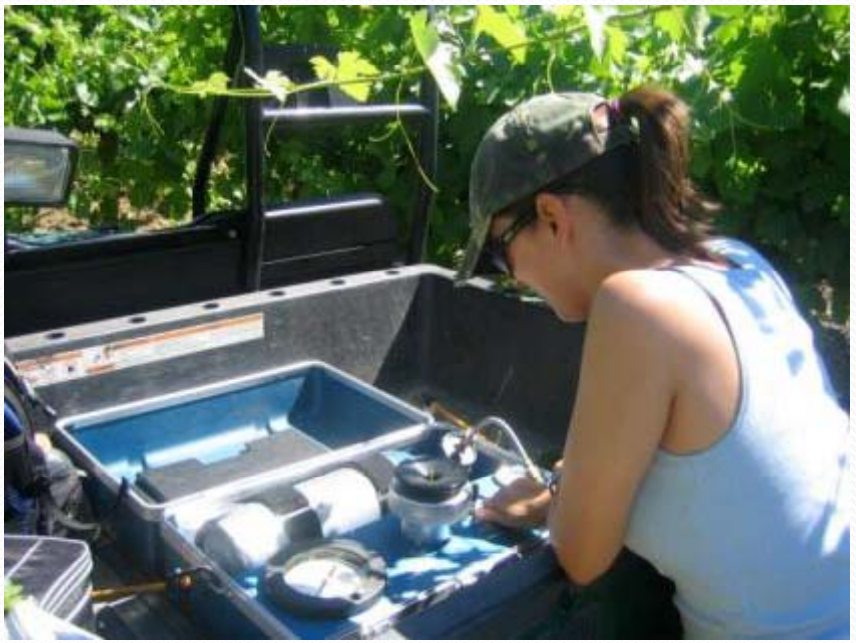
Dormant Pruning

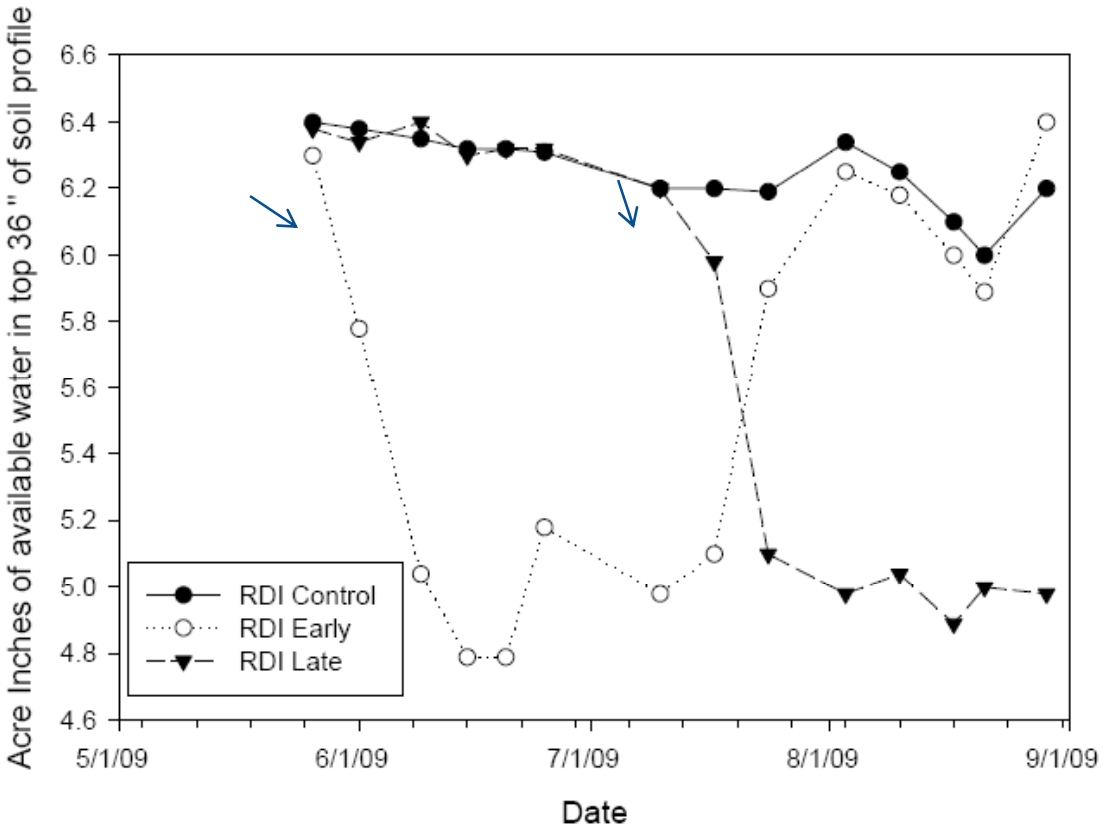
Irrigation Management

Managed in the top 900mm of soil profile using Di-Electric Probe

Weekly Leaf Water Potential Measurements @ Mid-Day



Acre-inches of water available



N=48, p<0.0003

Wine Making

Field Lots Mechanically Harvested

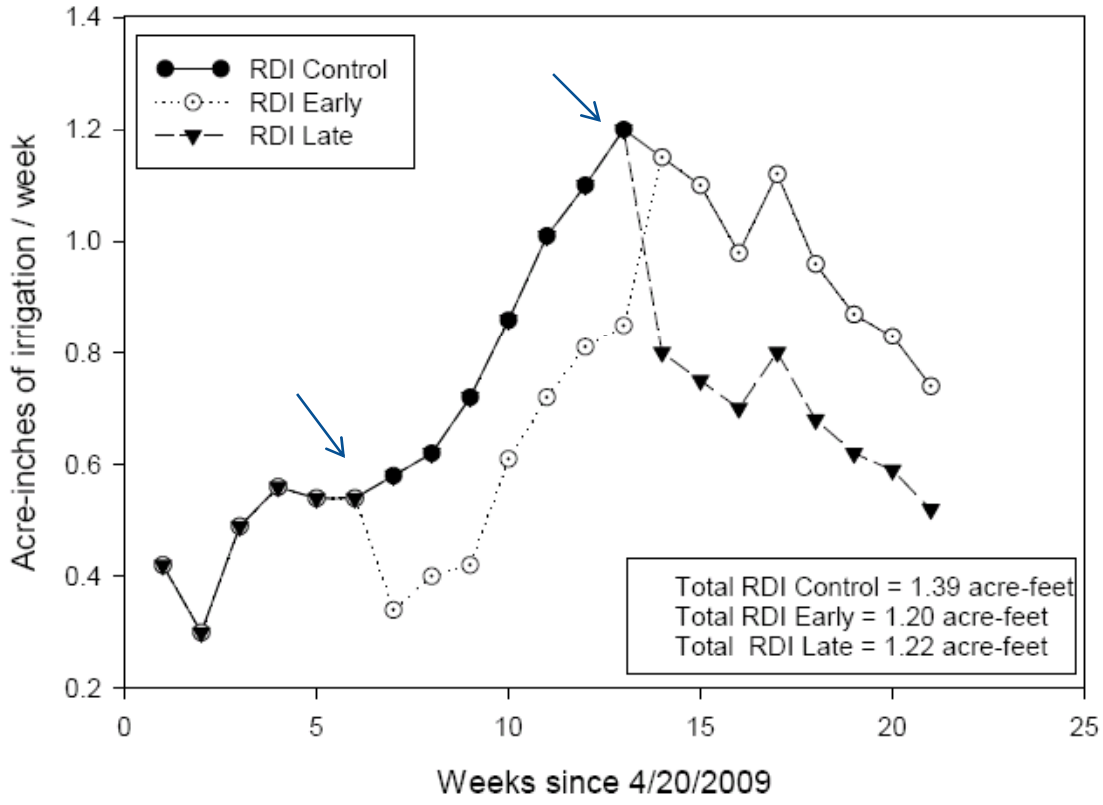
Standard Red Wine Fermentation

- All treatments harvested between 24 %TSS
- SO2 additions made @ crush and adjusted to 30ppm
- Fermented on skins at 82F
- Pressed and fermented to dryness
- ML culture added
- SO2 additions to 25 ppm
- UC Assay (2005) on samples

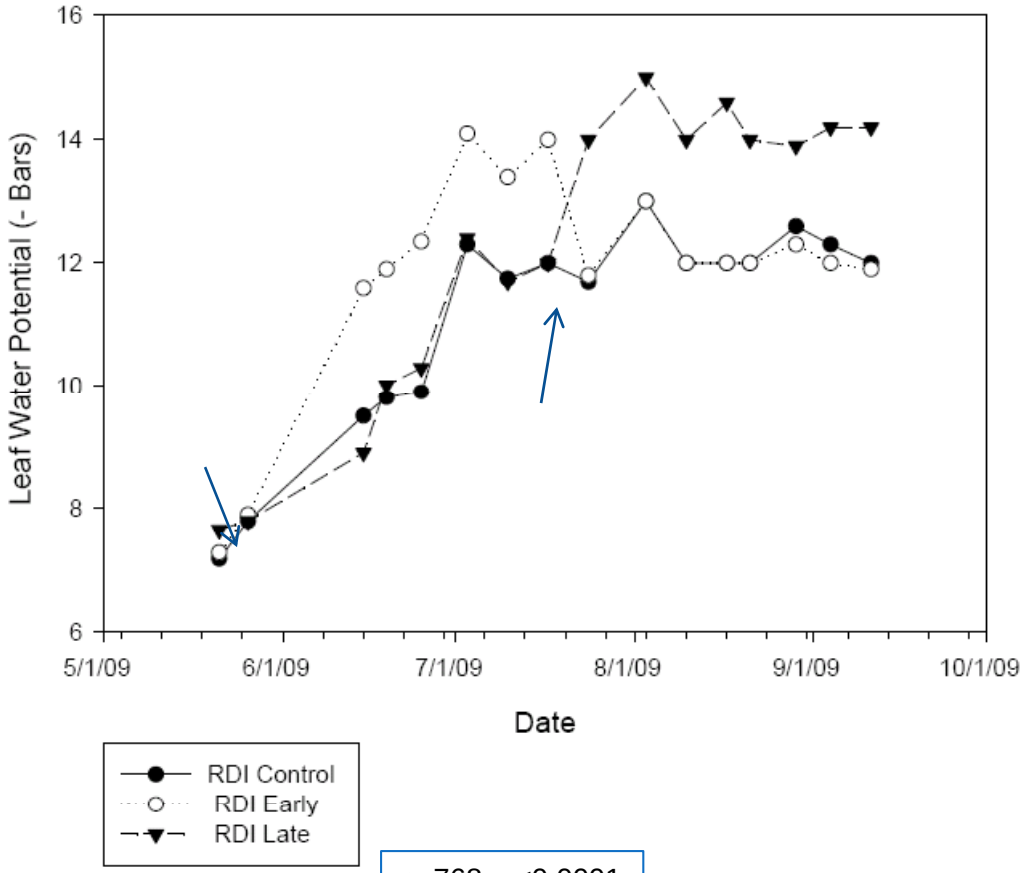
Results

Acre-inches of water applied/week

- N=48,



Effect of Timing of RDI Stress on LWP in 2009



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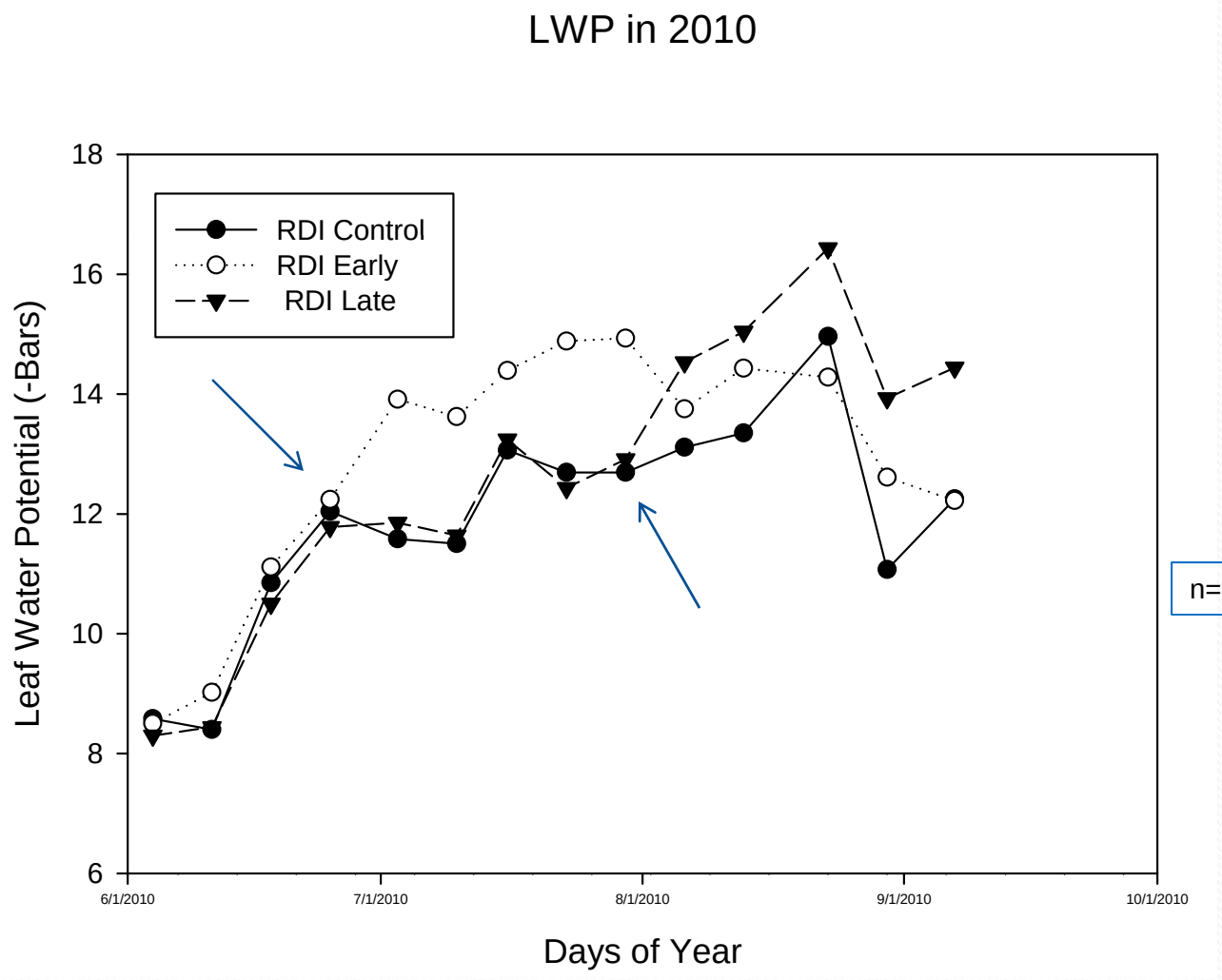
Effect of Timing of RDI Stress on LWP in 2010



n=768, p<0.0001

Effect of severity of canopy management on count, non-count and total shoots per foot of row in 2009 and 2010

Factor	Count shoots	Non-count shoots	Total shoots	Count shoots	Non-count shoots	Total shoots
Hand-Pruned	11 a	16	27 a	5 b	10	15 c
Crop load Low	5 c	10	14 b	7 ab	8	15 c
Crop load Mid	7 b	9	17 b	9 a	8	17 b
Crop load High	16 a	21	37 a	10 a	12	22 a
Pr>F	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Effect of mechanical canopy management and timing of RDI stress on canopy microclimate of Syrah in 2009 and 2010 at Veraison

	2009			2010		
CM	Shoots per Ha	Shoot distance(cm)	Leaf layers	Shoots per Ha	Shoot distance(cm	Leaf layers
Hand-pruned	110,906	2.7	6.9	46,993	6.5	3.5
Crop load low	51,366	6.4	3.1	65,873	4.9	4.3
Crop load Mid	67966	4.9	3.5	84,616	3.9	5.3
Crop load High	158,117	1.9	8.6	95,210	3.4	5.7
Pr>F	0.0001	0.0001	0.0001	0.0001	0.0034	0.0645
RDI						
RDI control	101,939	3.6	6.2	64,786	5.1	4.9
RDI early	93,464	4.2	4.8	72,731	4.9	4.3
RDI late	95,863	4.2	5.6	82,001	4.1	4.9
Pr>F	0.5845	0.3501	0.0387	0.1473	0.0774	0.2508
CM x RDI	0.8594	0.4824	0.7649	0.1321	0.6411	0.0298

Canopy Gaps at Veraison

Effects of Canopy Management and Timing of RDI Stress on Cluster Architecture of Shiraz in 2009 and 2010 at immediate pre-veraison

	2009			2010		
Canopy Management	Berry number	Berry weight (g)	Berry Volume (mL)	Berry number	Berry weight (g)	Berry Volume (mL)
Hand Pruned	**141**	**0.76**	**0.74**	**120**	**0.88**	**0.85**
Crop Load Low	**115**	**0.80**	**0.79**	**103**	**0.75**	**0.73**
Crop Load Mid	**116**	**0.74**	**0.71**	**97**	**0.72**	**0.70**
Crop Load High	**115**	**0.72**	**0.70**	**96**	**0.72**	**0.69**
Pr>F	**0.0002**	**0.0624**	**0.0033**	**0.0018**	**0.0072**	**0.0067**
RDI						
RDI Control	**126**	**0.80**	**0.80**	**0.76**	**0.76**	**0.73**
RDI Early	**110**	**0.61**	**0.58**	**0.71**	**0.71**	**0.69**
RDI late	**129**	**0.84**	**0.83**	**0.83**	**0.83**	**0.80**
Pr>F	**0.0031**	**0.0001**	**0.0001**	**0.0001**	**0.0001**	**0.0001**

Effects of Canopy Management and Timing of RDI Stress on Yield Components of Shiraz in 2009 and 2010

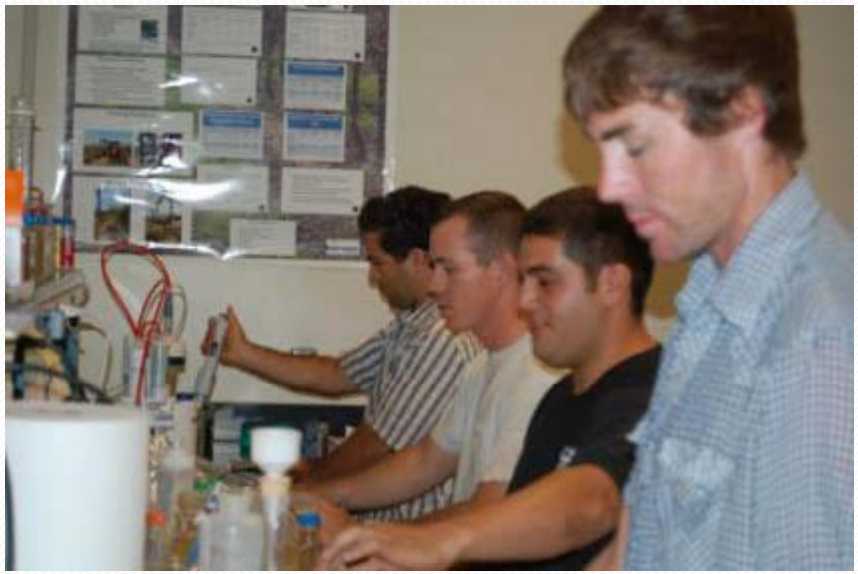
	2009			2010		
Canopy Management	Berry Weight(g)	Clusters/Vine	Yield (Tons/Acre)	Berry Weight(g)	Clusters/Vine	Yield (Tons/Acre)
Hand Pruned	**1.33**	91	**10.7**	**1.56**	**65**	**6.0**
Crop Load Low	**1.30**	76	**7.2**	**1.37**	**97**	**7.2**
Crop Load Mid	**1.26**	121	**11.2**	**1.27**	**145**	**10.0**
Crop Load High	**1.20**	145	**12.5**	**1.28**	**163**	**11.0**
Pr>F	**0.0191**	0.0001	**0.0006**	**0.0003**	**0.0001**	**0.0001**
RDI						
RDI Control	***1.35***	113	**11.8**	**1.42**	**123**	**9.1**
RDI Early	***1.13***	109	**8.4**	**1.32**	**111**	**7.9**
RDI late	***1.33***	103	**10.9**	**1.35**	**119**	**8.4**
Pr>F	***0.0001***	0.2185	**0.0001**	**0.0031**	**0.0060**	**0.0001**
CM x RDI	0.0802	0.8150	0.6897	0.0001	0.0001	0.0002

Fruit Composition

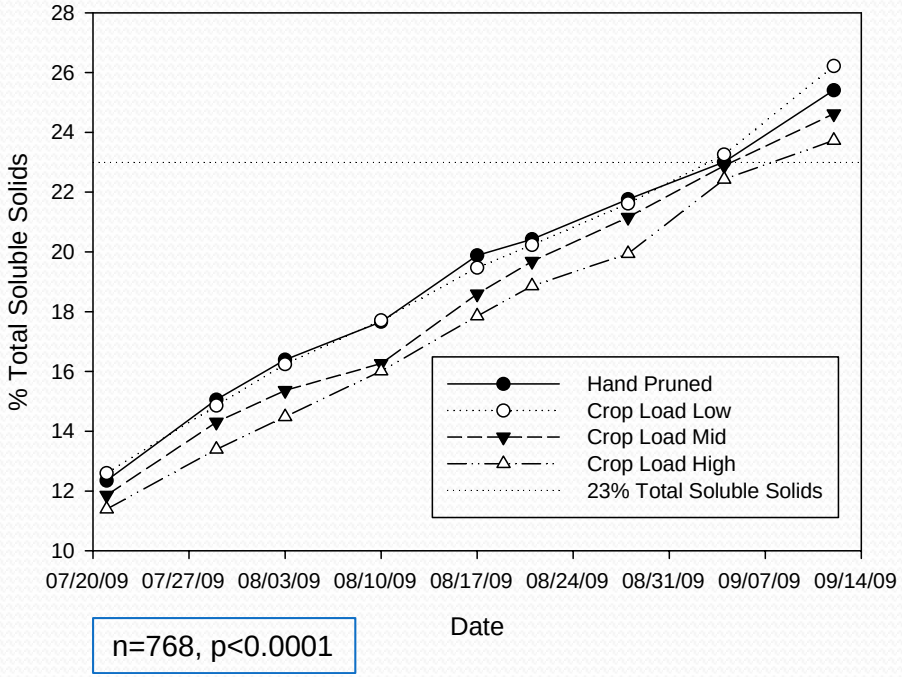
Traditional Wet Chemistry

- Brix, pH, TA
  - Weekly starting at 16Brix
- Pigments, Phenolics, Tannins
  - Weekly starting at 16Brix
  - Using Harbertson Assay (2005)

Labor pool



Total Soluble Solids 2009



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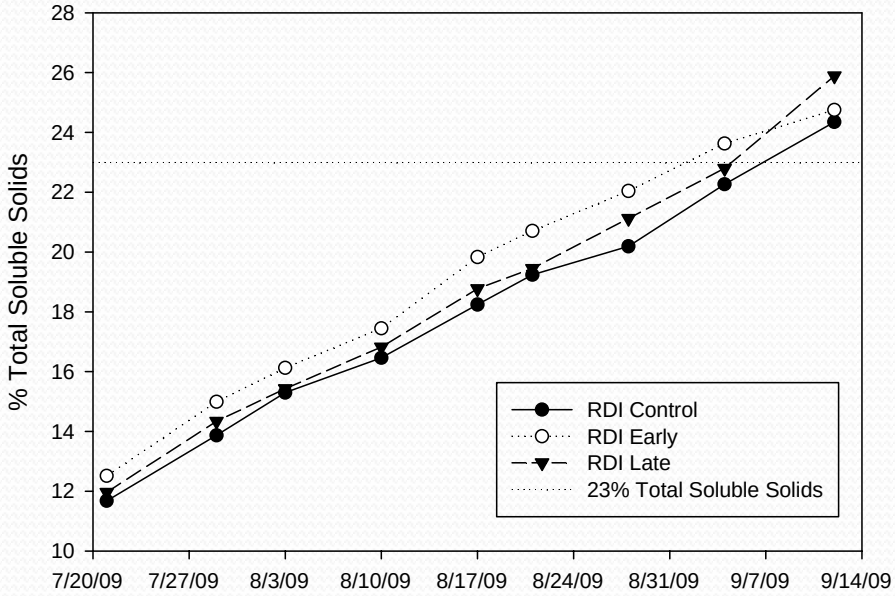
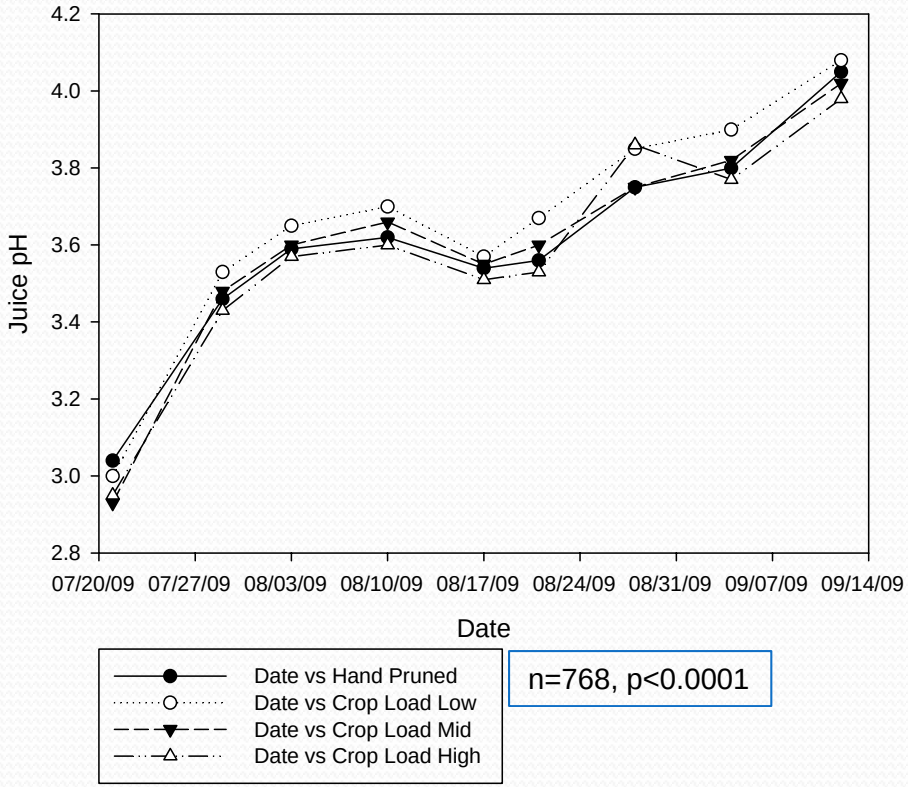
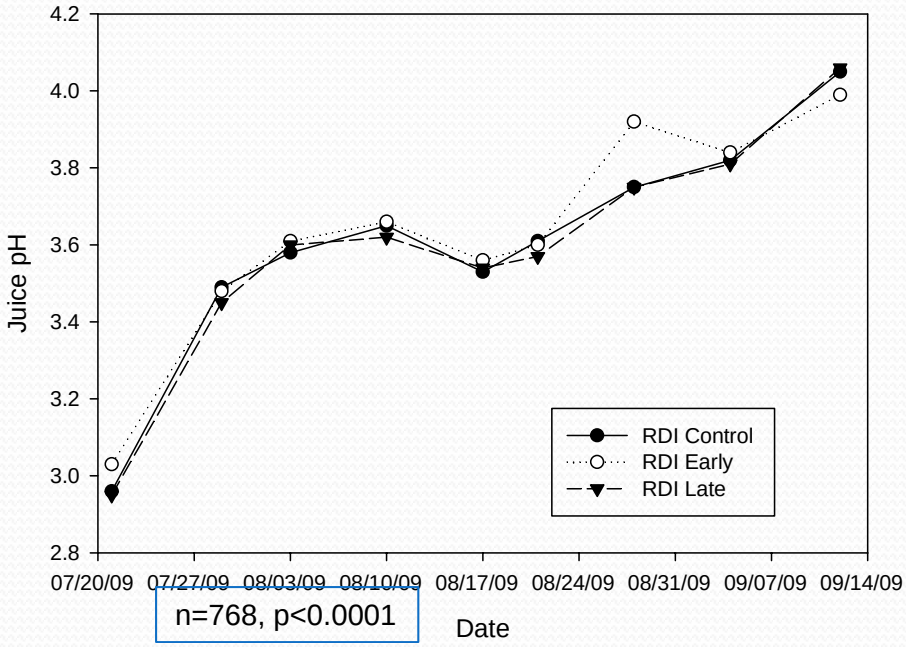


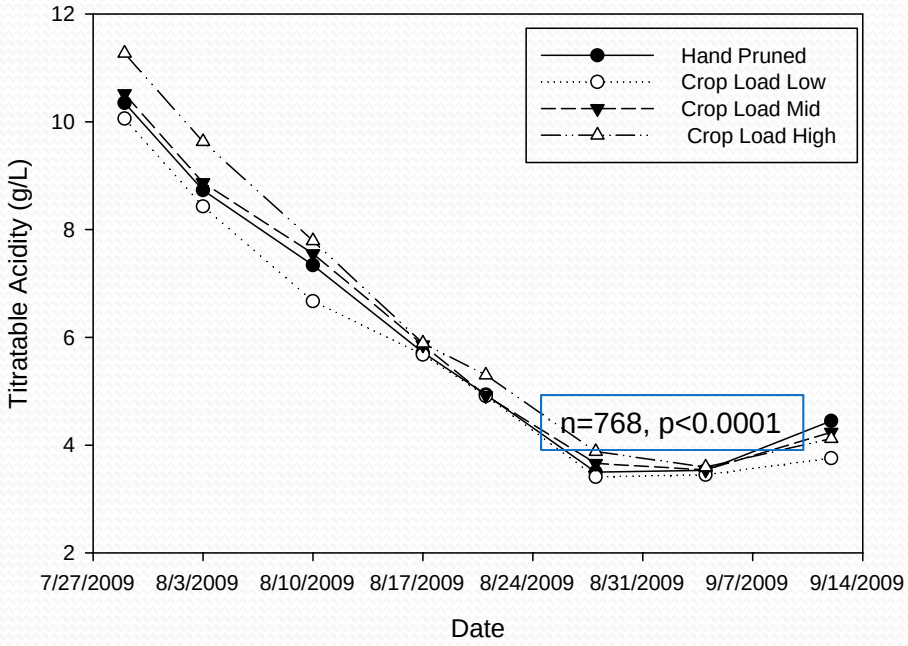
n=768, p<0.0001

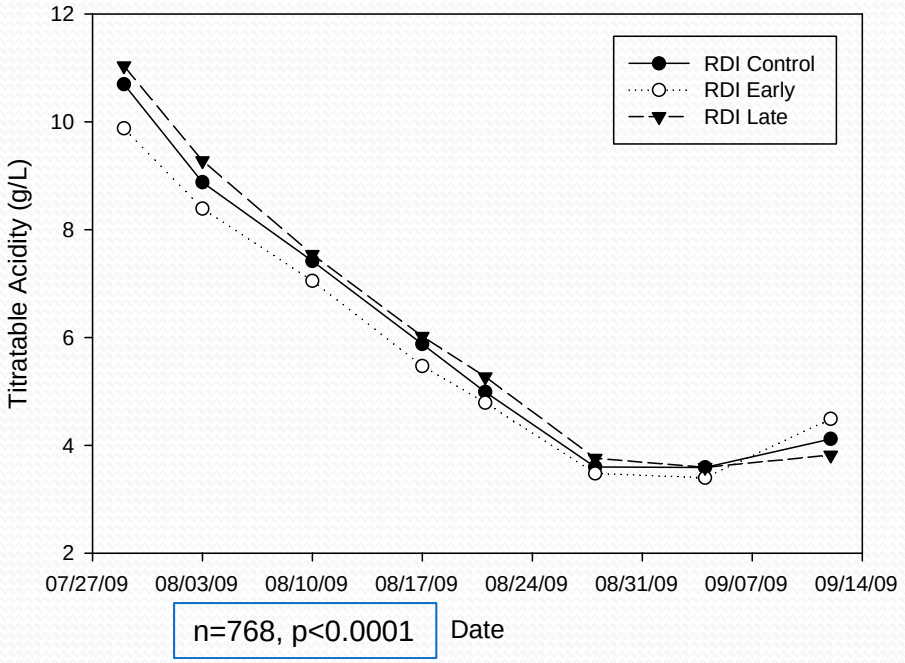
Juice pH in 2009



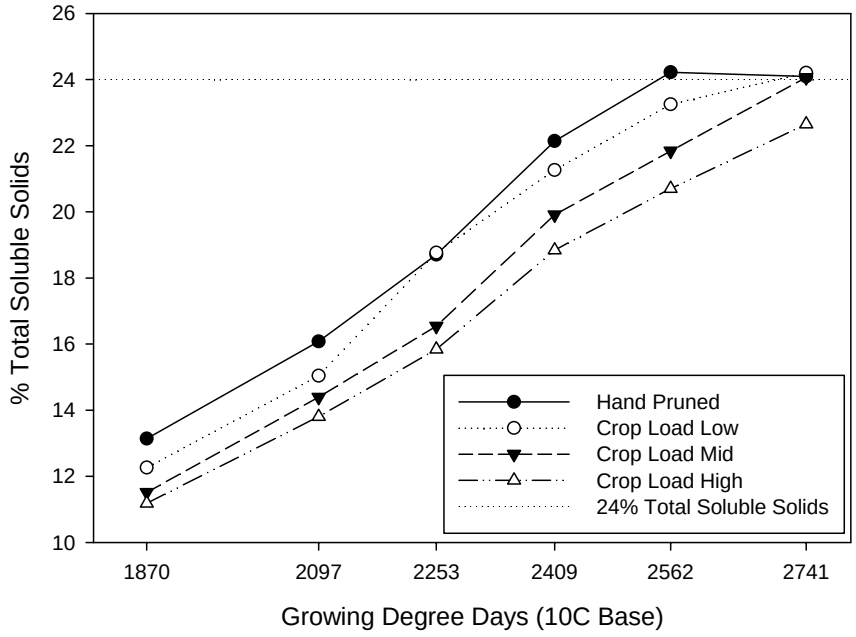


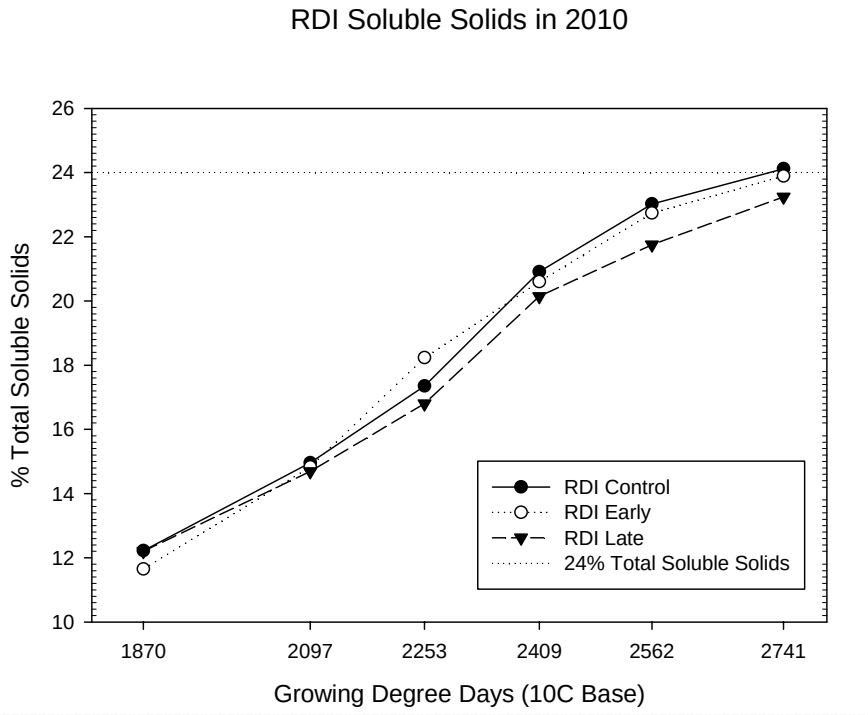
TA in 2009


12
10
8
6
4
2
Titratable Acidity (g/L)
Hand Pruned
Crop Load Low
Crop Load Mid
Crop Load High
n=768, p<0.0001
7/27/2009
8/3/2009
8/10/2009
8/17/2009
8/24/2009
8/31/2009
9/7/2009
9/14/2009
Date

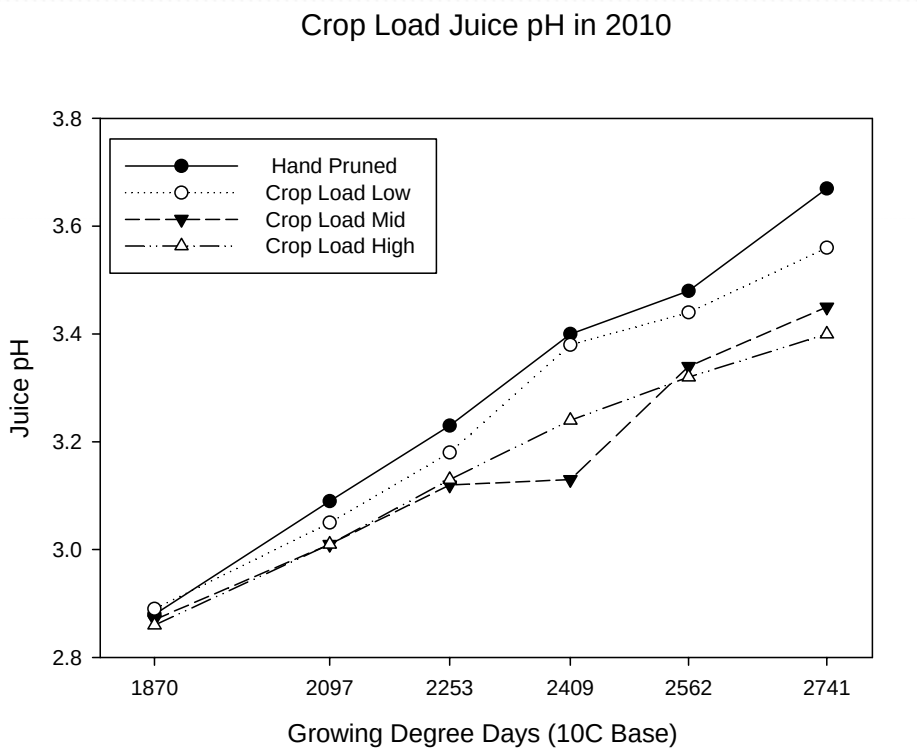

12
10
8
6
4
2
Titratable Acidity (g/L)
RDI Control
RDI Early
RDI Late
07/27/09
08/03/09
08/10/09
08/17/09
08/24/09
08/31/09
09/07/09
09/14/09
n=768, p<0.0001
Date

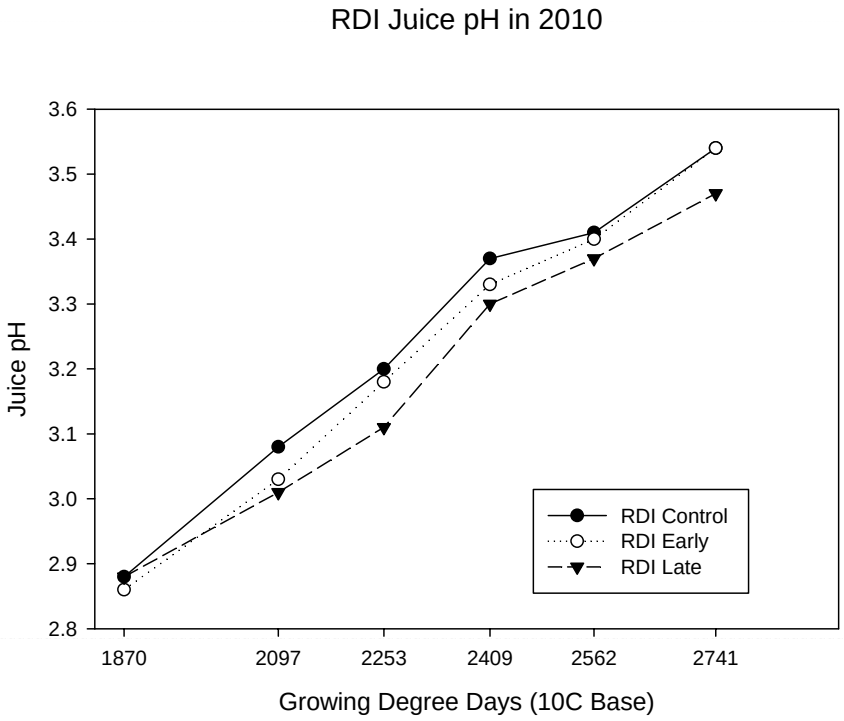
Total Soluble Solids in 2010





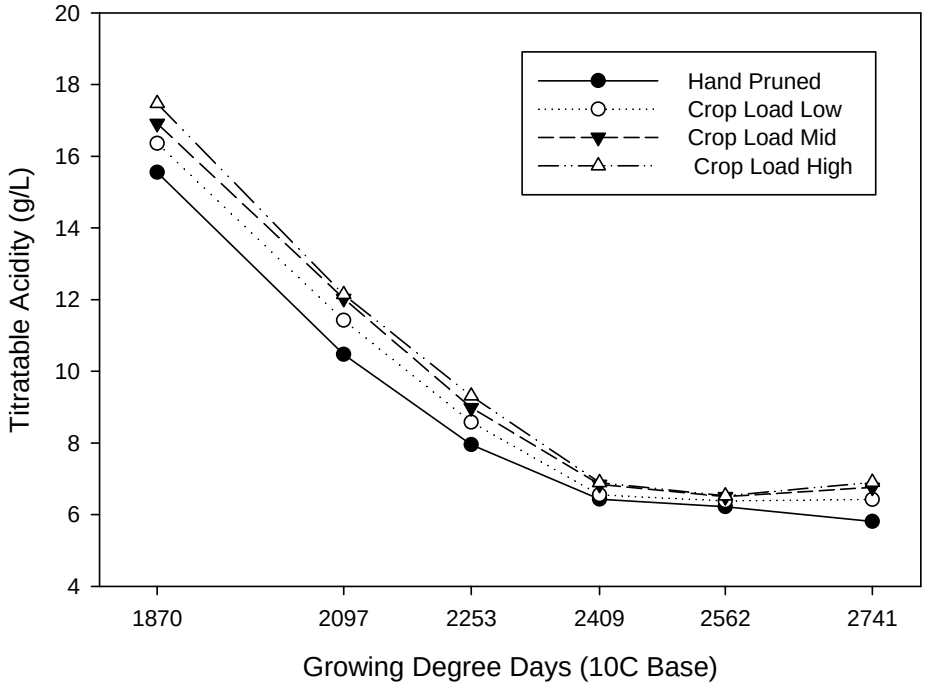
Juice pH in 2010



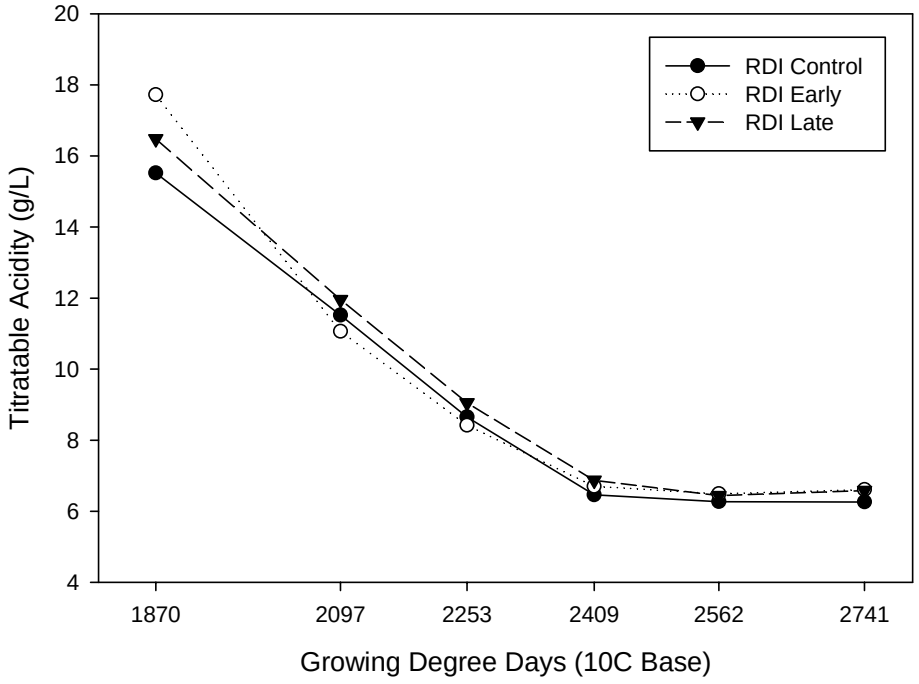


TA in 2010

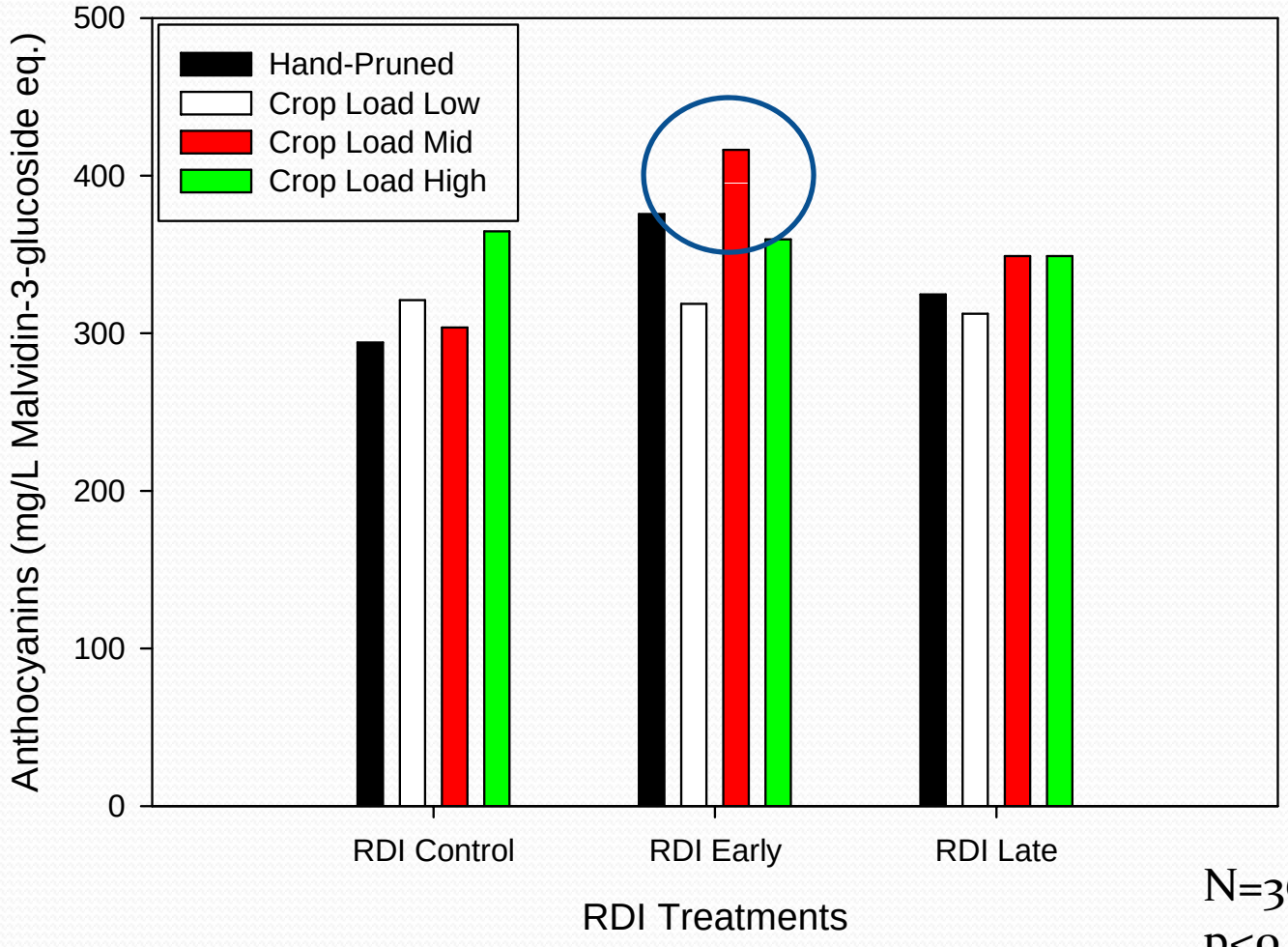
Crop LoadJuice TA in 2010



RDI Juice TA in 2010



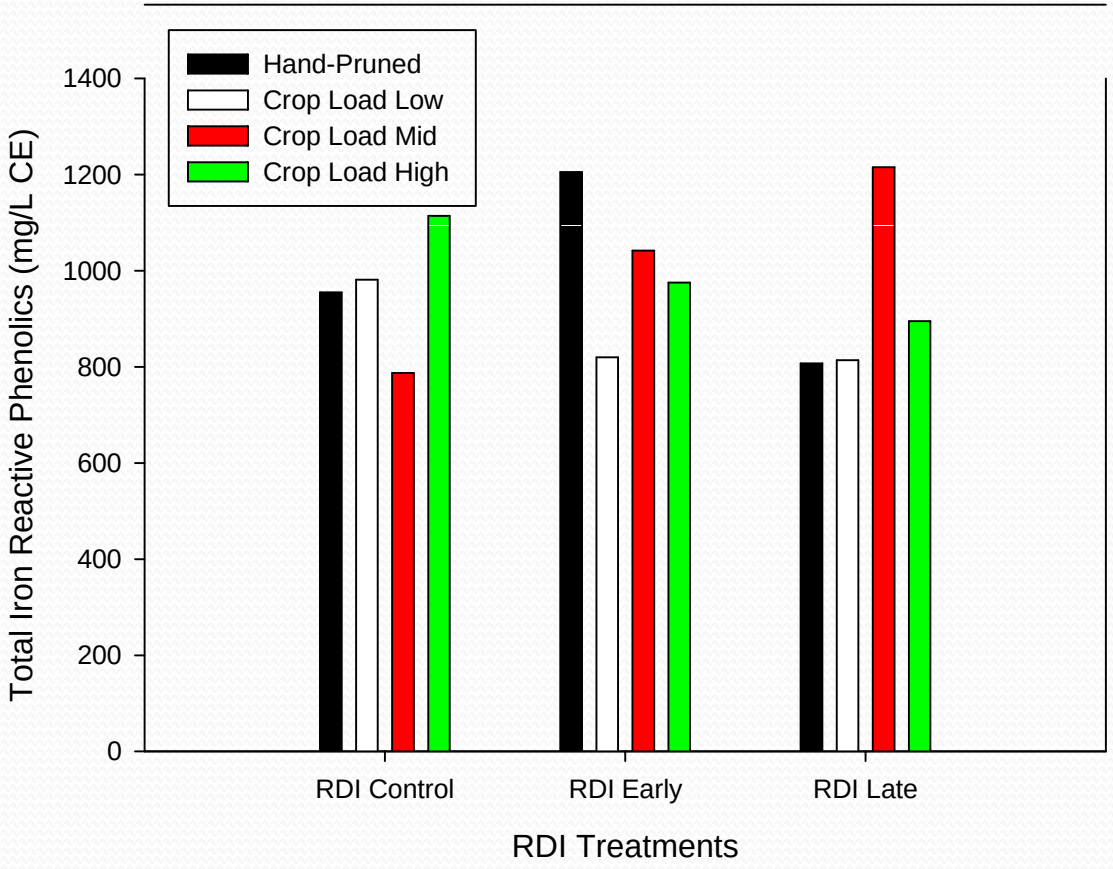
Anthocyanin Concentration in 2009



N=36

p<0.0001

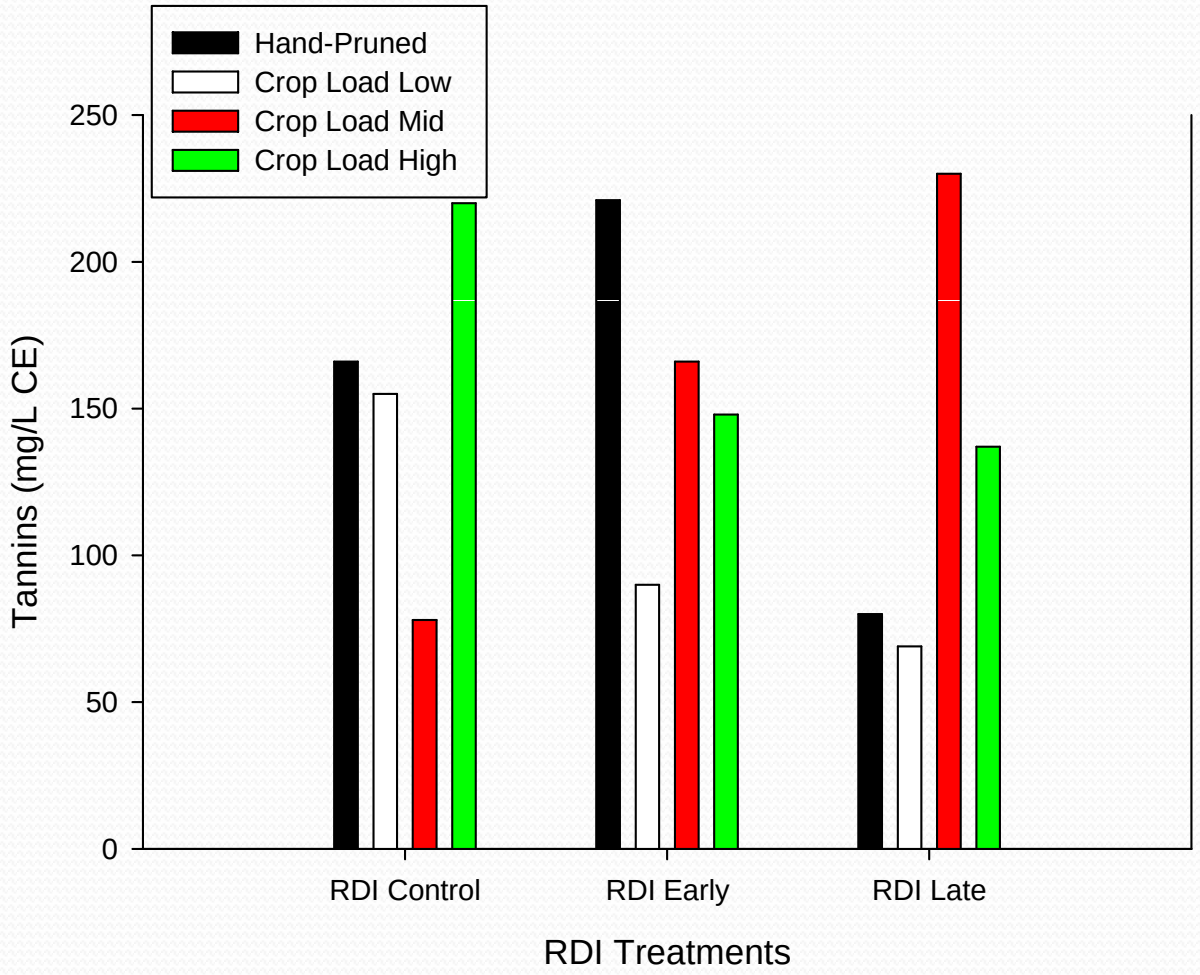
Total Iron Reactive Phenolics in 2009



N=36

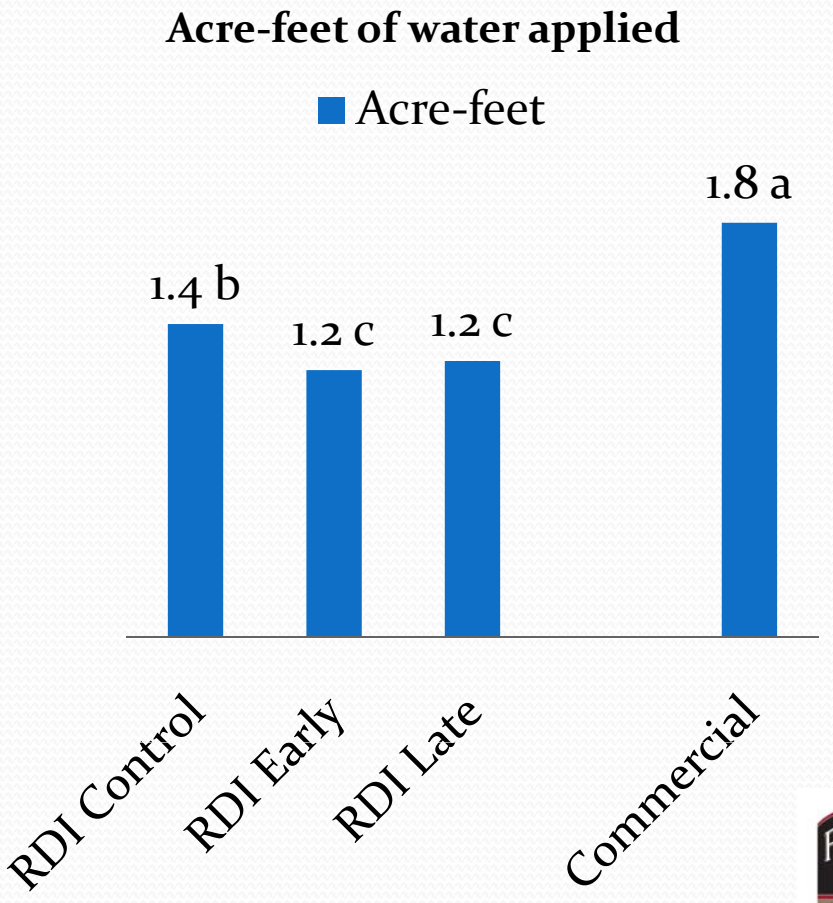
p<0.0001

Tannins in 2009



N=36
p<0.0001

Amount of Irrigation 2009-2010



Source to Sink Ratio of Syrah (m^2/kg)

Canopy Management	2009		2010
Hand Pruned	1.48		1.46
Crop Load Low	0.99		1.64
Crop Load Mid	**1.48**		**1.65**
Crop Load High	1.45		1.30
Pr>F	0.0003		0.6056
RDI			
RDI Control	**1.11**		1.28
RDI Early	1.24		1.68
RDI late	1.11		1.57
Pr>F	0.4351		0.2914
CM x RDI	0.6175		0.3005

Summary

Mechanized Canopy Management

- Reducing Shoot Number per foot by 36% resulted in
  - **39% less shoots exposed per unit area**
  - **Increased distance between shoots by 80%**
  - **Reduced Leaf Layers and Leaf area by 50%**
  - **Reduced Berry weight by 5%**
  - **Reduced cluster weight by 22%**
  - **Increased yield by 5%**
  - **Reduced leaf area to fruit ratio by 54%**
  - **At the Farm Gate**
    - **Increased total phenolics by 9%**
    - **Increased anthocyanins by 15%**
    - **Increased tannins by 6%**

Timing of RDI Stress

- RDI early reduced leaf layer number by 22%
- RDI early reduced cluster weight by 26%
- RDI early reduced berry weight by 16%
- RDI early reduced yield by 30%
- At the Farm Gate
  - RDI early increased total phenolics by 7%
  - RDI early, and late increased anthocyanins by 31%, and 13% respectivley

CM Take Home Message

- Box Prune to 4" hedge
- Mechanically manage canopies to 7 count shoots per foot of row and 9 count flowers per foot row
- Dormant pruning 44 mins/acre
- CM operations 37 mins/acre
- Results in 3-4 leaf layers with, smaller berries, looser clusters with:
  - **11 tons/acre yield with increased phenolics and anthocyanins**

RDI Take Home Message

- Imposing RDI at fruit set results in 25% savings in irrigation
- RDI early can be used as a management tool to express phenolics and anthocyanin color, however yield reduction of 30% for SJV growers might not be profitable

Acknowledgements

- American Vineyard Foundation
- Bronco Wine Company
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