Interactive Effects of Canopy Management Steps for Pinot Grigio in the San Joaquin Valley

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Introduction

- California accounts for 90% of wine grape production in the U.S.
- The San Joaquin Valley accounts for 70% of wine grapes crushed in the U.S.
- Grapes grown in the SJV garner lower prices at the farm gate
  - Growers rely on high yields to remain profitable
- Growers retain too many nodes to meet production goals
- Out-of-balance vines
  - Increased irrigation input
  - Undesirable canopy microclimate

Vicious Cycle of High Vigor

- High vigor + inadequate trellis result in
  - Vegetative Growth Cycle
- Vegetative Growth Cycle:
  - Favors shoot growth over fruit production
  - Excess shade depresses individual processes that affect yield
  - Crop Weight per shoot is low
  - In response to low yield, shoot growth is encouraged
  - Shade problems keep increasing

What is the Canopy?

- It is the Shoot System
- Shoots+Leaves+Clusters
- Collectively
  - Length
  - Height
  - Width
  - Leaf Layers Numbers

Steps in Canopy Management

- Dormant Pruning*
- Shoot Thinning*
- Shoot Positioning
- Cluster Thinning
- Leaf Thinning*
- Hedging/Skirting

Literature Review

- 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).

- Improves wine **quality**, increases **yield**, reduces **disease**, and decreases the production **costs** (Smart 1991)
- CM practices are based on the concepts that increasing the **exposed leaf area** improves fruit quality and that optimal exposure of leaf area can be manipulated by management practices (Reynolds and Vanden Heuvel 2009)

- Light microclimate of the canopy impacts
  - fruit bud differentiation
  - cluster exposure
  - vine water status
  - leaf transpiration
- Translates into higher brix, antho-cyanins, and tannins and lower titratable acidity, malic, and tartaric acids (Reynolds and Vanden Heuvel 2009)

- Few studies have compared the relative composition of fruits exposed to the wide range of sunlight exposures typically encountered in commercial vineyards (Bergqvist, Dokoozlian et al. 2001)
- Mechanized vineyard operations are fast, and make incremental adjustments for fine tuning the crop load a reality (Morris 2007)
  - Shown to reduce labor costs, maintain yield and quality at the farm gate, and reduce the overhead associated with human resources
  - Cost to manage per Hectare decreased by 33% compared to conventional methods (Wample and Kurtural, 2009; Kurtural et al., 2010)

Justification of Research

- Pinot Grigio is an abundant varietal in the SJV
  - Will increase by 25% in 2011 based on plantings
- Lack of knowledge related to sustaining yield and quality at the farm gate and in the cellar by canopy management in the SJV

Objectives

- To evaluate the effects of conventional and mechanical canopy management on:
  - Canopy microclimate
  - Yield components
  - Fruit Composition
  - Wine composition
    - Wine making potential
  - Vine balance
    - Maintain vine capacity and longevity

Hypothesis

- Can we sustain larger yields of Pinot Grigio in the southern San Joaquin Valley by applying steps of canopy management without adversely affecting fruit and wine composition?

Materials and Methods

Plant Materials and Vineyard Management

- Time frame 2010-2012
- PNG/1103P
- Premier sandy-loam
- 2.8m x 3.4m N-S oriented rows
- Bi-lateral cordon at 1.35m
- Foliage support at 1.7m
  - 30cm T-Top
- Drip irrigated
  - Emitters spaced at 105cm
  - 2.4L/h/vine

Experimental Design

- Treatments Factorially Arranged, in 4 Randomized Complete Blocks
- Dormant Pruning
  - Spur-pruned, bilateral cordon-trained
    - (22 Nodes)
  - Mechanically hedged, bilateral cordon-trained
    - (10 cm Hedge)
- Shoot Density
  - Low shoot density (23 shoots/m)
  - Medium shoot density (32 shoots/m)
  - High shoot density (49 shoots/m)
- Leaf thinning
  - Leaf thinned on the East side of canopy (45 cm zone)
  - Not Leaf thinned

Dormant Pruning

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Leaf Thinning Application 20 Days PB

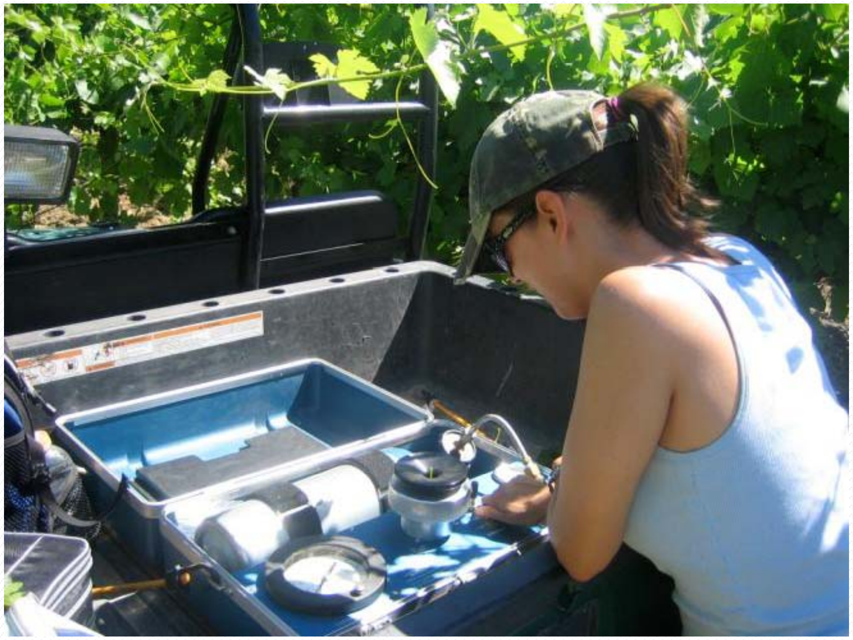
Oxbo-Korvan De-leafer
M62084

45 cm window after leaf thinning

Irrigation Management

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

Weekly Leaf Water Potential Measurements @ Mid-Day



2010 Results

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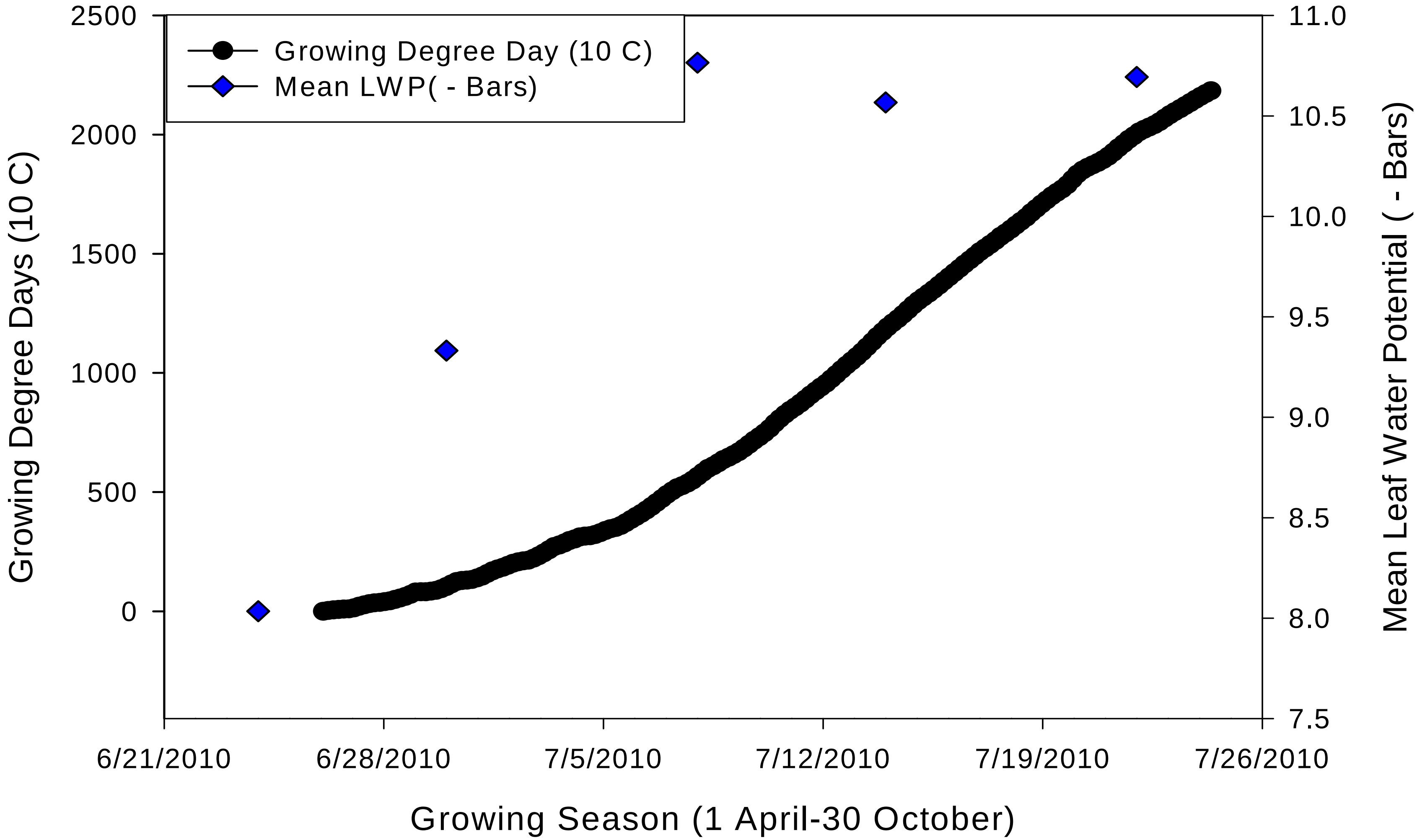
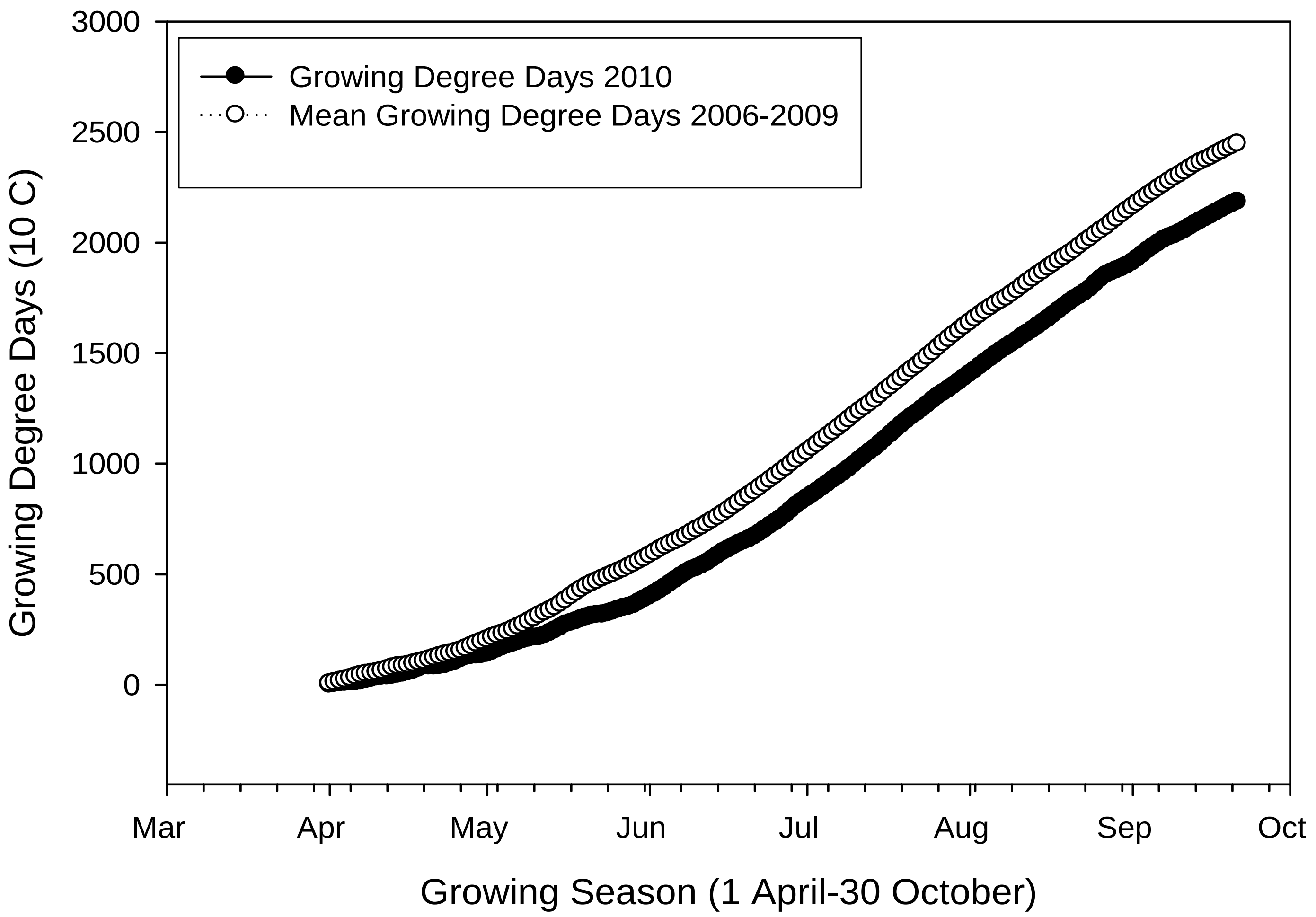
Climate



Growing Degree Day (10 C)
Mean LWP(- Bars)
Growing Degree Days (10 C)
Mean Leaf Water Potential (- Bars)
Growing Season (1 April-30 October)
2500
2000
1500
1000
500
0
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
6/21/2010
6/28/2010
7/5/2010
7/12/2010
7/19/2010
7/26/2010

Comparison of GDD



Number of count and non-count shoots, total shoots per 0.30 m of canopy after pruning and mechanical shoot thinning

Factor			
Pruning Method	Count shoots [t]	Non-count shoots [s]	Total Shoots [r]
Spur [y]	6.5 b	8.1 b	14.6 b
Mechanical	13.6 a	10.2 a	23.9 a
Hedging [x]			
Pr>F	0.0001	0.0067	0.0001
Shoot Density			
Low [w]	8.9 b	8.3	17.3
Medium [v]	10.0 ab	9.7	19.7
High [u]	11.2 a	9.5	20.7
Pr>F	0.0363	0.2756	0.0866
Pruning Method x Shoot Density	0.0181	0.0011	0.0012

Effects of pruning method and shoot density on petiole macronutient concentration at bloom

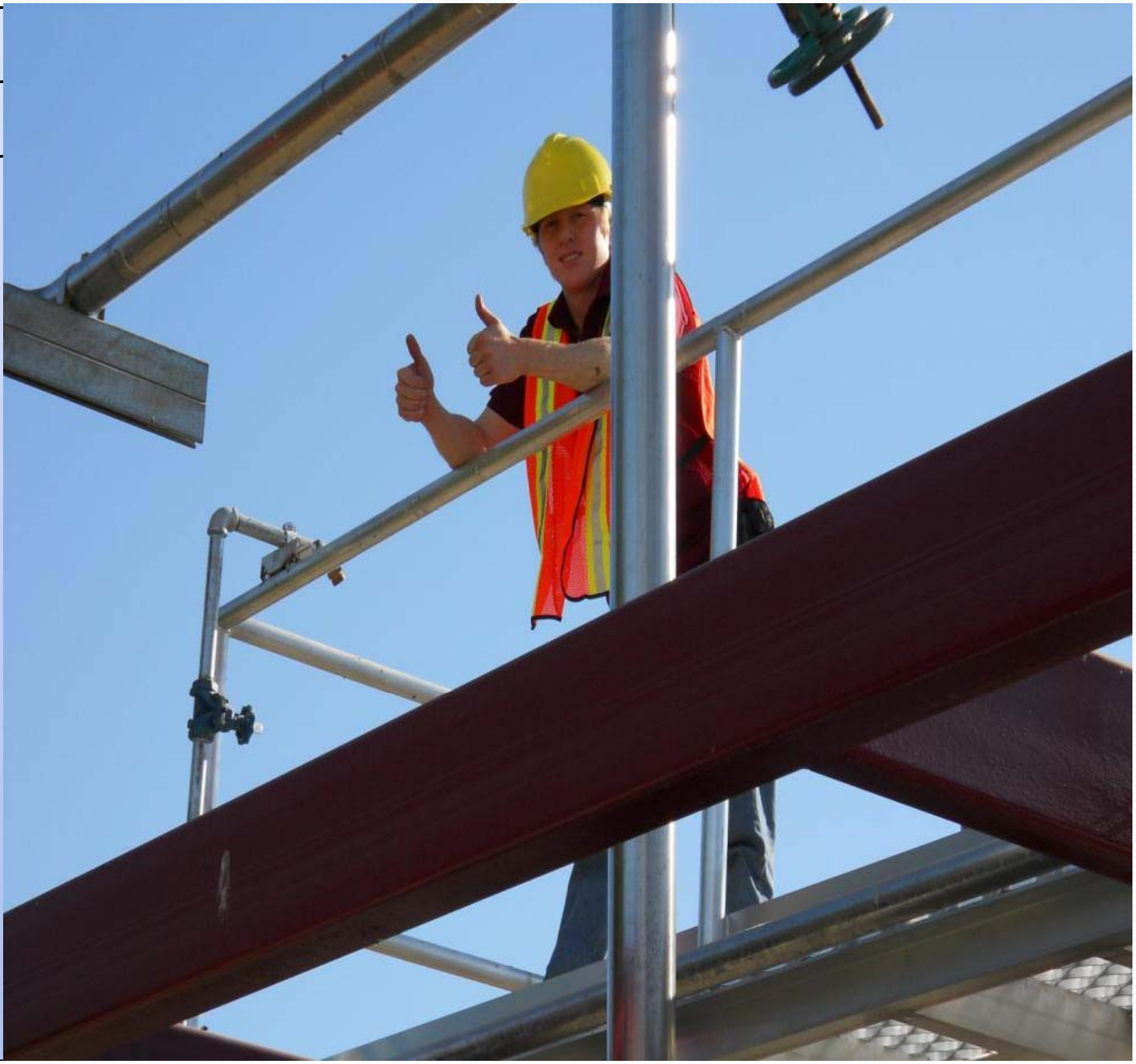
Factor	Macronutrients		
Pruning Method	Nitrate (mg/kg)	Phosphorus (%)	Potassium (%)
Spur	1530 a	0.39 a	1.80
Mechanical Hedging	894 b	0.36 b	1.83
Pr>F	0.0001	0.0001	0.5249
Shoot Density			
Low	1392 a	0.39 a	1.78
Medium	1254 a	0.39 a	1.82
High	988 b	0.36 b	186
Pr>F	0.0008	0.0012	0.4493
Pruning x Shoot Density	0.2035	0.1333	0.3228

Effects of pruning method, and shoot density on petiole micronutrient content at bloom

Factor		Micronutrients		
Pruning Method	Boron (mg/kg)	Zinc (mg/kg)	Sodium (%)	Iron (mg/kg)
Spur	40.3	103.7 a	0.018	73.7
Mechanical Hedging	39.6	82.0 b	0.021	74.0
Pr>F	0.1551	0.0001	0.1796	0.8370
Shoot Density				
Low	40.5	98.8 a	0.0219	75.0
Medium	39.9	93.0 a	0.0175	73.5
High	39.5	86.8 b	0.0193	73.1
Pr>F	0.2918	0.0009	0.1604	0.4145
Pruning Method x Shoot Density	0.5842	0.0126	0.6305	0.1290

Effect of pruning method, shoot thinning and leaf thinning on canopy microclimate and photosynthetic photon flux density transmittance through the fruit zone

Factor	Post-shoot thinning [y]
Pruning Method	**% PPFD [q] transmittance**
Spur [w]	22.4 a
Mechanical	11.4 b
Hedging [v]	
Pr>F	0.0001
Shoot Density	
Low [u]	22.6 a
Medium [t]	15.4 b
High [s]	12.7 b
Pr>F	0.0004
Leaf thinning [r]	
No	-
Yes	-
Pr>F	-
Pruning x Shoot Density	0.5660
Pruning x Leaf Thinning	-
Shoot Density x Leaf Thinning	-
Pruning x Density x Leafing	-



Effect of Pruning Method, Shoot Thinning, & Leafing on Fruit Set

Factor				
Pruning Method	Cluster weight(g)	Berries set/cluster	Set berry weight(g)	% berries set/cluster
Spur [y]	68.4	167	0.34	31
Mechanical Hedging [x]	65.1	161	0.34	32
Pr>F	0.3307	0.3412	0.6010	0.2579
Shoot Density				
Low [w]	62.7	155	0.34	30
Medium [v]	70.6	174	0.34	32
High [u]	66.9	164	0.34	32
Pr>F	0.1775	0.0926	0.6479	0.1269
Leaf thinning [t]				
No	66.7	163	0.35	31
Yes	66.8	164	0.33	32
Pr>F	0.9925	0.8207	0.0735	0.7572
Pruning x Shoot Density	0.2023	0.1441	0.0977	0.4200
Pruning x Leaf Thinning	0.2596	0.1180	0.1031	0.2231
Shoot Density x Leaf Thinning	0.0367	0.0253	0.7335	0.0407
Pruning x Density x Leafing	0.6391	0.8696	0.3980	0.6897

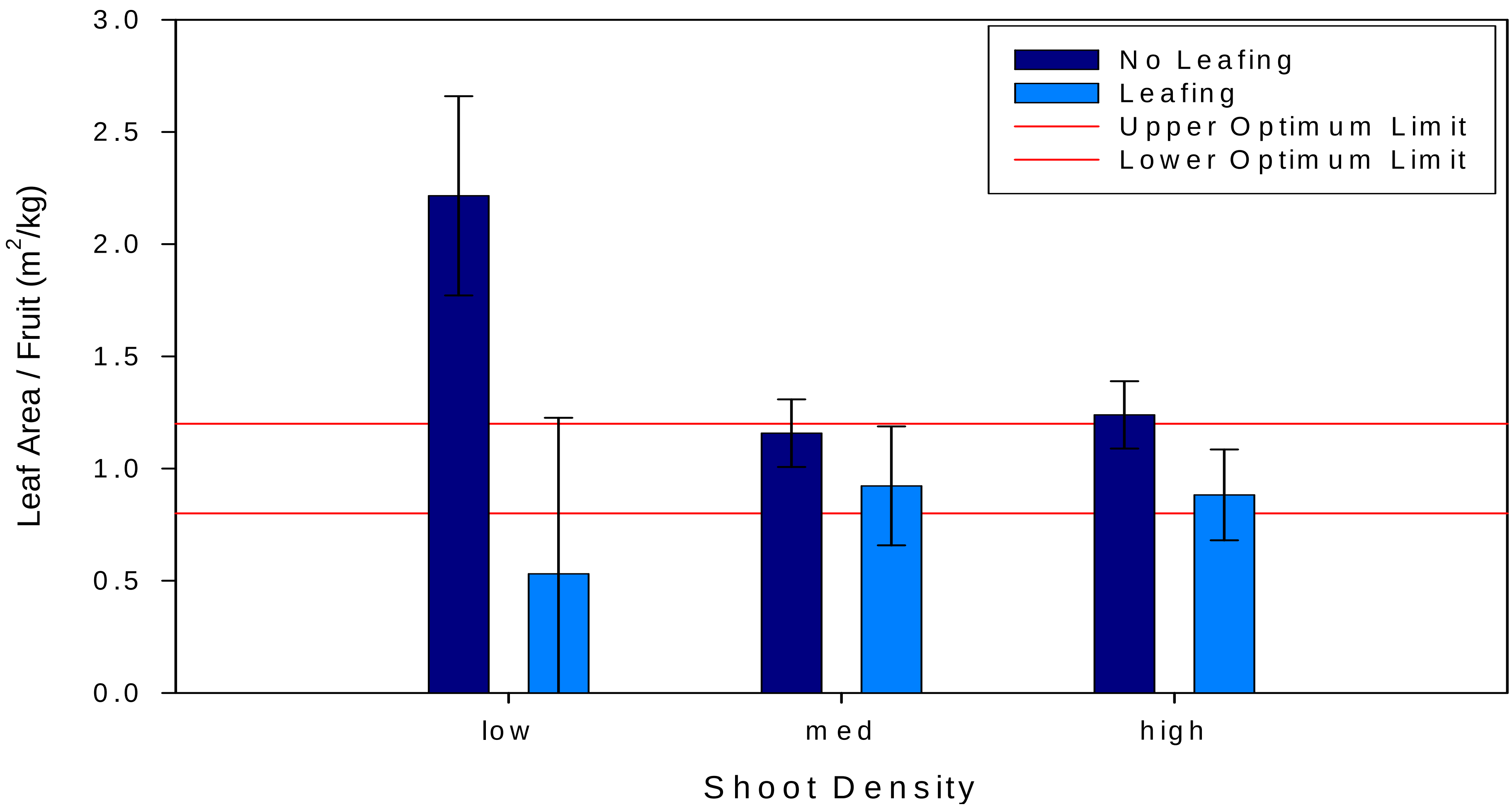
Effect of pruning method, shoot thinning and leaf thinning on yield components

Factor					
Pruning Method	Berry Weight (g)	Clusters per vine	Cluster weight (g)	Yield per vine (kg)	Yield per acre (Tons/Acre)
Spur [y]	1.28 a	85 b	120.3 a	22.6 b	6.4 b
Mechanical Hedging [x]	1.12 b	170 a	104.1 b	38.9 a	11.0 a
Pr>F	0.0001	0.0001	0.0001	0.0001	0.0001
Shoot Density					
Low [w]	1.24 a	108 b	111.3	26.2 c	7.4 c
Medium [v]	1.20 ab	123 b	113.4	30.4 b	8.6 b
High	1.16 a	151 b	111.9	35.8 a	10.1 a
Pr>F	0.0356	0.0001	0.8499	0.0001	0.0001
Leaf thinning [t]					
No	1.20	127	113.0	31.0	8.8
Yes	1.20	127	111.4	30.6	8.7
Pr>F	0.9945	0.9846	0.5942	0.7905	0.7905
Pruning x Shoot Density	0.1578	0.0021	0.1524	0.1488	0.1488
Pruning x Leaf Thinning	0.9917	0.4014	0.7860	0.4541	0.4541
Shoot Density x Leaf Thinning	0.4739	0.5580	0.6422	0.5551	0.5551
Pruning x Density x Leafing	0.9511	0.1926	0.4810	0.1134	0.1134

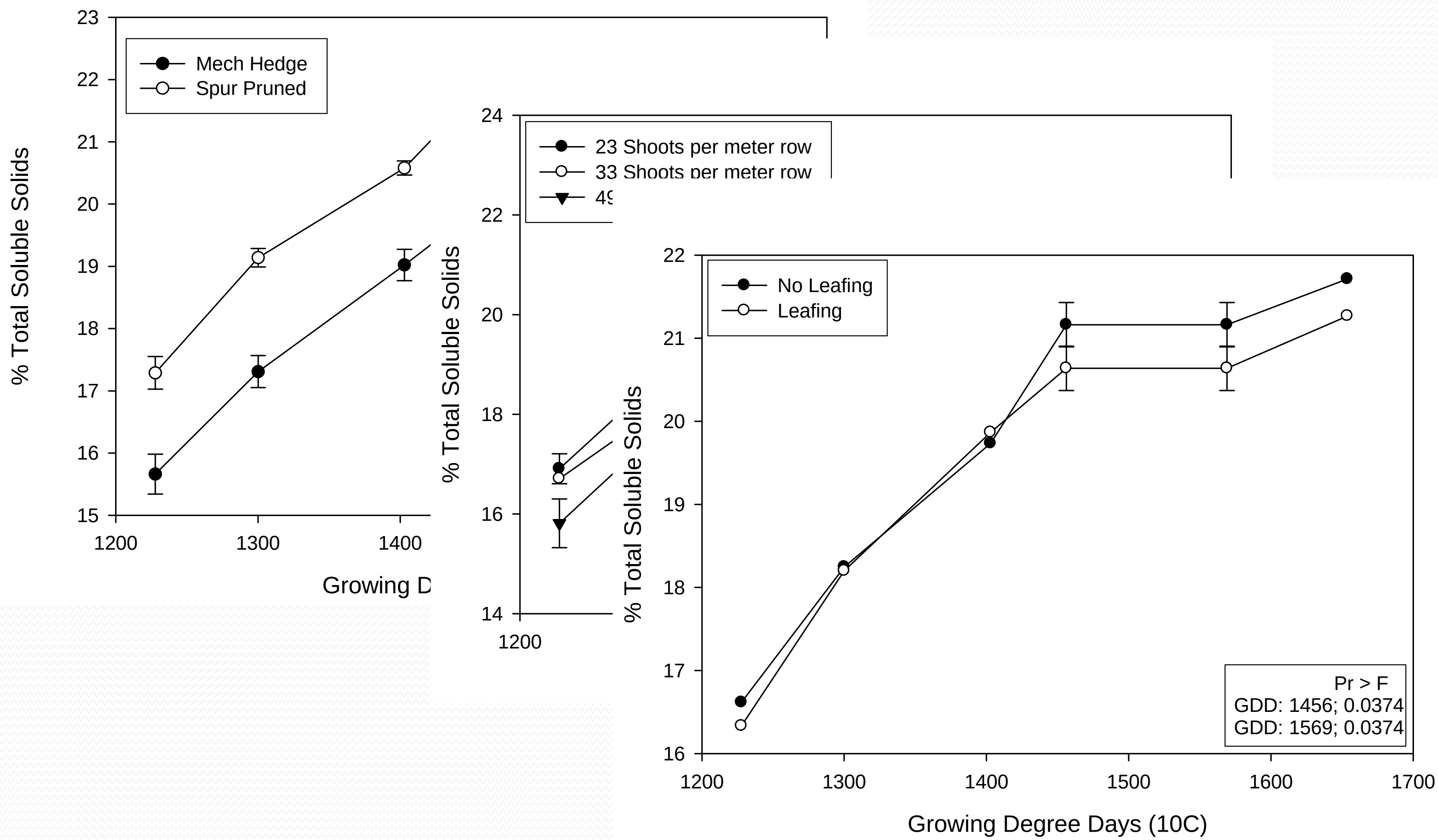
Effect of pruning method, shoot thinning and leaf thinning on the source to sink relationship

Factor				
Pruning Method	Canopy Area (m^2)	Leaf Area to Fruit Ratio (m2/kg)	Distance Between Shoots (cm)	Shoots / ha
Spur [y]	10.78	1.110	5.007	6,3471
Mechanical Hedging [x]	21.44	1.205	2.435	133,307
Pr>F	0.0005	0.6531	0.0001	0.0001
Shoot Density				
Low [w]	16.15	1.373	3.968	8,7400
Medium [v]	14.85	1.040	3.646	9,7484
High	17.33	0.610	3.549	110,282
Pr>F	0.7628	0.3582	0.6044	0.0259
Leaf thinning [t]				
No	21.10	1.537	3.928	91,314
Yes	11.12	0.7788	3.513	105,464
Pr>F	0.0009	0.0010	0.2492	0.0381
Pruning x Shoot Density	0.6796	0.5175	0.3371	0.0123
Pruning x Leaf Thinning	0.6046	0.4250	0.6608	0.1032
Shoot Density x Leaf Thinning	0.0288	0.0136	0.3590	0.2065
Pruning x Density x Leafing	0.4132	0.3884	0.6464	0.8445

Source to sink relationship



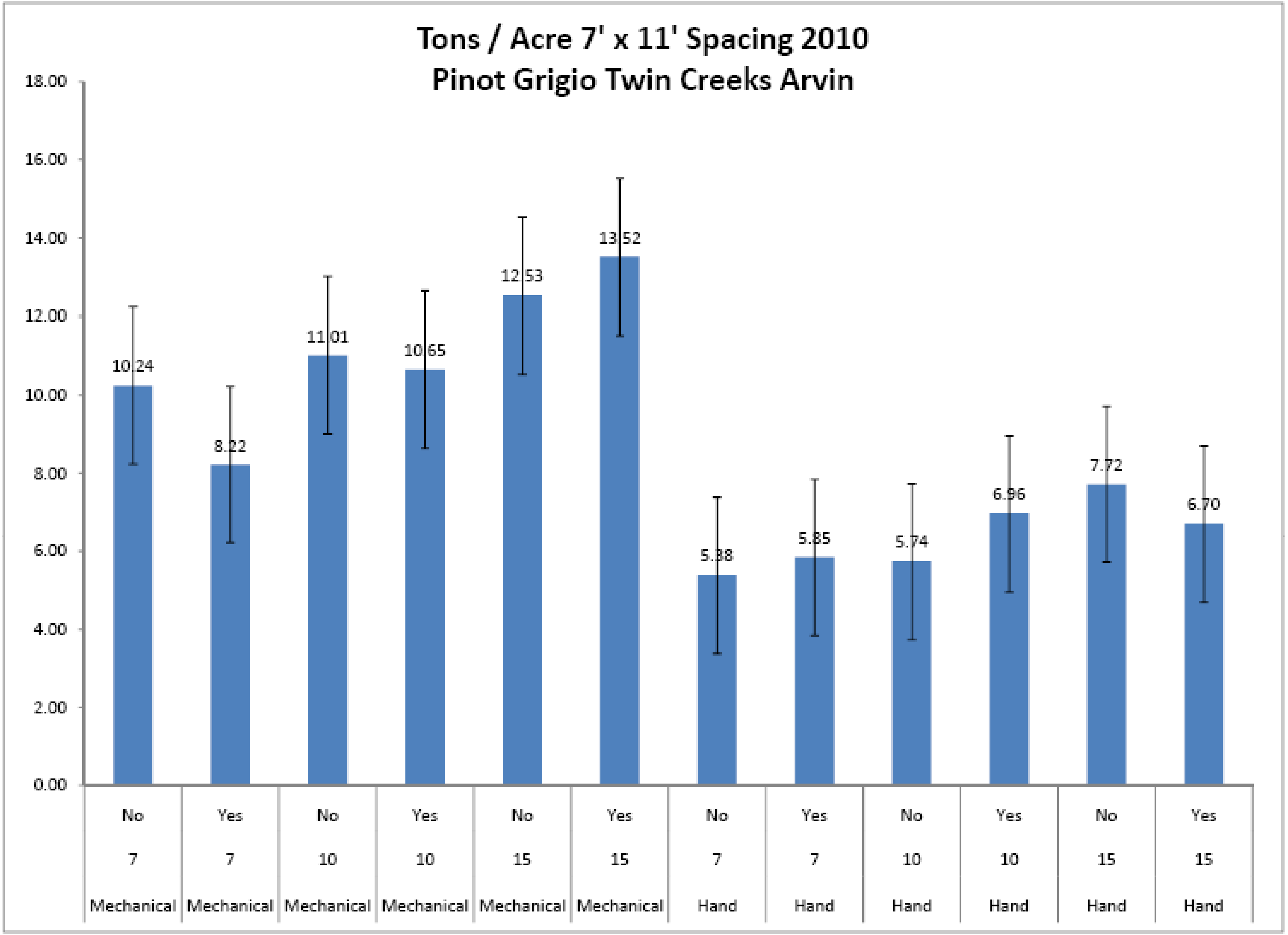
Fruit Chemistry of PNG in 2010



Effect of pruning method, shoot thinning and leaf thinning on total iron reactive phenolics, tannins, and non-tannin phenols

Factor Pruning Method	Total iron reactive phenolics (mg/L CE)	Tannins (mg/L)	Non-tannin phenolics (mg/L)
Spur [y]	110.6	3.0	107.6
Mechanical Hedging [x]	119.8	2.9	116.8
Pr>F	0.4058	0.6190	0.4032
Shoot Density			
Low [w]	125.4	2.9	122.4
Medium [v]	110.4	3.1	107.3
High [u]	109.8	2.9	106.9
Pr>F	0.4230	0.3837	0.4248
Leaf thinning [t]			
No	107.4	2.9	104.6
Yes	122.9	3.1	119.8
Pr>F	0.1724	0.0997	0.1793
Pruning x Shoot Density			
Pruning x Leaf Thinning	0.2375	0.2590	0.2436
Shoot Density x Leaf Thinning	0.3725	0.5564	0.3794
Pruning x Density x Leafing	0.0423	0.1036	0.0449

Interaction Means of Yield



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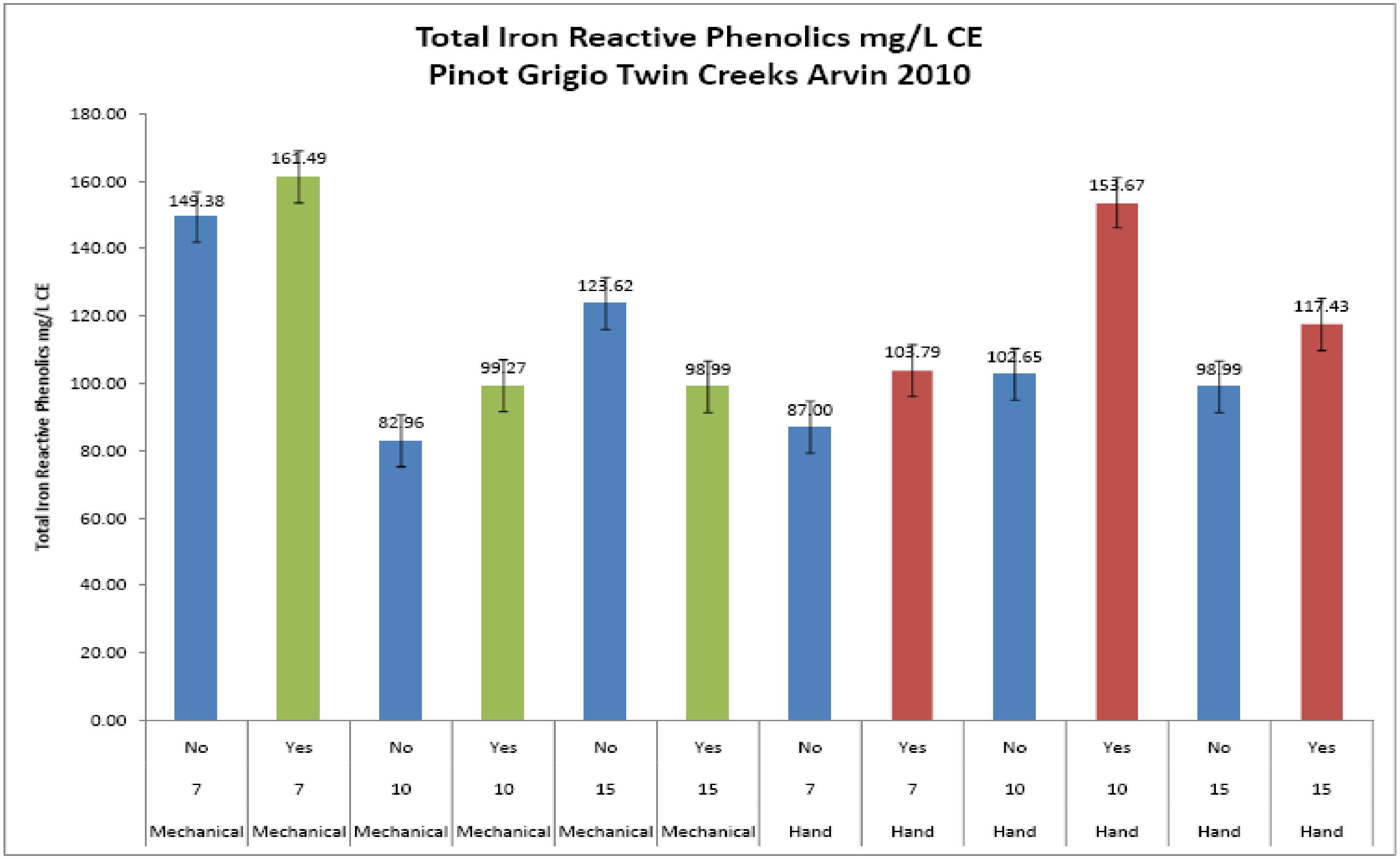
Interaction Means of Wine Phenolics



2010 Summary

- Leaf thinning increased PPFD transmittance in 2010
- Yield per vine was higher in mechanically hedged vines regardless of shoot thinning compared to hand pruned treatments
- Optimum source to sink (vine balance) levels were obtained for vines with medium shoot density (regardless of leafing), and high shoot density with leafing
- Vines that were mechanically hedged with lower shoot density and that were leaf thinned had the highest total iron reactive phenolics in finished wine in 2010

Future Work

- Dormant pruning & vine size to assess production efficiency
- Repeat the study in 2011
- Improve wine making protocol
- Create recommended canopy management protocols for Pinot Grigio varietals in the San Joaquin Valley

Acknowledgements

- American Vineyard Foundation
- Bronco Wine Company
- West Coast Grape Farming
- Cottonwood Creek Winery
- Geoffrey Dervishian and everybody in the Bronco Lab

Economics

- Hand Harvesting
  - Going piece rate is $80-100+ per ton
  - 5-6 people (on avg) to pick a ton of grapes in one hour
  - @ 7 ton/acre = 35 man-hours per acre = $560-$700/ac
  - You need 4 truckloads in 8 hrs? You'll need 60 people!

- Machine Harvesting
  - Costs range from $275-325 per acre
  - 3 people can harvest 2.5 to 3 acres per hour (*10' rows, 2+mph*)
  - = 17.5 – 21 tons per machine hour (@ 7 ton/acre)
  - = 1.0 – 1.2 man-hours per acre (= 97% savings)
  - Cost / ton = $40-50 per ton (= 50% savings)
  - Harvest 4 truckloads in 4.5 hours

- Annual savings on 300 acres = $28,000 to $35,000

Statistics from Greg Burg, Viticulturist, OXBO Int.

Hand Pruning (HP) Cost

	Monthly Salary *	Salary/hour	Time (hour/vine)	Cost/vine
Supervisor	$5576	$34.85	-	$0.08**
Workers	-	$8.90	0.047	$0.42
TOTAL				$0.50

* 2008 Agricultural Wage and Benefit Survey Report

** 1 supervisor oversee 20 workers who pruning 420 vines in one hour

Machine Pruning (MP+MT) Cost

	Cost/acre	Time (hour/vine)	Vine/acre	Cost/vine
Machine (precision pruning pass)	$91.27	0.01	516	$0.18
Machine thin/cordon clean pass	$56.17	0.03	516	$0.11
TOTAL				$0.29

Twin Creeks Pinot Gris Layout 2010

Spur = 21 2-bud spurs per vine	Hedge= Box Prune 4" Hedge

51 Total Rows- 4 12-row treatment blocks, with a guard row between blocks

	Treatments											
	1	2	3	4	5	6	7	8	9	10	11	12
Pruning	spur	spur	spur	spur	spur	spur	hedge	hedge	hedge	hedge	hedge	hedge
Shoots/ft.	7	10	15	7	10	15	7	10	15	7	10	15
Leafing	No	No	No	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes

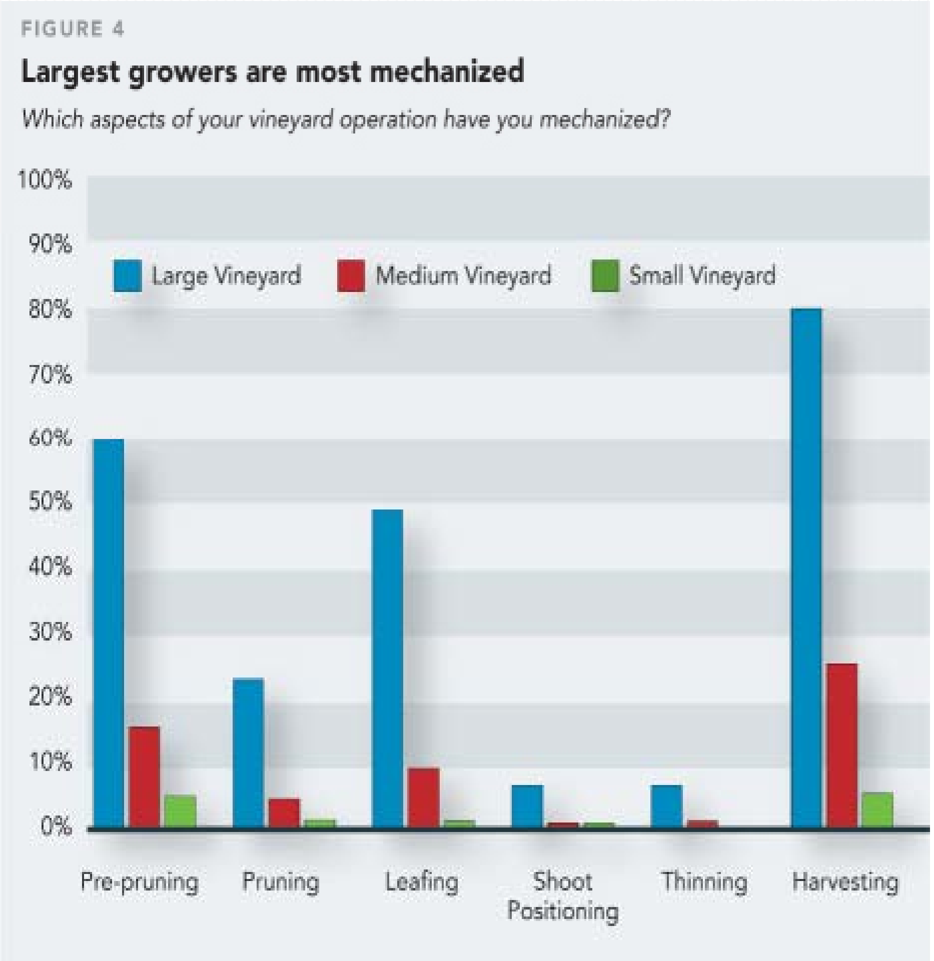
Block 1= 12 consecutive rows													
Row	125	126	127	128	129	130	131	132	133	134	135	136	137
Treatment	9	11	2	5	10	12	3	8	4	6	1	7	Guard

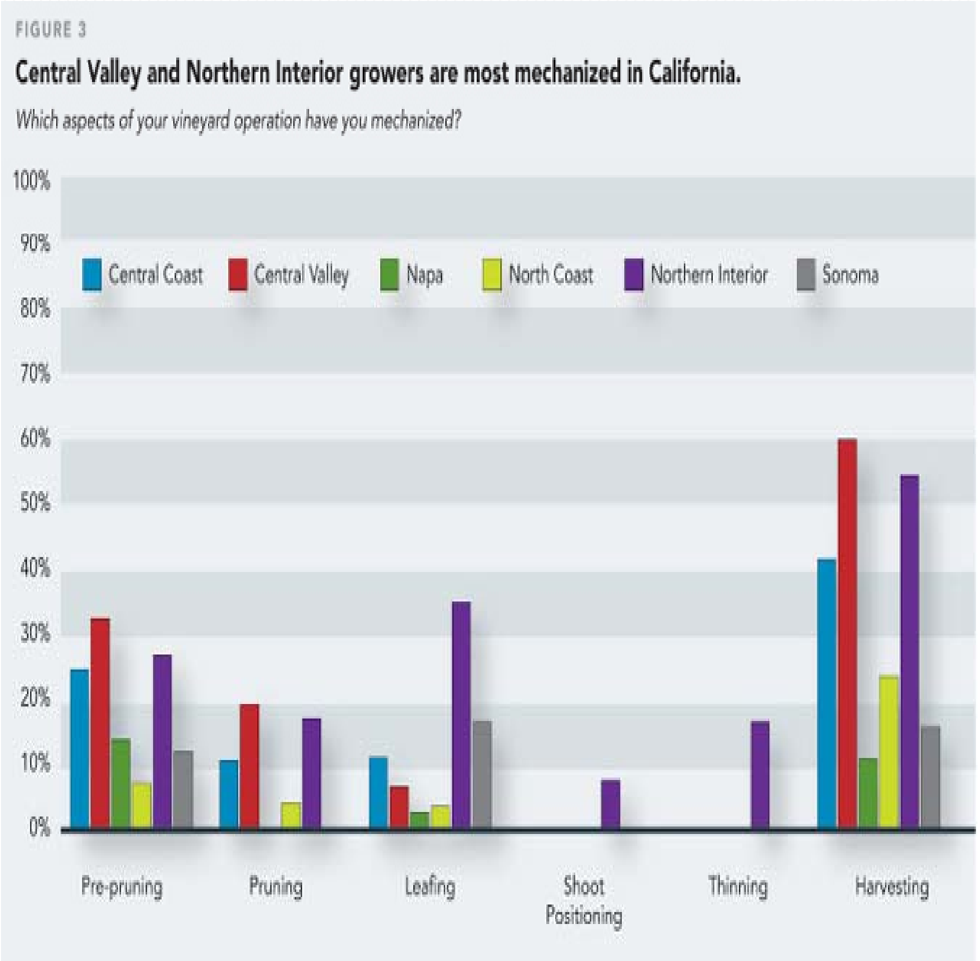
Block 2= 12 consecutive rows													
Row	138	139	140	141	142	143	144	145	146	147	148	149	150
Treatment	6	3	9	1	4	7	12	10	2	11	8	5	Guard

Block 3= 12 consecutive rows													
Row	151	152	153	154	155	156	157	158	159	160	161	162	163
Treatment	11	7	8	1	5	6	9	3	10	2	4	12	Guard

Block 4= 12 consecutive rows													
Row	164	165	166	167	168	169	170	171	172	173	174	175	176
Treatment	12	9	2	11	10	6	5	1	3	8	7	4	Guard

Mechanization in CA Grape Industry





Wine Business Monthly Nov. 15, 2009