Research efforts to achieve a more favorable vine balance with Cabernet Sauvignon

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18 February 2011
Virginia Vineyards Association's Annual Technical Conference

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What is "balance"?

- Amount of vegetative growth
- Duration of vegetative growth
- Relationship of leaf area or other vegetative growth metrics to crop

How does balance relate to vine "capacity"?

How does balance and capacity relate to wine quality potential?

High capacity vines

Low capacity vines

Measures of balance

Crop load – 5 to 10 pounds of crop per pound of cane prunings

Leaf area: 1.2 to 1.5 m^2 of leaf area per kg of crop

Leaf area: about 1.5 m^2 of leaf area per meter of canopy

Shoot growth cessation at or shortly before veraison; minimal lateral shoot development

Greater homogeneity of fruit ripening and year-to-year performance

Consequences of imbalance

Increased disease pressure within canopy and on fruit

Reduced fruit quality (pH/acid imbalance, color)

Potential negative impact on tannins and herbaceousness

Added labor costs in canopy management (remedial measures)

Remedial means of targeting vine balance

These measures generally treat the symptoms, and not necessarily the fundamental causes of imbalance

- Shoot hedging
- Selective leaf removal
- lateral shoot removal

Proactive means of targeting vine balance

Site Selection (topography, soils and soil hydrology

- Surface drainage (avoid areas of soil /water import)
- Slopes – decreased moisture retention with increased slope
- Internal drainage (permeability)
- Water-holding capacity
- Fertility (avoid high OM soils)

Soil feature	Importance in site selection[1]	Desirable value	Undesirable value	Ability to modify[2]
Internal water drainage	*****	> 2” / hour	< 2” / hour	+ (tile drainage is possible but expensive
Water holding capacity	****	< 0.10 inch/ inch of soil	> 0.15 inch/ inch of soil	++ (can be increased)
Effective rooting depth	***	> 3 feet	< 1 foot in the absence of irrigation	-- (deep ripping may increase rooting depth)
Moist bulk density	***	< 1.5 g/cm^3	$\geq$ 1.5 g/cm^3	-- (can be increased)
Fertility	****	Relatively infertile	Highly fertile	+++ (can be increased)

[1] Relative importance, with multiple asterisks indicating greater importance in site selection process.

[2] Relative ease of adjustment: +++ denotes readily adjusted and – indicating increasingly difficult or impossible (---) to practically adjust.

Proactive means of targeting vine balance

More elaborate training systems

- Divided canopy training as example

Proactive means of targeting vine balance

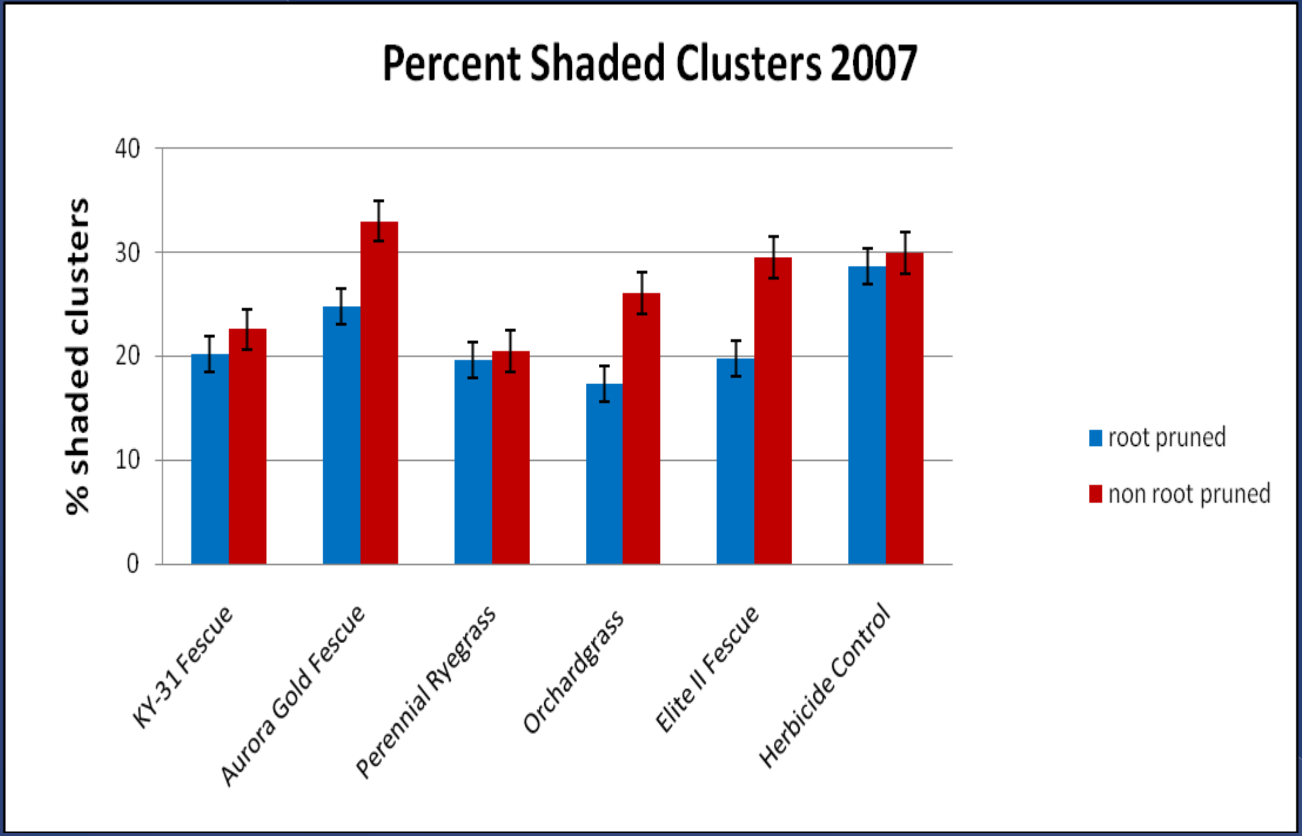
Other measures

- Planting density?
- Rootstocks
- Cover Crops
- Root restriction?
- Root-pruning?

Cane pruning weights from cover crop / root-pruning project in Dobson, NC (2008) Gill Giese's project. Pruning weights are in kg per vine, where the "optimum" vine size would range from 0.55 – 1.10 kg per vine (vines are 6' apart in the row.

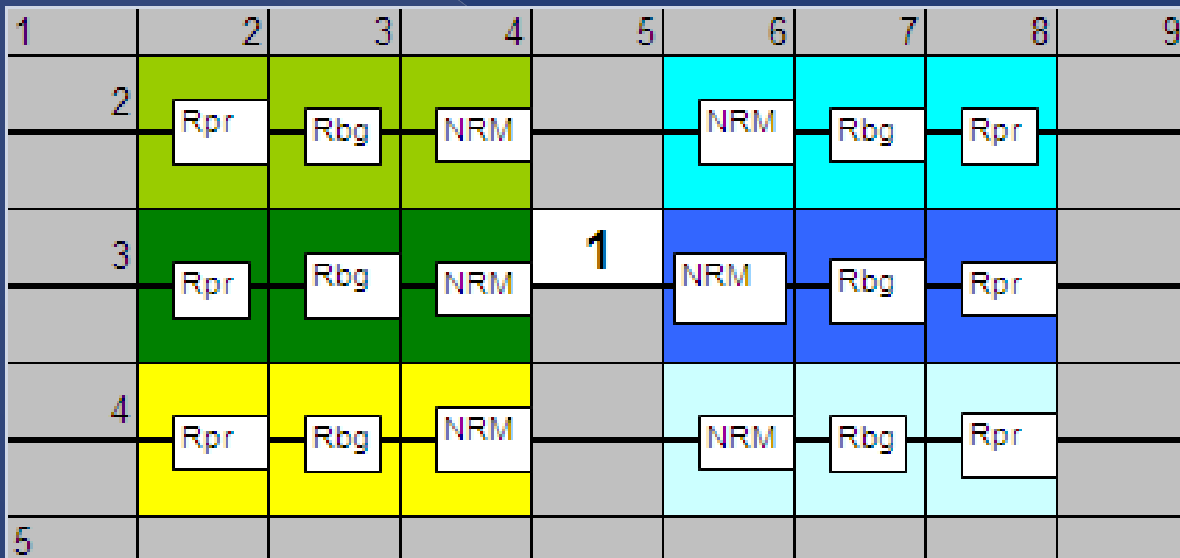
Treatment	Root-pruned		Mean
	Yes	No	
Fescue 31	0.86	1.35	1.11 bc
Aurora Gold fescue	0.90	1.40	1.15 bc
Perennial Ryegrass	1.00	1.46	1.23 b
Orchardgrass	1.11	1.42	1.27 b
Elite II turf-type fescue	0.79	1.19	0.99 c
Herbicide Control	1.41	1.52	1.47 a

Fruit exposure from cover crop / root-pruning project in Dobson, NC (2007) Gill Giese's project. Percent shaded cluster counts were derived from canopy point quadrat analyses.



Treatments

- Cover crops vs herb. strip
- Rootstocks
- Root manipulation



1 =	101-14			
2 =	420-A		or	
3 =	riparia			
				Plots **without** cover crop under trellis
				Plots **with** cover crop under trellis

Data collection:

- Vines planted 2006; data collected since 2008
- Vegetative development (lateral growth, leaf area, canopy architecture)
- Plant water status
- Soil moisture
- Fruit components of yield and fruit chemistry

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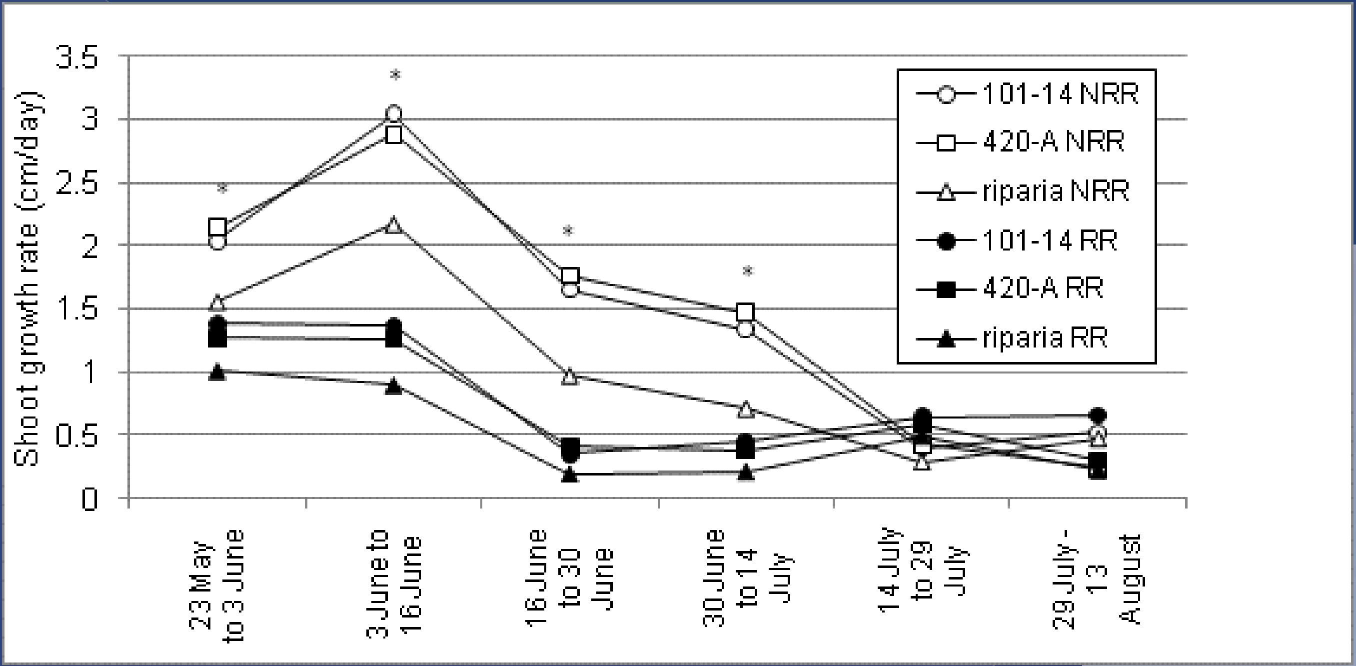

Shoot growth rate

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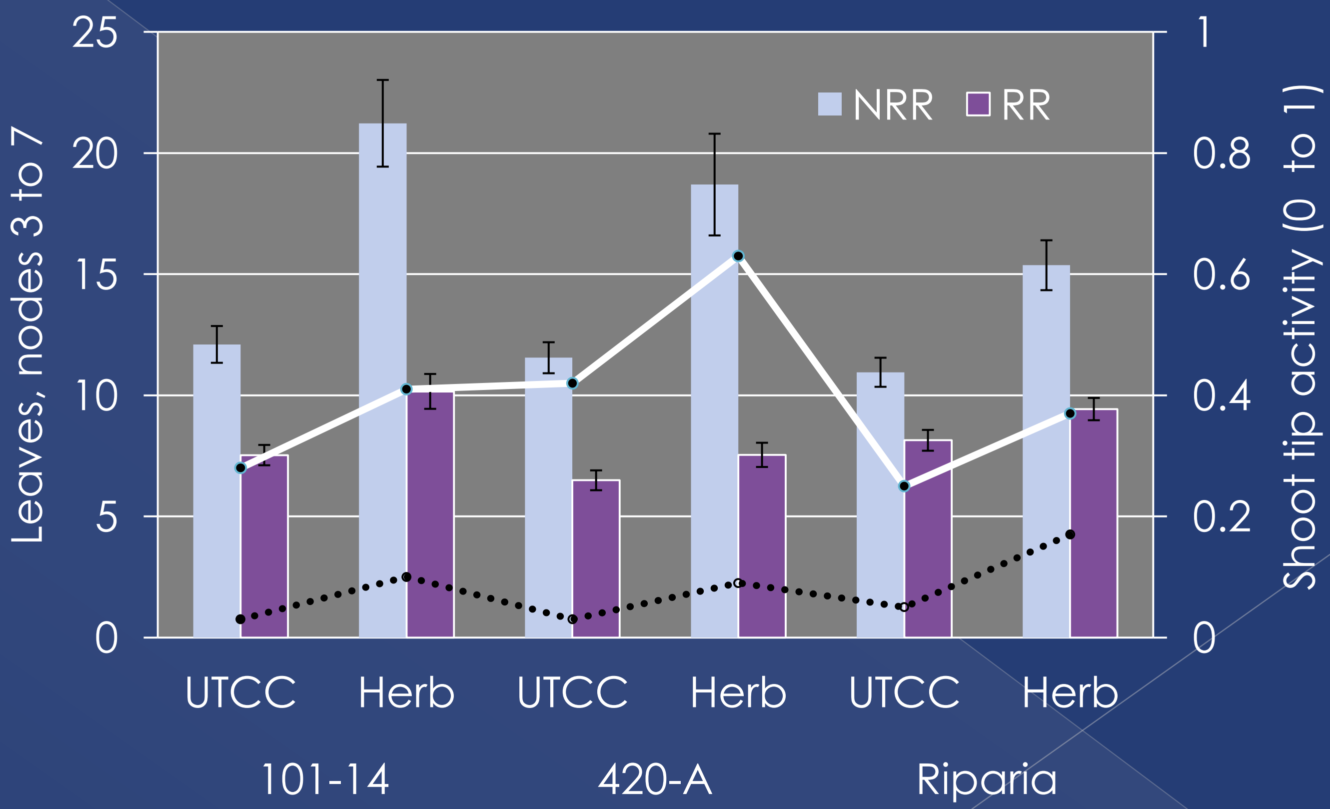
Lateral shoot development

- additional leaf area
- additional shade

Sum of lateral leaves borne at nodes 3 to 7 of primary shoots and “shoot tip activity score” veraison, 2010



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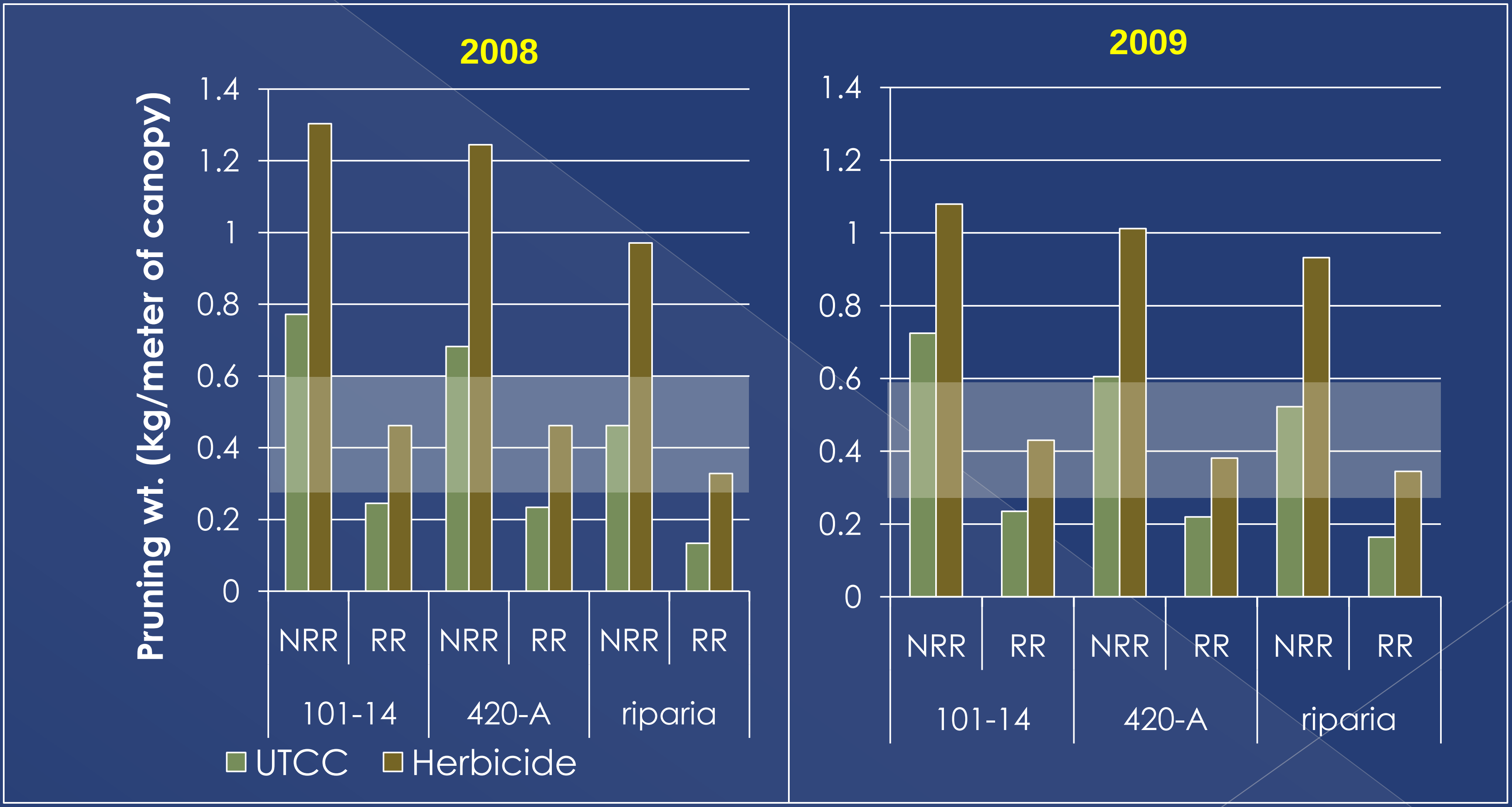
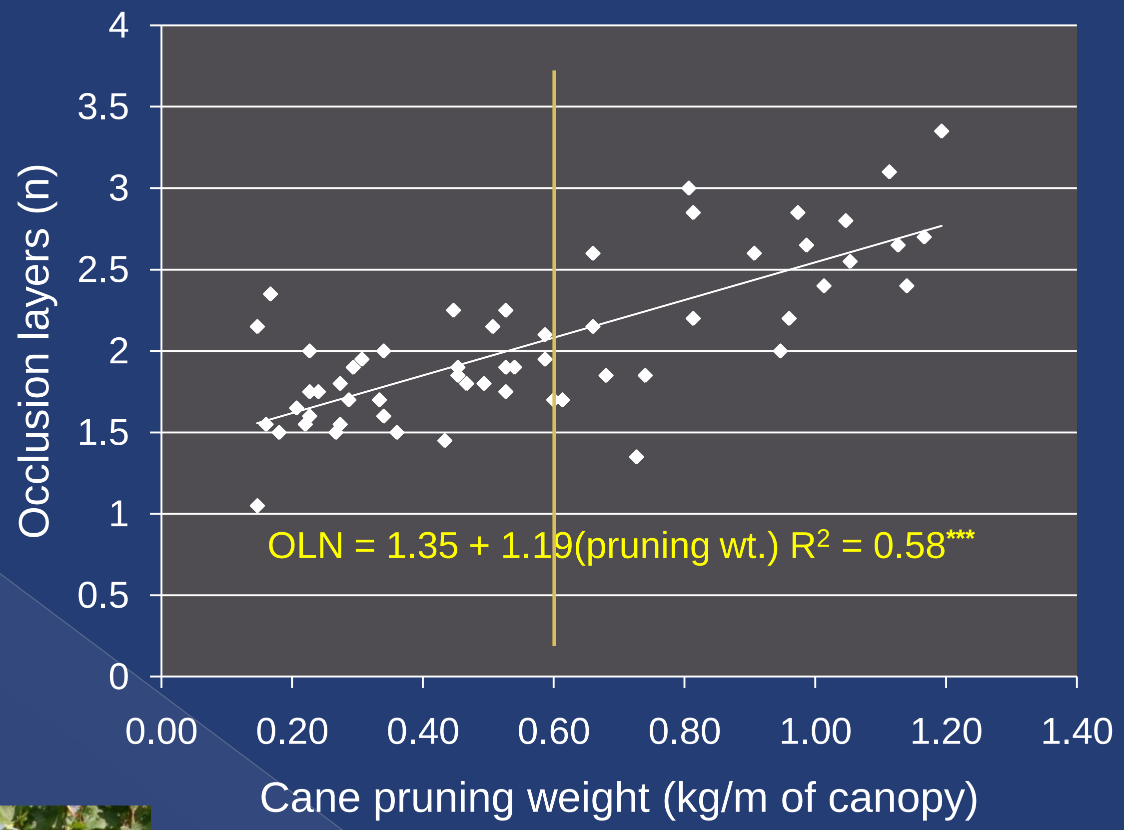
Cane pruning weights were reduced by under-trellis cover crop (47%), riparia rootstock (25%) and by root restriction (> 50%).



Occlusion layers are, for the most part, leaves – here the number of leaves potentially blocking sunlight penetration into fruit zone.

When pruning weight exceeds 0.60 kg/m of canopy, the OLN is generally in excess of 2 (about 1.5 is desirable).



			2008	2009	2008	2009	2008	2009
UTGC	**Rootstock**	**RM**	**Brix**		**pH**		**TA (g/L)**	
UTCC	**101-14**	**NRR**	24.2	23.6	3.4	3.3	4.9	7.0
		RR	23.3	22.7	3.4	3.4	4.4	5.6
	420-A	**NRR**	23.9	23.2	3.4	3.3	4.4	8.0
		RR	23.9	22.8	3.5	3.4	4.1	5.8
	riparia	**NRR**	23.5	23.4	3.4	3.3	4.8	7.2
		RR	22.8	22.6	3.5	3.4	5.1	6.0
Herbicide	**101-14**	**NRR**	23.1	23.1	3.3	3.4	6.1	6.9
		RR	22.0	22.7	3.3	3.4	5.9	5.7
	420-A	**NRR**	22.4	22.7	3.2	3.3	5.8	7.6
		RR	21.6	22.3	3.2	3.3	5.9	6.3
	riparia	**NRR**	22.4	23.2	3.2	3.4	6.2	7.6
		RR	21.5	22.2	3.2	3.3	6.1	6.4

Effect	**p-value**					
UTGC	0.0023	ns	0.015	ns	0.0162	ns
Rootstock	ns	ns	ns	ns	ns	ns
Rootstock X UTGC	ns	ns	ns	ns	ns	ns
RM	0.001	0.0044	0.035	0.0109	ns	0.0009
RM X UTGC	ns	ns	0.0353	0.0003	ns	ns
RM X Rootstock X UTGC	ns	ns	ns	ns	ns	ns

Some of the 2010 harvest data

Treatment	Avg. Berry Weight	Crop yield/vine (lbs)	°Brix
NRM + Herb	1.29 a	8.5 a	25.04 bc
NRM + CC	1.25 a	7.4 b	25.38 b
LOW + RBG + Herb	1.23 ab	7.3 bc	23.42 d
HIGH + RBG + Herb	1.12 bc	6.5 bc	24.76 c
LOW + RBG + CC	1.06 c	6.3 c	25.94 a
HIGH + RBG + CC	0.90 d	4.6 d	23.6 d

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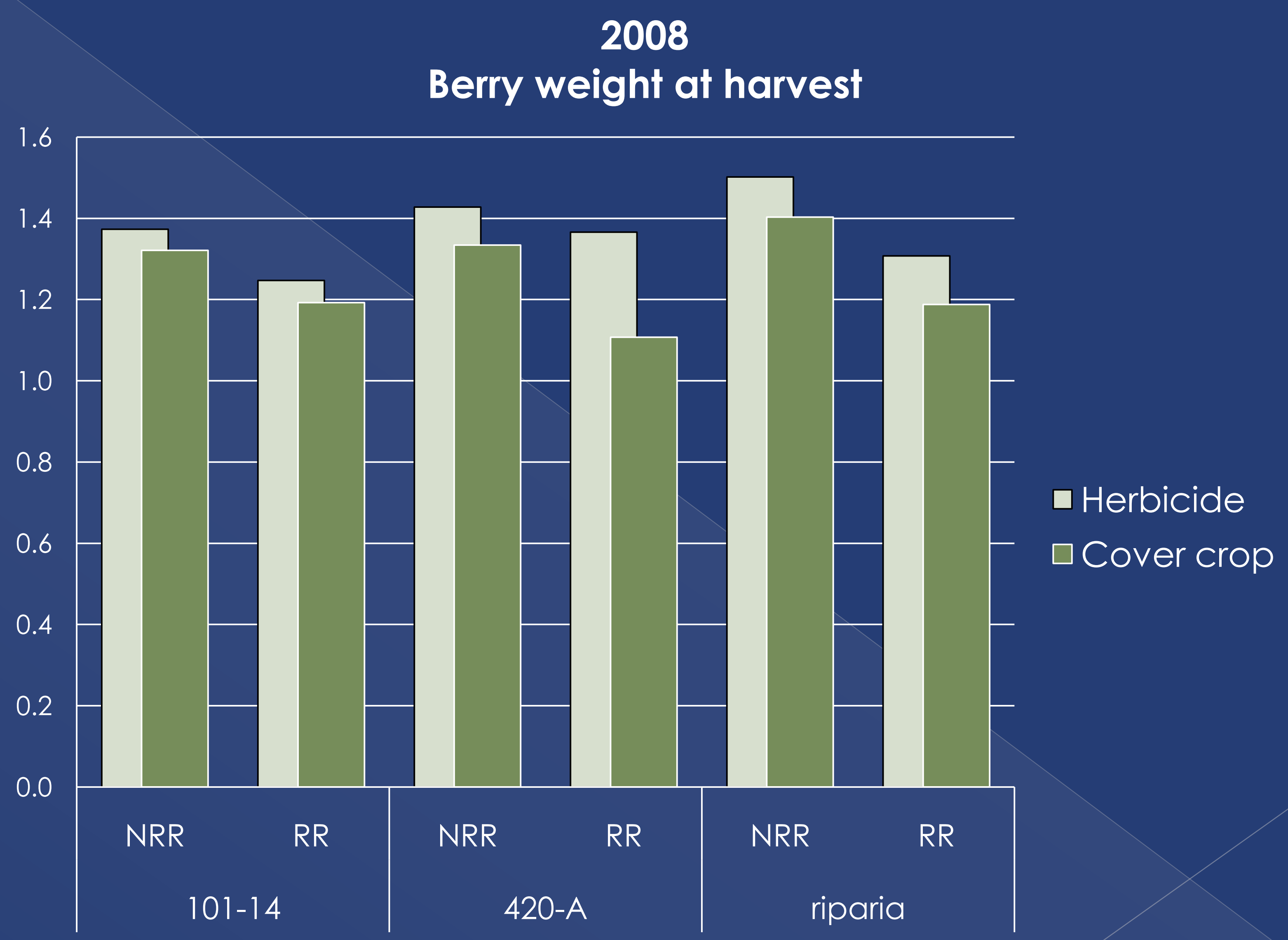
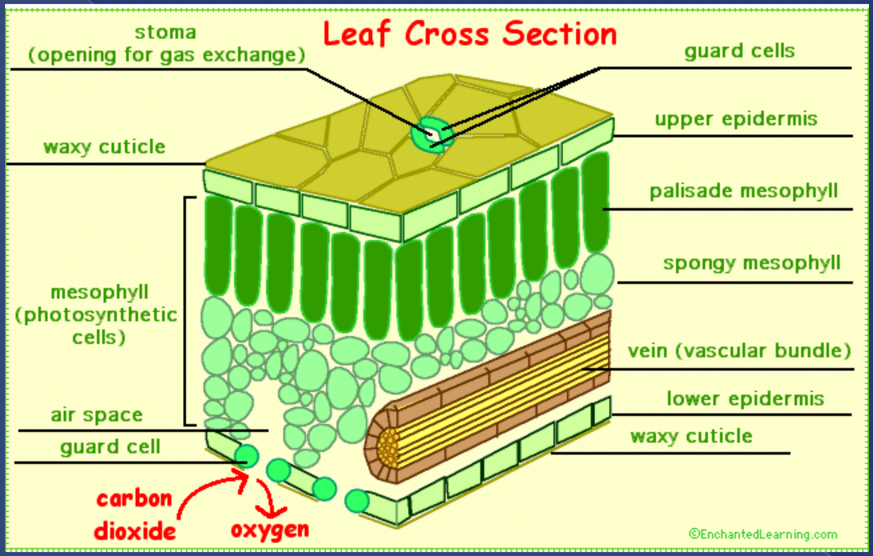
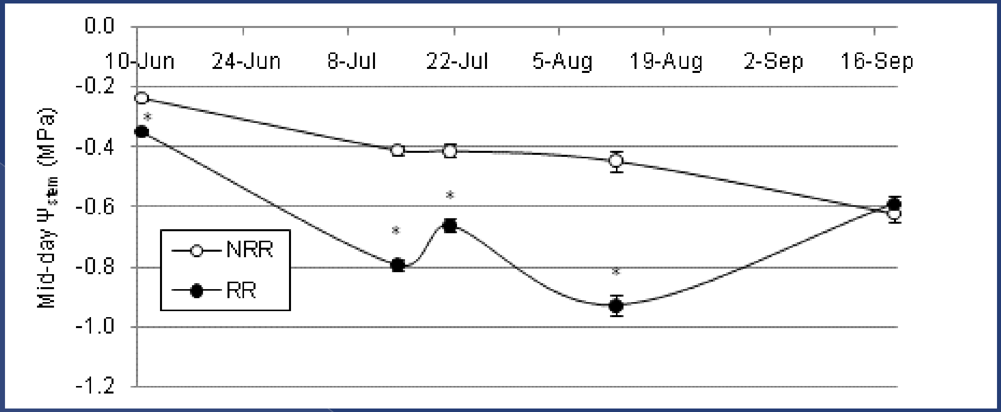

2008
Berry weight at harvest
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
NRR
RR
NRR
RR
NRR
RR
101-14
420-A
riparia
Herbicide
Cover crop

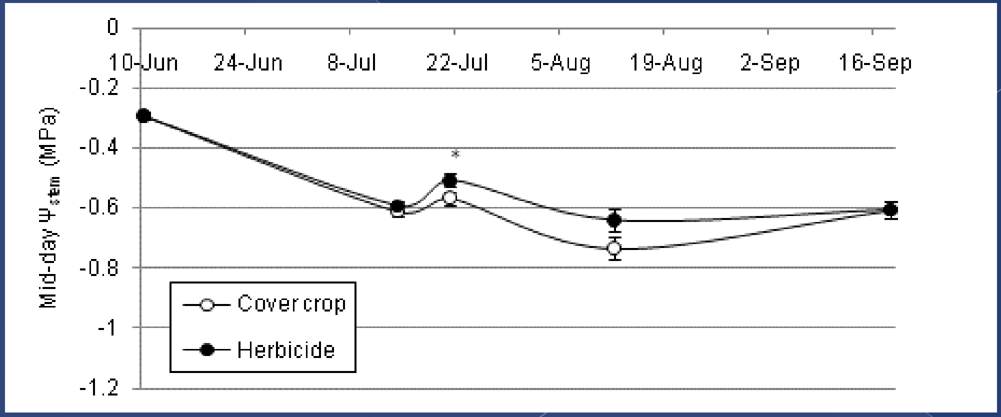


Grapevine water relations

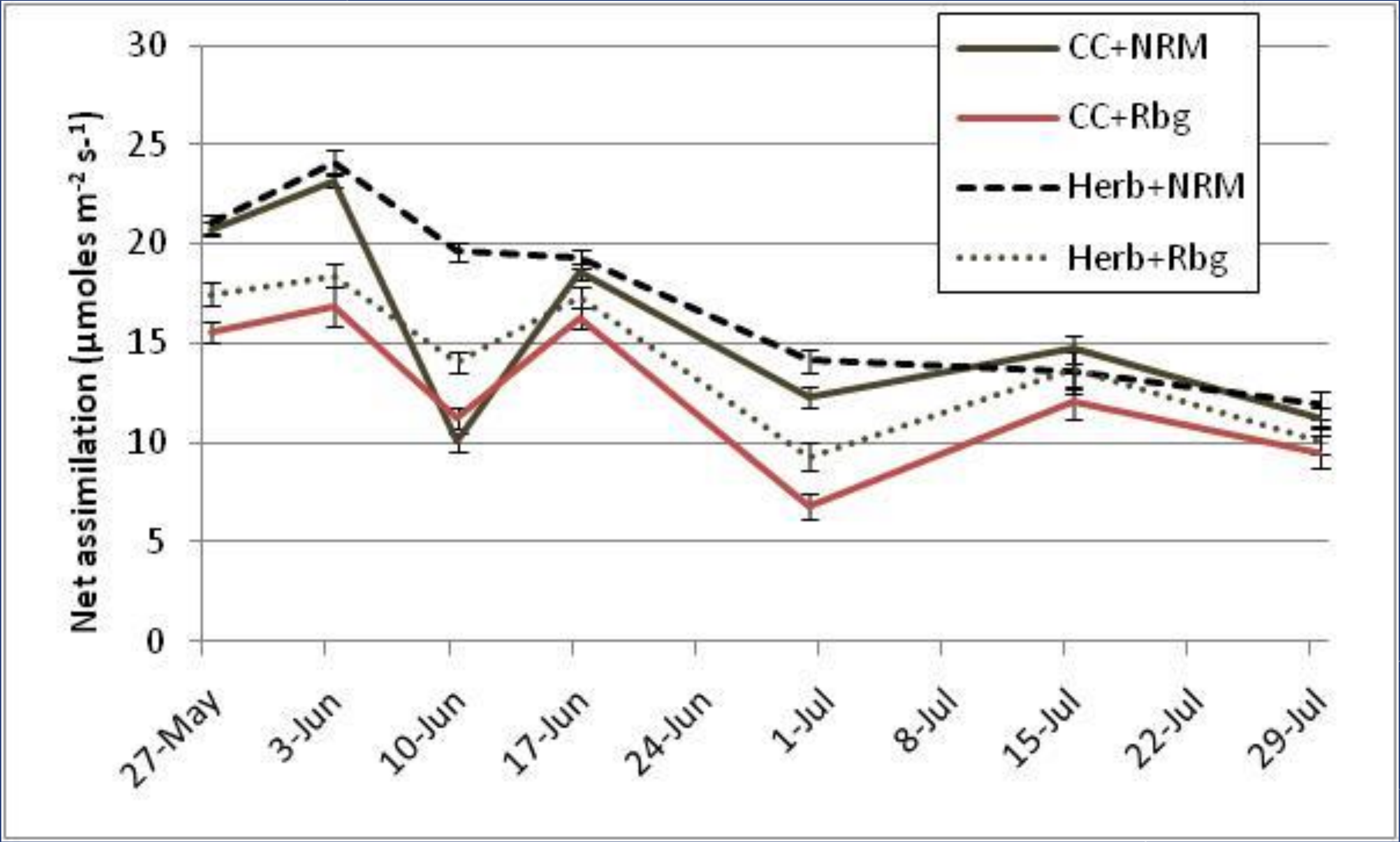
-How do treatments impact seasonal water status?

-What thresholds are associated with cessation of shoot growth, but not so severe as to stop carbon assimilation?





Leaf net assimilation rates over the 2010 growing season. Note that root-bag treatment vines were typically depressed, relative to non-rootbagged vines.



Post-fermentation wine chemistry, 2009

UTGC	RM	Alcohol (v/v)	Malic acid (g/L)	pH	TA* (g/L)	VA† (g/L)
Herbicide	NRR	13.57	3.75	3.73	7.95	0.49
UTCC	NRR	13.43	3.47	3.66	7.95	0.49
Herbicide	RR	13.20	2.76	3.54	7.49	0.40
UTCC	RR	13.47	2.75	3.55	7.62	0.42
ANOVA						
Effect		p - value				
UTGC		ns	ns	ns	ns	ns
RM		ns	0.0044	0.0046	0.0355	0.0237
UTGC X RM		ns	ns	0.0544	ns	ns

Post fermentation color analysis.

UTGC	RM	A_{280}	A_{320}	A_{420}	A_{520}	color density (A)	Hue (A)
Herbicide	NRR	26.3	10.3	2.6	3.5	6.1	0.7
UTCC	NRR	30.5	12.4	3.2	4.6	7.8	0.7
Herbicide	RR	31.0	11.1	2.7	4.2	6.9	0.6
UTCC	RR	35.1	11.9	3.4	5.1	8.6	0.7
Probability of > *P*							
Effect							
UTGC		ns	ns	ns	0.0463	0.05	ns
RM		ns	ns	ns	0.0287	0.03	0.05
UTGC x RM		ns	ns	ns	ns	ns	ns

Preliminary summary -- and where do we go from here?

- Root restriction and under-trellis cover crop (UTCC) were independently effective in suppressing vegetative development of vines
- Riparia Gloire rootstock was the most effective rootstock in limiting vegetative development amongst the three evaluated
- Canopy architecture was generally improved by both UTCC and by root restriction, but generally unaffected by rootstock
- The principal direct effect of the UTCC and the root-restriction treatments was a sustained reduction in stem (xylem) water potential (ψ_{stem})
- Differences in wine were *detected* among the treatments, but sensory evaluations are necessary to fully describe the wines
- Plant nitrogen levels were depressed by UTCC in both 2009 and 2010

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