UC DAVIS VITICULTURE AND ENOLOGY

IMPACT OF RED BLOTCH DISEASE ON GRAPE AND WINE COMPOSITION

A. Oberholster, R. C. Girardello, L. A. Lerno, S. Eridon, M. L. Y. Cooper, R. H. Smith, C. A. Brenneman, H. Heymann, M. Sokolowsky

Recent Advances in Viticulture and Enology
ARC, UC Davis
December 9, 2016

UCDAVIS VITICULTURE & ENOLOGY

UC DAVIS VITICULTURE AND ENOLOGY

Introduction

- Grapevine red blotch-associated virus (GRBaV)
  - Red Blotch disease was first described in Cab Sauv, Zin and Cab Franc in New York and California (1)
  - A DNA virus (GRBaV) was shown to be the causal agent of red blotch diseases (2)
  - Widespread in vineyards in USA and Canada

UCDAVIS

(1) Al Rwahnih et al., (2013) Phytopath. 103: 1069-1076
(2) Fuchs (2013) http://lecture.ucanr.org/Mediasite/Play/7e6250539e5e4676ad4cd88051164c1d

UC DAVIS VITICULTURE AND ENOLOGY

Introduction

- Red Blotch disease symptoms
  - RB disease shows symptoms similar to Leafroll disease
    - Unlike Leafroll – RB show red veins on leaf undersides and no rolling

UC DAVIS VITICULTURE AND ENOLOGY

Introduction

- Red Blotch disease spread
  - Widespread occurrence of Red Blotch disease indicate primary spread through propagation (1)
  - Increase incidence in young healthy vines adjacent to infected vineyards suggest vector (3)
  - 3-cornered alfalfa treehopper (*Spissistilus festinus)* have recently be shown to be able to spread the disease (Bahder and Zalom)

UCDAVIS

(1) Al Rwahnih et al., (2013) Phytopath. 103: 1069-1076
(3) Poojaric et al. (2013) PLosONE 8: e64194

UC DAVIS VITICULTURE AND ENOLOGY

Perceived impact of RB disease on grape composition

- ↓ Sugar accumulation
  - As much 4-5 °Brix less
  - Delay in ripening
- ↓ Color development
- ↑ TA
  - Current research - show not always true
  - ↑ Malic acid
    - True for CH and CS, not Zin
    - For CH, ↓yield

UCDAVIS

UC DAVIS VITICULTURE AND ENOLOGY

Impact of RB disease on grape & wine composition

- Much not known
  - Influence of cultivar and site?
  - Influence of stress?
  - Seasonal/climatic impact?
  - No well documented influence on grape development
  - Effect on wine composition and quality?
    - Wine ageability?

UC DAVIS VITICULTURE AND ENOLOGY

Study objectives

- To determine the impact of GRBaV on the composition of grapes at harvest and the resulting wines
- To investigate potential sensory and quality differences between wines made from GRBaV positive and negative grapes

UCDAVIS

UC DAVIS VITICULTURE AND ENOLOGY

Experimental layout

- Virus testing (GRBaV and GRLaV) of subset vines to determine GRBaV (+) and (-) sample plots
- Sample grapes at harvest
  - Basic chemical panels (Brix, pH, TA)
  - Metabolomics analysis (primary and secondary metabolite profile)
  - Phenolic profile (AH-assay, RP-HPLC)
  - Tannin composition (SPE isolation, phloroglucinolysis)

UCDAVIS

UC DAVIS VITICULTURE AND ENOLOGY

Experimental layout

- Winemaking from GRBaV (+) and (-) grapes
  - Chemical analyses similar to grapes (previous slide)
  - Descriptive sensory analysis
    - Correlate wine composition with sensory attributes
    - Impact of GRBaV on wine style/quality

UCDAVIS

UC DAVIS VITICULTURE AND ENOLOGY

Experimental layout

Variety (site #)	Source County	Grape Sampling	Winemaking
Chardonnay 1a	Sonoma	Yes	Yes
Chardonnay 1b	Sonoma	Yes	No
Chardonnay 2	Sonoma	Yes	No
Merlot 1	Napa	Yes	No
Merlot 2	Napa	Yes	Yes
Cab Sauv 1	Napa	Yes	Yes
Cab Sauv 2	Napa	Yes	Yes

UCDAVIS

UC DAVIS VITICULTURE AND ENOLOGY

Results: Grape chemical composition

Sample	GRBaV Status	Harvest Date	°Brix	pH	TA (g/L)
Chardonnay 1a	-	12-Sep-14	24.4	3.4	6.0
	+	12-Sep-14	23.0		6.7
Chardonnay 1b	-	11-Sep-14	23.0	3.4	6.6
	+	11-Sep-14	22.5		6.9
Chardonnay 2	-	16-Sep-14	24.1	3.3	7.8
	+	16-Sep-14	24.2		8.9

↓6%

↓2%

0%

- ↓°Brix 0-6% GRBaV(+) CH grapes
- Small differences in pH
- ↑ TA in GRBaV(+) grapes

UCDAVIS

UC DAVIS VITICULTURE AND ENOLOGY

Results: CH 1a chemical composition

CH 1a	GRBaV Status	Harvest Date	°Brix	pH	TA (g/L)
2014	-	12-Sep-14	24.4	3.4	6.0
	+	12-Sep-14	23.0		6.7
2015	-	9-Sep-15	25.7	3.5	5.3
	+	9-Sep-15	23.6		6.3
2016	-	12-Sep-16	23.7	3.4	6.1
	+[1]	12-Sep-16	22.7		5.9
	+[2]	19-Sep-16	23.7	3.7	5.6

↓6%

↓8%

↓4%

- For all 3 years a ↓°Brix 4-8% GRBaV(+) CH grapes
- Small differences in pH
- Variable TA impact of GRBaV in grapes

UCDAVIS

UC DAVIS VITICULTURE AND ENOLOGY

Results: Red grape chemical composition

Sample	GRBaV Status	Harvest Date	°Brix	pH	TA (g/L)
Merlot 1	-	29-Aug-14	25.0	3.6	3.2
	+	29-Aug-14	21.1	↓16%	3.6
Merlot 2	-	26-Sep-14	24.9	3.5	4.2
	+	26-Sep-14	23.5	↓6%	4.7
Cab Sauv 1	-	18-Sep-14	25.7	3.5	7.8
	+	18-Sep-14	20.6	↓20%	8.6
Cab Sauv 2	-	7-Oct-14	26.3	3.6	4.8
	+	7-Oct-14	25.2	↓4%	4.9

- ↓°Brix 6-16% GRBaV +) ME and 4-20% in CS grapes
- Small differences in pH
- ↑ TA in GRBaV(+) grapes

UC DAVIS VITICULTURE AND ENOLOGY

Results: Grape chemical composition

CS 2	GRBaV Status	Harvest Date	°Brix	pH	TA (g/L)
2014	-	7-Oct-14	26.3	3.6	4.8
	+	7-Oct-14	25.2	↓4%	4.9
2015	-	21-Sep-15	26.0	3.7	4.3
	+	21-Sep-15	22.4	↓14%	4.4

- Both years ↓°Brix 4-14% GRBaV (+)
- Small differences in pH
- ↑ TA in GRBaV(+) grapes

UC DAVIS VITICULTURE AND ENOLOGY

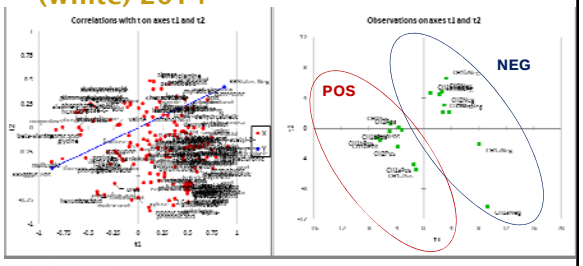
Results: Red grape chemical composition - 2016

Sample	GRBaV Status	Harvest Date	°Brix	pH	TA (g/L)
Merlot	-	15-Sep-16	25.2	4.2	4.2
	+[1]	15-Sep-16	22.1	↓12%	3.4
	+[2]	28-Sep-16	24.5	4.0	3.3
Cab Sauv	+	20-Sep-16	25.7	3.6	3.8
110 R	+[1]	20-Sep-16	21.8	↓15%	4.8
	+[2]	28-Sep-16	23.8	3.6	4.5
Cab Sauv	+	20-Sep-16	24.3	3.5	4.2
420 A	+[1]	20-Sep-16	22.2	↓9%	4.5
	+[2]	28-Sep-16	23.8	3.5	4.6

- ↓°Brix 12% GRBaV (+) ME and 9-15% in CS grapes
- Small differences in pH
- Variable TA impact of GRBaV in grapes

UC DAVIS VITICULTURE AND ENOLOGY

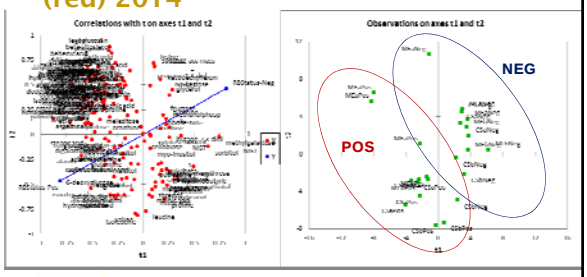
PLS-DA of metabolomics grape data (white) 2014



UCDAVIS

UC DAVIS VITICULTURE AND ENOLOGY

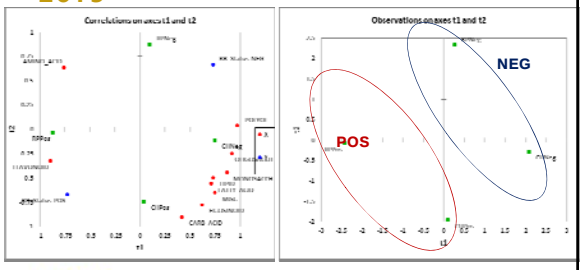
PLS-DA of metabolomics grape data (red) 2014



UCDAVIS

UC DAVIS VITICULTURE AND ENOLOGY

PLS-DA of metabolomics grape data 2015

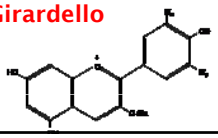


UCDAVIS

UC DAVIS VITICULTURE AND ENOLOGY

Results: Grape phenol composition (AH-assay and RP-HPLC)

- Variably response to RB disease within variety and per season
- No direct relationship with wine composition
  - Due to matrix and extraction effects?
- Red Blotch poster – R. Girardello

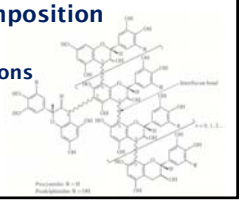


Anthocyanin

UC DAVIS VITICULTURE AND ENOLOGY

Results: Grape composition by phloroglucinolysis

- Tannin analysis showed signf differences among diffr varieties
  - No diffr due to disease status of grapes (mDP, % gallo units, % galloylation)
- It looks as if tannin composition similar
  - However method limitations



UC DAVIS VITICULTURE AND ENOLOGY

Results: Wine chemical composition

Wine	GRBaV Status	EtOH % (v/v)	pH	TA (g/L)	RS (g/L)	AA (g/L)
CH 1a	-	16.1 ± 0.2*	3.6 ± 0.2*	5.2 ± 0.1	1.9 ± 0.2*	0.1 ± 0.0*
	+	15.4 ± 0.0*	3.8 ± 0.2*	5.6 ± 0.0	1.1 ± 0.2*	0.1 ± 0.0*
ME 2 (b)	-	15.3 ± 0.1*	3.7 ± 0.2	5.2 ± 0.1	0.2 ± 0.0	0.0 ± 0.0
	+	14.1 ± 0.1*	3.7 ± 0.2	5.3 ± 0.0	0.1 ± 0.0	0.0 ± 0.0
CS 1 (a)	-	14.6 ± 0.3*	3.2 ± 0.2*	7.4 ± 0.0	0.1 ± 0.0	0.1 ± 0.0*
	+	13.0 ± 0.1*	3.2 ± 0.2*	7.1 ± 0.4	0.1 ± 0.0	0.1 ± 0.0*
CS 2 (b)	-	15.8 ± 0.1*	3.9 ± 0.2*	4.8 ± 0.0*	0.3 ± 0.0	0.1 ± 0.0*
	+	14.9 ± 0.0*	3.7 ± 0.2*	5.5 ± 0.5*	0.2 ± 0.0	0.1 ± 0.0*

CH = Chardonnay; CS = Cabernet Sauvignon; ME = Merlot

*Indicate significance at $\alpha = 0.05$ within a site

UC DAVIS VITICULTURE AND ENOLOGY

Results: Wine chemical composition 2015

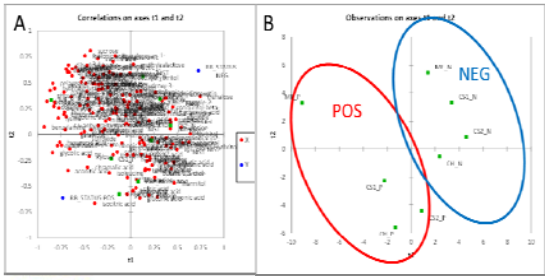
Wine	GRBaV status	EtOH % (v/v)	pH	TA (g/L)	Free SO2 (mg/L)	VA (g/L)
CH1a	-	16.0	3.45	6.23	27.7	0.10
	+	14.8	3.75	6.26	27.0	0.10
CS2	-	15.2	3.82	5.56	32.3	0.34
	+	12.9	3.62	6.0	34.0	0.31

Different letters indicate significance at $p < 0.05$

UCDAVIS

UC DAVIS VITICULTURE AND ENOLOGY

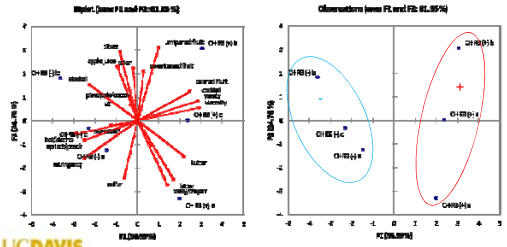
PLS-DA of wine metabolomics data 2014



UC DAVIS VITICULTURE AND ENOLOGY

White wine sensory data 2014

PCA scores and loading plot



UCDAVIS

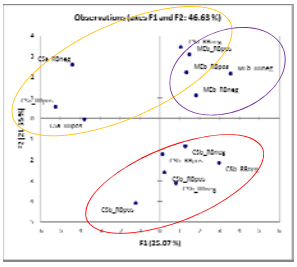
- PCA separation of the wines although very little diffr
  - Only 1 out of 18 attributes sigf diffr

UC DAVIS VITICULTURE AND ENOLOGY

Corrected F values for red DA attributes – 2014 data

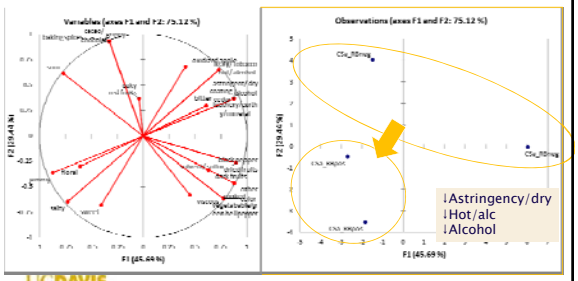
Attributes	F value wine	Significant
red fruits	1.184	no
dark fruits	1.393	no
dried fruits	2.744	yes**
oxidized apple	0.484	no
jammy	0.654	no
cooked vegetables/green bellpepper	1.551	no
leafy/tobacco	2.382	no
ceder	1.085	no
leathery/earthy/mineral	0.874	no
okay	0.970	no
alcohol	3.405	yes***
solvent/sulfur	0.520	no
baking spices	0.586	no
black pepper	0.805	no
cacao/chocolate	1.666	no
floral	1.135	no
sweet	1.994	yes
sour	3.798	yes
salty	1.418	no
bitter	1.753	no
coating	2.205	yes*
viscous	0.579	no
astringent/dry	6.484	yes***
grippy	2.205	yes*
hot/alcohol	2.587	yes**
color	1.630	no

PCA score plot



UC DAVIS VITICULTURE AND ENOLOGY

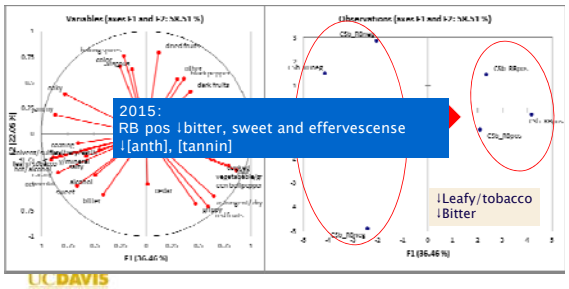
PCA: Descriptive analysis of CS (1)a



- Phenolic analyses: RB (+) ↓ [tannin], [pol pigments] and % Alc

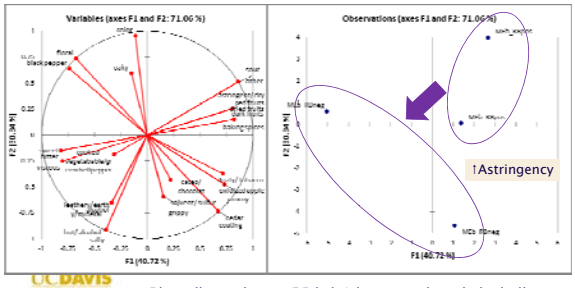
UC DAVIS VITICULTURE AND ENOLOGY

PCA: Descriptive analysis of CS (2)b



- Phenolic analyses: RB (+) only small differences
- ↓ [anth], [pol pigments], [pol phenols], % Alc

PCA: Descriptive analysis of ME (2)b



- Phenolic analyses: RB(+) ↑ in most phenols including [tannin], [anth]

In Summary

- Results indicate RB impact is not variety but site specific
  - Seasonal impact
- Untargeted metabolomics indicated large impact on primary metabolites
  - Organic acids
  - Sugars
  - Amino acids
  - Polysaccharides
- Some volatile and non-volatile secondary metabolites (phenols, aroma precursors) also impacted

Next Steps

- Make wines from RB (+) and (-) grapes with the same sugar content
  - Sequential harvesting - 2016
- Continue to explore impact of site on variety
  - Find correlation with soil, nutrients…..
- Targeted analysis combined with transcriptomics to identify metabolic pathways altered by RB disease resulting in changes in biochemical composition
- Use impact on gene expression to develop potential counter measures

UC DAVIS VITICULTURE AND ENOLOGY

Acknowledgements

- AVF – funding
- Napa Valley Grapegrowers
- Agri Analysis, Inc.
- Monica Cooper
- Rhonda Smith
- Raul Girardello
- Larry Lerno
- Sean Eridon
- Martina Sokolowsky
- Vanessa Rich
- Karen Block
- Hildegarde Heymann
- Chik Brenneman
- Lab assistants

UC DAVIS VITICULTURE AND ENOLOGY

THANK YOU

UCDAVIS