

**Irrigation Research in a Cool Climate Area
Niagara Peninsula, Canada.
Effect of Time and Water Regimes on
Vine Physiology and Wine Sensory Profile
of two grape wine cultivars**

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OUTLINE

- INTRODUCTION
- OBJECTIVES
- HYPOTHESES
- BACKGROUND
- MATERIALS AND METHODS
- RESULTS
- CONCLUSIONS

The starting point..... Some Facts

- Niagara Peninsula does not have a long history of drought
- Six out of 10 vintages have been subject to prolonged drought in southern Ontario and north-eastern U.S. (Reynolds et al. 2007)
- Many climatic models have predicted an increase of temperature between 2 - 4.5 °C until 2100 (IPCC 2000)
- Most of the research on effects of irrigation have been conducted in arid and semi-arid areas
- Increase the frequency of extreme weather dry and hot with cool and wet periods (Smith and Pilifosava 2003)

Research Objective

To investigate the effect of different irrigation strategies on vine physiology, grape composition and wine sensory profiles on two wine grape cultivars

Hypothesis

By controlling the vine water status at various vegetative stages, we could manipulate vine metabolism, increase yield and minimize the possible negative dilution effects of irrigation on grape quality

BACKGROUND

An Increase of Water Deficit in Grapevines:

- leaf water potential decreases (Naor and Wamplé 1994), stomata close, transpiration and photosynthesis are reduced (Flexas et al. 2004)
- canopy growth rate decreases (shoot cessation) (Smart et al. 1990)
- early and late mild water deficits can improve berry composition (Matthews et al. 1990, Smart et al. 1990)
- berry size decreases, polyphenol concentration increases (Esteban et al. 2001), anthocyanin accumulation in grape berries is accelerated (Castellarin et al. 2007)

Implications of water deficit on grapevine

Con't

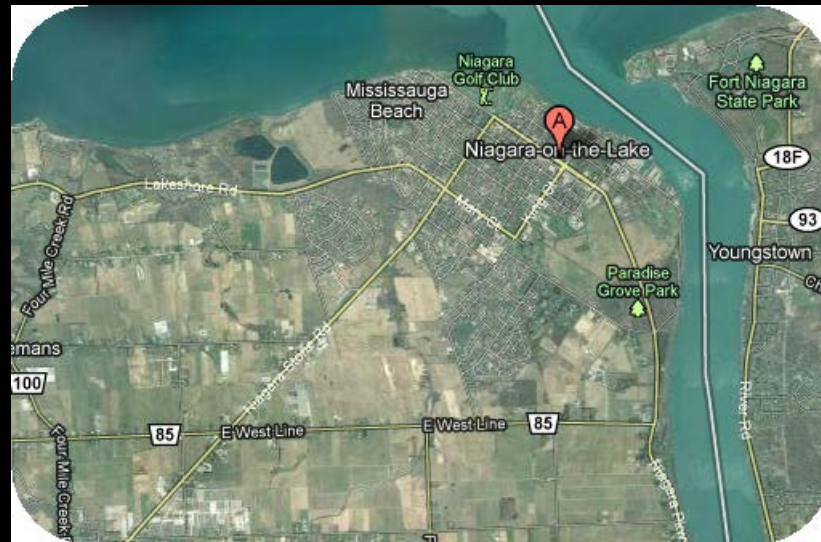
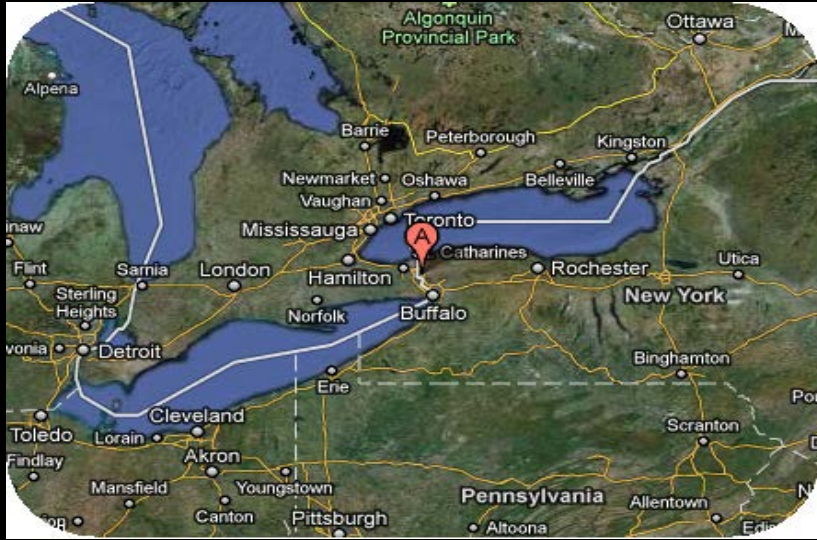
- reduce dry matter production and cause early leaf abscission (Fanizza and Ricciardi 1990)
- reduce yields (Smart et al. 1974)
- water stress during flowering reduces yield up to 50% (Goodwin 1995)
- persistent water stress also depresses the fruitfulness of latent buds (Buttrose 1974)
- diminish winter hardiness, delay maturity, determine poor fruit composition (low sugar, low or high pH), reduce nutrient uptake, and diminish wine quality (Pool and Lakso 2001)

Implication of water deficit on aroma compounds in grapes

- mild water deficit increases flavor and aroma compounds (McCarthy and Coombe 1985)
- water deficit associated with nitrogen deficiency may lead to ATA off flavor in aromatic whites (Henick-Kling et al. 2005)
- postveraison water stress causes poor flavor development (Smart and Coombe 1983)
- increases FVT and PVT with decreasing the duration of water stress (Reynolds et al. 2005)

Materials and Methods

LOCATION



EXPERIMENTAL DESIGN 2005 - 2007

Irrigation trials



Baco noir block:

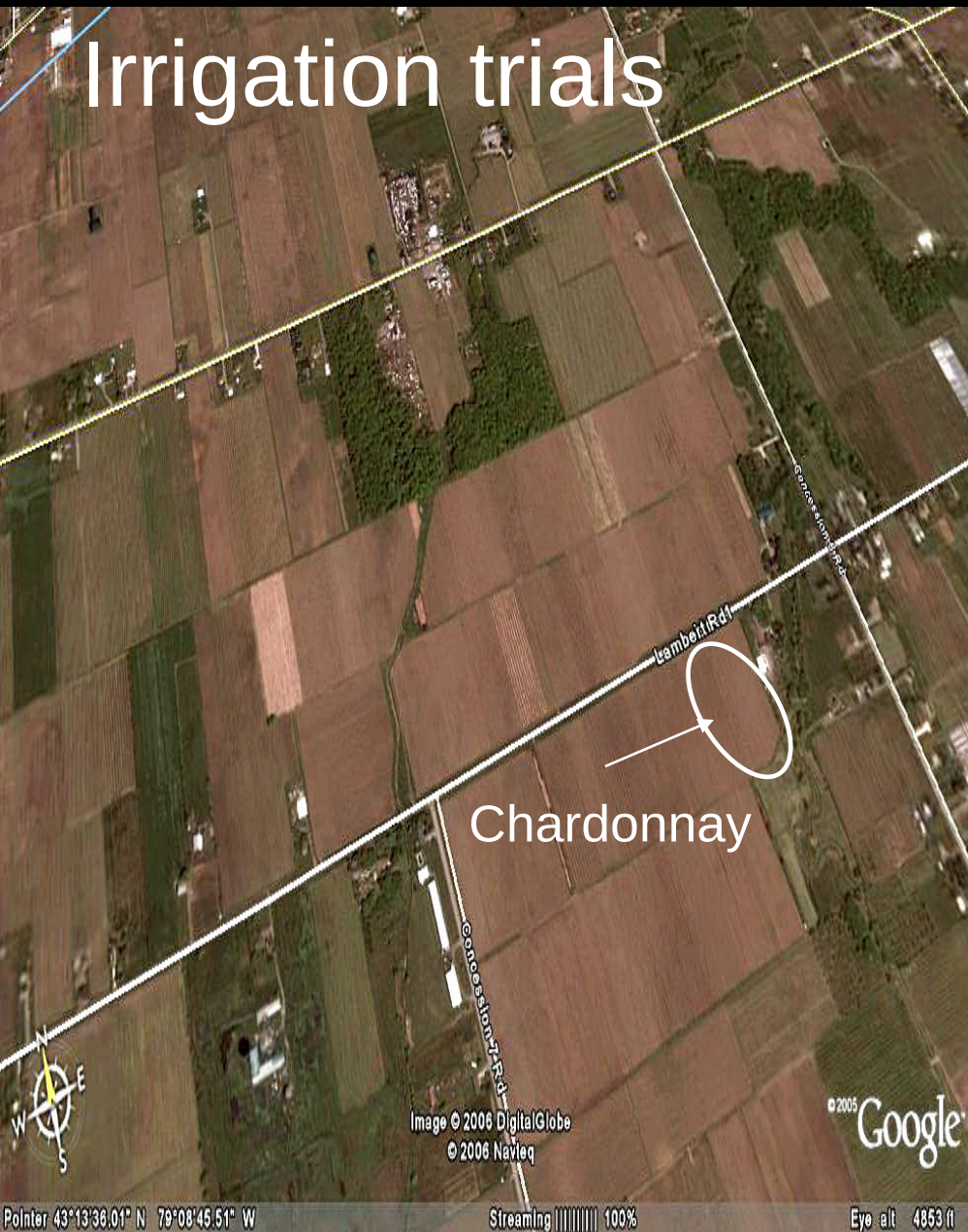
- **ten treatments:**
 - control (non-irrigated)
 - three water regimes (100, 50, 25 % ET_c) combined with three irrigation initiation times (fruit set, lag phase and veraison)
- **three replicates**

EXPERIMENTAL DESIGN 2005 -2008

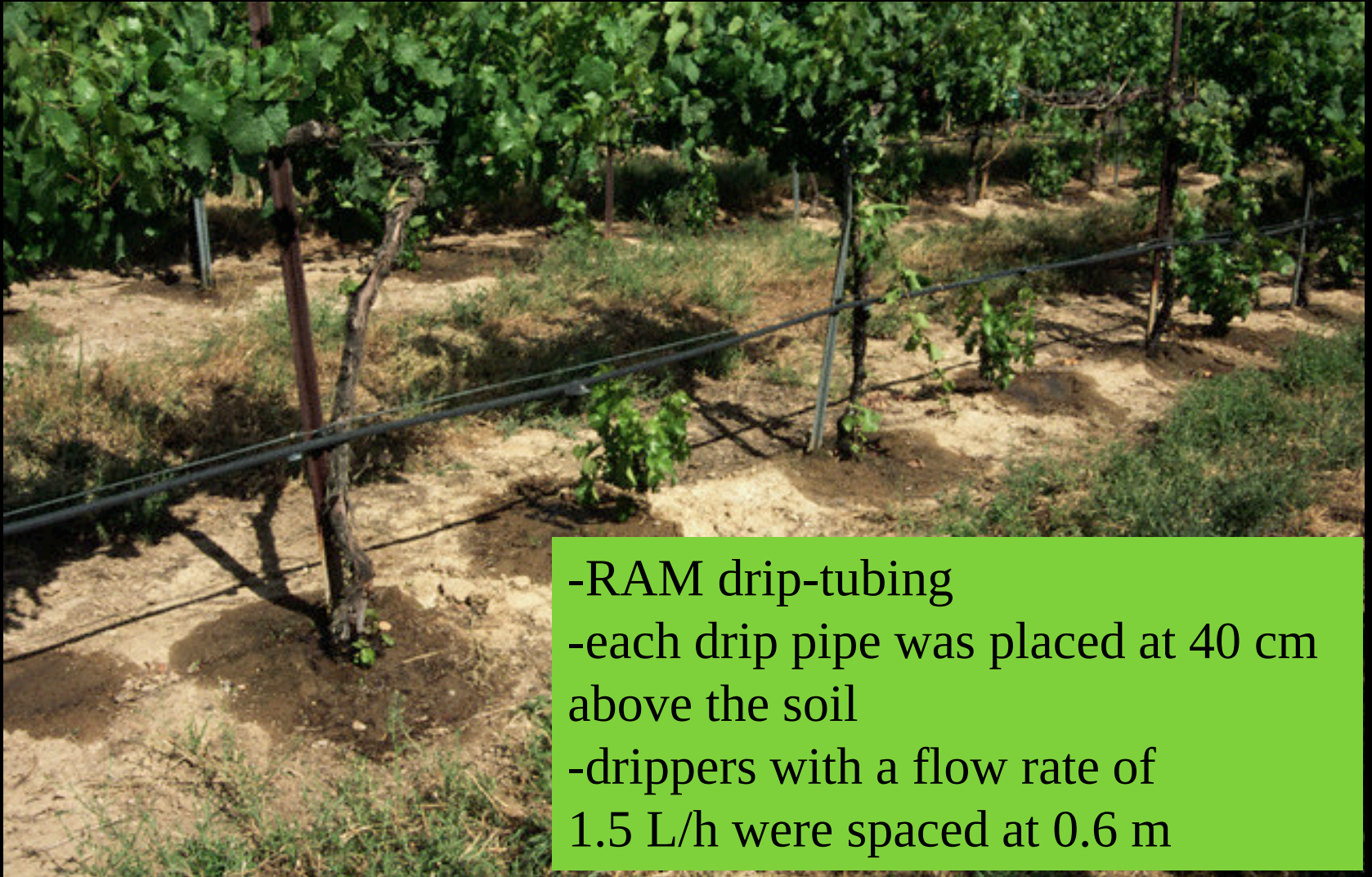
Irrigation trials

Chardonnay block:

- **seven treatments:**
 - control (non-irrigated)
 - three water regimes (100, 50, 25 % ET_c) combined with two irrigation initiation times (fruit set and veraison)
- **three replicates**



IRRIGATION SET UP - RDI



- RAM drip-tubing
- each drip pipe was placed at 40 cm above the soil
- drippers with a flow rate of 1.5 L/h were spaced at 0.6 m

Water Needs

Calculation Methodology

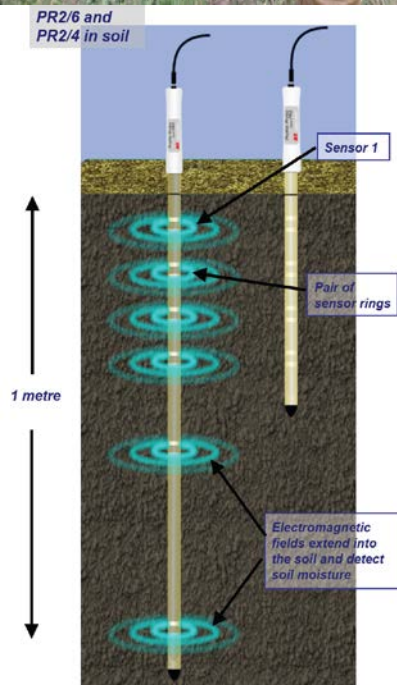
- Water needs – based on weekly ET_0 calculated with Penman Monteith equation
- Meteorological data collection:
min and max temperature, wind speed, solar radiation, min and max relative humidity
- Data provided by Weather Innovation Incorporated for Virgil Station, NOTL
- ET_0 was adjusted to the crop evapotranspiration (ET_c) using a crop coefficient (K_c)
- Using Van der Gulik's equations the amount of water per vine was calculated



Data Collection

Soil water status:

- bi-weekly and the day prior applying irrigation
- from 10 experimental vines per each treatment replicate
- soil moisture data was collected at 20 cm depth using Fieldscout 300 (TDR), in all four blocks
- soil moisture was recorded at six depths using a profile probe
- one Teflon tube was inserted into the soil, and placed in the middle of each treatment replicate row



Data Collection Con't

Plant water status

Transpiration & leaf temperature

- bi-weekly
- LI-1600 steady state porometer
- three leaves per vine
- three vines per treatment replicate
- between 10-3 pm

Leaf water potential (Ψ)

- pressure bomb
- three leaves per vine
- three vines per treatment replicate
- between 10-2 pm



Data Collection Con't

Vine size and vigor



➤ Pruning weights:

- annual wood was weighed
- time: December to March

➤ Shoot growth rate:

- bi-weekly
- three shoots per vine were measured
- three vines per treatment replicate
- three sampling times

Data Collection Con't

➤ Yield components:

- grapes were harvested 2-3 days before commercial harvest
- yield and number of clusters data were collected from each experimental vine
- berry and cluster weight
- number of berries per cluster

➤ Berry composition:

- soluble solids (Brix), titratable acidity, pH, total anthocyanins and phenols, color intensity and hue

Sensory Analysis Methodology Con't

➤ Descriptive analysis

- wines only from one field replicate were used for training
- the panelists were asked to find out any flavor or aroma attributes that could describe the variability among wines
- a lexicon was developed
- a set of aroma standards were created
- a two way unstructured scale (15 cm) with verbal descriptions at the end points was used



Sensory Analysis Methodology Con't

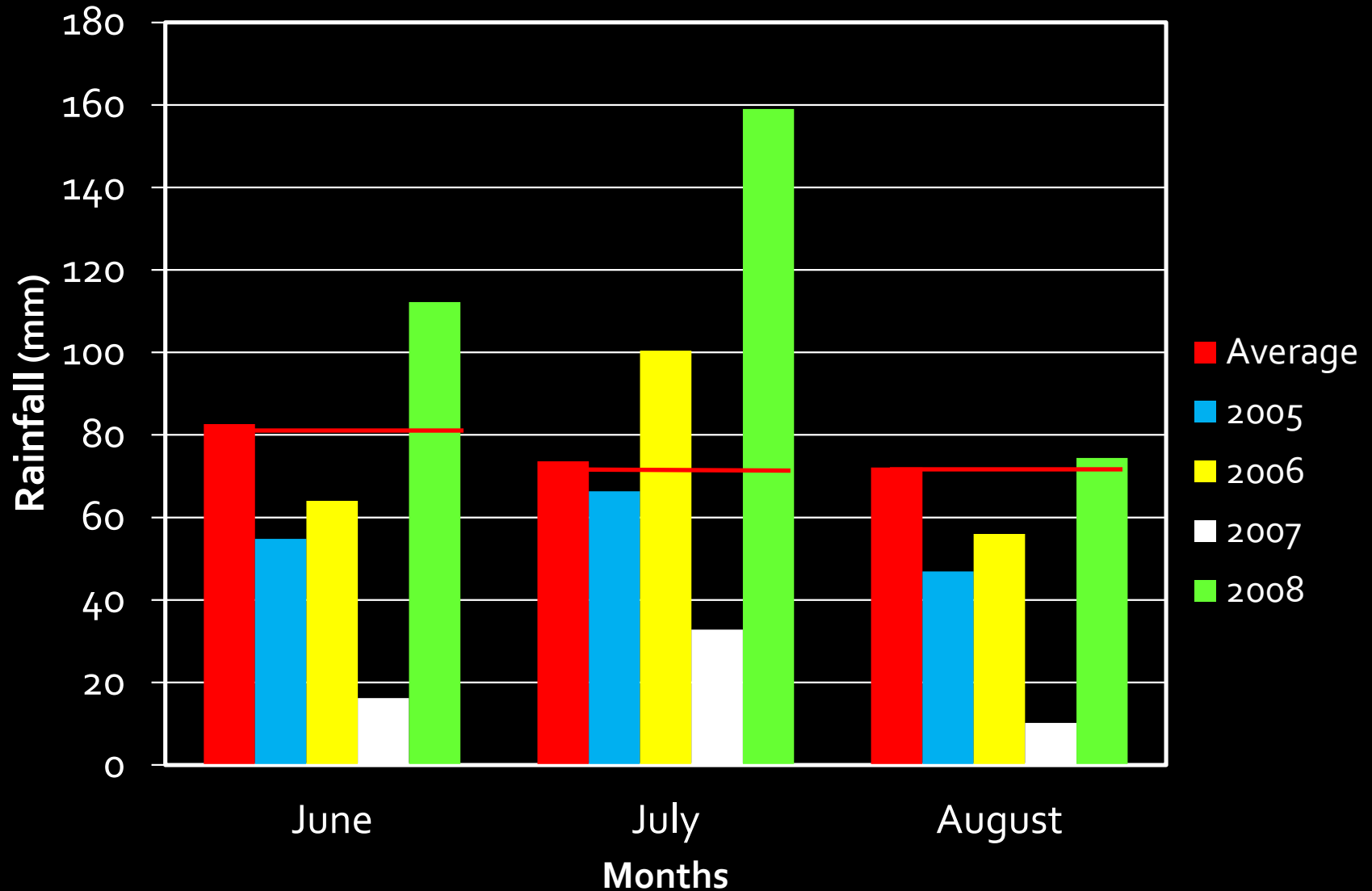


➤ Data Collection:

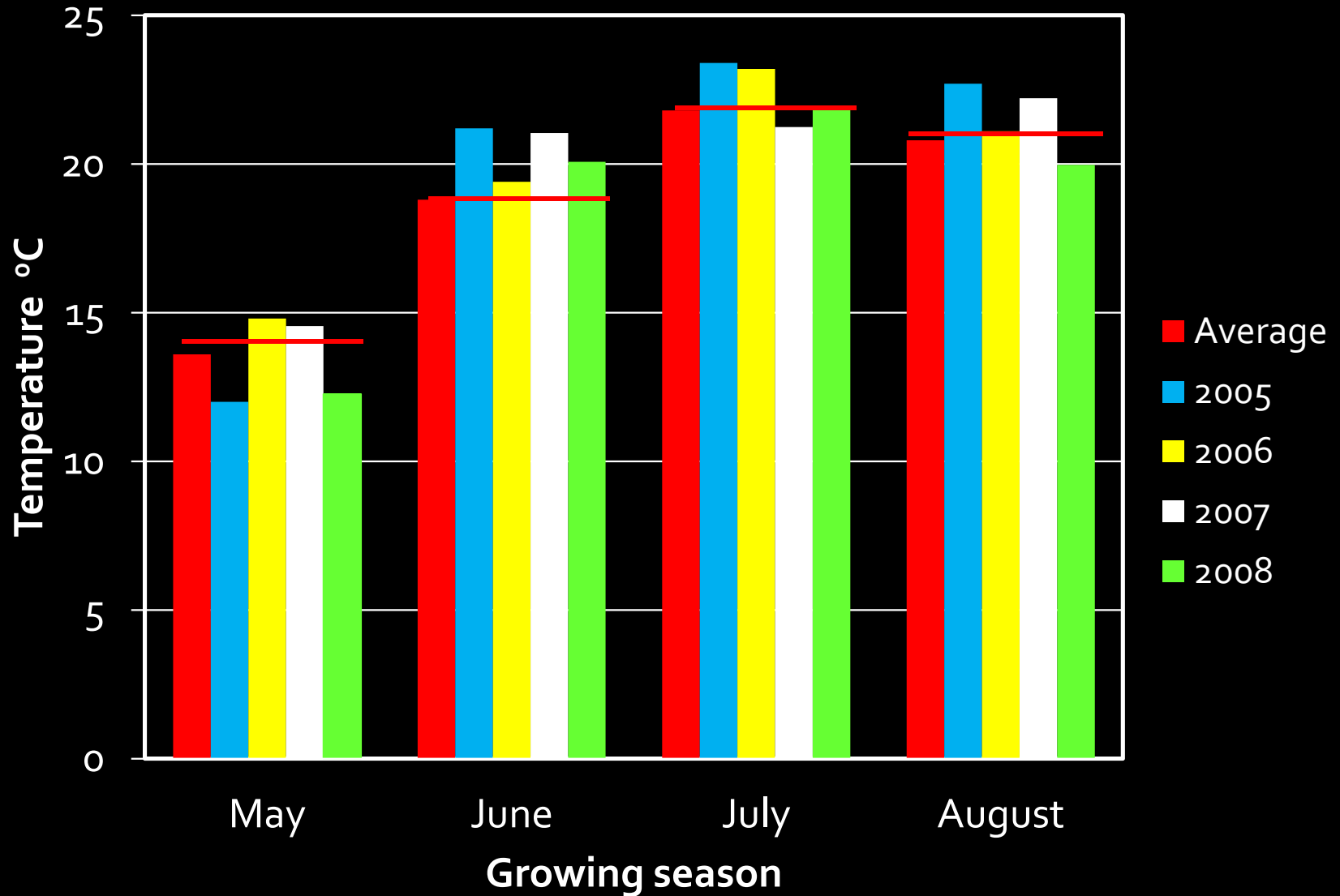
- took place in the sensory laboratory at CCOVI (Brock University) using a sensory software (Compusense c5v4, Guelph, ON)
- samples were evaluated in individual sensory booths under red light to mask wine hue
- the wines from irrigated treatments were assessed in replicates and in random order
- panelists rated the samples based on the list of attributes on an unstructured scale with double way
- they were asked to move the cursor left or right of the control's anchor (located in the middle of the scale)

Weather Data Summary

Total rainfall during the experimental period (2005-2008), Virgil Station, NOTL, ON

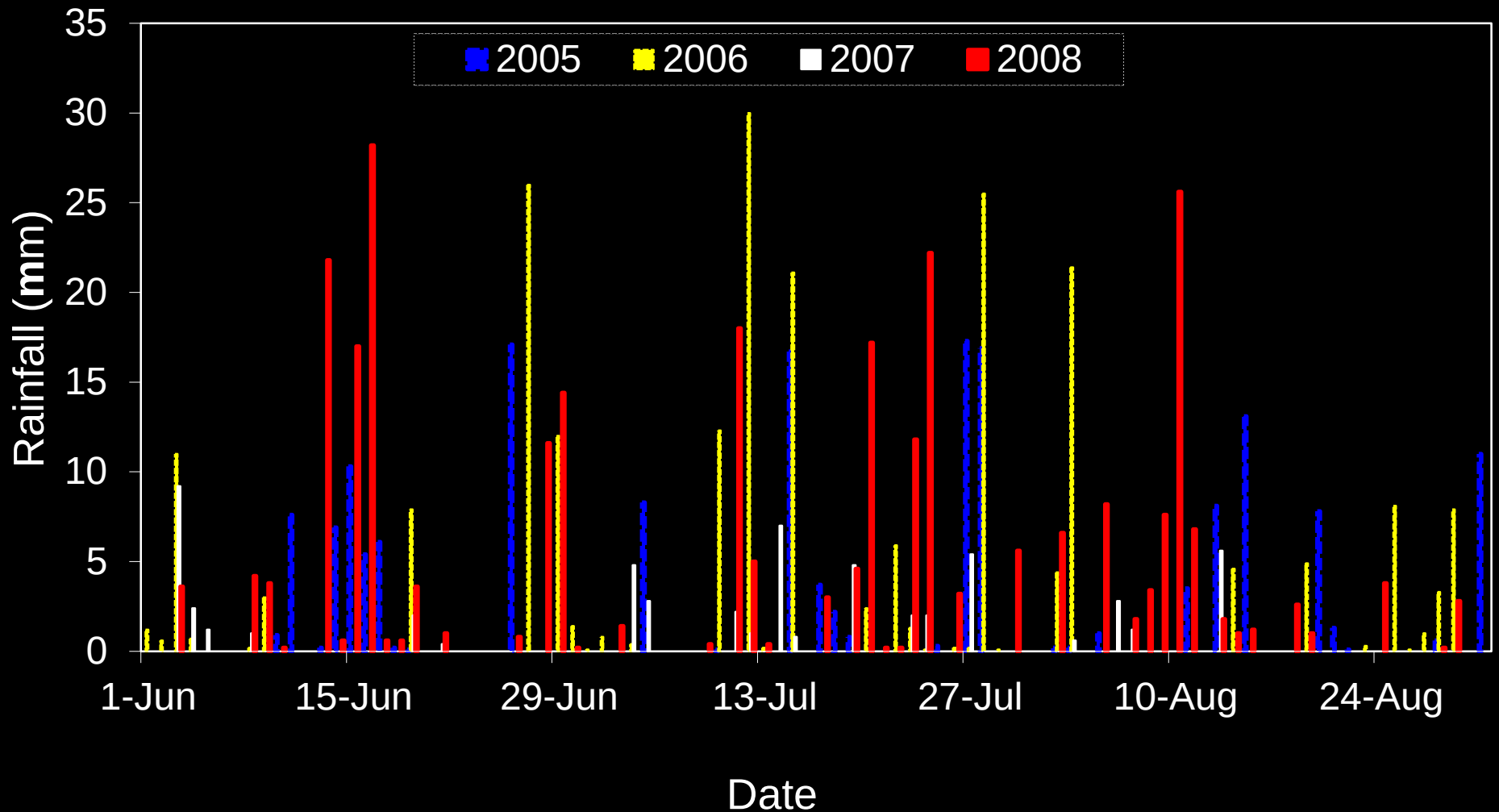


Mean monthly temperature during the experimental period Virgil Station, NOTL, ON



Rainfall distribution during the growing season

Virgil Station, NOTL, ON.



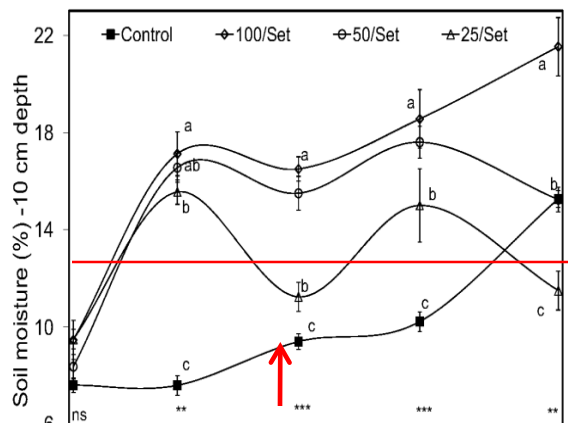
Baco Noir - Results



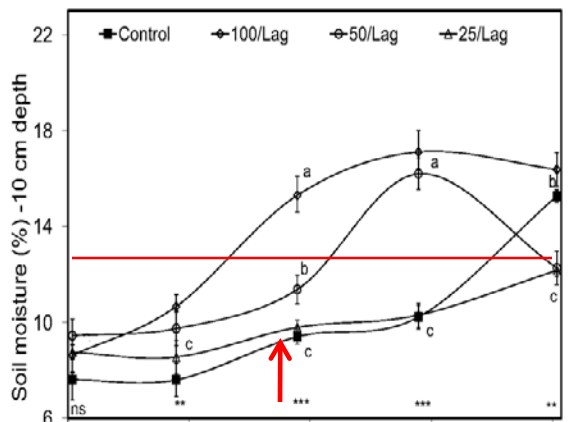
Soil Moisture (2007)

10 cm
Depth

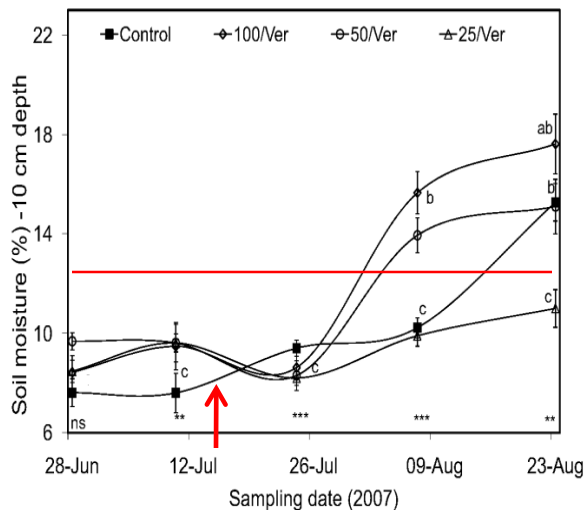
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Lag

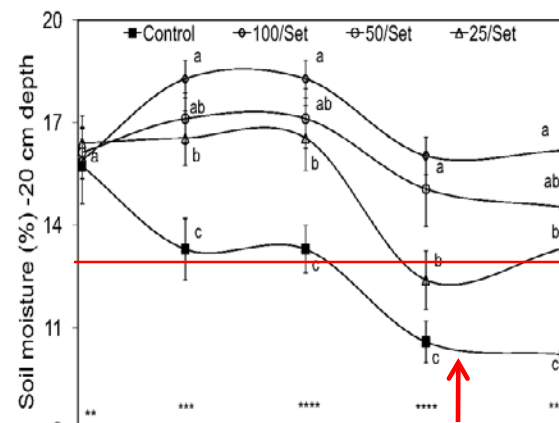


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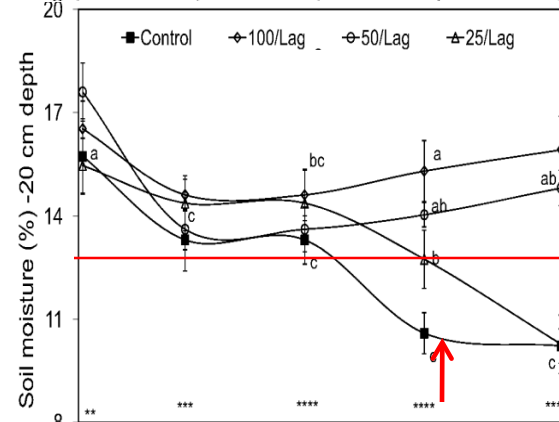


20 cm
Depth

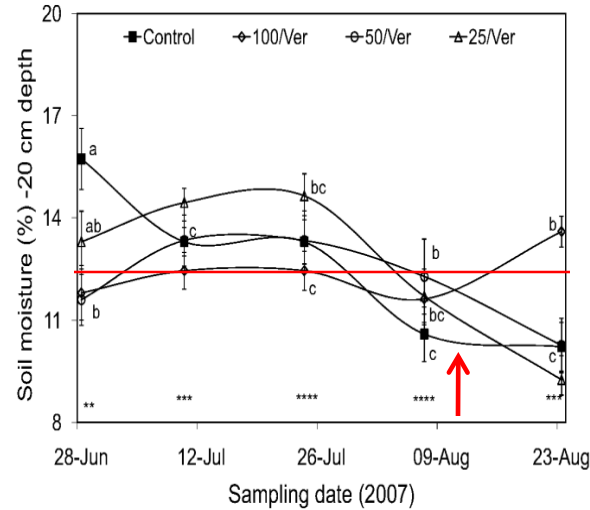
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Lag



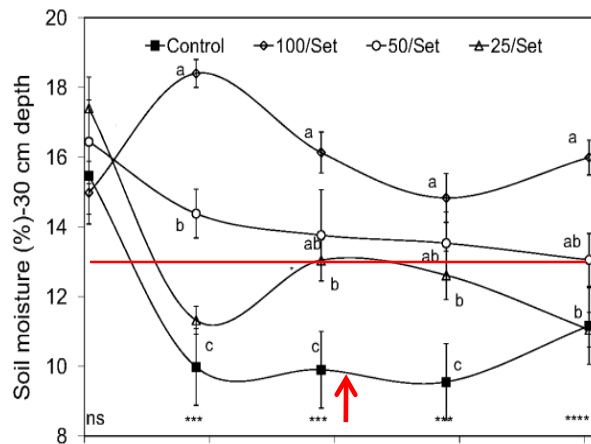
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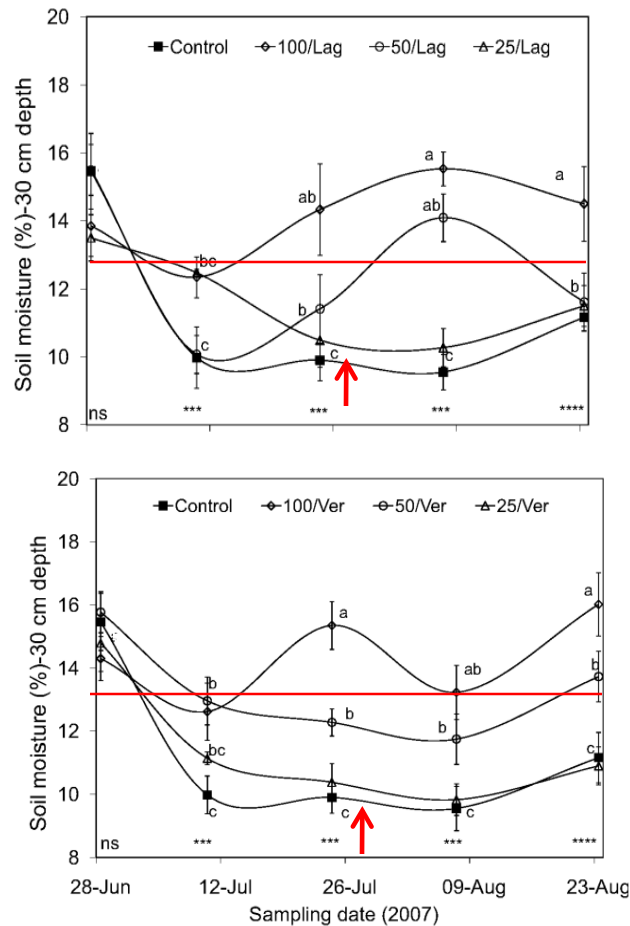
Soil Moisture (2007)

30 cm
Depth

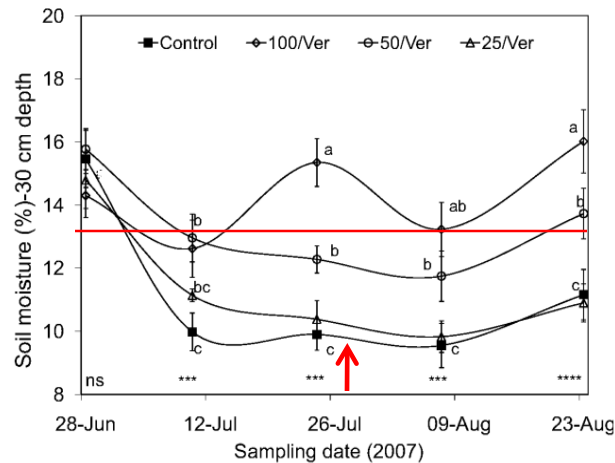
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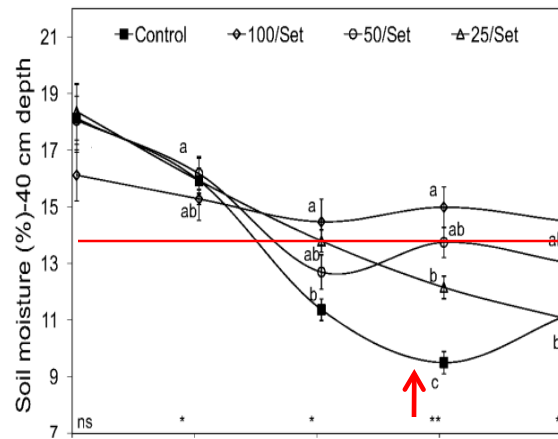


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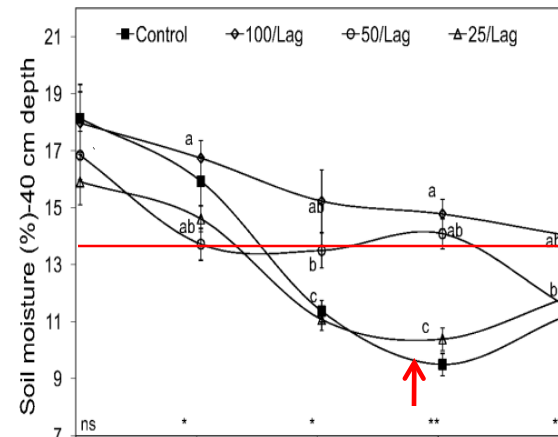


40 cm
Depth

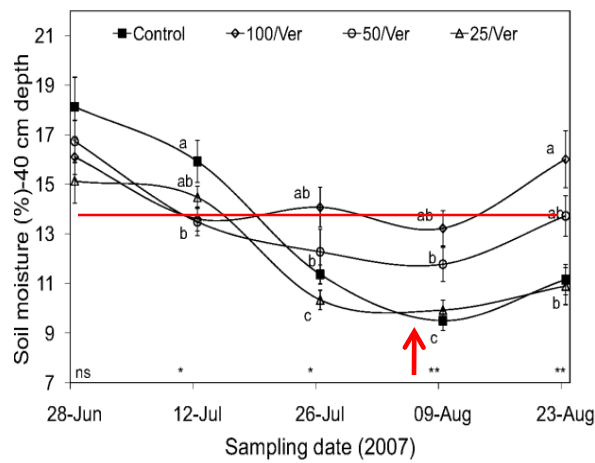
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Lag



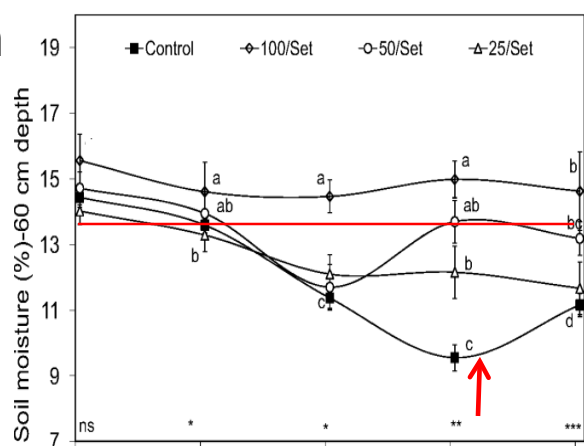
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Soil Moisture (2007)

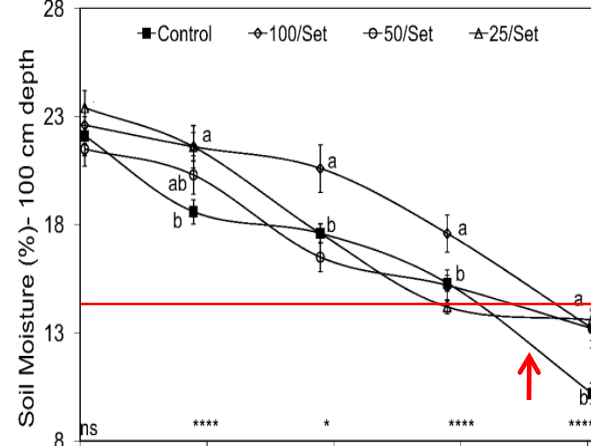
60 cm
Depth

Set

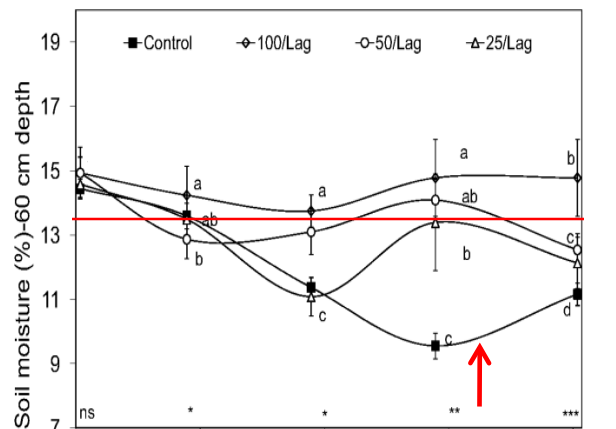


100 cm
Depth

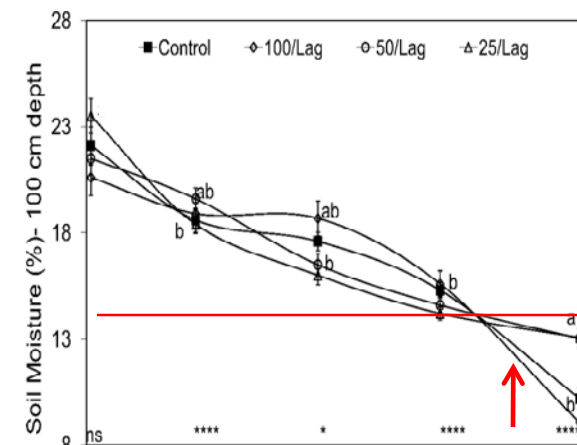
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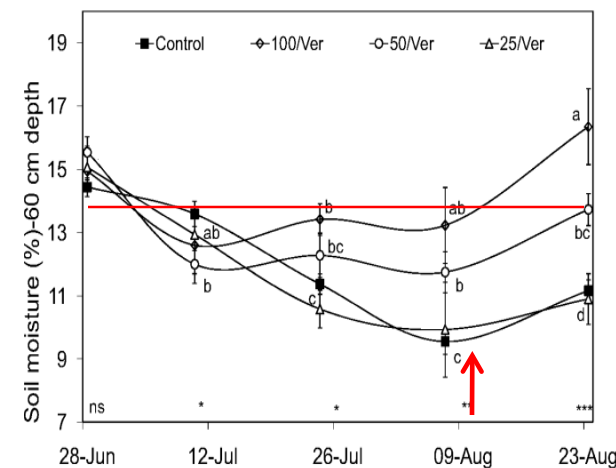
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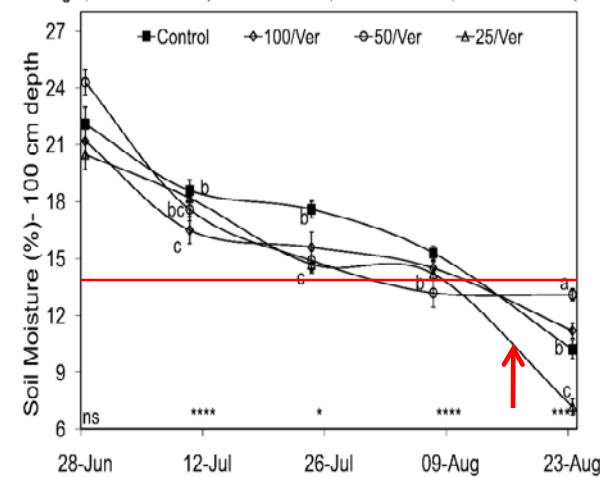
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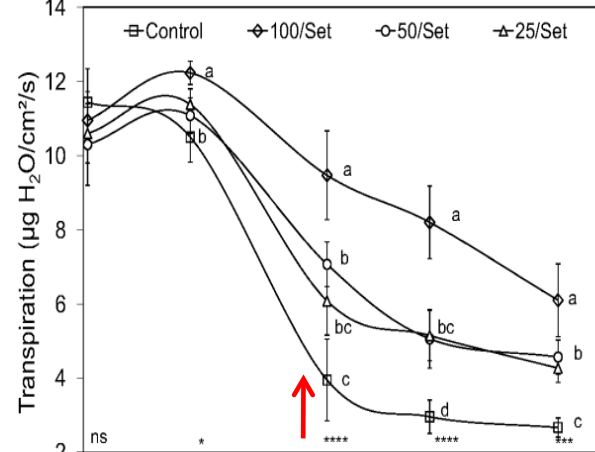
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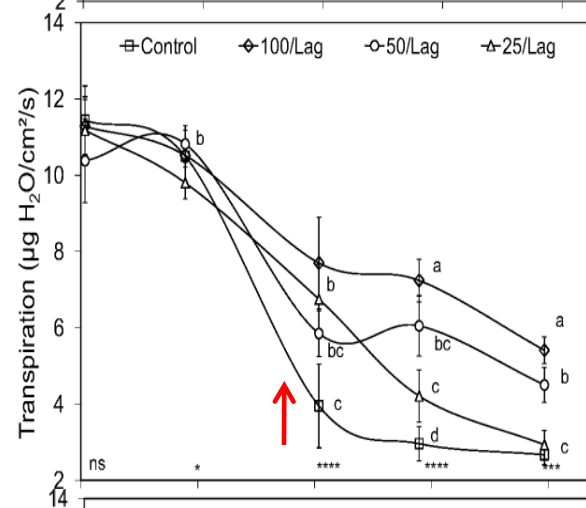
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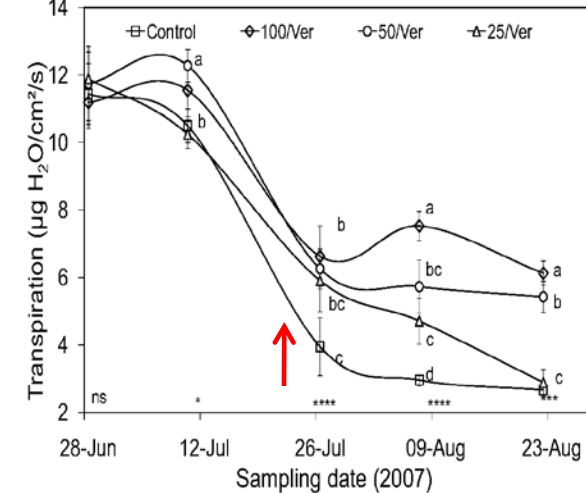
Transpiration (2007)



Set

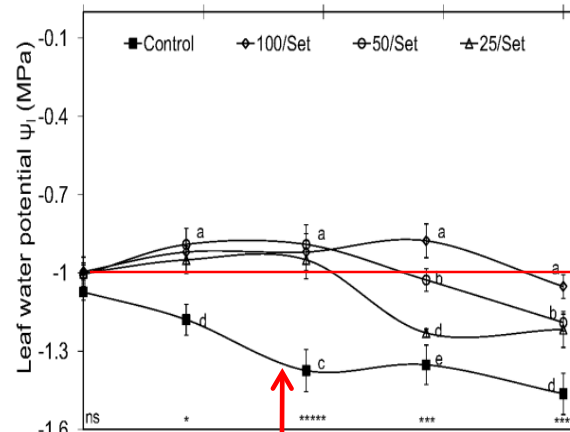
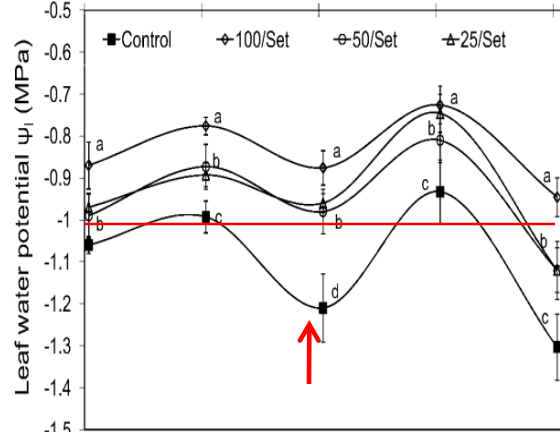


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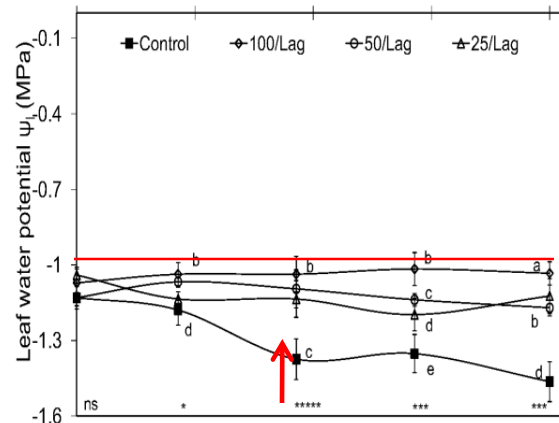
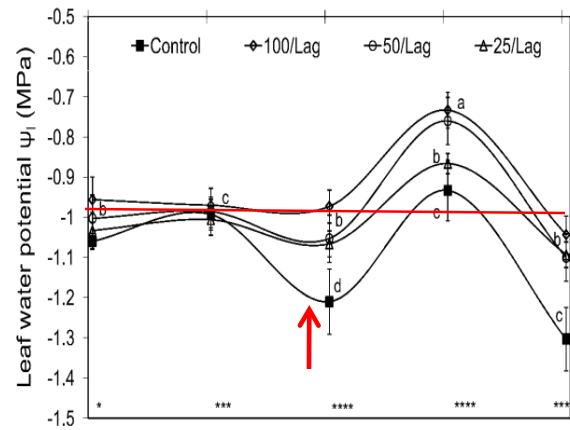


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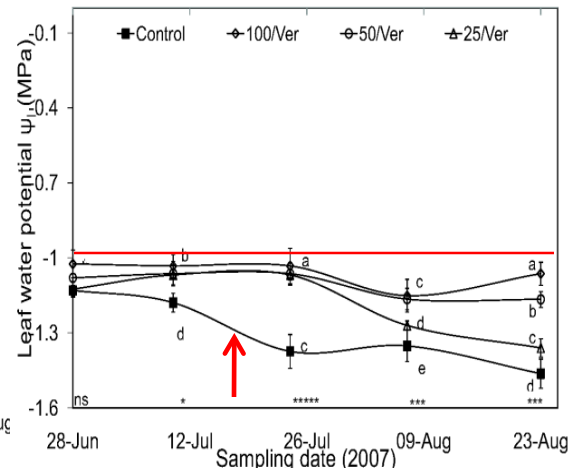
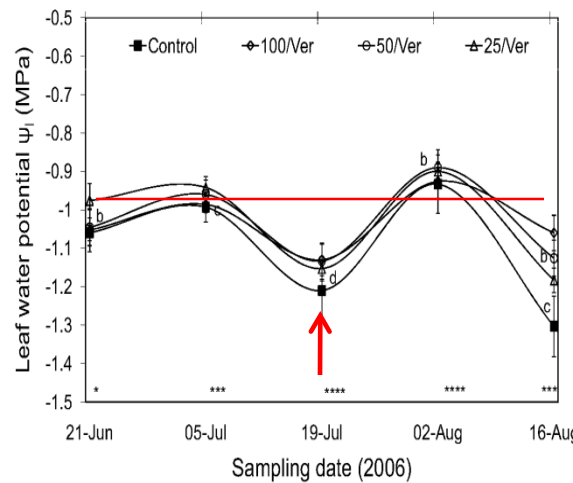
Leaf water potential (2006-2007)



Set



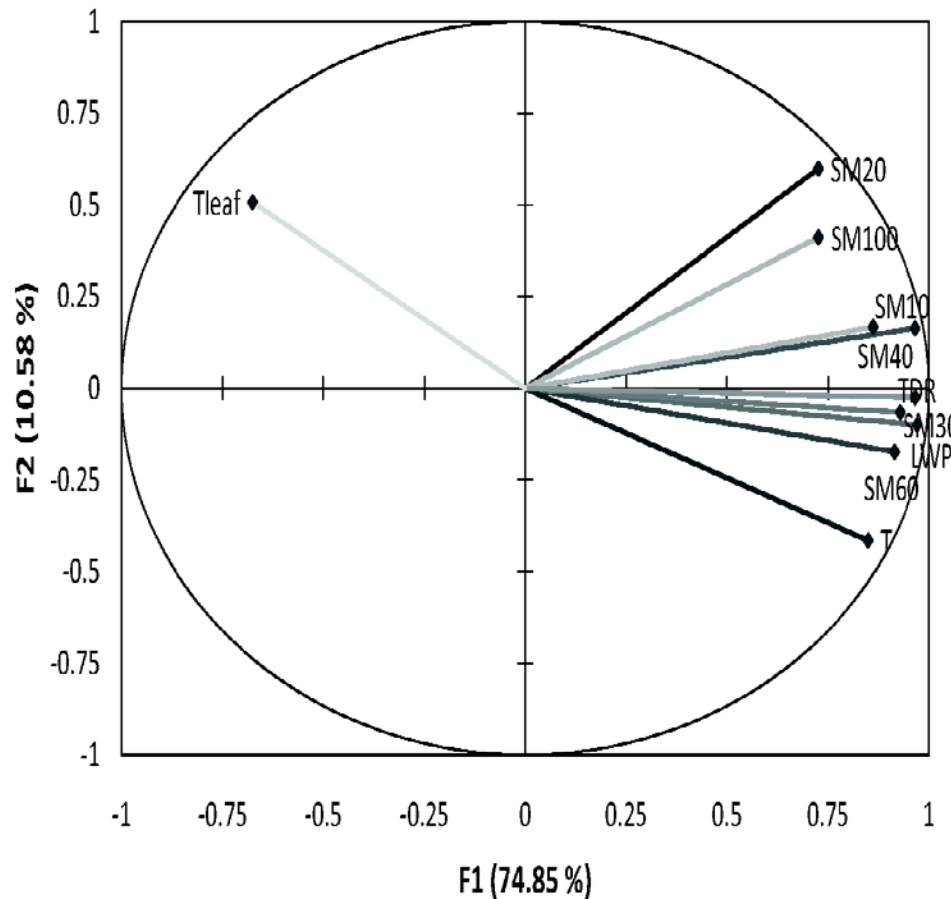
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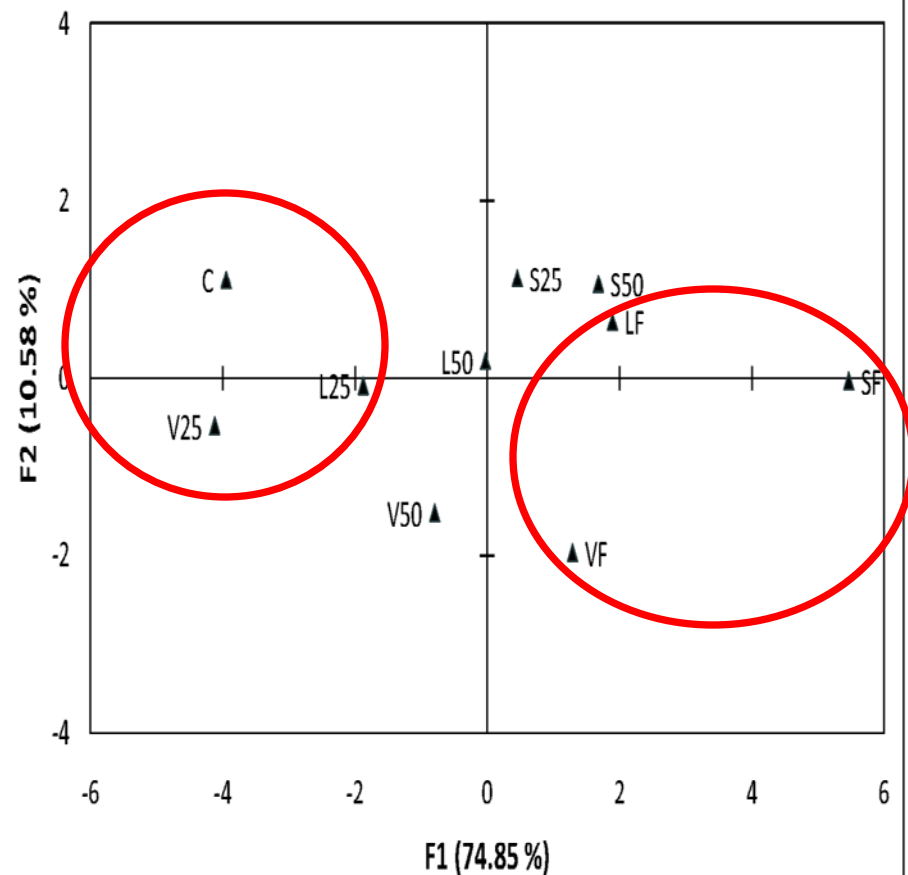
Ver.

Principal Component Analysis on Field Data Baco noir (2007)

Variables (axes F1 and F2: 85.43 %)

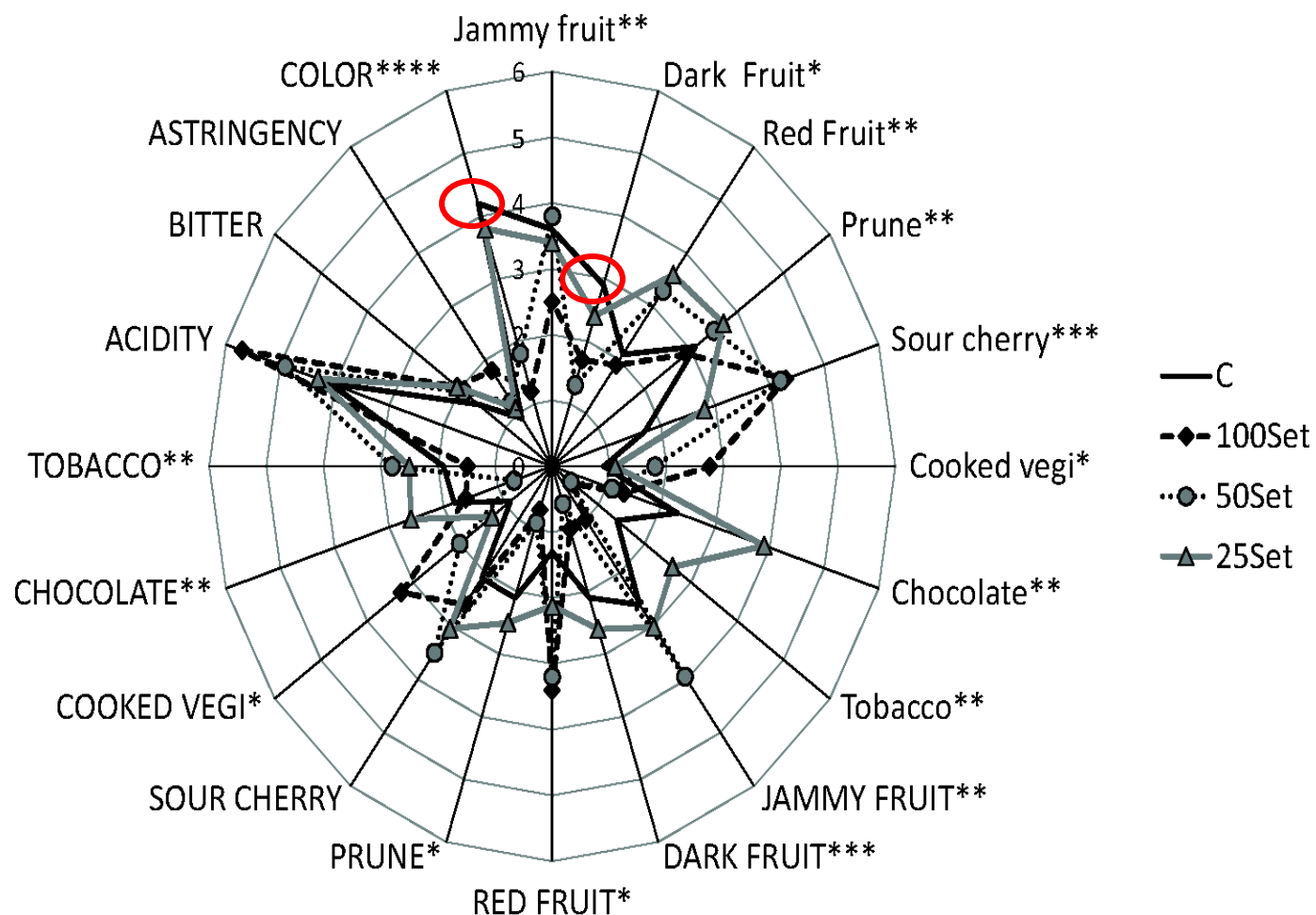


Observations (axes F1 and F2: 85.43 %)



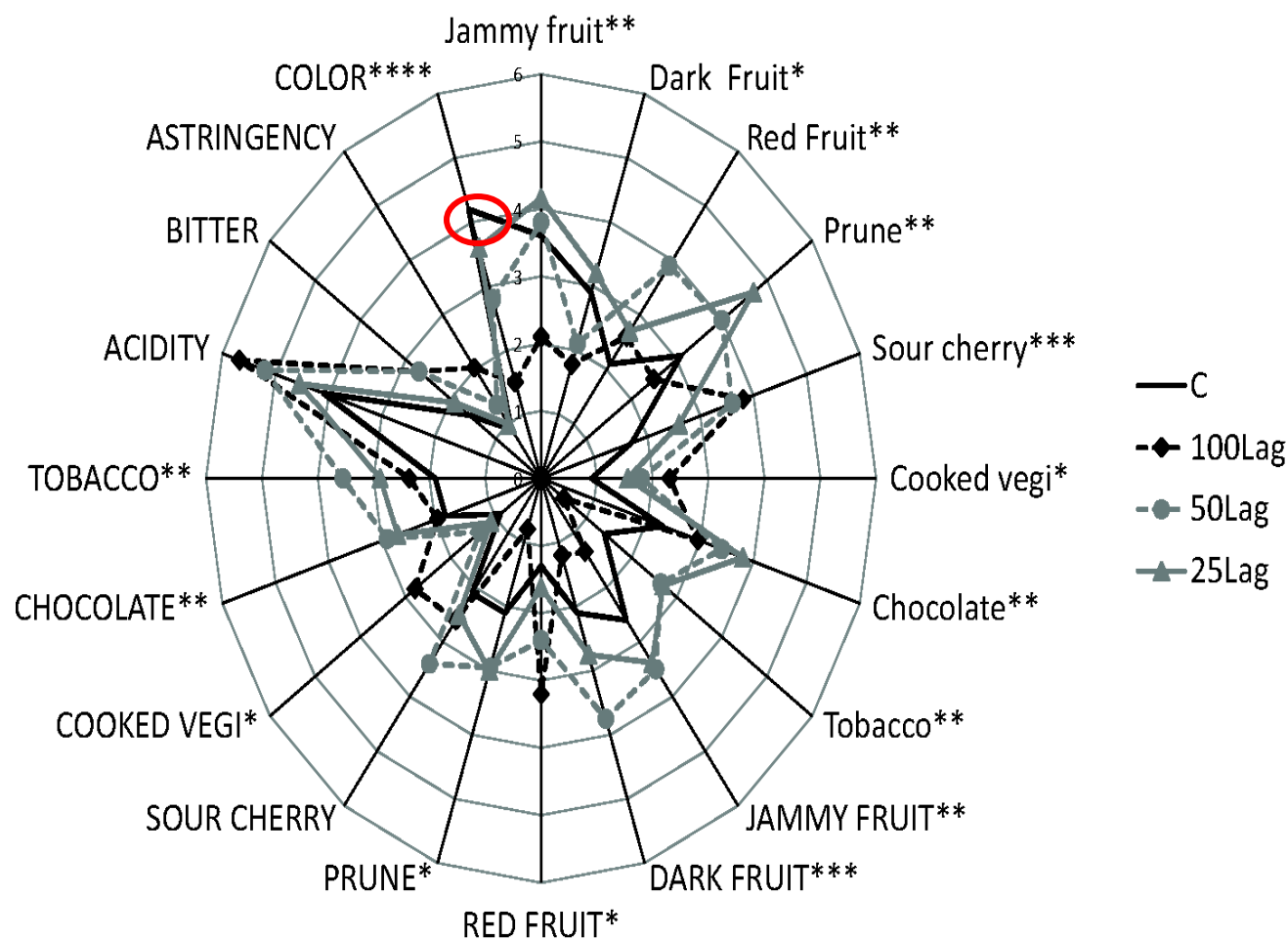
Baco noir Wine Sensory Profile (2007)

Fruit Set



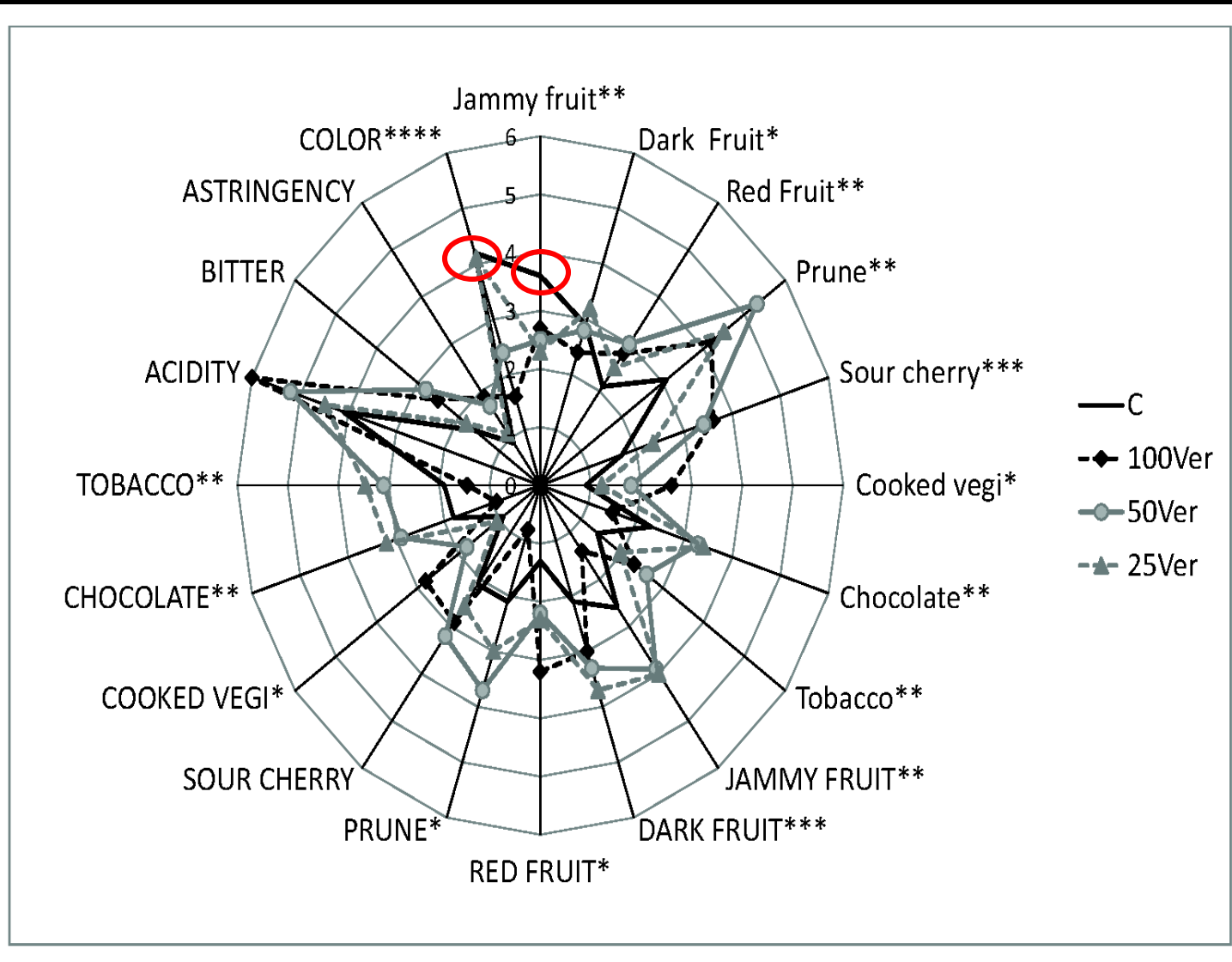
Baco noir Wine Sensory Profile (2007)

Lag



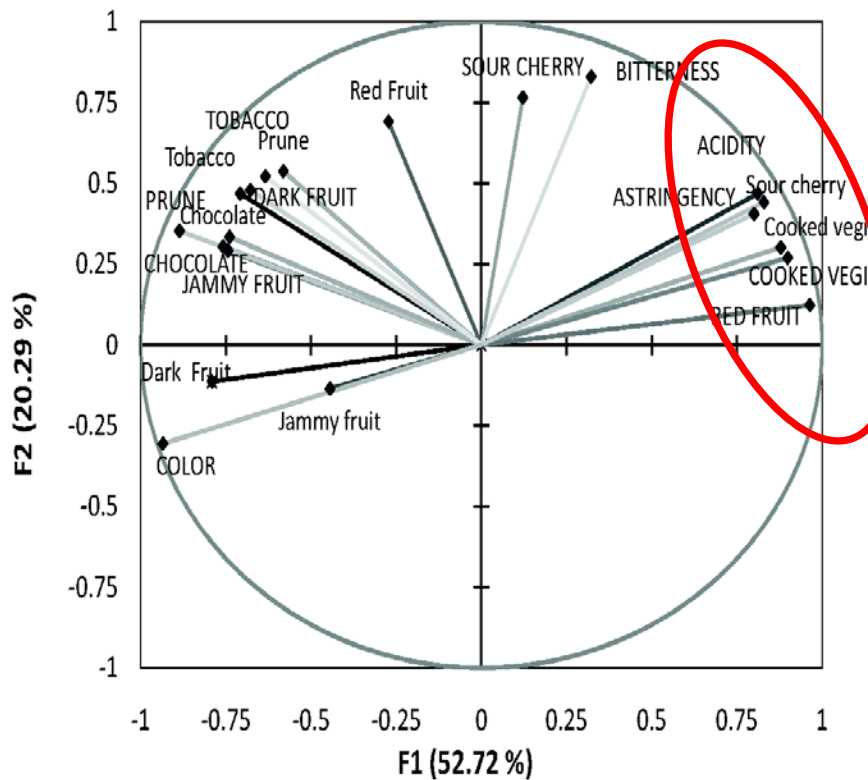
Baco noir Wine Sensory Profile (2007)

Veraison

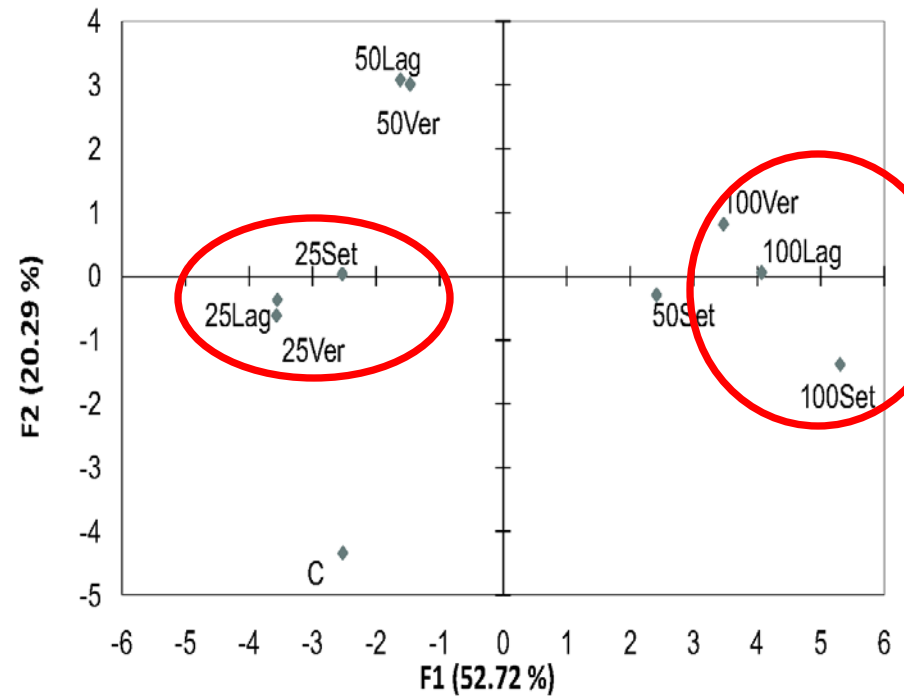


Principal Component Analysis on Sensory Data Baco noir (2007)

Variables (axes F1 and F2: 73.00 %)



Observations (axes F1 and F2: 73.00 %)

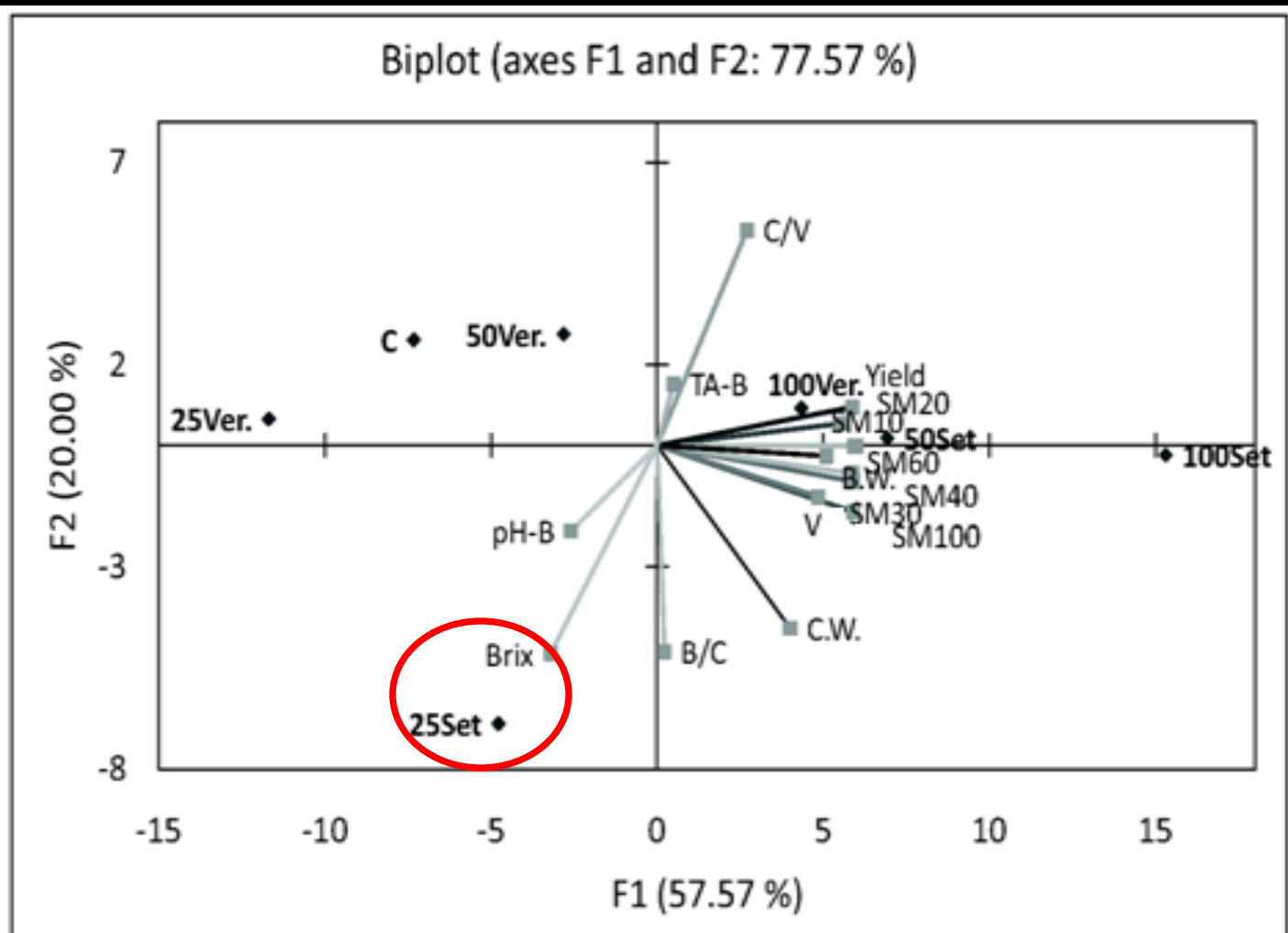


Chardonnay



Chardonnay

PCA on field and yield components (2007)

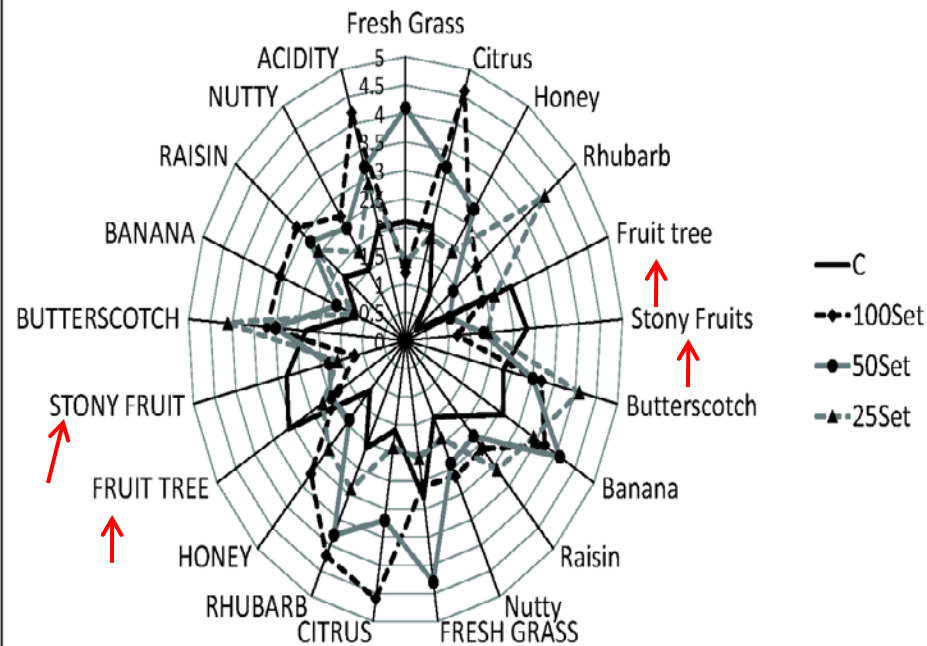


Chardonnay Wine Sensory Profile (2007)

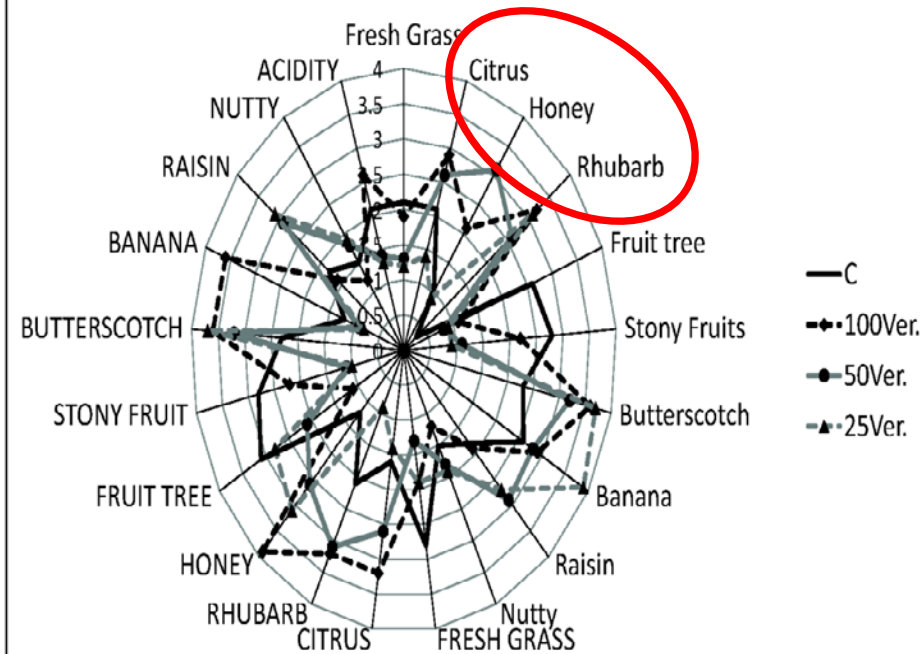
Fruit Set

Veraison

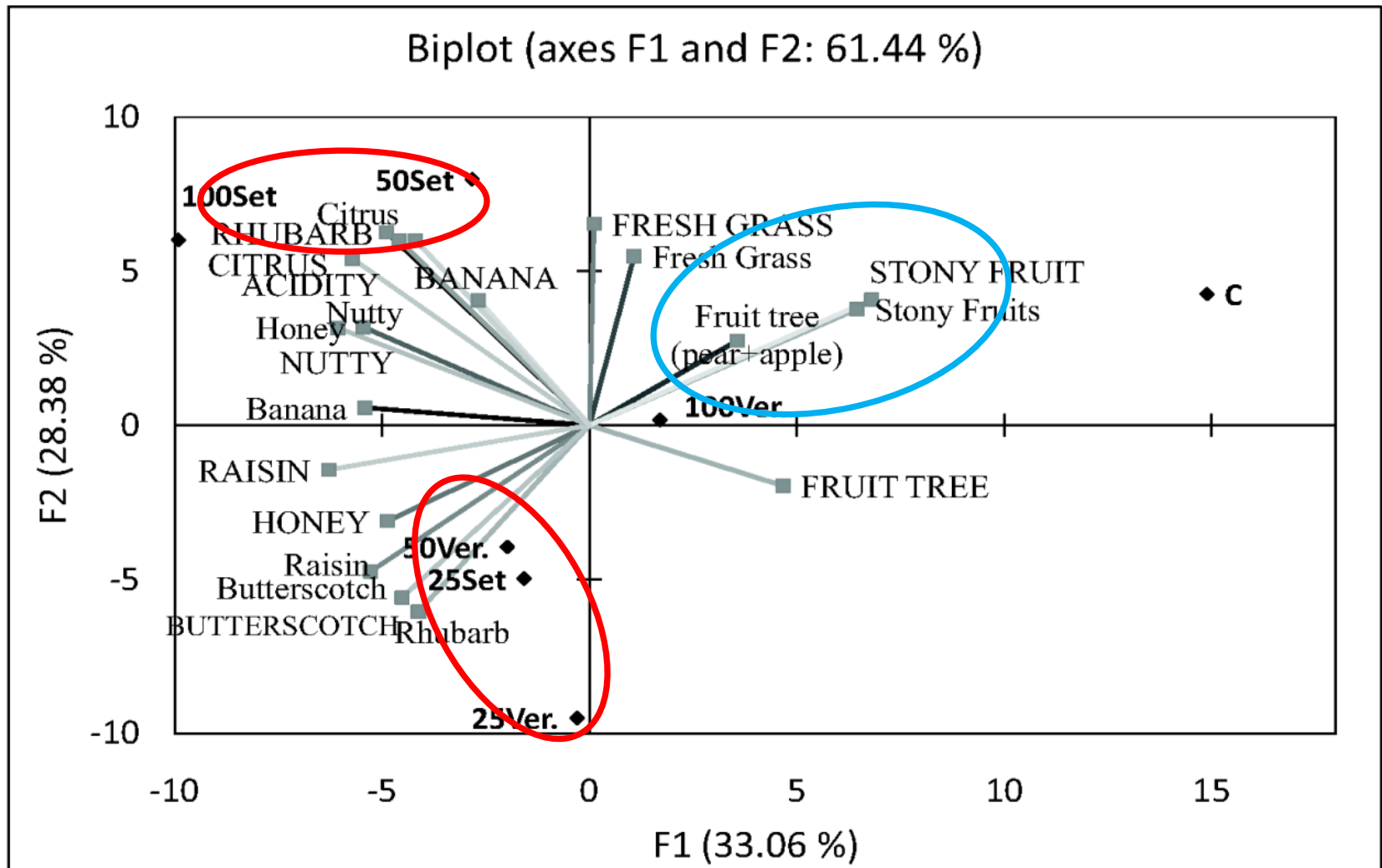
A



B



PCA of Chardonnay sensory data (2007)



Results Summary

- Irrigation treatments affected moisture on the soil profile in all blocks and experimental years
- The magnitude of difference in soil and vine water status between irrigation treatments and control varied with the amount of water applied
- The greatest effect of the irrigation treatments on grapevine physiology compared to the control was observed in 2007 (driest season)
- Soil moisture had the same trend in all treatments, with low variation among treatments at the top and bottom of the soil profile and high variation in the root zone
- Physiological parameters in 25 % ET_c treatments were close to those from the control in almost all years during the growing seasons

Results Summary

- Vigor was highly increased in full irrigated treatments, however vine size was not affected by water status in all years and cultivars
- Transpiration and leaf Ψ were highly positively correlated with soil moisture and negatively correlated with leaf temperature in almost all blocks
- Baco noir and Chardonnay grapevines responded positively at both irrigation initiation time and the regime of water used
- Yield was affected mostly by the berry weight and less by the cluster number or number of berries per cluster
- Low vine water status appears related to low berry weights and titratable acidity, and high Brix
- 25 and 50 % ET_c treatments had the most beneficial effect on fruit composition and wine sensory (typicity/complexity) profile

Conclusions

- Irrigation could be effective on wine grapes in cool climates and dry years
- Physiological changes in vine were dependant on soil moisture and variety
- Keeping the vineyard under moderate water stress by applying deficit irrigation strategy could improve berry composition and wine sensory profile
- Irrigation initiation time is as important as the regime of water applied
25 and 50 % ET_c applied at lag phase or veraison had the most beneficial effect on fruit composition and wine sensory profile
- Not all varieties have the same water needs (some of them react better at irrigation then others), so the irrigation should be applied differentially

Acknowledgements



- Dr. Reynolds – supervisor
- Dave Lambert from Lambert Vineyards
- Funding and scholarships: Natural Sciences and Engineering



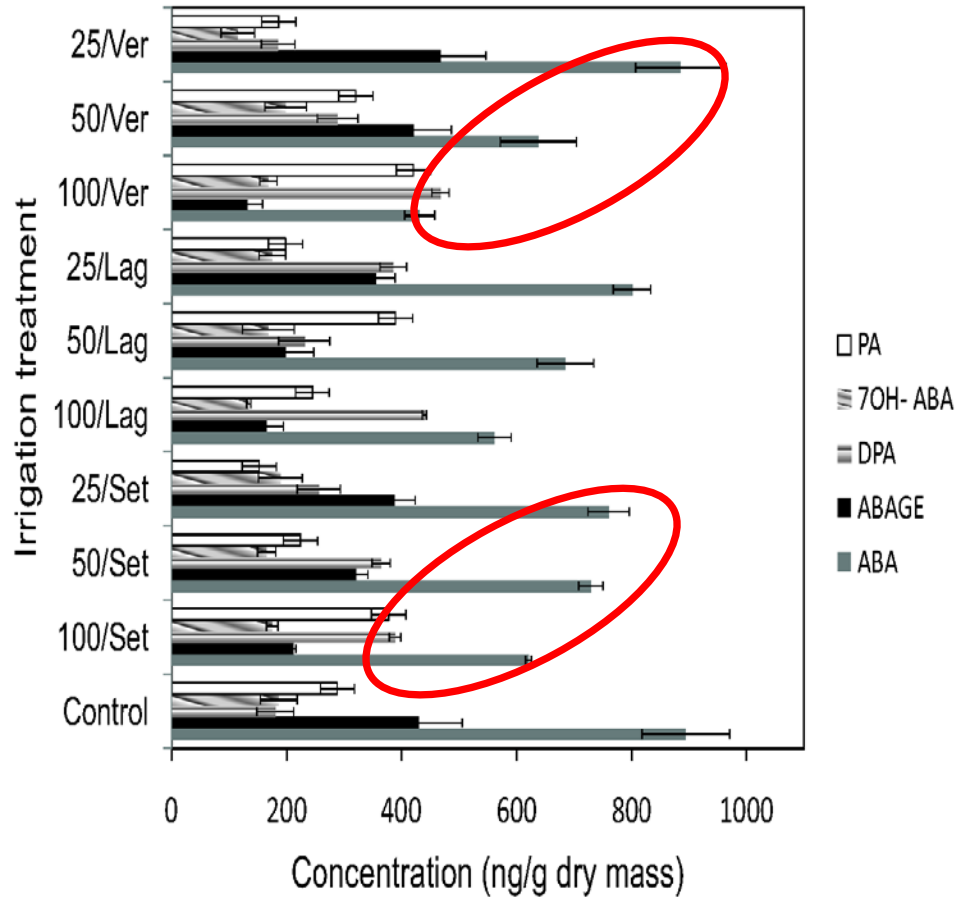
Thank you

Hypothesis II

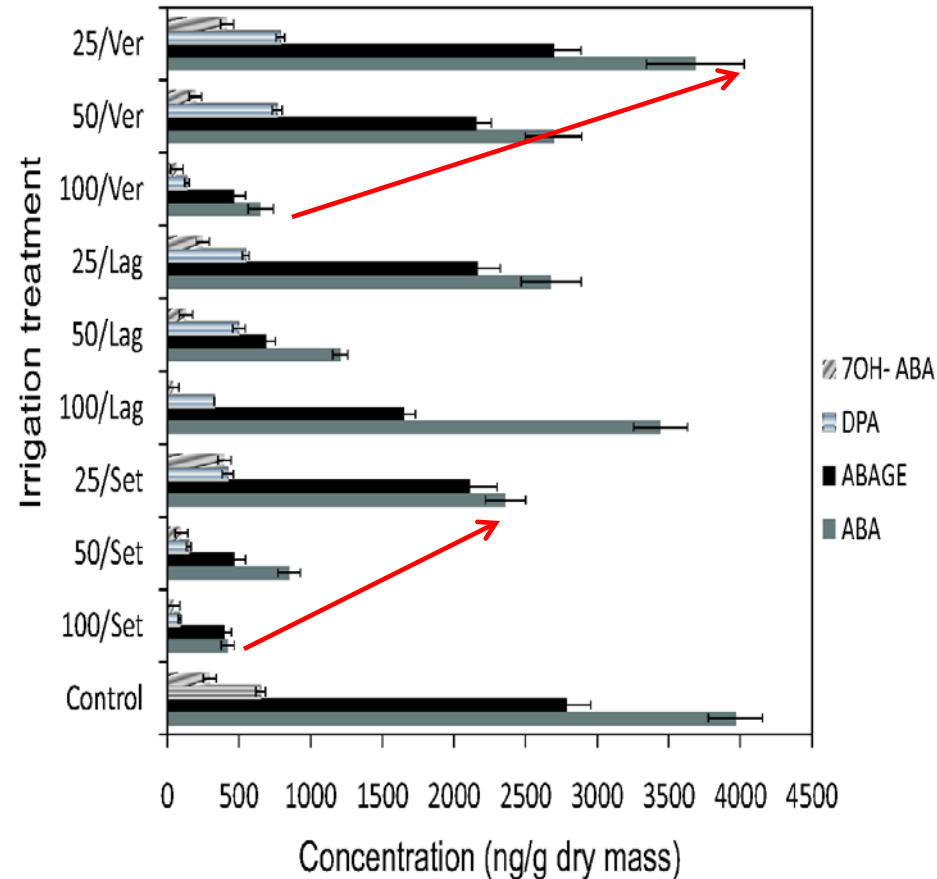
ABA and its catabolites profiles would vary in leaves and berries during the vegetation period, and could accurately reflect the water status level

ABA and its catabolites profile from Baco noir leaves (last sampling date), 2006 - 2007

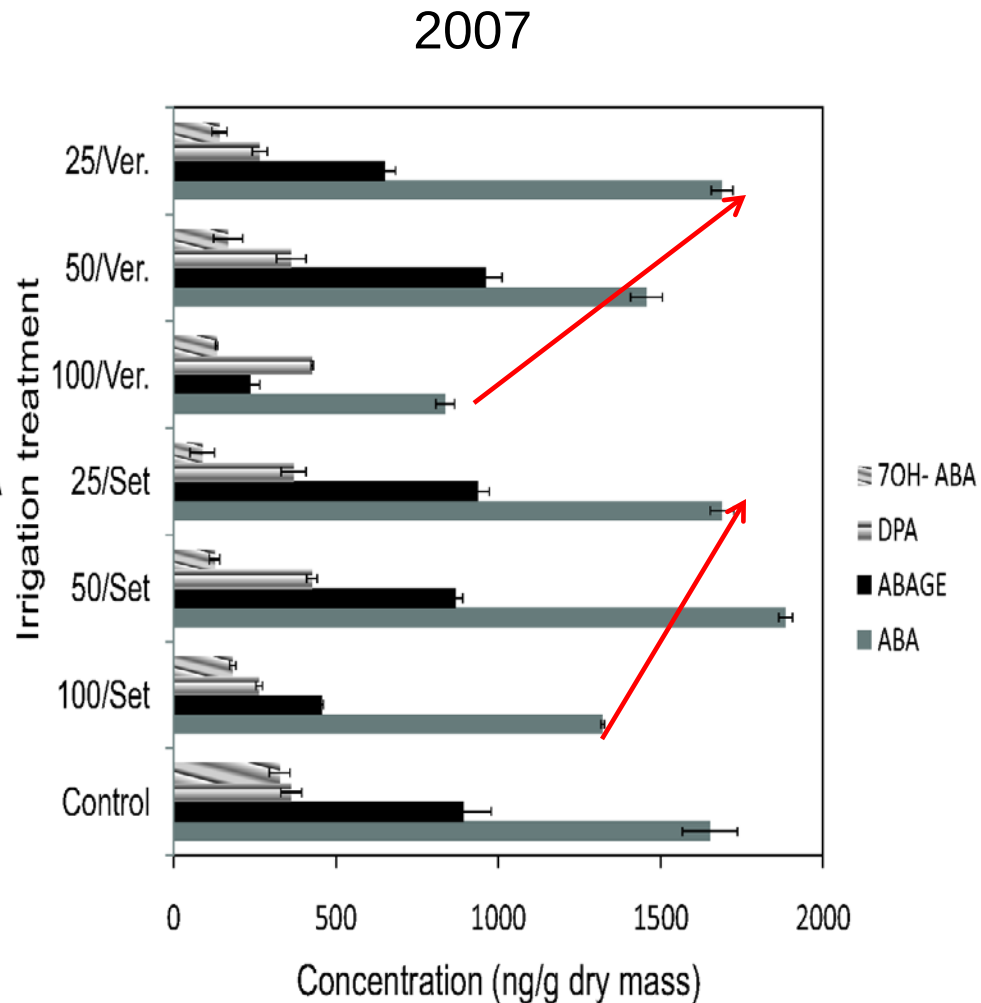
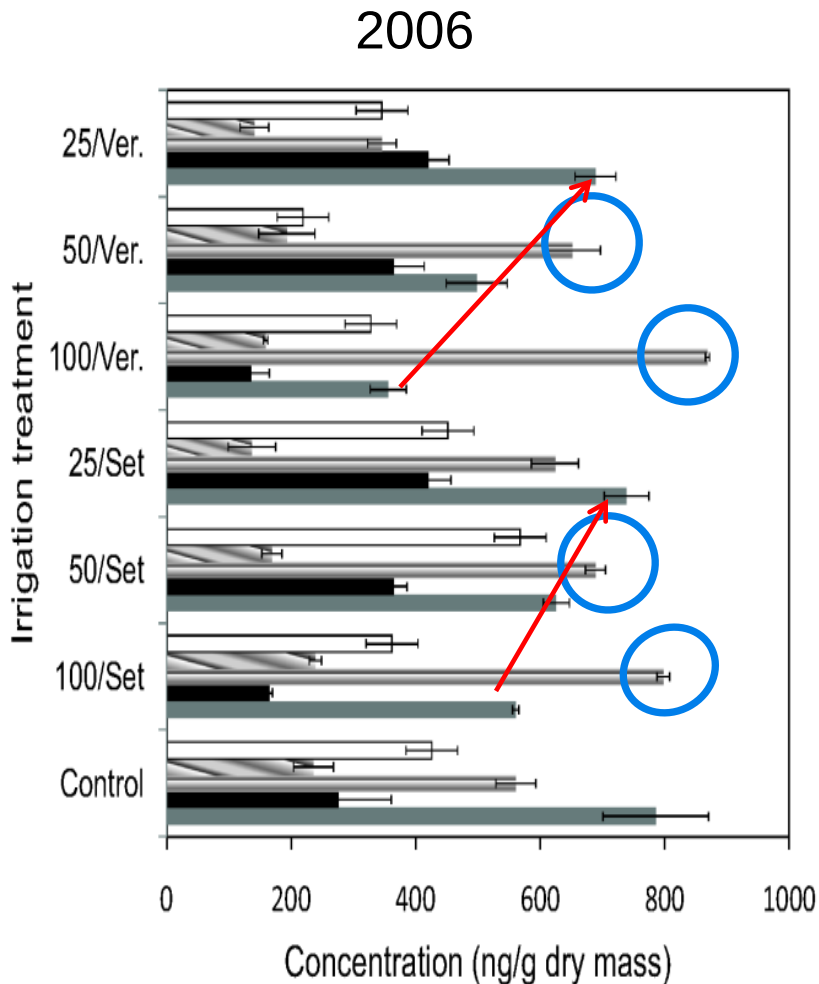
2006



2007

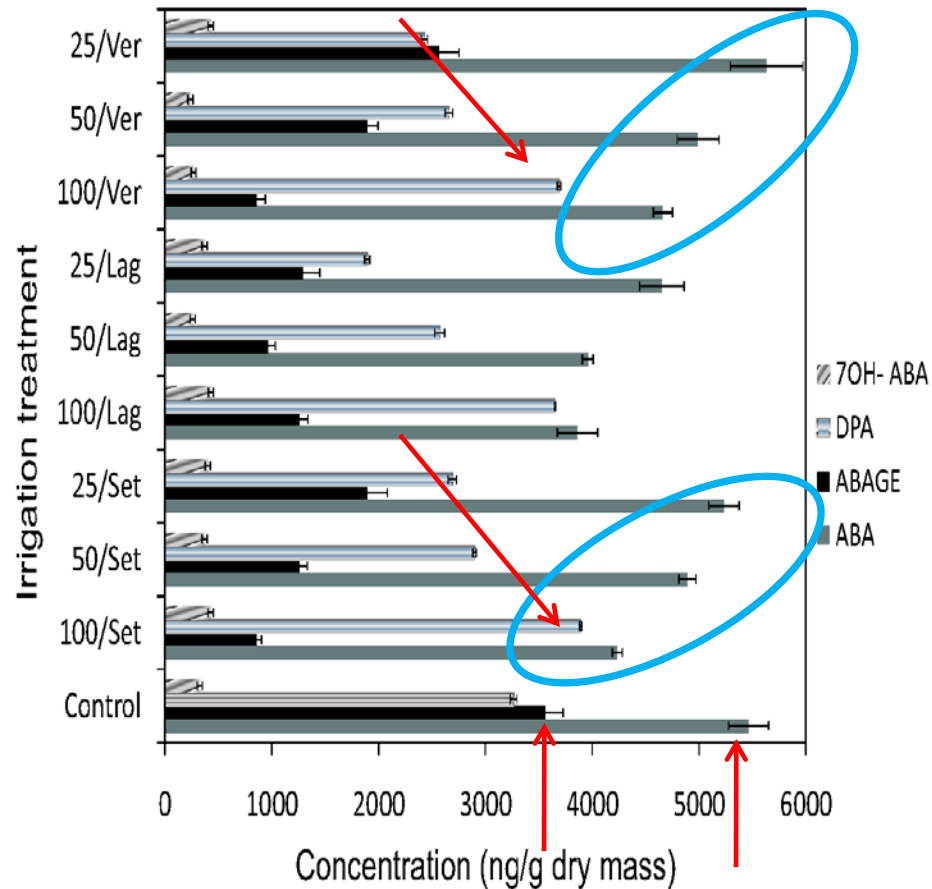


ABA and its catabolites profile from Chardonnay leaves (last sampling date), 2006 - 2007

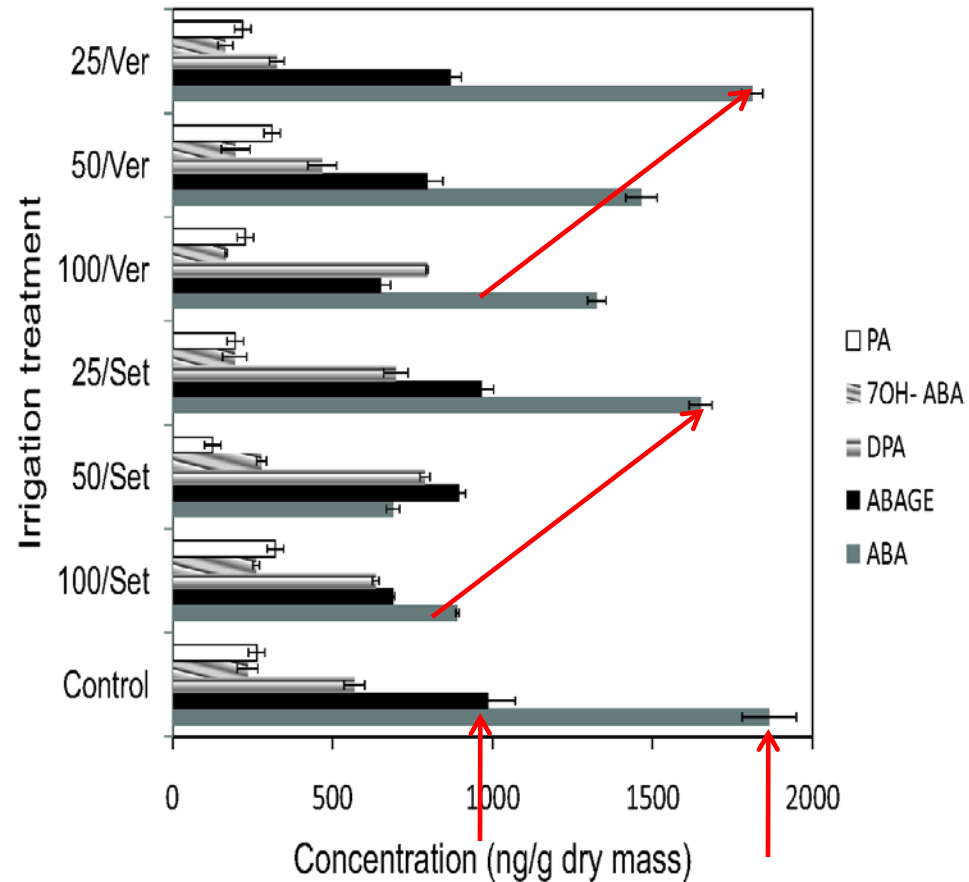


ABA and its catabolites profile in berry skin at veraison, Baco noir and Chardonnay grapes 2007

Baco noir

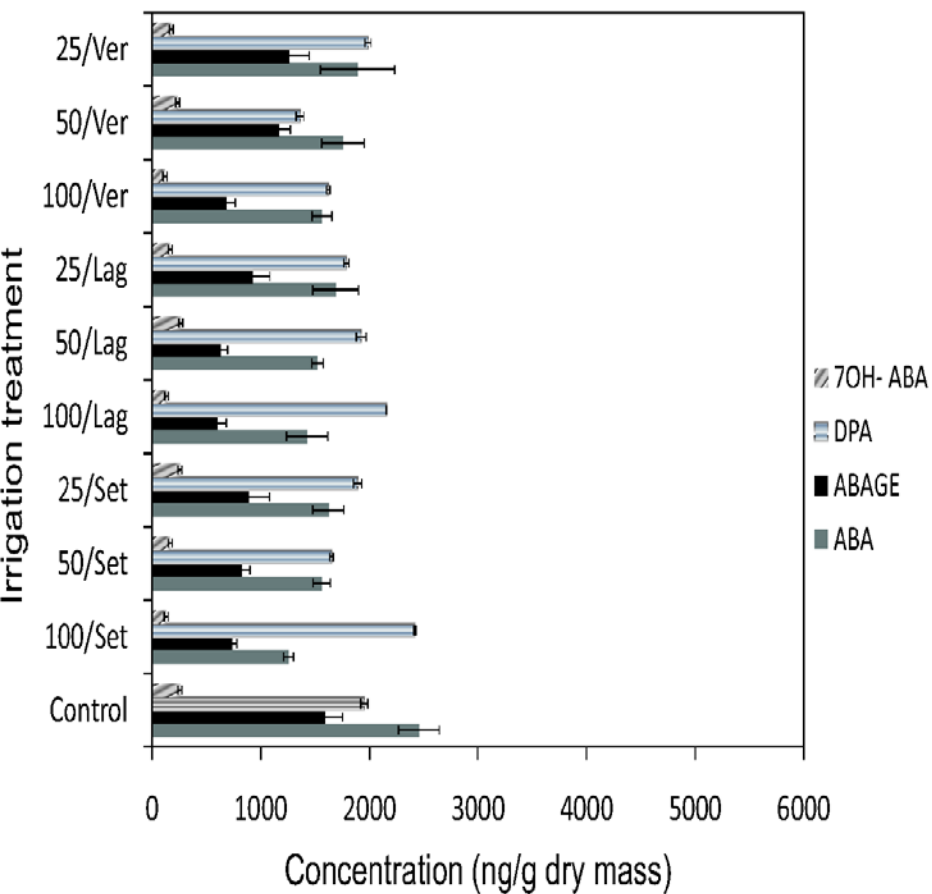


Chardonnay

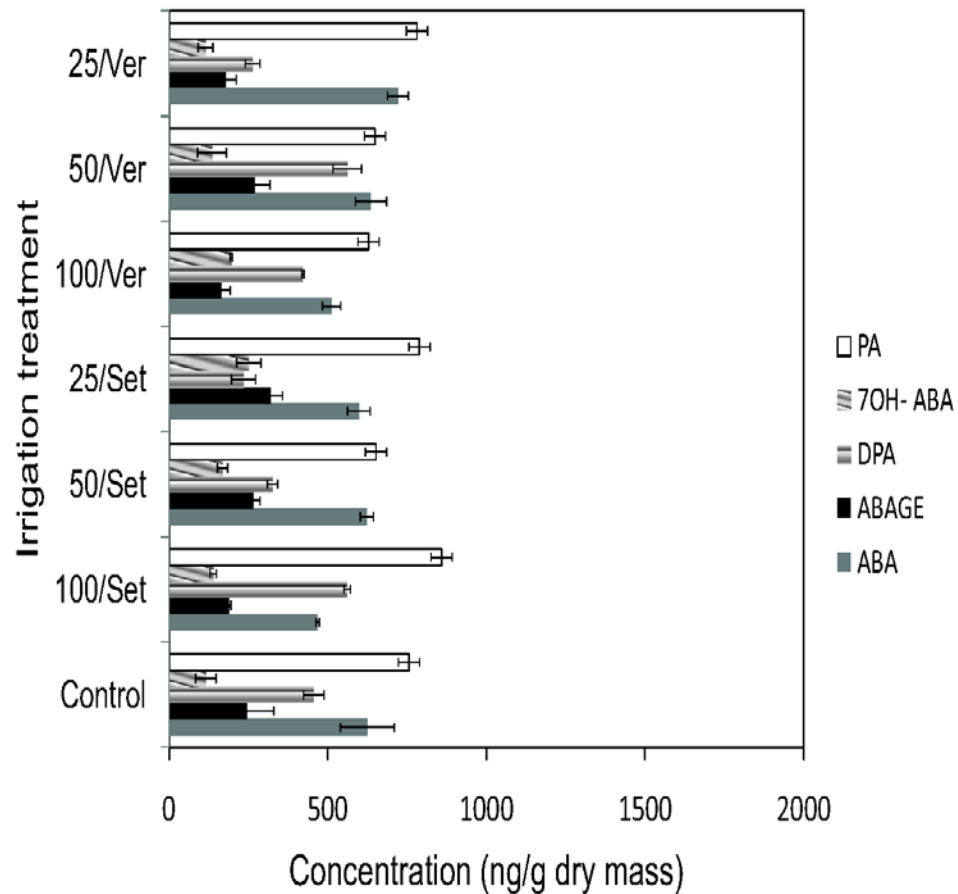


ABA and its catabolites profile in berry skin at harvest from Baco noir and Chardonnay grapes 2007

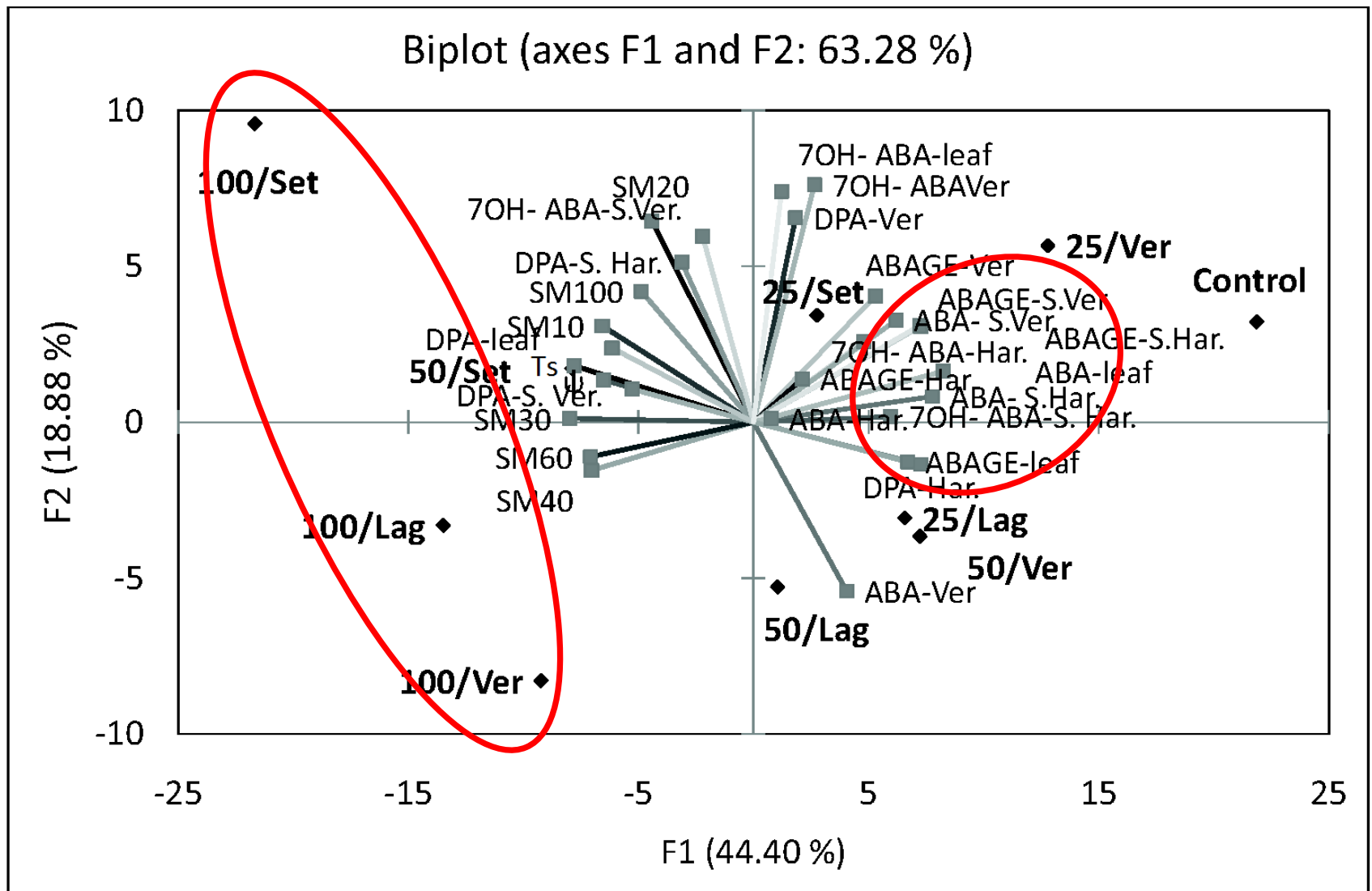
Baco noir



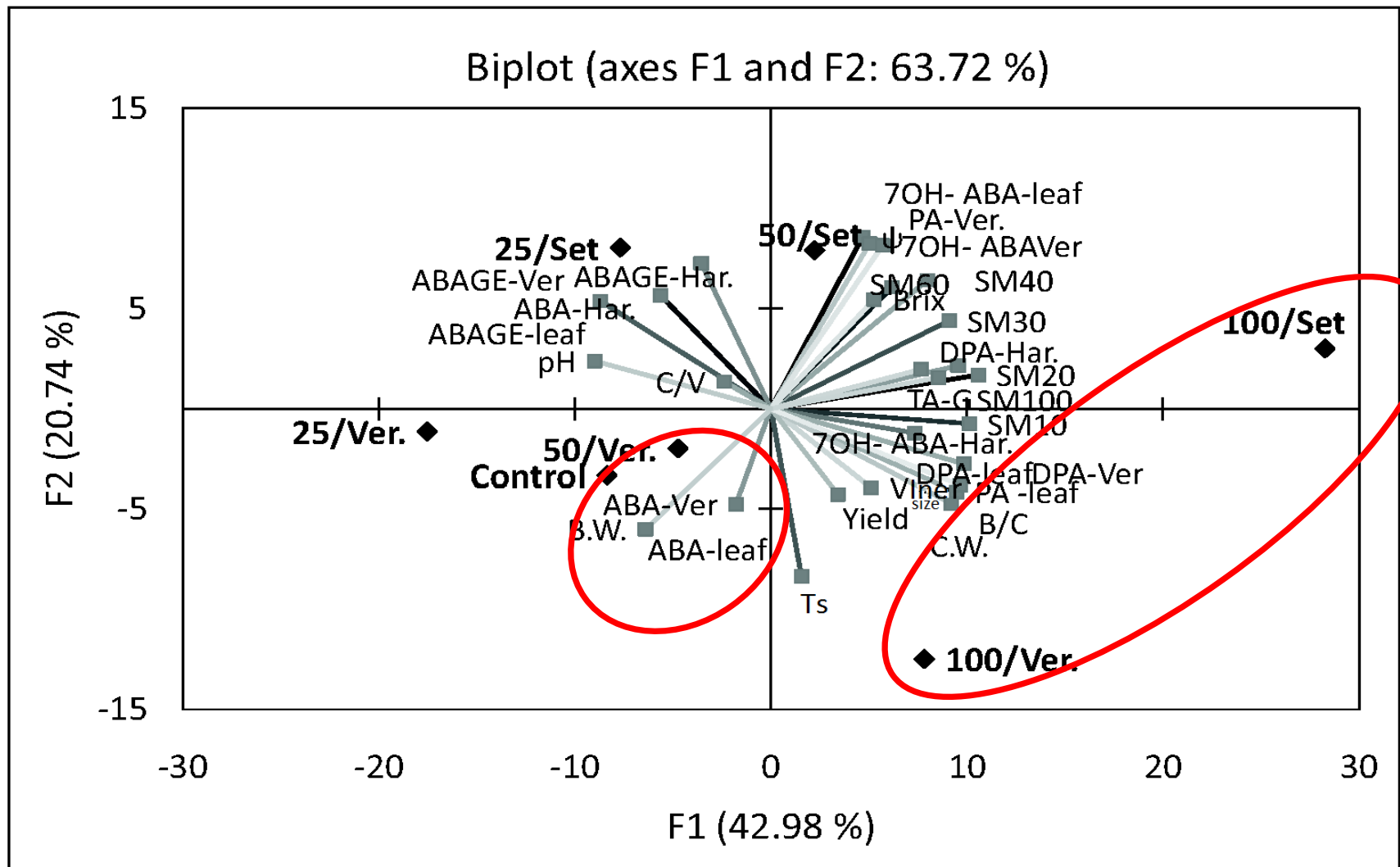
Chardonnay



PCA on field and hormone data of Baco noir (2007)



PCA on field and hormone data of Chardonnay (2007)



Summary Results

- ABA and its catabolites profiles were affected in both cultivars by level of water status and time of irrigation initiation
- From all analytes studied only ABA, ABAGE, 7-OH ABA, PA and DPA were found in detectable amounts
- Under dry and hot conditions only ABA and ABAGE were mostly affected by the irrigation treatment
- Under high water status PA and DPA were found in higher amounts compared to the other catabolites
- ABA and its catabolites were found in higher amounts in Baco noir leaves compare to Chardonnay
- ABA and ABAGE content was much higher in berry skin at veraison compared to harvest time in both cultivars
- ABA and ABAGE were found in higher amounts in Baco noir berries compared to Chardonnay
- The hormone profiles were different in 2006 and 2007 for both cultivars
- Changes in the ABA concentration did not translate to equivalent changes in the amount of its metabolites

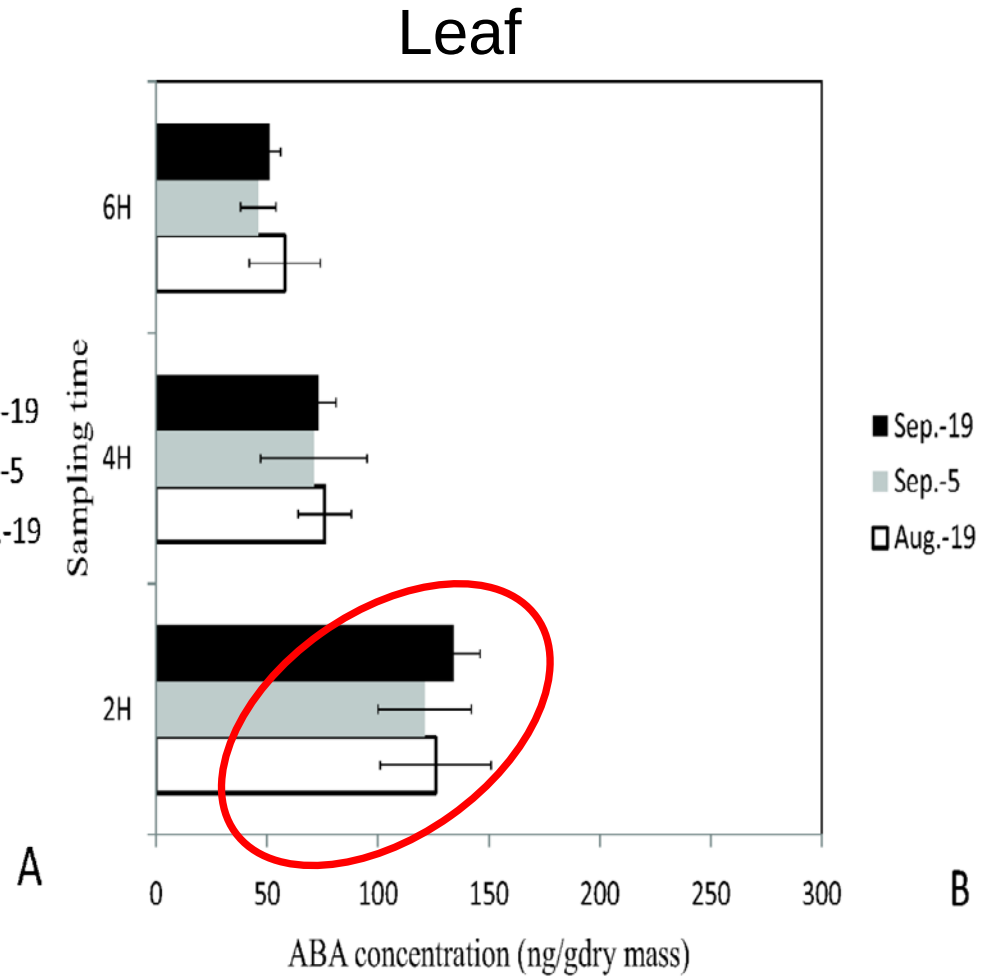
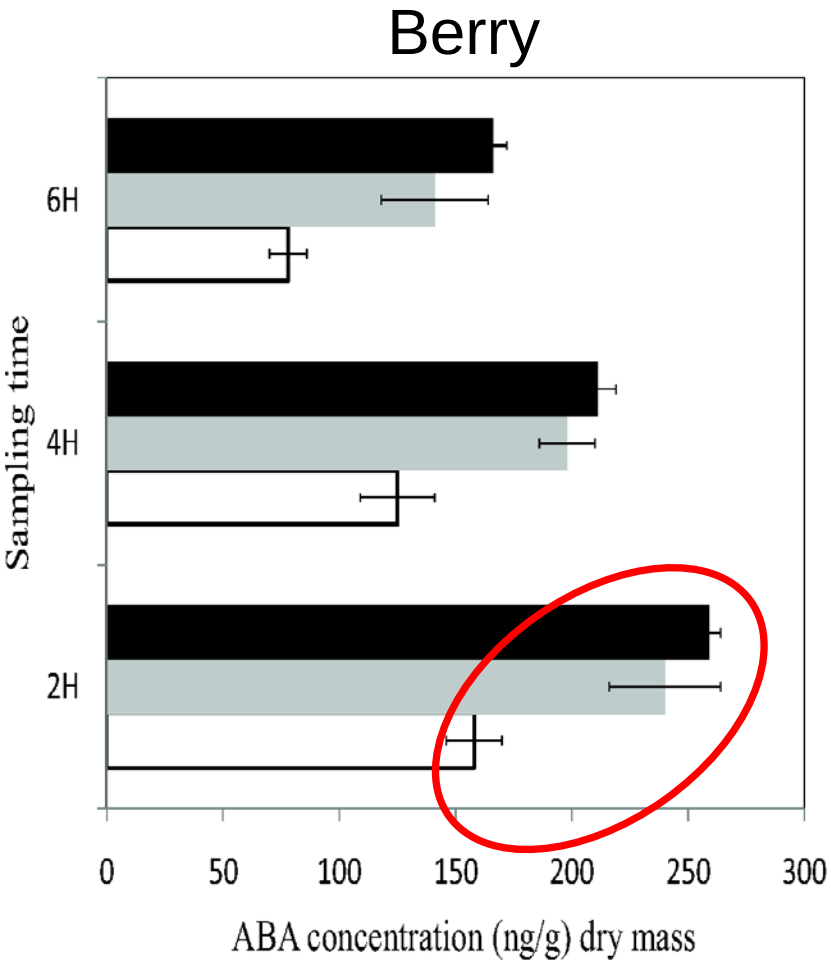
Conclusions

- ABA and its catabolites can accurately describe grapevine water status
- ABA and its catabolites are under genetic control
- Translocation could play a higher role in ABA variation than the catabolism process
- ABA and its catabolites profile in pulp and berry skin at veraison and harvest confirm their importance in the ripening process

Hypothesis III

By applying exogenous ABA onto vines in cool and wet years, one could mimic the positive effects of moderate water stress, hasten veraison and improve grape composition of Cabernet Sauvignon

Infiltration rate of exogenous ABA in Cabernet Sauvignon vines after 2, 4, and 6 hours following treatment application 2008

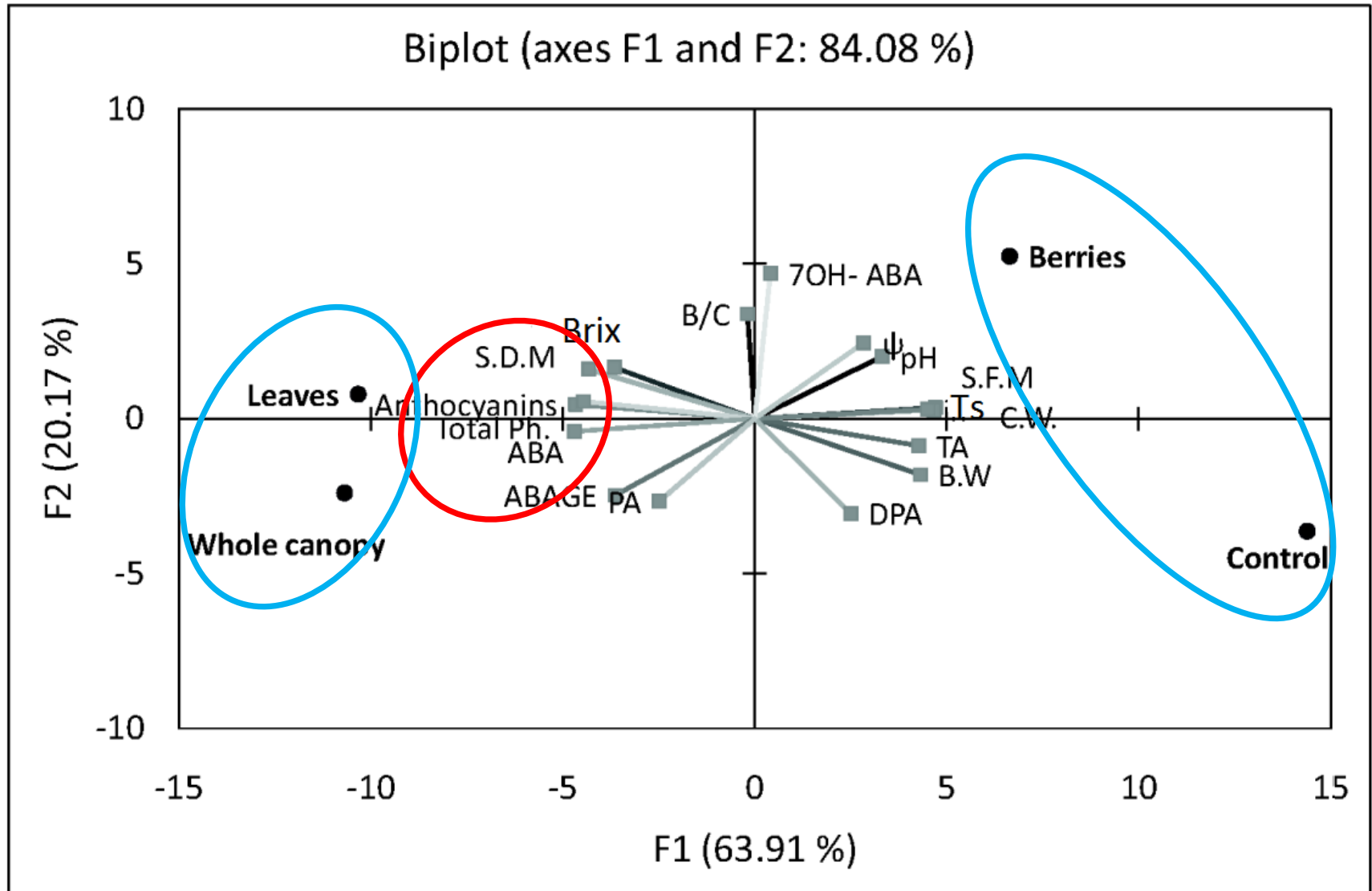


Impact of exogenous ABA on yield components and berry composition of Cabernet Sauvignon

Treatment	Cluster weight (g)	Berries/ cluster	Berry weight (g)	S.F.M (mg/berry)	S.D.M. (mg/berry)	°Brix
2008						
Control	140 a	96 b	1.45 a	109 a	49 c	18.9 c
Berries	141 a	112 a	<u>1.26 c</u>	<u>97 b</u>	56 ab	19.3 b
Leaves	<u>129 b</u>	101 ab	<u>1.28 c</u>	<u>89 c</u>	53 b	19.3 b
Whole canopy	<u>128 b</u>	94 b	<u>1.38 b</u>	<u>94 bc</u>	57 a	19.6 a
Significance	*	*	*	*	*	*
2009						
Control	143 a	91 b	1.41 a	111 a	46 c	18.3 b
Berries	<u>137 b</u>	96 ab	<u>1.32 b</u>	<u>105 b</u>	53 b	18.9 ab
Leaves	<u>118 c</u>	98 a	<u>1.25 c</u>	<u>93 b</u>	52 b	19.1 ab
Whole canopy	<u>116 c</u>	88 b	<u>1.29 b</u>	<u>89 b</u>	56 a	19.2 a
Significance	**	*	**	**	*	*

*, **, ***, ****, ns: Significant at $p < 0.05$, 0.01 , 0.001 , 0.0001 , or not significant, respectively. Letters represent means separated at $p < 0.05$, Duncan's multiple range test. Boldfaced data indicate those values significantly greater than the control, Dunnett's t-test; boldfaced and underlined data are significantly less than the control

PCA of physiological data, yield components, berry composition and hormones concentration means from four ABA treatments of Cabernet Sauvignon, 2009



Clusters of *Vitis vinifera* L. cv. Cabernet Sauvignon after two weeks following first ABA application: A) Control (non-treated), B) Only clusters sprayed, C) Only leaves sprayed, D) Whole canopy sprayed (2008)



Clusters of *V. vinifera* L. cv. Cabernet Sauvignon after four weeks following first ABA application: unsprayed, 150 and 300 mg/L Lambert Vineyard, NOTL, ON, 2008



Results Summary

- Leaves had higher uptake rates for exogenous ABA compared to berries
- Exogenous ABA affected mostly yield components, Brix, total anthocyanins and individual anthocyanins
- Exogenous ABA hastened the veraison process
- The organ targeted for spraying was more important than ABA concentration in terms of their effects on grape quality

Conclusions

- Exogenous ABA could regulate water uptake into the berries and also improve berry composition
- ABA was effective in hastening veraison of Cabernet Sauvignon
- ABA could be successfully introduced as an alternative cultural practice to mitigate the negative effect in a wet vintage

Overall Conclusions Con't

- ABA and its catabolites profiles could accurately indicate the grapevine water status
- ABA catabolism pathways varied according to the grapevine water status
- ABA seems to play an important role in triggering the grape ripening process
- ABA and its catabolites profile are under genetic control
- Exogenous ABA could regulate water uptake into berries and improve fruit composition
- Different grapevine organs have different uptake rates for exogenous ABA which is reflected in its effect on berry composition
- ABA could be used as an alternative cultural practice in order to improve berry composition in wet and cool years

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