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Viticulture Consortium Program

North Coast Viticultural Research Group

Annual Progress Report
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Project Title: Influence of Row Orientation and Canopy Density on the Microclimate and Composition of Cabernet Sauvignon Grapes

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Summary

The effects of row orientation and canopy density (as defined by leaf layer number or LLN in the fruit zone) on the fruit zone microclimate and composition of Cabernet Sauvignon was studied in a commercial vineyard located near Oakville, CA in the Napa Valley. A mature Cabernet Sauvignon vineyard with adjacent blocks of north-south and east-west oriented rows was used. Fruit zone microclimate was manipulated within each row orientation immediately after berry set by varying the amounts of basal leaf and lateral shoot removal in the fruiting zone (primary shoot basal nodes 1-5). The following four treatments were applied: 1. untreated control; 2. remove basal leaves only; 3. remove lateral shoots only; 4. remove basal leaves and lateral shoots. The LLN values created by these treatments ranged from 0 (complete basal leaf and lateral shoot removal) to approximately 2.5 (untreated) in the fruit zone. A negative, near linear relationship was found between fruit zone LLN and the percentage of exterior clusters in both row orientations. The percentage of exterior clusters ranged from approximately 30% (LLN~2.5) to over 90% (LLN=0). Berry temperature and cluster sunlight exposure increased as LLN in the fruiting zone declined. Fully exposed clusters (LLN=0) on the south (E-W rows) and west (N-S rows) sides of the canopy had the greatest mid-day berry temperatures in the experiment, averaging approximately 6C greater than ambient air temperature by late afternoon on most

sunny days. Berry weight was generally least for fully exposed berries and greatest for shaded berries, regardless of row orientation. In N-S rows, soluble solids were lowest in fully exposed berries and increased slightly as LLN increased. No trend was observed between cluster exposure and soluble solids levels in E-W oriented rows. Titratable acidity and malic acid content generally declined as cluster exposure increased, while juice pH increased slightly as cluster exposure increased. Observed differences in skin anthocyanins in N-S rows reflected differences in berry temperature resulting from sunlight exposure; fully exposed clusters on the west exposure had lower anthocyanin concentrations compared to partially shaded clusters. No strong trend in berry color development due to cluster exposure was observed in E-W rows, although fruit in E-W rows generally had greater color development for all exposure levels compared to fruit in N-S rows. The results indicate that berry exposure to direct sunlight during the afternoon (west or south facing exposures) leads to elevated berry temperatures and undesirable reductions in berry color and acidity. Chemical and sensory analyses of experimental wines produced from each treatment will be completed during the spring of 2002.

Objectives

1. Examine the effects of row orientation and cluster exposure to sunlight on the microclimate and composition of Cabernet Sauvignon grape clusters.

2. Correlate berry microclimate with compositional analyses including sugar, organic acids, juice pH, anthocyaninins and total phenolics, as well as berry weight and diameter.

3. Determine the effects of row orientation and cluster exposure to sunlight on wine composition and sensory properties.

Experiments Conducted to Meet Stated Objectives

Vineyard site

The trial was conducted in a commercial vineyard located near Oakville, CA. A mature Cabernet Sauvignon vineyard with adjacent blocks of both north-south and east-west oriented rows was used. The blocks were planted in the same year, grafted to the same rootstock (3309), bilateral cordon trained and spur pruned, and trellised to vertically shoot positioned (VSP) system. The vines in both blocks are spaced 6' x 8' (vine x row spacing) and drip irrigated.

Treatments and experimental design

Fruit zone microclimate was manipulated within each row orientation (north-south or east-west) immediately after berry set by varying the degree or amount of basal leaf (on primary shoots) and lateral shoot removal in the fruiting zone (basal nodes 1-5). The following four treatments were applied: 1. untreated control; 2. remove basal leaves only; 3. remove lateral shoots only; 4. remove basal leaves and lateral shoots. The LLN values created by these treatments ranged from 0 (complete basal leaf and lateral shoot removal) to approximately 2.5 (untreated). The experiment was designed as a randomized complete block within in each row orientation and location, with each treatment replicated eight times using five vine plots. The middle three vines

in each plot was used for data collection, fruit sampling, wine making and leaf area measurements (following harvest). All experimental vines were thinned to similar cluster numbers (one cluster per shoot) prior to treatment initiation at each location.

Light measurements

Photosynthetically active radiation (PAR) incident to each fruit zone was determined at the following stages of fruit development: fruit set (initiation of the experiment), fruit set + 3 weeks, veraison and several weeks prior to harvest. Measurements on each cluster were taken at two-hour increments beginning at 7:00 and concluding at 19:00 Pacific Daylight Time (PDT), and performed on clear, sunny days. PAR was measured using a sunfleck ceptometer placed in the middle of the fruit zone and oriented upward and toward both row middles (3 measurements taken per location).

Temperature measurements

Berry temperature was measured at the same fruit development stages and times as described above using a handheld Omega HH 23 temperature monitor with dual hypodermic thermocouples (Omega Engineering, Inc., Stamford, CT). Berry temperature was measured by insertion of the probe into the berry center. A shielded probe is placed next to the berry to monitor ambient air temperature. A single berry from the center of each cluster was used for temperature measurements. Berries were removed from the cluster and discarded immediately following temperature measurements.

Fruit analyses

Approximately 200 berries were randomly collected from each plot at harvest, placed in plastic bags and transported to the laboratory. Berries were randomly separated into two equal sub-samples. The first sample was used for anthocyanin and total phenolic determinations, while the remaining sample was reserved for pH, titratable acidity and total soluble solids determinations. The weight and diameter of all berries in each sample was recorded, and then the berries were stored in sealed plastic bags at -20ºC until analyzed. Frozen berries were thawed at room temperature, placed between two layers of muslin, and macerated using a mortar and pestle. The juice was collected in plastic tubes, and soluble solids (ºBrix) determined using a handheld temperature compensated refractometer. Following soluble solids determinations, 5ml of juice from each sample was placed into a 20ml plastic vial containing 10ml of distilled water. Titratable acidity was determined by titration with 0.1N of NaOH to a pH 8.2 end point and expressed as g $100ml^{-1}$ of tartaric acid. The pH of undiluted juice of each sample was determined using a pH meter. For anthocyanin and phenolic analyses, samples was removed from the freezer and thawed at room temperature. Berry skins were removed from the pulp by hand, rinsed with tap water, rinsed with distilled water, then blotted dry with paper towels. The skins were weighed, placed in centrifugation tubes containing 50ml of acidified methanol (1% HCl, v/v), and stored in darkness for 48 hours. After appropriate dilution with acidified methanol, the absorbance of a 5ml aliquot of the extract was determined at 520nm using a spectrophotometer (Spectronic, Rochester, NY). Anthocyanin concentration (expressed as mg pigment g^{-1} berry skin) was determined using the molecular weight (529) and molar absorbance (28,000) values for malvidin-3-glucoside (Amerine and Ough, 1980). A 10ml aliquot of the above extract was reserved for the determination of the total phenol content by the modified

Folin-Ciocalteu method (Slinkard and Singleton, 1977). Total phenol content was expressed as mg of gallic acid g^{-1} of berry skin.

PRELIMINARY RESULTS AND ACCOMPLISHMENTS

A negative, near linear relationship was found between fruit zone LLN and the percentage of exterior clusters in both row orientations (Figure 1). The percentage of exterior clusters ranged from approximately 30% (LLN~2.5) to over 90% (LLN=0). Berry temperature and cluster sunlight exposure increased as LLN in the fruiting zone declined in both row-orientations. Clusters on the afternoon sun exposed portions of the canopy (i.e. S side of E-W rows and W side of N-S rows) received greater amounts of sunlight and were higher in temperature from mid-day to early evening compared to clusters from their respective afternoon shaded sides. On most sunny days the difference in light exposure and berry temperature was greatest around 4 pm. Just before harvest in late August, the berry temperature of fully exposed clusters (LLN=0) on the south (E-W rows) and west (N-S rows) sides of the canopy were 5.9C and 6.7C greater than ambient air, respectively (Table 1). In contrast, the berry temperature of clusters on vines with LLN~2.4 were similar to or slightly less than ambient air (Table 1). PAR reaching the surface of fruiting zone changed dramatically during the day, with clusters on southern and western exposures receiving a significantly larger total fluence compared to fully exposed clusters on north and east exposures. By late afternoon fully exposed clusters on the south side of E-W rows received approximately 63 umol m^{-2} sec^{-1}, compared to 123 umol m^{-2} sec^{-1} for fully exposed clusters on the west side of N-S oriented rows (Table 1).

Berry weight was generally greatest in shaded clusters and least for fully exposed berries, regardless of row orientation (Table 2). Clusters from southern and western exposures generally produced smaller berries at all canopy densities compared to clusters on the east and west. In N-S rows (E and W cluster exposures), soluble solids were lowest in fully exposed berries and increased slightly as LLN increased (Figure 2). No significant trend was observed between cluster exposure and soluble solids levels in E-W oriented rows. The titratable acidity and malic acid content of clusters from southern (E-W rows) and western (N-S rows) exposures declined as LLN decreased, and these clusters were significantly lower in acidity compared to clusters on northern and eastern exposures. Canopy density had relatively little impact on the acidity of northern and eastern exposed clusters. Juice pH decreased slightly as LLN increased in N-S rows, while no clear trend in pH was observed due to canopy density in E-W rows (Figure 3).

Skin anthocyanins increased slightly as LLN increased in N-S rows (Figure 4), while no clear trend in color development was observed due to canopy density in E-W rows. It should be noted that fruit in E-W oriented rows generally had greater color development compared to fruit in N-S oriented rows. This result likely reflects the cumulative effects of the sunlight exposure/temperature differences described above during ripening.

Several chemical analyses (total phenolics, tannins and anthocyanin composition) remain to be completed on the fruit in this experiment. It is anticipated that these analyses will be completed no later than March 1, 2002. Chemical and sensory analyses of experimental wines produced from each treatment will also be completed during the late spring of 2002.

OUTSIDE PRESENTATIONS

The results of this study were presented to the Napa Valley Viticultural Research Group (March 2001), the Robert Mondavi Research Group (April 2001), Kendall-Jackson Grower Meeting (April 2001), Stags Leap Growers Meeting (April 2001), the UC Canopy Management Short Course (August 2001) and the UC Winegrape Production Short Course (January 2001) and Lake County Grape Day (December 2001). The results will also be presented in the upcoming months at a variety of county and statewide grape industry meetings including the Unified Grape and Wine Meeting (January 2002), Lodi Grape Day (February 2002) and the Salinas Valley Grape Day (February 2002). Written summaries of the work were included in the proceedings of these meetings when requested.

STATUS OF FUNDING

Approximately $4,000 remains in this project account as of November 1, 2000. The funds will be used for graduate student/SRA support necessary to complete the berry and wine analyses described above.

Table 1. Influence of row-orientation and canopy density on the mean berry temperature and sunlight exposure of Cabernet Sauvignon grape clusters in the late afternoon. Oakville, CA.[1] August 28, 2001; 4:00 pm (PTD).

Row orientation	Exposure	LLN	Mean increase in berry temperature compared to ambient (°C)	Mean PDFD at cluster (µmol m^{-2} sec^{-1})
N-S	East	0	+1.2	22
		1.2	+0.8	12
		2.0	0	7
		2.4	0	8
	West	0	+6.7	123
		1.2	+3.2	58
		2.0	+0.3	12
		2.4	-0.1	8
E-W	North	0	+1.6	38
		1.3	+1.8	23
		1.9	-0.1	10
		2.4	-0.5	8
	South	0	+5.9	63
		1.3	+3.8	28
		1.9	-0.5	7
		2.4	-0.3	8

[1]Each data point represents the mean of 20 single berry (temp) or cluster (light) measurements in each replicate.

Table 2. Influence of row-orientation and canopy density on the titratable acidity and malic acid levels of Cabernet Sauvignon grape clusters. Oakville, CA 2001.

Row orientation	Exposure	LLN	Berry wt. (g)	Titratable acidity (g/L)	Malic acid (g/L)
N-S	East	0	0.86 bc[1]	7.3 b	2.2 b
		1.2	0.89 b	7.6 a	2.4 a
		2.0	0.97 a	7.7 a	2.5 a
		2.4	0.98 a	7.7 a	2.4 a
	West	0	0.82 c	6.3 c	1.3 d
		1.2	0.86 bc	6.2 c	1.2 d
		2.0	0.88 b	6.8 b	1.7 c
		2.4	0.92 b	6.9 b	1.8 c
E-W	North	0	0.97 a	7.1 b	2.5 c
		1.3	1.10 a	7.7 a	2.6 c
		1.9	1.01 a	7.6 a	2.5 c
		2.4	1.11 a	7.7 a	2.4 c
	South	0	0.91 b	5.7 e	1.4 a
		1.3	0.92 b	6.3 d	1.9 b
		1.9	0.97 a	6.8 c	1.8 b
		2.4	0.98 a	6.9 bc	2.5 c

[1]Numbers followed by the same letter within columns and row orientations are not significantly different at the 5% level.

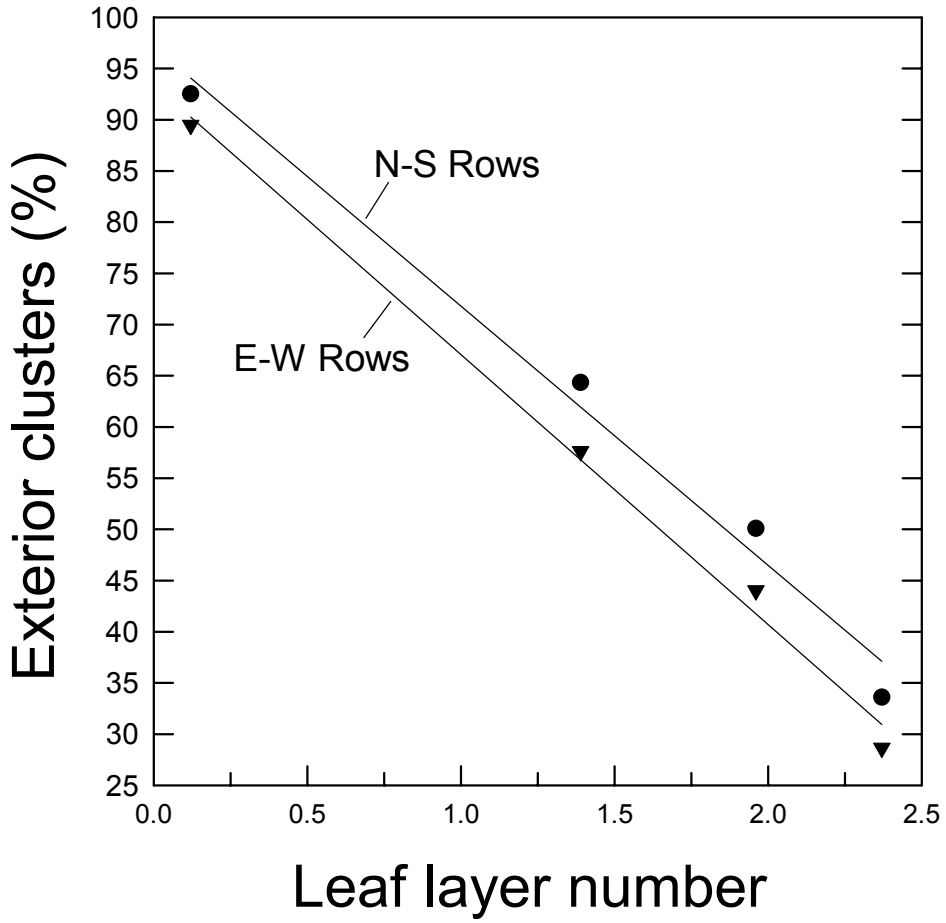
Exterior clusters (%)
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
0.0
0.5
1.0
1.5
2.0
2.5
N-S Rows
E-W Rows
Leaf layer number

Figure 1

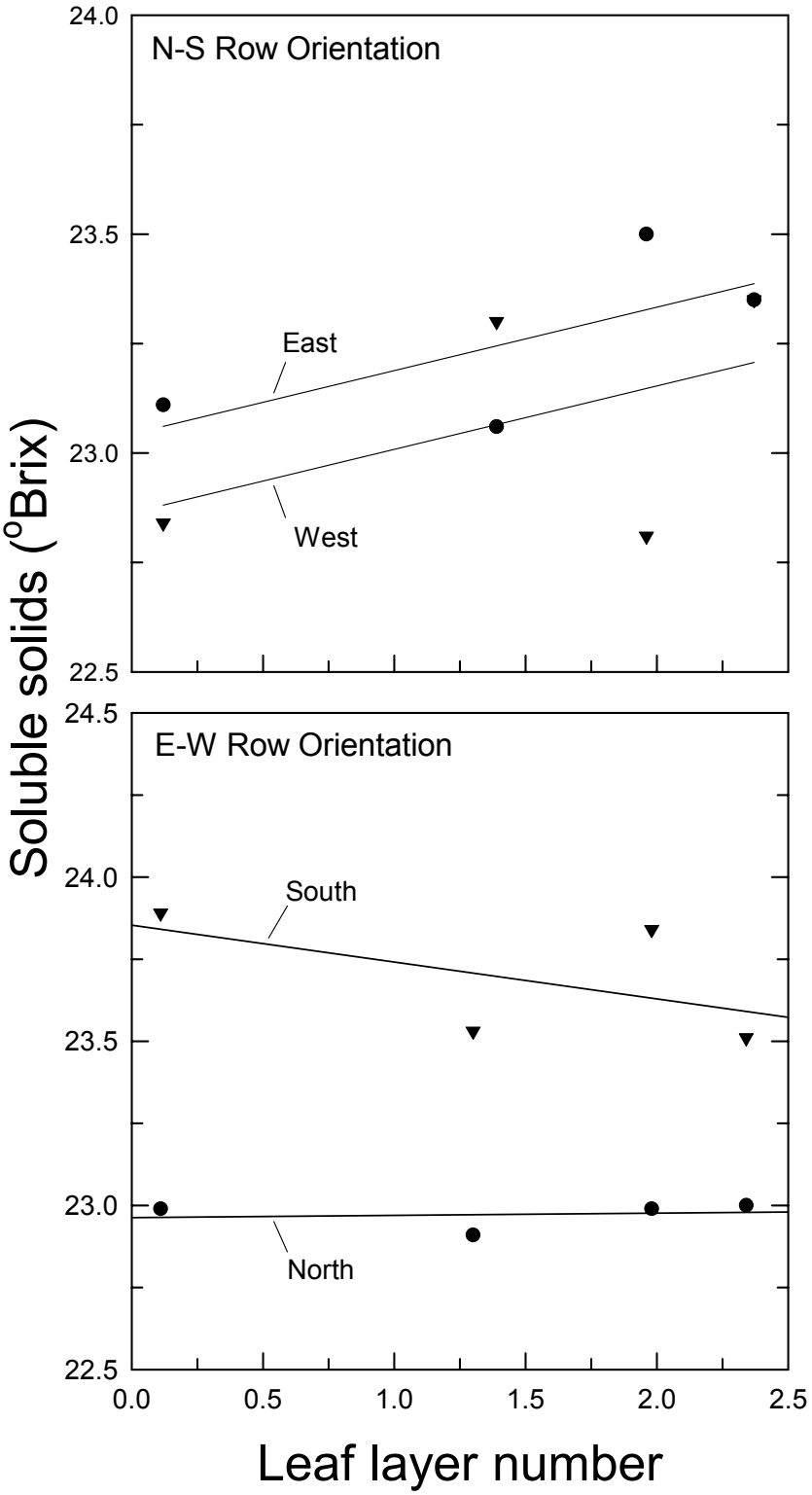
N-S Row Orientation
East
West
E-W Row Orientation
South
North
Soluble solids (°Brix)
Leaf layer number
24.0
23.5
23.0
22.5
24.5
24.0
23.5
23.0
22.5
0.0
0.5
1.0
1.5
2.0
2.5

Figure 2

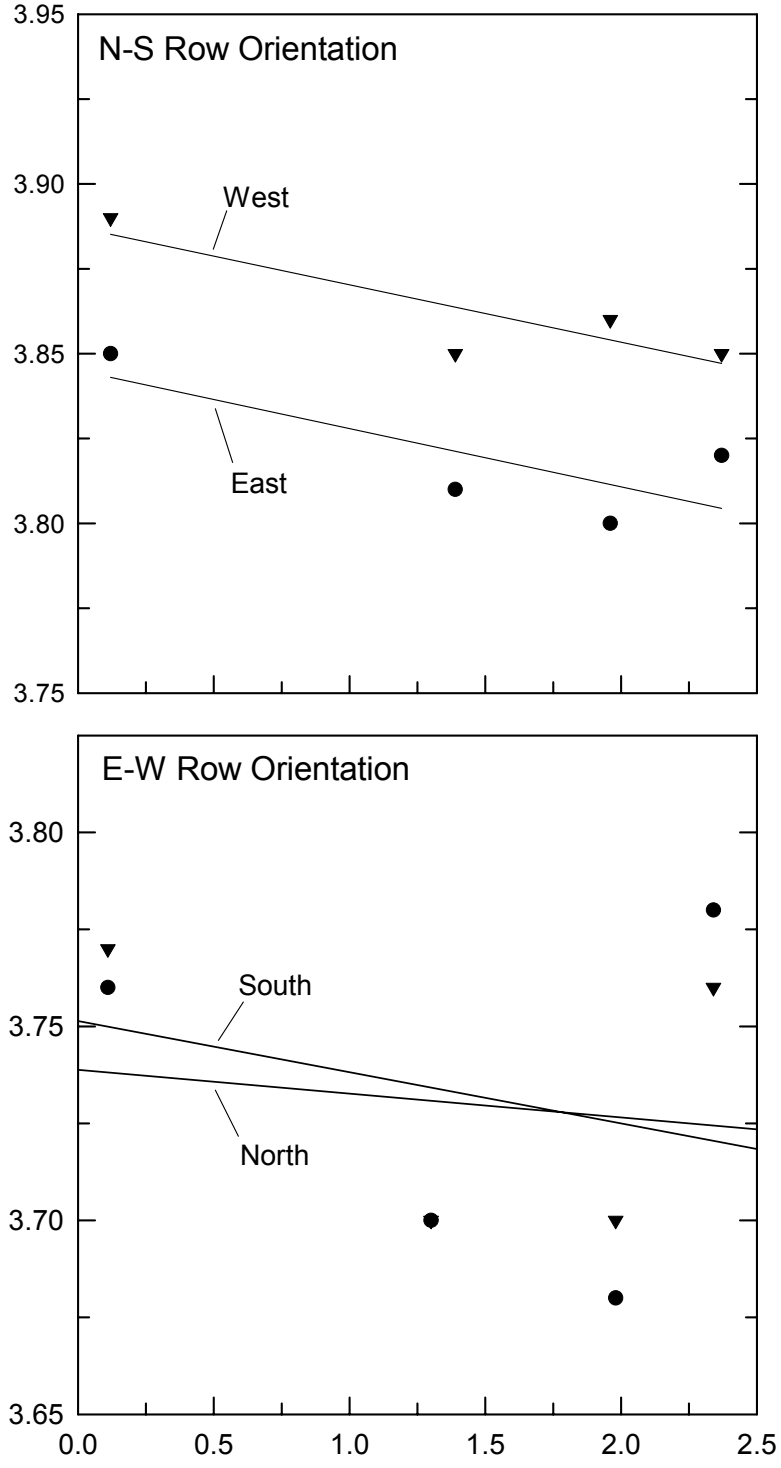
N-S Row Orientation
West
East
E-W Row Orientation
South
North
3.95
3.90
3.85
3.80
3.75
3.80
3.75
3.70
3.65
0.0
0.5
1.0
1.5
2.0
2.5
Leaf layer number

Figure 3

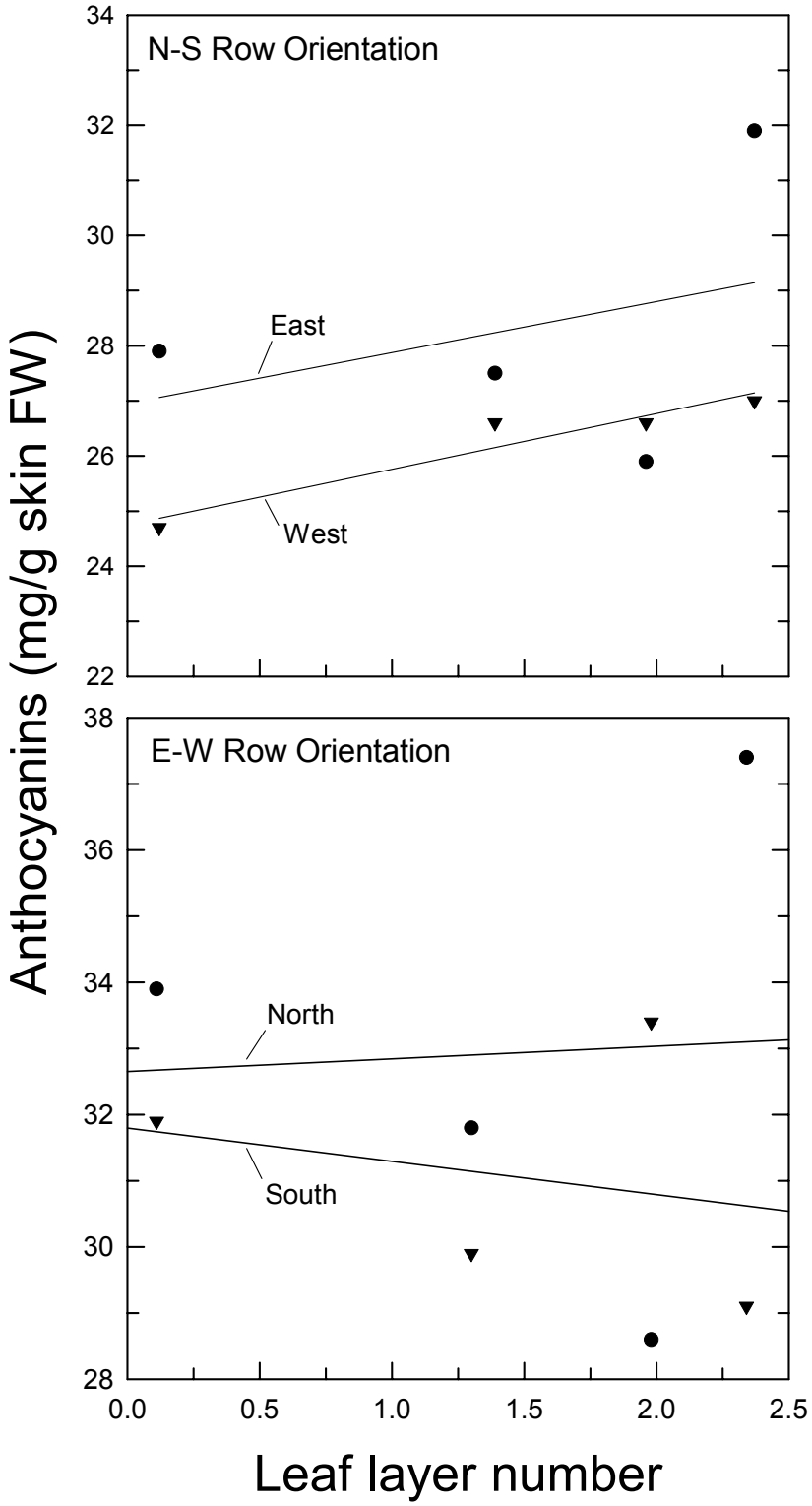
N-S Row Orientation
East
West
E-W Row Orientation
North
South
Anthocyanins (mg/g skin FW)
Leaf layer number
34
32
30
28
26
24
22
38
36
34
32
30
28
0.0
0.5
1.0
1.5
2.0
2.5

Figure 4

Executive Summary

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Summary

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