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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 Cluster Exposure to Sunlight on the Microclimate and Composition of Cabernet Sauvignon Grapes

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Summary

The effects of row orientation and cluster exposure to sunlight on the microclimate and fruit composition of Cabernet Sauvignon was studied in a commercial vineyard in the Napa Valley. Eight clusters per vine (one cluster/shoot) were selected for use immediately after berry set. Clusters were divided into two groups of four, with each group located on either the morning exposed (north or east side of the vine row, respectively, for east-west and north-south oriented rows) or afternoon exposed (south or west side of the vine row, respectively, for east-west and north-south oriented rows) portion of the vine row. Four cluster sunlight exposure categories were established: (1) full exposure, (2) moderate to high exposure, (3) moderate to low exposure, and (4) shaded. A positive, near linear relationship was found between berry temperature and PAR incident to the cluster surface following veraison. Fully exposed clusters 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. Berry weight was generally greatest for fully exposed berries and least for shaded berries, regardless of row orientation. Soluble solids followed a similar trend, with the lowest ^{o}Brix found in clusters on the east side of N-S rows and the highest clusters grown on the south of E-W rows. Titratable acidity was generally similar among exposure treatments, while

malate levels in shaded fruits were significantly greater compared to exposed fruits. Observed differences in both skin anthocyanins and total phenolics among the treatments reflected differences in berry temperature resulting from sunlight exposure; fully exposed clusters on the south (E-W rows) and west (N-S rows) exposures had lower anthocyanin concentrations compared to shaded clusters. 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, total phenolics and malate.

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).

Treatments and experimental design

Eight clusters per vine (one cluster/shoot) were selected for use immediately after berry set. Clusters were divided into two groups of four, with each group located on either the morning exposed (north or east side of the vine row, respectively, for east-west and north-south oriented rows) or afternoon exposed (south or west side of the vine row, respectively, for east-west and north-south oriented rows) portion of the vine row. Four cluster sunlight exposure categories were established: (1) full exposure, (2) moderate to high exposure, (3) moderate to low exposure, and (4) shaded. Fully exposed clusters received direct sunlight, while high to moderately exposed clusters had one to two leaf layers for shade. Clusters with moderate to low exposure had two to three leaf layers for shade, while shaded clusters were located in the canopy interior with four or more leaf layers. Selected leaf removal, as well as the trimming or tying of shoots adjacent to clusters, was performed as necessary to establish desired exposure levels. Experimental clusters were evenly distributed between cordons, and positioned to hang freely and parallel to the vine row. Experimental clusters were selected from shoots of similar vigor, with two-thirds or more of their leaves exposed to full sunlight. The experiment was designed as a randomized complete, split plot with row direction serving as the main plot (non-replicated)

and cluster exposure level as the sub-plot. Each cluster exposure treatment was replicated twenty-five times using single-cluster plots, with all treatments within a replicate placed on the same vine.

Light measurements

Photosynthetically active radiation (PAR) incident to each cluster 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 handheld Li-Cor LI-189 quantum sensor (Li-Cor, Inc, Lincoln, NE), placed in the middle of the cluster and oriented perpendicular to its plane. Cluster sunlight exposure was expressed as actual PAR with respect to cluster location and categorized as follows: <10, 10-30, 31-50, 51-100, 101-200, 201-600 and >600 μmol m^{-2} sec^{-1} at mid-day. Canopy manipulations (leaf removal or shoot positioning) were performed as needed in order to maintain clusters within +/- 10% of their initial sunlight exposure (% ambient PAR) recorded at berry set.

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 was 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

Berries from the exterior plane (berries facing outward, toward the row middle) of each cluster were removed 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, 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

The effects of row orientation and cluster exposure on mean mid-day PAR (1300 hr) incident to the cluster surface are presented in Figure 1. Highly exposed clusters on the south side of E-W rows received nearly 1000 umol m^{-2} sec^{-1} at mid-day, compared to less than 100 umol m^{-2} sec^{-1} for fully exposed clusters on the north side of these canopies. Fully exposed clusters on the west side of N-S rows received over 300 umol m^{-2} sec^{-1} at mid-day compared to approximately 150 umol m^{-2} sec^{-1} for fully exposed clusters on the east side. PAR reaching the surface of exposed clusters changed dramatically during the day, with clusters on southern and western exposures receiving a significantly larger total fluence rate compared to fully exposed clusters on north and east exposures (data not presented). The influence of mid-day PAR incident to the cluster surface on berry temperature is presented in Figure 2. A positive, near linear relationship was observed between PAR at the cluster surface and the difference between ambient air and berry temperature. Berry temperature for fully exposed clusters, which received over 1000 umol m^{-2} sec^{-1} PAR at mid-day, exceeded air temperature by 6 to 9 ^{o}C (10 to 16 ^{o}F).

Berry weight was greatest for fully exposed berries and least for shaded berries, regardless of row orientation (Figure 3). Clusters from southern and western exposures generally produced larger berries at all light levels compared to clusters facing east and west. Soluble solids followed a similar trend, with the lowest ^{o}Brix found in clusters on the east side of N-S rows and the highest in clusters grown on the south side of E-W rows (Figure 4). While titratable acidity was similar among row orientation and cluster exposure treatments, malate levels in shaded fruits were significantly greater compared to exposed fruits. The highest malate levels were found in shaded clusters on the east-side of N-S rows, and the lowest in exposed clusters from the west side of N-S rows. Differences in both skin anthocyanins and total phenolics among the treatments likely reflect differences in berry temperature resulting from sunlight exposure. Exposed clusters on the south (E-W rows) and west (N-S rows) exposures had lower anthocyanin concentrations compared to shaded clusters. The highest skin anthocyanin concentration was found in fully to moderately exposed fruit on the east side of N-S rows, and the lowest in exposed clusters from the west side of N-S rows.

The preliminary results indicate that cluster exposure to direct sunlight during the afternoon (west or south facing exposures) leads to elevated berry temperatures and undesirable reductions in berry color, total phenolics and malate. Several objectives of this study remain to be completed, including more detailed statistical analyses of berry temperature/light and compositional data. In addition, chemical and sensory analyses must be performed on wines from each row orientation and exposure level. It is anticipated that this work will be completed by March 1, 2001.

OUTSIDE PRESENTATIONS

Because it is recently completed, no formal presentations of this work have been made to date. An abstract of this work has been submitted for presentation at the 2001 Annual Meeting of the American Society for Enology and Viticulture.

STATUS OF FUNDING

Approximately $3,500 remains in this project account as of November 1, 2000. The funds will be used to complete the data and wine analyses.

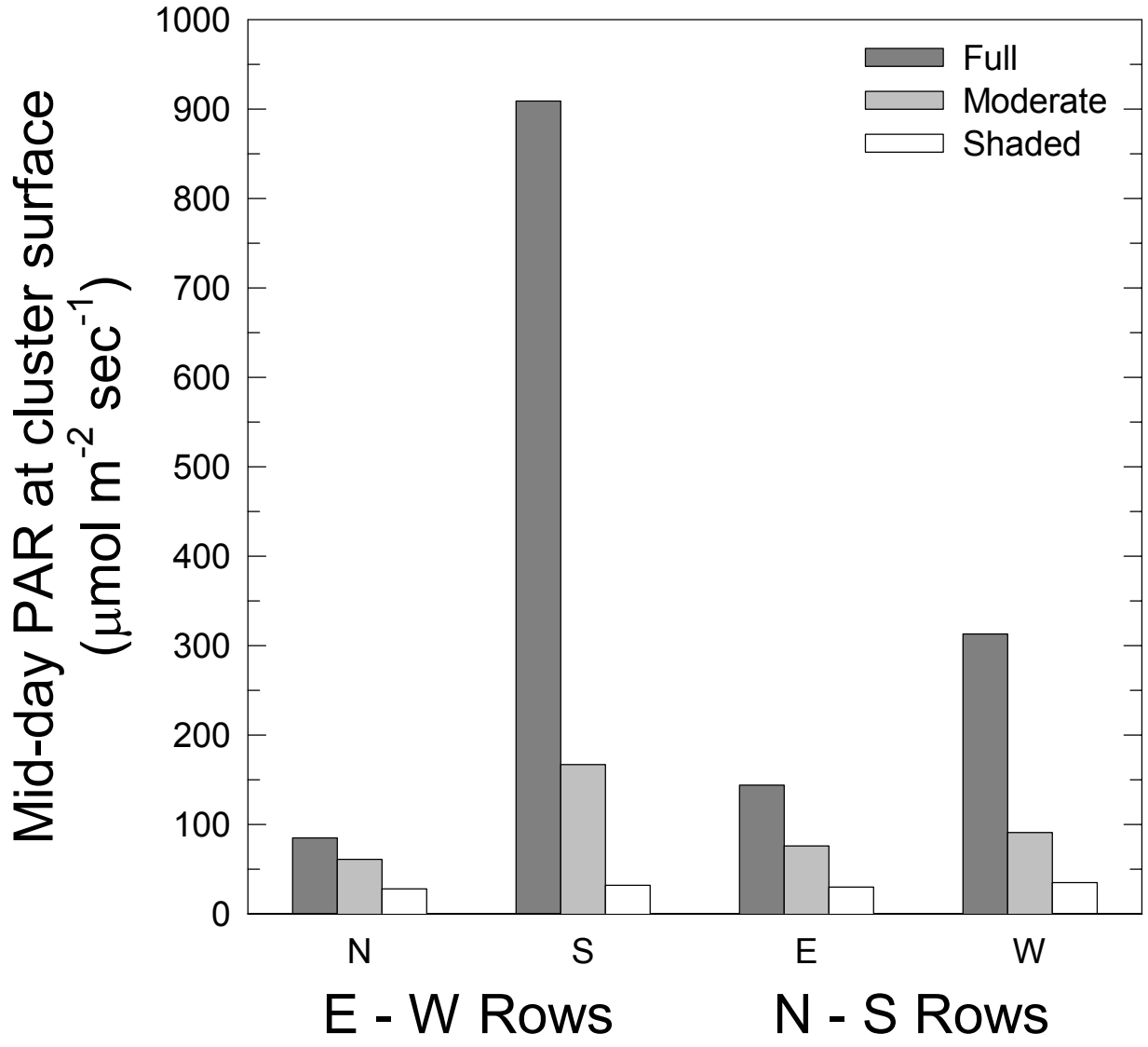
Mid-day PAR at cluster surface
(µmol m-2 sec-1)
1000
900
800
700
600
500
400
300
200
100
0
Full
Moderate
Shaded
N
S
E
W
E - W Rows
N - S Rows

Fig. 1

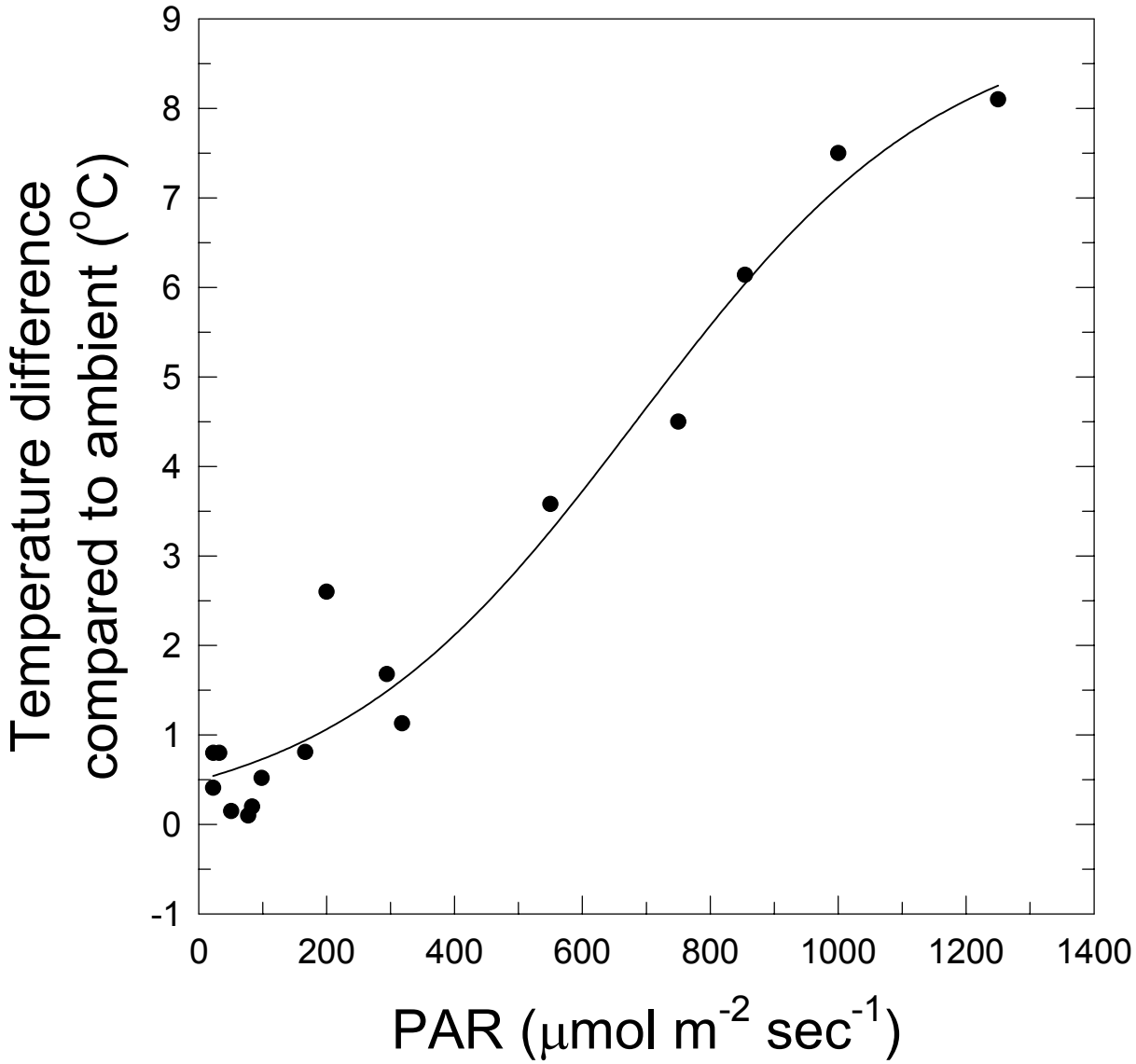
Temperature difference compared to ambient (°C)
9
8
7
6
5
4
3
2
1
0
-1
0
200
400
600
800
1000
1200
1400
PAR (μmol m-2 sec-1)

Fig. 2

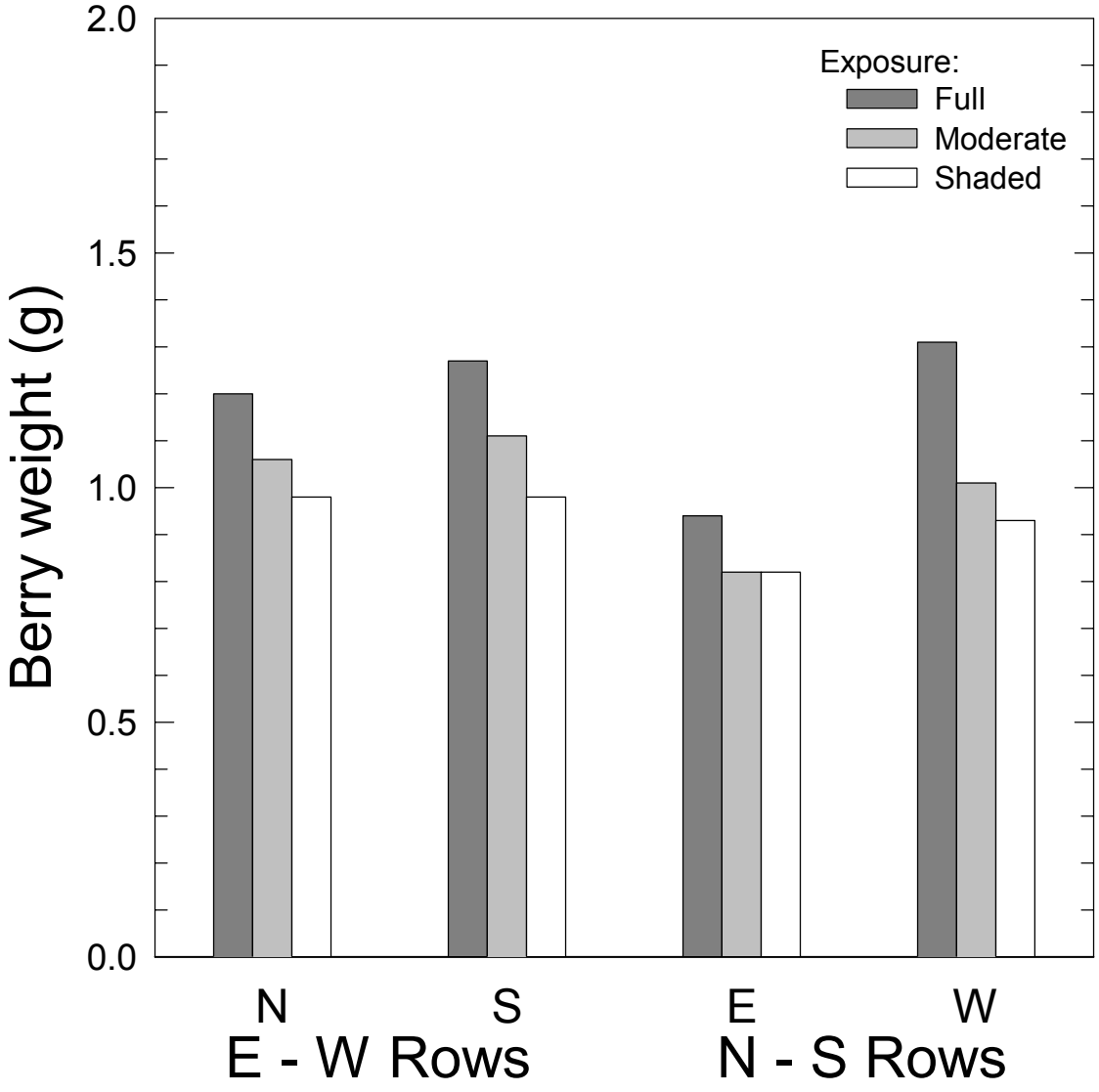
Berry weight (g)
2.0
1.5
1.0
0.5
0.0
Exposure:
Full
Moderate
Shaded
N
S
E
W
E - W Rows
N - S Rows

Fig. 3

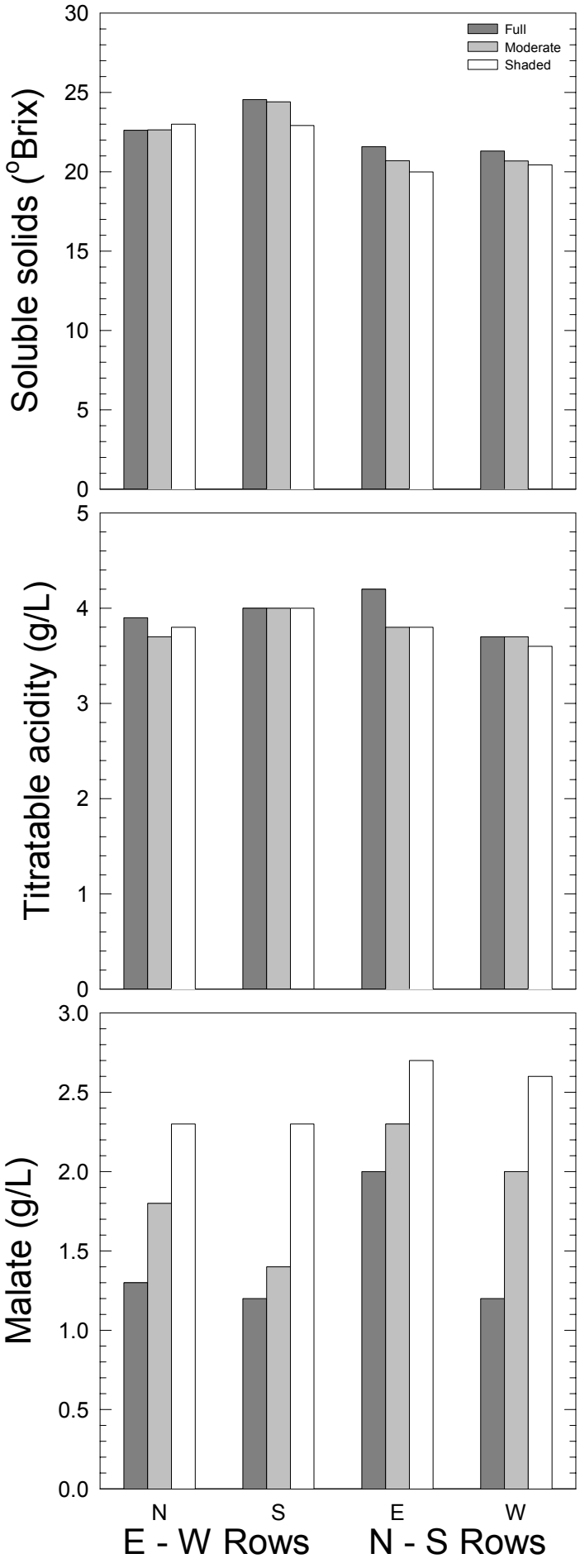
Full
Moderate
Shaded
Soluble solids (°Brix)
30
25
20
15
10
5
0
Titratable acidity (g/L)
5
4
3
2
1
0
Malate (g/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
N
S
E
W
E - W Rows
N - S Rows

Fig. 4

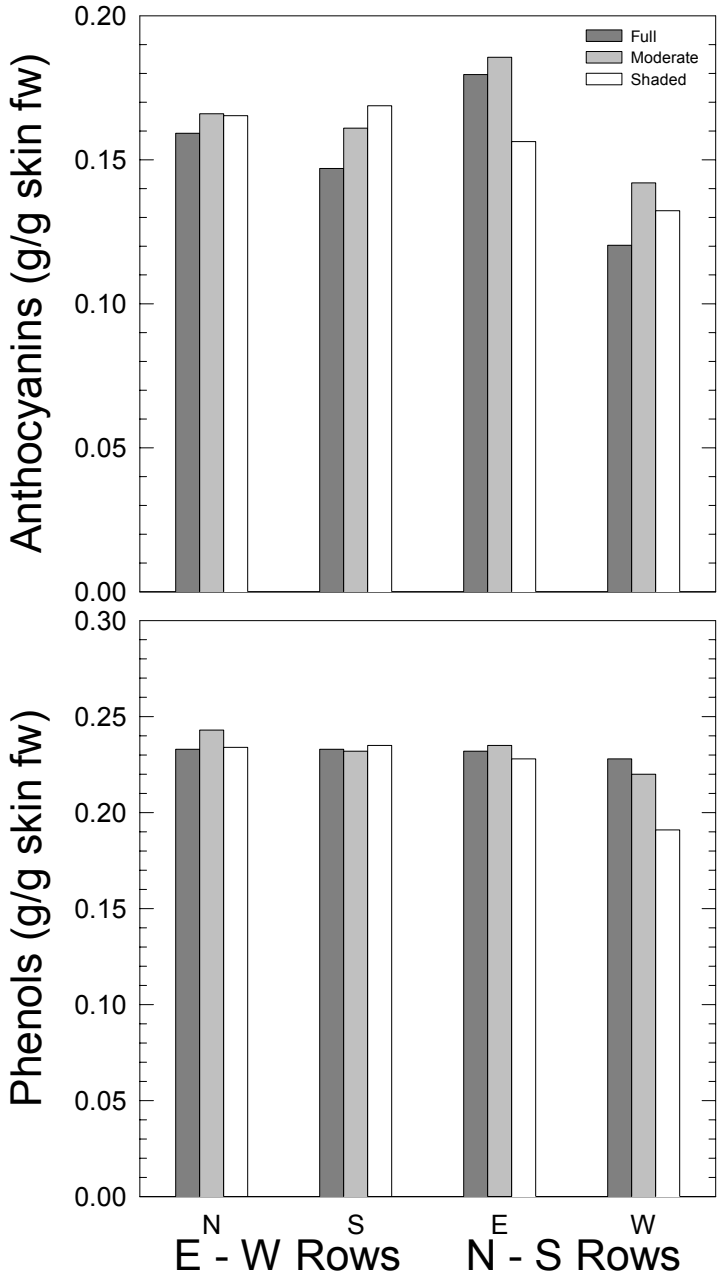
Anthocyanins (g/g skin fw)
0.20
0.15
0.10
0.05
0.00
Full
Moderate
Shaded
Phenols (g/g skin fw)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
N
S
E
W
E - W Rows
N - S Rows

Fig. 5