The Response of Table Grape Growth, Production, and Ripening to Water Stress

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Introduction

Arizona is currently experiencing an explosion in the commercial cultivation and production of table grapes. Decreasing water supplies, increasing water cost, and recent groundwater legislation are forcing Arizona growers to be more water efficient if they are to remain competitive with other markets. Research was begun in 1989 to determine the effects of water stress on vine growth and berry ripening.

Materials and Methods

"Flame Seedless" table grapes in their fourth leaf growing at Verde Grande Vineyards in Stanfield, Arizona, were subjected to increasing water stress levels based upon infrared canopy temperatures and the crop water stress index (CWSI). Twelve drip-irrigated (2 one-half gallon per hour emitters per plant) rows containing 65 plants, spaced 8 feet on row and 12 feet between rows, were randomized into three water treatments containing four replicates. Infrared temperature readings were taken with an Everest Interscience, Inc. Model 112 infrared thermometer with a 15-degree field of view from the southeast and southwest side of each row on the 10th, 33rd, and 55th plants and averaged. Vapor pressure deficits were taken at 15 minute intervals with a Psychro-dyne aspirated psychrometer. Readings were collected two to three times per week when skies were clear from April 6 to October 15. Attempts to schedule irrigations were made when the average CWSI of the four replicates approached or exceeded 0.15 units, 0.25 units, and 0.35 units for the wet, medium, and dry treatments, respectively.

Soil moisture content was monitored to a 4 foot depth in 1-foot increments with a Campbell Pacific Nuclear Model 503DR neutron moisture meter between the 32nd and 33rd plant on each row. When irrigations were scheduled, attempts were made to add only enough water to refill the soil profile to field capacity. Water applied was measured with Arad flow meters on each row.

Ripening data (cluster weight, berry weight and diameter, brix, and titratable acidity) were collected on May 23, May 30, and June 5 from the three plants per row which were used for the infrared readings. Each row was harvested on June 5 by the grower. The number of packed boxes (grades 1 and 2) and raisins included packed boxes were recorded for each row. Vine growth was measured from total pruning weights per row on December 21, 1989, and January 4, 1990.

Results and Discussion

The target CWSI for irrigation was overshot for the wet and medium treatments and slightly undershot for the dry treatment, although the actual values are within the + or - 0.05 unit standard error commonly associated with CWSI field measurements. Actual CWSI's at irrigation were 0.18, 0.30, and 0.33 for the wet, medium, and dry treatments respectively (Table 1). There were significant differences in total water applied ($P=0.05$) and vine pruning weights ($P=0.01$), but not in packed boxes and raisins included packed boxes. The wet treatment required more water at 44.7 inches and also produced the highest amount of growth at 603 pounds of prunings per row. The medium treatment had the highest packed boxes (grades 1 and 2) at 50 boxes per row, while the wet treatment had the highest raisins included packed boxes at 88.7, although no significant differences were measured for either variable. This discrepancy in production will be discussed later in this report.

There was a very high linear correlation between the CWSI at irrigation and 1) total applied water (r=0.9996), 2) raisins included packed boxes (r=0.9538), and 3) vine pruning weight (r=1.00) indicating the CWSI is a useful tool to measure water stress effects on growth and production of table grapes. The relationship between the CWSI at irrigation and packed boxes (grades 1 and 2) was lower with r=0.7125.

The change in cluster weight over time is shown in Figure 1. The wet treatment achieved the highest cluster weight (445.5 gm per cluster) and at an earlier date. The wet treatment also sized earlier with a greater berry weight (3.93 gms/berry) and berry diameter (11.9/16 in) than the medium and dry treatment (Figures 2 and 3, respectively). The earlier sizing and weight of the wet treatment is probably due to the increased vine vigor, resulting in higher overall sugar and water accumulation than the weaker growth medium and dry treatments. Figures 4, 5, and 6 depict the change in degree brix, titratable acidity, and the degree brix to acid ratio over time, respectively. There are only small insignificant differences indicating water stress had a lesser effect on these ripening criteria.

The difference in production ranking of the three treatments for packed boxes and raisins included packed boxes can now be explained (Table 1). The test was located within a 40 acre block managed by the grower, therefore the timing of harvest was based on the performance of the entire block, and not on the individual CWSI treatments. The grower block was monitored with the CWSI, and the CWSI at irrigation was between the wet and medium treatments (CWSI=0.24 units). The wet treatment matured earlier as indicated in Figures 1, 2, and 3, and by the time the block was harvested, the wet treatment had predominately gone to raisins. If the wet treatment had been harvested earlier, the production (packed boxes grades 1 and 2) would have probably been considerably higher. Since this was the first year of the test, the effect of time of harvest on production was not foreseen. However, the price of table grapes was 33% higher when the wet treatment was ready for harvest than at the time of actual harvest. The greater vine vigor may be a useful tool for the grower to harvest earlier at a higher market price. This aspect will be investigated when the test is repeated in 1990.

Summary

The CWSI is a useful tool to determine the effects of water stress on table grape growth and ripening as indicated by the very high linear correlations between the CWSI at irrigation and 1) total applied water, r=0.9996; 2) raisins included packed boxes, r=0.9538; and 3) vine pruning weights, r=1.00. A lower water stress level (CWSI=0.18 units at irrigation) promoted earlier berry sizing, increased berry weight, and increased cluster weight over drier treatments. Significantly higher growth (P=0.01), based upon pruning weights, also was attained at the lower water stress level. However, highest production (grades 1 and 2 packed boxes) was attained when irrigations were scheduled at 0.30 CWSI units, although this may be due to the timing of harvest by the grower. Total applied water to maintain the wet, medium, and dry treatments was 44.7 inches (CWSI=0.18), 30.5 inches (CWSI=0.30), and 26.3 inches (CWSI=0.33), respectively. The University of Arizona will continue efforts to better define the effects of water stress on table grape growth, production and ripening.

Table 1. The relationship among the CWSI at irrigation, total water applied, packed boxes grades 1 and 2, raisins included packed boxes, and vine pruning weight.

Treatment	CWSI at Irrigation	Total Applied Water* (in/ac)	Packed Boxes Grades 1 and 2*	Raisins Included Packed Boxes*	Vine Pruning Weight (lbs/row)**
Wet	0.18	44.7 a	41.0 a	88.7 a	603 a
Medium	0.30	30.5 b	50.0 a	86.3 a	479 b
Dry	0.33	26.3 b	45.0 a	86.6 a	448 b

Means followed by the same letter are not significantly different at the P=0.05 (*) and P=0.01 (**) level. (Duncan's Multiple Range Test).

Figure 1. Change in Cluster Weight

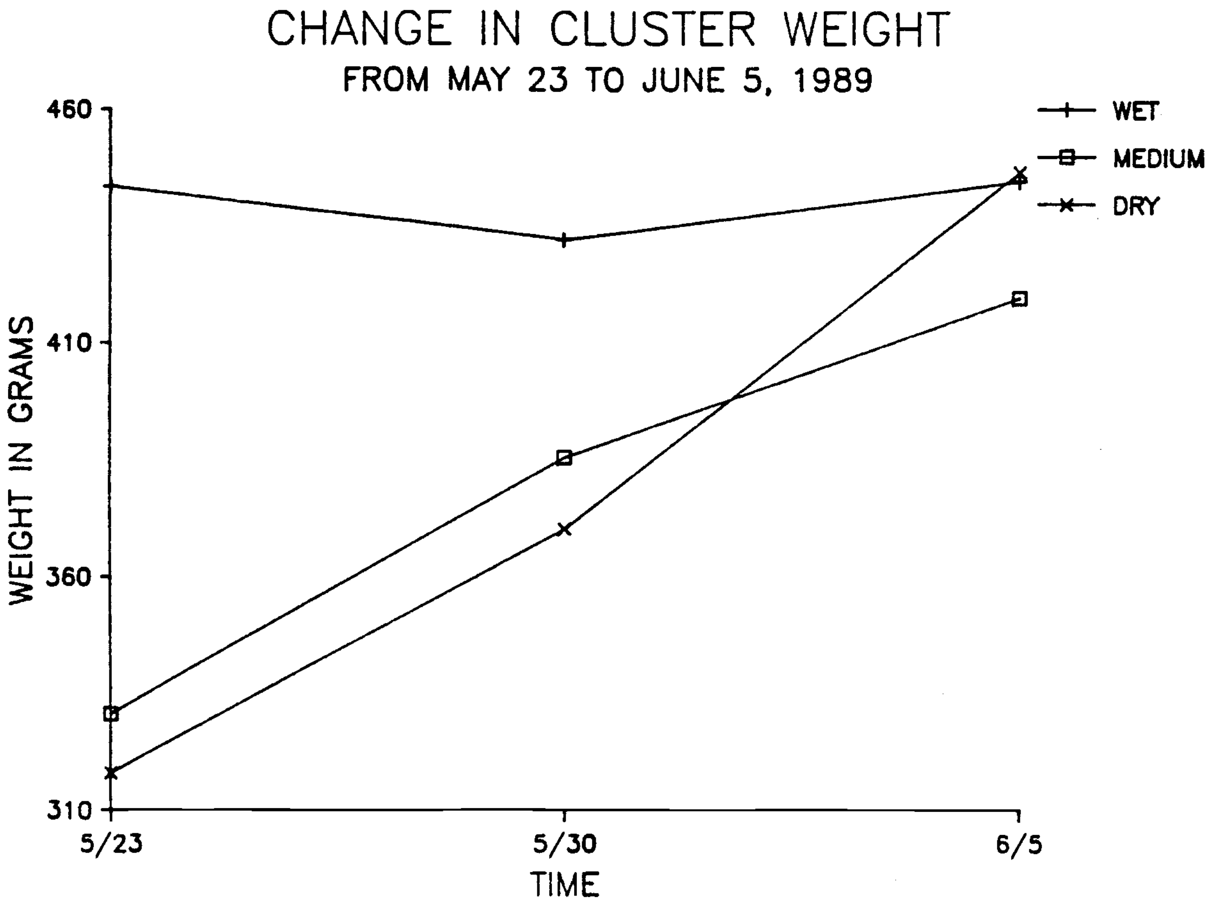

Figure 2. Change in Berry Size (Weight)

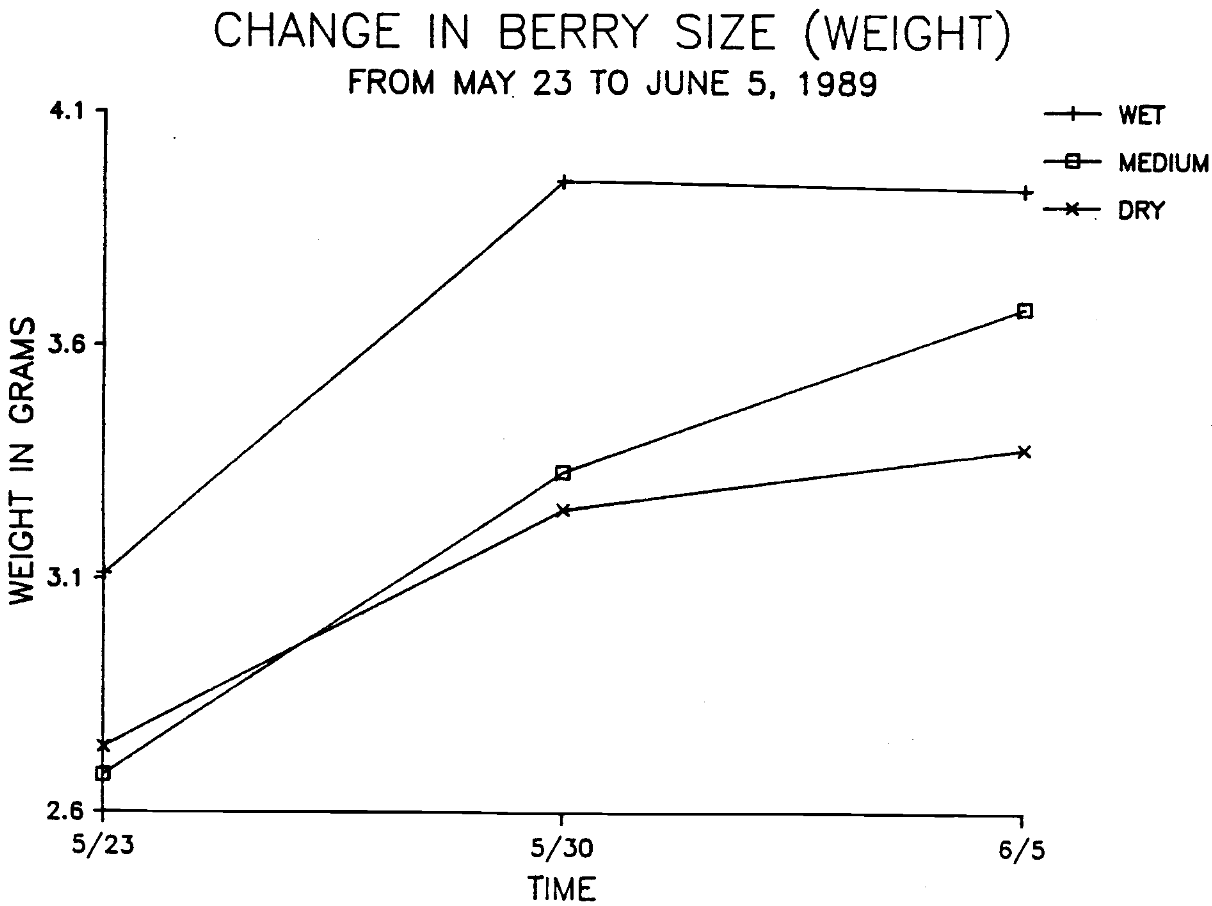

Figure 3. Change in Berry Size (Diameter)

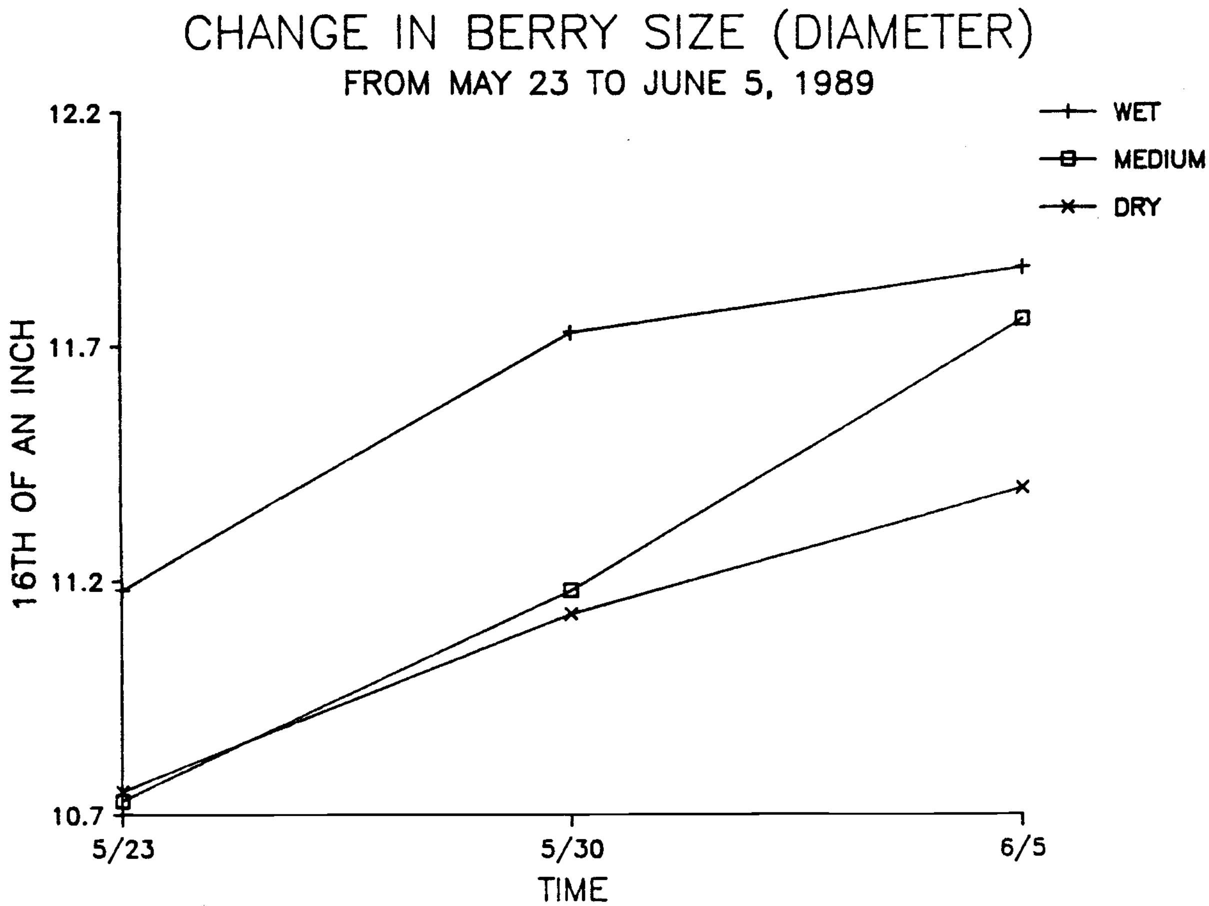

Figure 4. Change in Brix

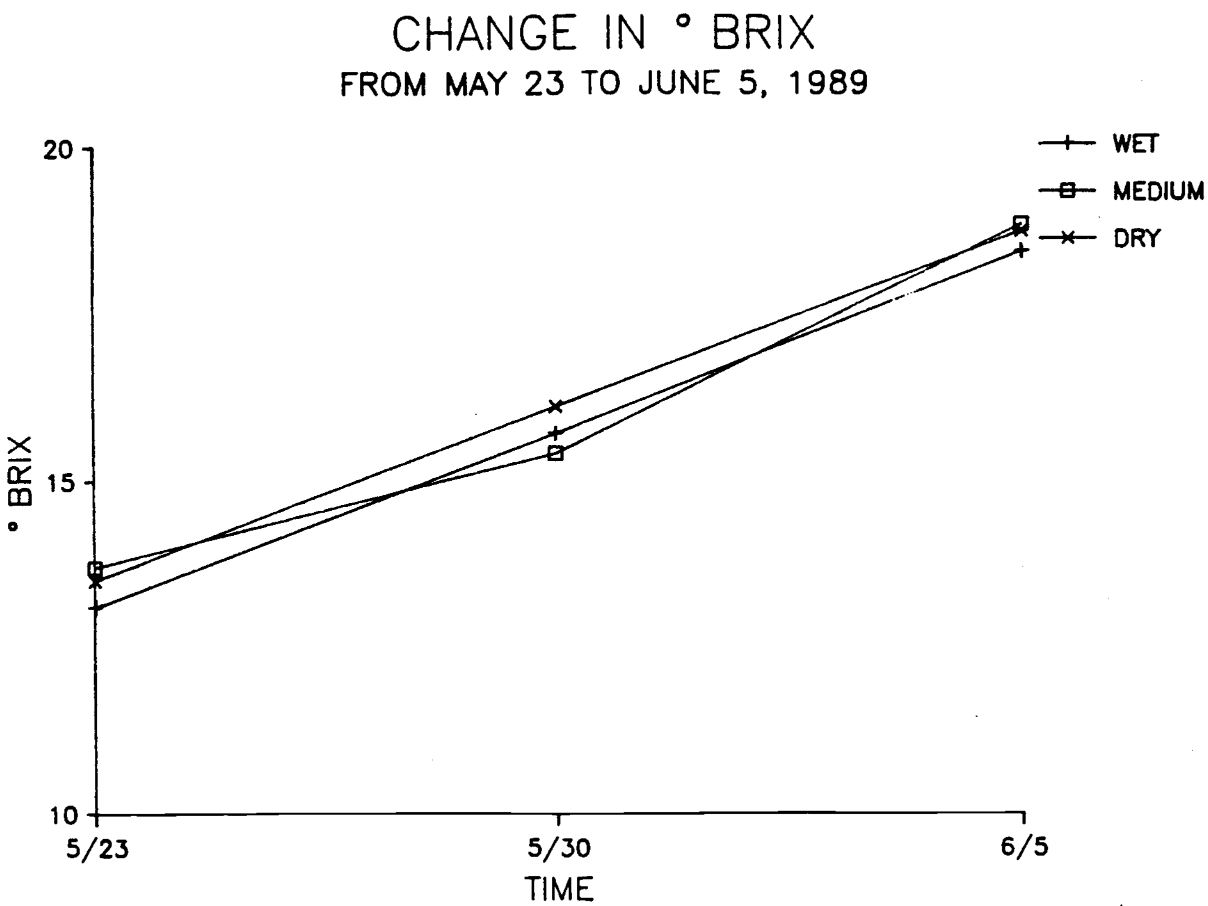

Figure 5. Change in Titratable Acidity

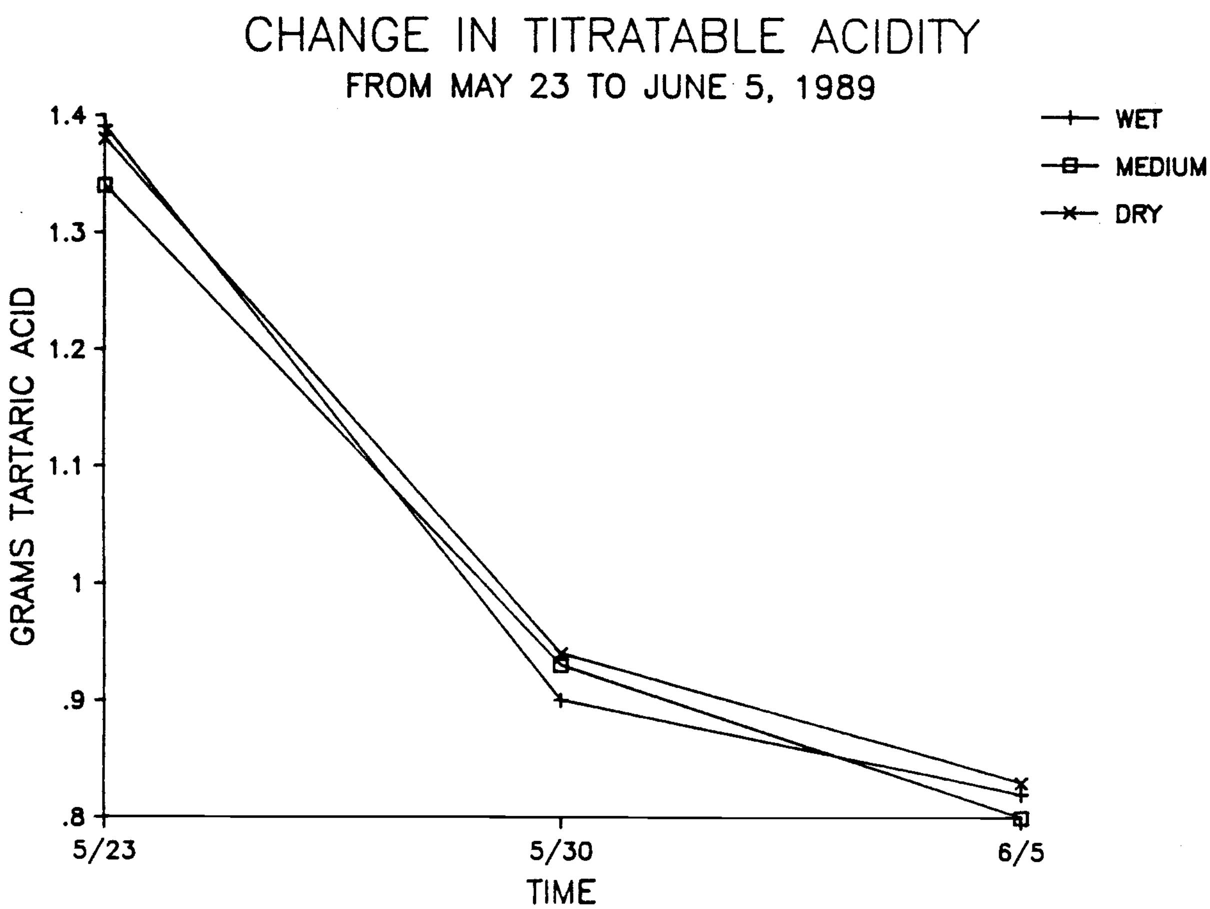

Figure 6. Change in Degree Brix: Acid Ratio