TABLE GRAPE PLANT GROWTH REGULATOR WORKSHOP

Visalia Convention Center
Tuesday, June 29, 2010

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TOUR ORGANIZING COMMITTEE

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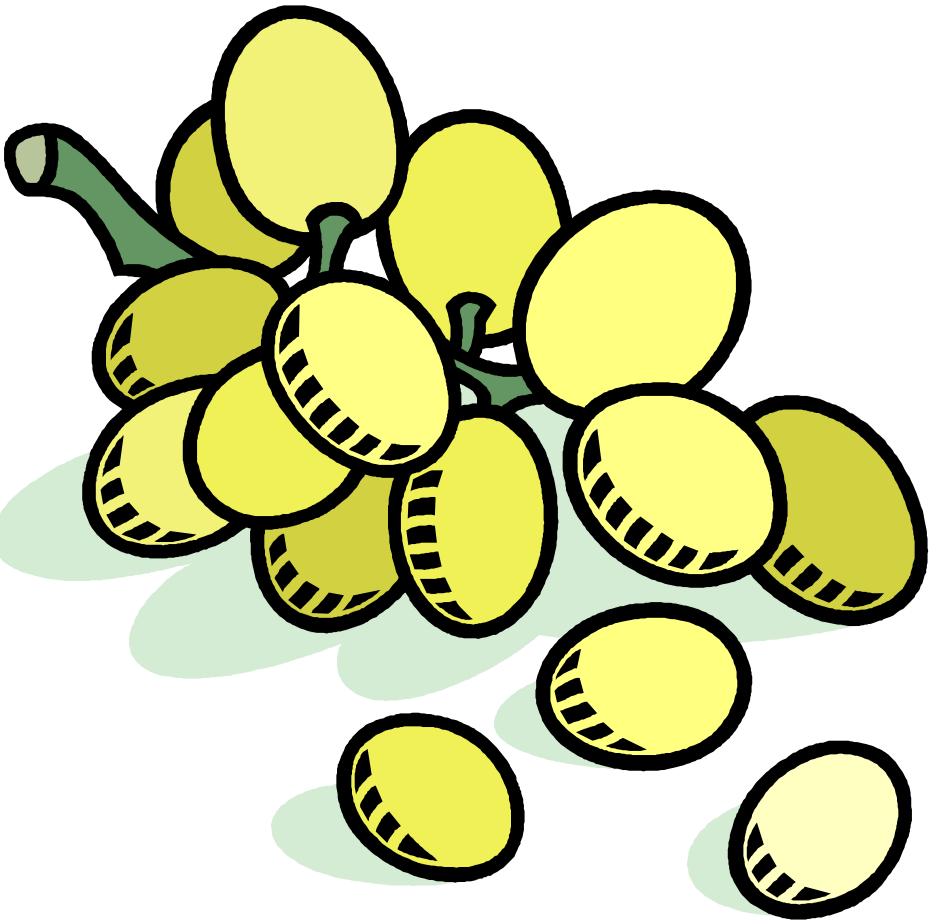

University of California Cooperative Extension

TABLE GRAPE PLANT GROWTH REGULATOR WORKSHOP

Visalia Convention Center, 303 E. Acequia, Visalia, CA 93291

Tuesday, June 29, 2010

10:45-11:00am
Welcome and Introductions

11:00 to 11:15
The potential benefits or demerits of using gibberellic acid for thinning and sizing some of the important new seedless table grape varieties.

Jennifer M. Hashim, UCCE Viticulture Farm Advisor
1031 S. Mt. Vernon Avenue
Bakersfield, CA 93307 USA

11:15 to 11:30
The use of CPPU by table grape growers in South Africa; varieties treated, typical use rates, and effects on berry quality.

Pieter Raath, Lecturer
Department of Viticulture and Oenology
Stellenbosch University, Stellenbosch, South Africa

11:30 to 11:45
Ethephon for improving the color of red and black table grapes

William Peacock, UCCE Viticulture Farm Advisor Emeritus
Tulare County, USA

11:45 to 12:00pm
The use of S-ABA (ProTone™) for improving the color of table grapes.

Mr. Rob Fritts, Jr
Valent BioSciences Corporation
870 Technology Way, Libertyville, IL 60048, USA

12:00 to 12:15
Experimental work toward the development of abscission agents for producing individual table grapes.

Giuseppe Ferrara, PhD, Assistant Professor
Dipartimento di Scienze delle Produzioni Vegetali
University of Bari, Via Amendola 165/A 70126 Bari, Italy

12:15 to 12:30
Moderated question and panel discussion

Matthew Fidelibus, PhD
Department of Viticulture and Enology
University of California, Davis, CA, USA

NOTES

INFLUENCE OF GIBBERELLIC ACID APPLIED AT BLOOM AND BERRY SET ON FRUIT QUALITY OF 'SCARLET ROYAL' AND 'SWEET SCARLET' TABLE GRAPES

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INTRODUCTION

Early research on gibberellin for use on grapes revolutionized the table grape industry by significantly increasing the size of seedless grapes (Peacock, 2000). The primary use of gibberellic acid (GA) is to stimulate flower abscission and reduce berry set and to increase the size of seedless grape cultivars (Christodoulou et al., 1968; Weaver and McCune, 1959). Treatment rates and timings are highly cultivar specific and vary depending on region and desired result (Dokoozlian, 2003). Due to this variability, treatment guidelines must be developed for each individual cultivar. These recommendations should be frequently tested and improved so that treatment programs provide consistent results under many different growing conditions. Guidelines should assist growers to make the best possible treatment decisions, and more importantly avoid decisions that may damage fruit.

In 2008 and 2009, we conducted trials to examine the influence of gibberellin treatment on 'Scarlet Royal' and 'Sweet Scarlet' table grapes, developed by David Ramming and Ronald Tarailo of the USDA-ARS, in the southern San Joaquin Valley of California.

MATERIALS AND METHODS

In order to determine influence of GA on bunch density and fruit quality, GA thinning experiments were conducted in two commercial 'Scarlet Royal' vineyards located in Arvin and Earlimart, California and two commercial 'Sweet Scarlet' vineyards located in Arvin and Shafter, California. The plots were designed in a randomized complete block design, with 10 treatments (Table 1), 6 replications and using single vine plots. All treatments were applied with a gas-powered hand-held wand sprayer using 2000 liters of spray solution per hectare.

The 'Scarlet Royal' vineyard in Arvin was planted in 2006. The vineyard in Earlimart was planted in 2007. In each vineyard, vines are on their own roots, quadrilateral cordon trained and spur pruned. Vines in Arvin are trellised to an open-gable, or "Y" system and vines in Earlimart are trellised to a double cross-arm system. Girdling and cluster tipping/thinning was not performed on 'Scarlet Royal'. Fruit was treated with a 13 mg/L GA sizing spray by the cooperating grower in Arvin and a 20 mg/L sizing spray by the cooperating grower in Earlimart.

The 'Sweet Scarlet' vineyard in Arvin was planted in 2006 and vines are on their own roots. The vineyard in Shafter was planted in 2006 and vines were grafted to 'Freedom' rootstock. In each vineyard, vines are quadrilateral cordon trained, spur pruned and trellised to an open-gable system. Following fruit set, 'Sweet Scarlet' vines were girdled, large clusters were tipped to the top 4 shoulders and cylindrical clusters, or those without defined shoulders, were tipped to 15-18 cm. Fruit was treated with a with a 13 mg/L GA sizing spray by the cooperating grower in Arvin and 20 mg/L GA sizing spray in Shafter.

In addition, experiments were conducted to evaluate berry-sizing treatments in the same vineyards using similar methods as described above (Table 1). All experimental 'Scarlet Royal' vines in Arvin received a 2.5 mg/L GA thinning spray, while vines in Earlimart received a 2.3 mg/L treatment. Only

'Scarlet Royal' vines marked "girdle only" were girdled at fruit set in Arvin. Vines were not girdled in Earlimart, as the trunk diameter was not of sufficient size. All experimental 'Sweet Scarlet' vines were girdled at fruit set, with the exception of control vines and clusters were tipped and thinned as previously described. A bloom spray was not applied to 'Sweet Scarlet' vines.

Table 1. Experimental gibberellic acid rates and treatment timing to reduce berry set and increase berry size of 'Scarlet Royal' and 'Sweet Scarlet' table grapes.

GA Bloom Applications					GA Sizing Applications 'Scarlet Royal' and 'Sweet Scarlet'		
'Scarlet Royal' Treatment		'Sweet Scarlet' Treatment		Application Timing	Treatment		Application Timing Berry diameter
mg/L	g/ha[x]	mg/L	g/ha[x]	% Bloom	mg/L	g/ha[x]	(mm)
0.0	0.0	0.0	0.0	-	0.0	0.0	-
2.0	4.0	0.5	1.0	1X - 50-60%	Girdle Only		5-6
2.0	4.0	0.5	1.0	2X - 50-60%, 80-90%	10.0	20.0	4-7
2.5	5.0	1.0	2.0	1X - 50-60%	10.0	20.0	8-10
2.5	5.0	1.0	2.0	2X - 50-60%, 80-90%	20.0	40.0	4-7
5.0	10.0	2.0	4.0	1X - 50-60%	20.0	40.0	8-10
5.0	10.0	2.0	4.0	2X - 50-60%, 80-90%	30.0	60.0	4-7
10.0	20.0	4.0	8.0	1X - 50-60%	30.0	60.0	8-10
10.0	20.0	4.0	8.0	2X - 50-60%, 80-90%	40.0	80.0	4-7
2.5	5.0	2.0	4.0	1X – 120%	40.0	80.0	8-10

[x]Rates in grams are based on a spray volume of 2000 L/ha.

Berry sampling, measurement of fruit set, fruit quality and compositional analysis: Clusters were counted on each data vine during the spring to ensure that an adequate and uniform number of clusters were present prior to application of GA treatments and to determine the effects of return fruitfulness on vines treated during the previous year. Cluster compactness (estimation of berry set) and shot berry were evaluated in GA thinning plots. Fruit quality characteristics including berry size (weight, length, and diameter), soluble solids, titratable acidity, pH, color, firmness and post-harvest shatter were evaluated in GA sizing plots. Data was evaluated by ANOVA with means separated by Fisher's Protected LSD when appropriate.

RESULTS AND DISCUSSION

Influence of gibberellin sprays on return fruitfulness the year following application on 'Scarlet Royal' table grapes: 'Scarlet Royal' vines receiving applications of GA to reduce berry set and increase berry size during the 2008 growing season were examined for effects on return fruitfulness in 2009. First, it should be noted that cluster counts in Arvin were considerably reduced in 2009 when compared to 2008. Furthermore, the result cannot be completely explained by GA treatments as there were 35% and 41% fewer clusters in 2009 (compared to 2008) on untreated vines in bloom spray and size spray plots, respectively. It is the opinion of the author that the reductions in fruitfulness in this plot were driven mainly by negative effects of severe shading in the fruit zone caused by excessive vigor. Applications of GA to reduce berry set of 'Scarlet Royal' did not reduce the number of clusters per vine in the following season, but it did reduce cluster weight at higher rates (10.0 mg/L; 1X or 2X), where weights were 46-54% smaller than untreated clusters. Applications of GA to increase berry size in 2008 had no significant effects on the number of clusters per vine or cluster weight in 2009.

Influence of gibberellin thinning sprays, as a means to reduce berry set, on bunch density of 'Scarlet Royal' table grapes: In Arvin, vines treated with a single GA spray (2.0 mg/L, 2.5 mg/L, 5.0 mg/L and 10.0 mg/L) applied at 50-60% bloom, significantly reduced bunch compactness in comparison to untreated vines. In general, rates ≥ 2.0 mg/L reduced bunch compactness from 19% to 29%. Double applications did not show any improvement over single applications. In fact, double applications actually produced inferior results compared to single applications and this occurs because multiple applications generally worsened the appearance of shot berries compared to single applications. This observation was repeated in Earlimart. During the 2009 season, GA applied at bloom did not significantly reduce bunch density compared to untreated vines in Earlimart. Overall, vines treated with high rates of GA (≥ 5.0 mg/L - 2X in Arvin; ≥ 5.0 mg/L -1X or 2X in Earlimart) produced significantly more shot berries per cm of lateral length. In addition, vines treated with 2.5 mg/L at 120% bloom did not have any effect on shot berry formation or bunch compactness.

Influence of gibberellin sizing sprays and girdling on berry size and fruit quality of 'Scarlet Royal' table grapes: In general, berry size was large at both plots, with natural berry weight on untreated vines ranging from 7.4 to 8.0 grams. GA sizing treatments had no significant effect on berry weight, berry length or berry diameter at either plot. In addition, GA sizing treatments had no significant effect on soluble solids, color characteristics of hue angle and chroma or berry firmness at either plot. Any significant differences observed between treatments for other quality characteristics were not meaningful. In Arvin, fruit treated with 40 mg/L early (4-7 mm berry diameter stage) significantly increased post-harvest shatter compared to untreated fruit, but this trend was not observed in Earlimart.

Influence of gibberellin sprays on return fruitfulness the year following application on 'Sweet Scarlet' table grapes: 'Sweet Scarlet' vines receiving applications of GA to reduce berry set and increase berry size during the 2008 growing season were examined for effects on return fruitfulness in 2009. Cluster number was not significantly affected by GA applications to reduce berry set during the following season; however applications at the high rate (4.0 mg/L -1X or 2X) did reduce cluster weight, where weights were 30-40% smaller than untreated clusters. Nearly all of the treatment rates/timings of GA to increase berry size in 2008 significantly reduced the number of 'Sweet Scarlet' clusters per vine in the year following application. In general, when applications at the 20 mg/L and 30 mg/L rate were made early (4-7 mm berry diameter stage), a 17-26% reduction in cluster was observed. When the application rate was increased to 40 mg/L and made early, cluster number was reduced by 37-39% compared to untreated vines, but the effects were lessened numerically (25-28% reduction) by delaying the application (8-10 mm berry diameter stage).

Influence of gibberellin thinning sprays, as a means to reduce berry set, on bunch density of 'Sweet Scarlet' table grapes: Vines treated with ≥1 mg/L -1X or 2X significantly reduced cluster compactness compared to untreated fruit in Arvin. Results were inconsistent in Shafter, where rates at 1.0 mg/L and 4.0 mg/L at both timings significantly reduced cluster compactness compared to untreated vines, but there was no effect at the 2.0 mg/L rate. Despite this result, there was a numerical reduction in the number of berries set per cm of lateral, when fruit was treated with GA at bloom and the reduction in bunch density decreased with increasing rates of GA. Vines treated with 2.0 mg/L at 120% bloom did not reduce bunch compactness, nor did it have any effect on shot berry formation. Vines treated with 2 mg/L-2X or 4 mg/L-1X or 2X produced significantly more shot berries per cm of lateral length compared to untreated fruit in Arvin. Furthermore, double applications generally worsened the appearance of shot berries compared to single applications.

Influence of gibberellin sizing sprays and girdling on berry size and fruit quality of 'Sweet Scarlet' table grapes: Berry size was larger in Arvin, with berry weights approximately 20% greater in Arvin compared to the Shafter. All GA treatments applied for berry sizing significantly increased berry weights, berry length and berry diameter compared to the untreated control in both locations. Furthermore, a girdle alone applied at fruit set increased berry weight, compared to fruit on untreated vines, by approximately 22%. Compared to fruit on the untreated vines, a girdle + GA applied early (4-7 mm berry diameter stage) at a rate of 10, 20, 30 and 40 mg/L increased berry weight by approximately 26%, 24%, 22% and 30% and treatment results for berry size characteristics (weight, length and diameter) were statistically equivalent among the 10, 20 and 30 mg/L rate in the Arvin plot. More pronounced effects were observed in Shafter, where a girdle + GA applied early (4-7 mm in berry diameter) at a rate of 10, 20, 30 and 40 mg/L increased berry weight by approximately 30%, 40%, 40% and 44% and as in Arvin, results for berry weight were statistically equivalent among the 10, 20 and 30 mg/L treatments.

GA sizing treatments and the application of a girdle at fruit set significantly reduced soluble solids and titratable acidity in the Shafter plot and the severity of delayed maturity increased with increasing concentrations of GA. However, there were no significant effects of GA sizing treatments on soluble solids and titratable acidity in Arvin. The mean hue angle of the berry skins in all plots were perceived as "red" in color. However, berry skin color of untreated fruit at the Shafter plot (hue angle, μ=17.31) can be described as being deeper red, given that the angle is narrow and lies closer to 0^{o} (red-purple) on the color wheel, while untreated fruit at the Arvin plot had a numerically wider angle (hue angle, μ=27.3), such that the color of berry skins could be described as red but were closer to 90^{o} (yellow) on the color wheel. Such differences could be explained by variations in ethephon (Ethrel®) use or temperature. In the Arvin plot, a girdle + GA significantly increased the hue angle and lightness of the berry skins. Similar trends were observed in Shafter. GA sizing treatments and the application of a girdle at fruit set significantly increased berry firmness in both plots. GA sizing treatments had no significant effect on post-harvest shatter in Shafter, though higher rates (>30.0 mg/L) may reduce shatter (as observed in Arvin) by strengthening capstem attachment.

ACKNOWLEDGEMENTS

The authors would like to thank the California Table Grape Commission for funding this study and the grower cooperators, David Ramming, USDA-ARS and Ronald Tarailo, USDA-ARS for without their participation and advice, this project would not be possible.

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UTILIZATION OF GIBBERELLIC ACID, CPPU AND BUNCH APPLIED CALCIUM TO INCREASE REDGLOBE BERRY FIRMNESS

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INTRODUCTION

Table grapes is an aesthetic product, therefore berry appearance, taste and texture should meet the demands of consumers. Firm grapes are preferred. Calcium applications to the bunches and calcium fertilisation, as well as gibberellic acid (GA_3) and synthetic cytokinin (CPPU) applications, are used by South African table grape producers to enhance berry firmness. However, these practices are not supported by scientific research.

Gibberellic acid is known to enhance the division and expansion of pericarp cells. The enlargement of cells results in a decrease of cell density (Ben-Arie *et al.*, 1997). Synthetic cytokinins (CPPU), on the other hand, increases cell density because it promotes cell division (Ben-Arie *et al.*, 1997). Grapes treated with GA_3 at vèraison were found to have increased firmness (Singh *et al.,* 1978; Ben-Arie *et al*., 1997). The firmness of berries was also increased by application of CPPU (Ebisuda *et al.*, 2003).

Calcium plays a major role in the structure of the cell wall. It acts as a binding agent in the middle lamellae and the ions increase the cohesion of cell walls. Most research relating calcium and fruit firmness was done on apples. Sams *et al.* (1984) found that fruit softening of apples treated with calcium was delayed because Ca^{2+} slowed down the degradation of cell wall polymers. These apples also retained their firmness and cell-to-cell contact, which plays an important role in the firmness of fruit. The untreated apples softened while their cell walls swelled and separated. The cell walls of Ca^{2+} treated apples were reported to be well preserved with very little degradation (Poovaiah *et al.*, 1988). Indications whether calcium applications have the same potential effect on table grapes, could not be found in literature. The potential commercial use of GA_3, CPPU and bunch applied calcium sprays to increase or ensure berry firmness of Redglobe was therefore investigated in this trail.

MATERIALS AND METHODS

The experiment was conducted in De Doorns, Western Cape, on a 12 year old *Vitis vinefera* L. cv. Redglobe vineyard (3m x 1.8 m), grafted on Ramsey. The trial was laid out in a randomized block design with four treatments (Table 1) that were replicated five times. The treatments were applied using a 20L knapsack sprayer just after sunrise. All the treatments were bunch directed. Each experimental unit consisted of four vines with only the central two that was used for experimental purposes.

Berry samples (four berries each) were randomly taken at five developmental stages (pea size, 15 mm diameter, vèraison, 14 days past vèraison and at harvest) from each experimental unit for transmission electron microscope (TEM) and light microscope (LM) studies. The berries were always sampled from the middle part of the bunch. From each berry one radial section was made for electron and light microscope studies. The procedure followed for the preparation of TEM and LM samples were similar to that described by Diakou *et al.* (2001). Berry samples (50 berries), randomly taken at the abovementioned stages, were used to determine berry mass (g), berry volume (cm^3), total soluble solids (˚Brix). Berry firmness (g/cm^2) of ten randomly selected berries was measured with an ISICUDISI grape and soft fruit compression tester. One carton per experimental unit were packed at 15˚B and stored for three weeks at -0,5˚C followed by one week at 10˚C. After cold storage the grapes were evaluated for

loose berries, rot, berry split and expressed as a percentage of the total weight of the carton. Berry firmness was again measured.

Analyses of variance was performed using SAS version 8.2. Non-normality was tested using the Shapiro-Wilk test. Student's t-test for least Significant Differences (LSD) was calculated at $p \leq 0.05$ and the standard deviations were used to calculate the standard errors at a 95% confidence level.

Table 1. Description of the treatments applied for increasing berry firmness.

Treatment abbreviation	Experimental treatments Redglobe
Control	No plant bioregulators applied.
GA_3	20 mg/L GA_3 (ProGibb[1]) applied at 10 mm mean berry size.
CPPU + GA_3	20 mg/L GA_3 (ProGibb[1]) plus 3 mg/L CPPU (Sitofex[2]) applied at 10 mm mean berry size.
Ca	Mixture of 8L/ha Stopit[3] plus 5 L/ha Caltrac[4] applied directly to bunches every two weeks from berry set to vèraison (Total of three applications).

1. ProGibb = 400g/kg gibberellic acid
2. Sitofex 10EC = 10g/L forchlorfenuron
3. Stopit = $CaCl_2$ at 160 g Ca^{2+}/L
4. Caltrac = $CaNO_3$ at 400 g Ca^{2+}/L

RESULTS AND DISCUSSION

Increased berry size was obtained for the GA_3 and CPPU + GA_3 treatments. Although not significant, the GA_3 and CPPU + GA_3 treatments showed the largest cells at harvest in the outer mesocarp, pointing to some effect by these plant bioregulators on cell expansion of the outer mesocarp tissues (Figure 1).

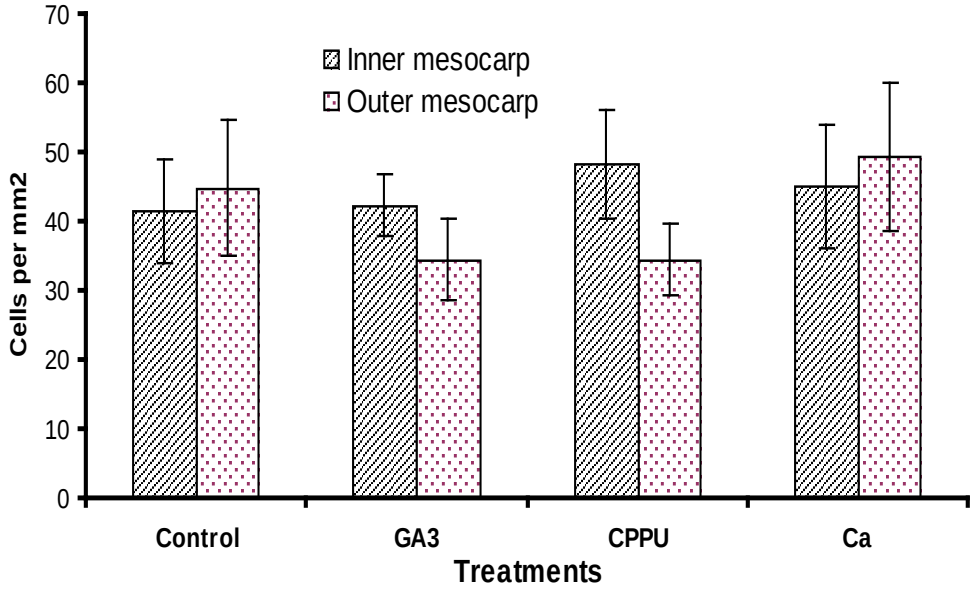

Figure 1. Effect of plant bioregulators and bunch applied Ca on the amount of cells per mm^2 of different tissues of Redglobe berries. Error bars indicate 95% confidence intervals.

Berry firmness increased significantly from vèraison to harvest while it decreased significantly during cold storage (Figure 2). The increase in firmness from véraison to harvest is ascribed to increased cell turgidity as sugar and potassium (K^+) are downloaded in the berries, stimulating water uptake driven by osmotic pressure of the berries. Since water loss occurs during cold storage the decrease in berry firmness during cold storage is ascribed to water loss, resulting in less turgid vacuoles/cells.

Increased berry firmness was obtained with GA_3 applications at harvest (significant) and with a combination of CPPU and GA_3 (Figure 3). In accordance with this, Singh *et al.* (1978) and Ben-Arie *et al*. (1997) also found increased firmness of berries treated with GA_3 while Ebisuda *et al.* (2003) found increased berry firmness with the use of CPPU + GA_3. One would expect the CPPU + GA_3 treatment also to be firmer than the control, since the amount of GA_3 applied is the same. The large variance obtained for the CPPU + GA_3 treatment however explains the lack of significant difference in firmness. Compared to the other treatments, the CPPU+ GA_3 treatment did not show a significant decrease of berry firmness during cold storage (Figure 3). It remained significantly firmer than the control after cold storage. CPPU increases the thickness of the skin (Ben-Arie *et al*., 1997); this may result in less water loss during cold storage which may affect berry firmness. The calcium treatment showed the most decrease in berry firmness during cold storage.

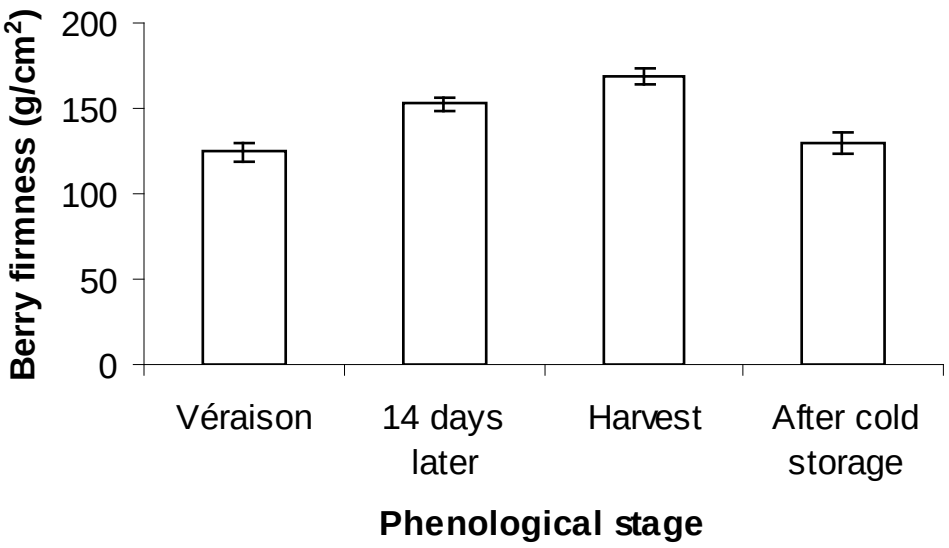

Figure 2. Changes in average firmness of Redglobe berries throughout development and cold storage (N = 10 berries x 20 experimental plots). Error bars indicate 95% confidence intervals.

The Ca and GA_3 treatments showed significantly more *Botrytis* rot than the control and CPPU + GA_3 treatments after cold storage (Table 2). A higher concentration of ProGibb than prescribed by the manufacturer was used in this trial. This may be the reason why this GA_3 treatment resulted in grapes of poorer post-storage quality. None of the treatments significantly affected the occurrence of loose berries, nor did it induce cracked berries (Table 2).

Table 2. Effect of plant bioregulators and bunch applied Ca on berry quality after cold storage of Redglobe.

Treatment	Quality parameters		
	Botrytis rot (%)	Loose berries (%)	Cracked berries (%)
Control	1.9 b	0.16 ab	0.97
GA_3	7.9 a	0.45 a	1.75
CPPU	1.0 b	0.02 b	3.03
Ca	7.0 a	0.17 ab	2.45
P≤ 0.05	LSD[1] = 4.6	LSD = 0.42	NS[2]

[1] SD = Least significant difference, means within columns followed by the same letter do not differ significantly.

[2] NS = Not significant at a confidence level of $p \leq 0.05$.

The CPPU + GA_3 treatment seems to have the best over-all effect on the grapes regarding berry size, berry firmness, keeping and eating quality (although last mentioned was reduced when compared to the control). The use of CPPU causes grapes to reach the required sugar level at a later stage than untreated grapes. The increased berry firmness measured for the CPPU + GA_3 treatment do not affect the storing capacity, but it showed a negative effect on the ripening and eating quality of the grapes. CPPU in combination with GA_3 applications can make a positive contribution to grape quality when general problems regarding berry size and firmness may occur.

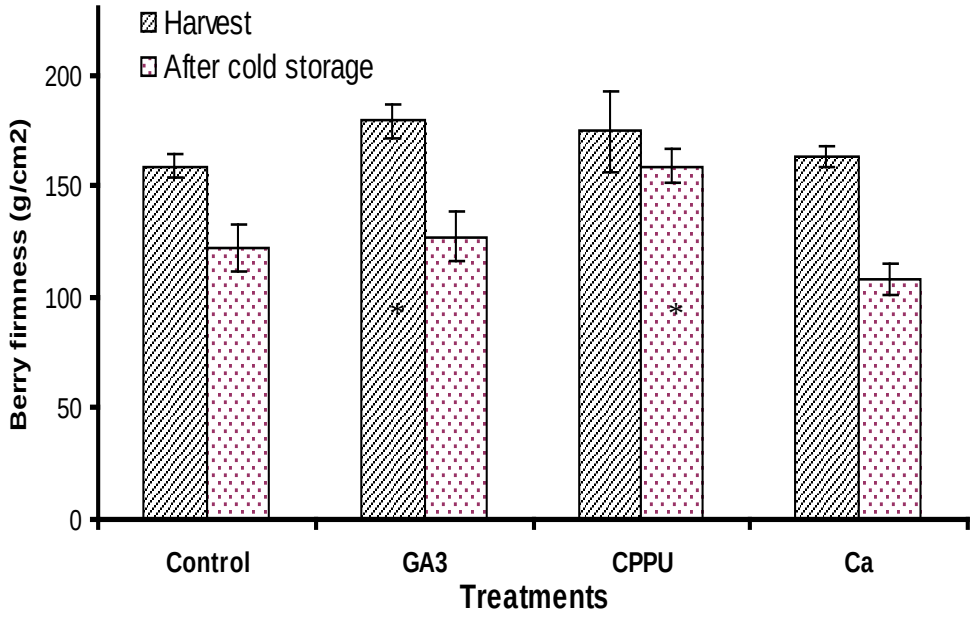

Figure 3. Effect of plant bioregulators and bunch applied Ca on the firmness of Redglobe. Error bars indicate 95% confidence intervals. * Significant compared to control.

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THE ROLE OF ETHEPHON IN THE PRODUCTION OF CALIFORNIA TABLE GRAPES

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Ethephon was first tested in 1972 on Emperor table grapes near Dinuba in the San Joaquin Valley. It was first registered for use on California table grapes in 1974. A considerable amount of research on the use of ethephon occurred in the 1970's, and research continues to this day.

Today, ethephon is a very important tool in the production of table grapes. It improves production efficiency by reducing the number of picks necessary to complete harvest, it reduces leafing requirement (labor intensive) necessary for full color development, and it advances harvest, especially important in early districts.

Ethephon is primarily applied to red pigmented cultivars to advance fruit color. Upon metabolism by the vine, it is converted into ethylene ($H_2C=CH_2$), a plant growth regulator involved with both growth and fruit maturity.

In California, ethephon has been successfully used to advance and increase color development on a number of red varieties: Scarlet Royal, Sweet Scarlet, Crimson Seedless, Flame Seedless, Redglobe, Christmas Rose, Emperor, Tokay, Red Malaga, Queen, Cardinal, and several proprietary varieties. Generally, it is applied during the period from color break (veraison) to within two weeks of harvest and using 1 pint per acre (200 ppm). Higher rates (up to 2 pints/acre) are sometimes applied but with caution. High rates can result in a dull, dark color rather than the desired bright red and berry firmness can be noticeably reduced.

Generally, the response of black pigmented cultivars to ethephon is poor (Fantasy Seedless, Summer Royal, Ribier, and Exotic). The exception is Autumn Royal which develops more uniform color with ethephon, but the improvement is subtle.

The anthocyanin pigments commonly found in Vitis vinifera grape berries consist of five sugar derived pigments: cyanidin, peonidin, delphinidin, petunidin, and malvidin. The color and intensity of grape berries is determined by the relative amounts of each of these pigments present in the skin.

It is not known if ethephon enhances berry color by increasing the accumulation of all of these pigments or not. However, the fact that ethephon enhances color development of red cultivars but has little impact on black cultivars suggests that the red and scarlet pigments (malvidin, cyanidin, peonidin) are reactive to ethephon while the black pigment (malvidin) is not.

Ethephon reduces leafing requirement necessary for full color development with a number of red cultivars. Light exposure three to four weeks prior to harvest is needed for most red cultivars for full color development. This requires that leaves be removed in the fruiting zone and canes cut, and this is labor intensive. Ethephon reduces the light required for full color, see Table 1.

Table 1. The benefit of ethephon under low light conditions.

	Treatment			
	No light (bagged)		Light (normal exposure)	
	1. no ethephon	2. ethephon	3. no ethephon	4. ethephon
Red Cultivars				
Cardinal	poor	good	good	good+
Emperor	poor	poor	fair	good
Flame Seedless	poor	fair	good	good+
Queen	poor	fair	good	good+
Tokay	very poor	very poor	fair	good
Ruby Seedless	poor	fair	good	good+
Black Cultivars				
Barlinka	good	good	good	good
Blackrose	poor	poor	good	good
Exotic	fair	fair	good	good
Ribier	good	good	good	good

Source: Jensen et al. Color and maturity promotion in table grape with ethephon. In: Proceedings of the University of Calfornia, Davis, Grapes and Wine Symposium. A.D. Webb (Ed). pp 118-121. University of California Press, Berkeley, 1980.

Ethephon does not improve color development on vines that are infected with leaf roll virus (old timers called it white Emperor virus). Ethephon is not a substitute for the viticultural practices (crop load, cluster architecture, irrigation, canopy management, and nutrition) necessary for good color development.

Ethephon enhances sugar maturity inconsistently (some years, but not every year; and in some cultivars, but not all). When applied to natural Thompson Seedless, sugar maturity can be advanced one degree brix (about 5%); therefore, it is widely used by raisin growers to improve raisin grade. But, ethephon does not advance sugar maturity when applied to Thompson Seedless grown for table production – an interesting enigma. In table grape production, the girdle and gibberellin applied at berry set both delay maturity. They also, apparently, interfere with the biochemical activity of ethephon. It is interesting to note that ethephon applied to Thompson Seedless table grapes can result in pigmented (reddish colored) berries in some years, and so its use should be avoided.

Fruit acid (tartaric acid) is almost always reduced with ethephon application, usually about 5% percent. This drop in acidity increases the sugar acid ratio and advances harvest, important in early districts (Coachella and Arvin).

Berry firmness is an important textural attribute of table grapes. Consumers like crisp fruit. Unfortunately, ethephon reduces berry firmness when applied to any of the cultivars listed above. When applied at a rate of ½ to 2 pints per acre, firmness is reduced by about 10 to 30 percent, respectively. Berries are crisp and firm when they have a berry firmness of ≥ 300 grams pressure (UC Pressure Tester, 4.8 mm-diameter probe, applied to flesh stylar end of berry). When berry firmness drops below 150 grams pressure, the fruit is no longer texturally acceptable to the consumer. Berry firmness slowly decreases with time in cold storage. Ethephon does not accelerate this process. The

inherent firmness of fruit varies considerably among cultivar and vineyard sites. Cultivars with less berry firmness are at greater risk of having storage life reduced by the application of ethephon and subsequent loss of firmness.
The application of ethephon within label rates and applied after veraison does not affect berry size. However, excessive berry shatter, smaller berries, and cluster abscission occurs when applied during the stage of bloom thru berry set. Ethephon should not be applied before veraison to avoid these responses.

Ethephon inhibits the growth of grapevine shoots. The degree of inhibition is a function of concentration, vine vigor, and time of application. Pruning weights are reduced by 20% or more when applied at veraison (2 pints per acre) to vigorously growing vines. Vine growth is mostly completed by August-September, and so late applications have much less impact on vine growth. Ethephon should not be applied to weak vines as it adds to vine stress.

Ethephon does not affect vine fruitfulness when applied at label rates. The year after treatment, flower cluster numbers and size are the same comparing treated and untreated vines.

The application period for maximum response is from the beginning of veraison to within three weeks of harvest. For late cultivars (Crimson Seedless, Emperor, etc.) color response is similar when comparing application made in mid-July (veraison) or late-August (three weeks prior to first pick). It takes three weeks to obtain full color benefit. EPA requires a two week interval from application until harvest.

For Flame Seedless, the time period from veraison until harvest is only three to four weeks. Therefore, for full benefit and early harvest ethephon must be applied at the first signs of veraison.

Research has shown no difference comparing ethephon applied in one application or the same amount divided and applied in multiple applications.

Complete coverage of fruit with ethephon is not necessary, as it is with gibberellin. Research has shown similar results when ethephon is applied to fruit only, leaves only, or both leaves and fruit. Ethephon can be effectively applied by air, although this application technique is not listed on the label.

Concluding Remark
More research is needed to evaluate the interactive roles of ethephon and vine nutrition in fruit maturity and quality.

Recent work has shown that fruit maturity of Redglobe and other table grape cultivars is enhanced by applying potassium (K) to clusters just prior and during the ripening phase (Smilanick). Potassium applications to raisin Thompson Seedless during fruit ripening also significantly advanced maturity, (Peacock). The advancement of maturity (up to two weeks) has positive implications for both table and raisin grape growers. The interaction of K, B, and ethephon is currently being researched with Flame Seedless and Crimson Seedless.

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EVALUATION OF S-ABA (PROTONE™) FOR IMPROVED COLORATION OF RED TABLE GRAPES

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INTRODUCTION

Worldwide, premium table grape production tends to be from warmer growing regions that are generally considered difficult coloring areas for high quality red varieties. However, the marketplace demands table grapes with sufficient red color. Development of this desired level of color is often a significant challenge for the grower. Due to the variability in color development, growers use multiple harvests, over an extended harvest period, in order to harvest an entire crop. Low color results in lower fruit quality, lower marketable yields, and potentially significant economic losses for the grower. If grapes have insufficient color, their value is substantially decreased or unmarketable.

In some years color development is further challenged due to extreme environmental conditions. Harvests are often delayed while waiting for sufficient color, even after marketable sugar levels have developed. Due to the delay in harvest "waiting" for color, quality declines, and market prices become lower. Under those conditions, the desired color may never develop and a significant portion of the crop may not be harvested. Growers often suffer substantial economic losses under these conditions.

Because of the importance of grape color, reliable tools to help improve color development would be valuable to the grape industry. In addition, tools that improve the harvest management of table grape crops would be important.

Anthocyanins are responsible for the red, scarlet, violet and purple colors in grape berries and are major contributors to berry color. Research has demonstrated that application of the plant hormone abscisic acid (S-ABA) to grape clusters increases fruit color in table grape varieties (Lee and Tomana, 1980; Kondo et al., 1998; Jeong et al., 2004; Peppi et al., 2006). Given the effect of S-ABA, it has the potential to be an important tool for the grape industry to manage color development and improve grape quality.

In 2008, a three-year Experimental Use Permit (EUP), and a temporary exemption of tolerance, were granted to Valent BioSciences Corporation (VBC) for the use of S-ABA on grapes in the US. During 2008 and 2009 large-scale grower trials, using conventional vineyard application equipment, were initiated in the table grape growing regions of Chile, South Africa, Australia, and California to determine the commercial feasibility of using S-ABA (ProTone™) as a color enhancing product for red table grapes. Additionally, preliminary trials have been initiated in Mexico, Brazil, Israel, Egypt, and Peru. S-ABA results have been similar in response worldwide; however, this report will focus only on California.

MATERIALS AND METHODS

Commercial table grape vineyards in Central California were selected for these EUP field trials. Vine spacing varied by vineyard, but was generally 7' x 12' for 519 vines per acre. Application timing was keyed to veraison, which is defined as the point at which 50% of the harvestable fruit has softened. For Flame Seedless, applications were made at veraison. For Crimson Seedless, applications were made one to three weeks after veraison. ProTone™ (a soluble granule containing 20% S-ABA) was applied at 150 grams of active ingredient (g AI) per acre using traditional airblast or high pressure boom sprayers, at 80

to 125 gallons per acre (gpa). Split rate and sequential timing treatments were also incorporated into each site. A wetting agent, Latron B-1956, was included at 2 to 4 ounces per 100 gallons.

Plot sizes varied from one to several acres encompassing multiple rows within each vineyard. An equivalent size area treated with the grower standard coloring program, typically multiple applications of ethephon, was evaluated from adjacent rows.

At mid season a separate treatment protocol was initiated to determine the effect of late season applications of S-ABA for coloring grapes under extreme conditions where color had not developed. Applications were made to vineyards where significant green fruit was still evident, yet marketable sugar levels had been achieved. Under these conditions the standard coloring program using ethephon applications are ineffective, and may only compound the problem of a lack of color by softening the fruit. S-ABA was applied at 150 g AI in 100 gpa. A wetting agent was included at 2 ounces per 100 gallons.

At commercial harvest all fruit in the blocks of each treatment were evaluated. The numbers of harvests varied from two to six, depending on the site, and were determined by the grower. Fruit were field packed into 19-lb boxes and all boxes from within each treatment were separately tallied. Total boxes per treatment were tallied and divided by the number of vines within each row to normalize the yields based on boxes per vine. The data was then transformed into boxes per acre based on vine spacing within each site. In addition to yield data, fruit firmness and soluble solids were recorded at harvest for each treatment at each vineyard site.

RESULTS AND DISCUSSION

Detailed harvest data was collected from ten commercial grower sites in California. S-ABA (ProTone) was effective at increasing grape berry color, measured as an increase in the number of packed boxes, at all ten sites (Figure 1).

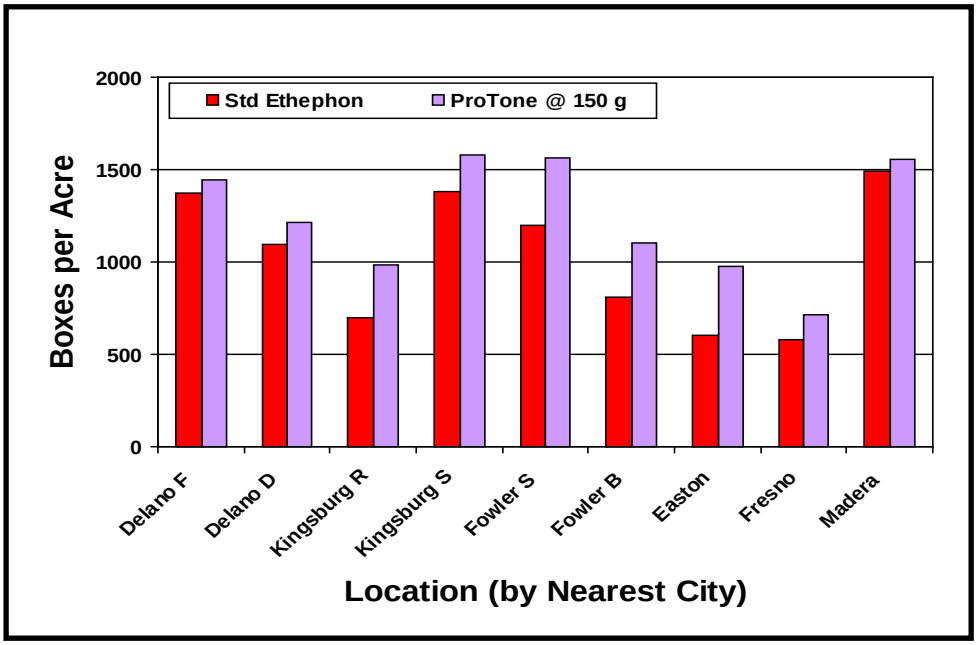

Figure 1. Yield of Crimson Seedless table grapes in the San Joaquin Valley of California following treatment with grower standard ethephon coloring program or ProTone at 150 g AI/acre.

Comparisons of fruit firmness and soluble solids between S-ABA and standard ethephon coloring programs were statistically similar statewide (data not presented). Detailed analysis of one Crimson Seedless site, Kingsburg R, showed an increase in total boxes harvested from S-ABA (ProTone) treatments, with the majority of that fruit being harvested several weeks before significant numbers of boxes were harvested from the standard ethephon treatment (Figure 2). Financial analysis comparing the single 150 g AI/acre S-ABA (one bottle of ProTone) treatment to the standard ethephon coloring program shows a significant economic advantage of S-ABA (ProTone) over the standard program (Table 1). This advantage is evident at a constant box price across all harvests; however an even greater advantage would be evident if the box prices were adjusted higher in the earlier harvests when prices historically are very strong.

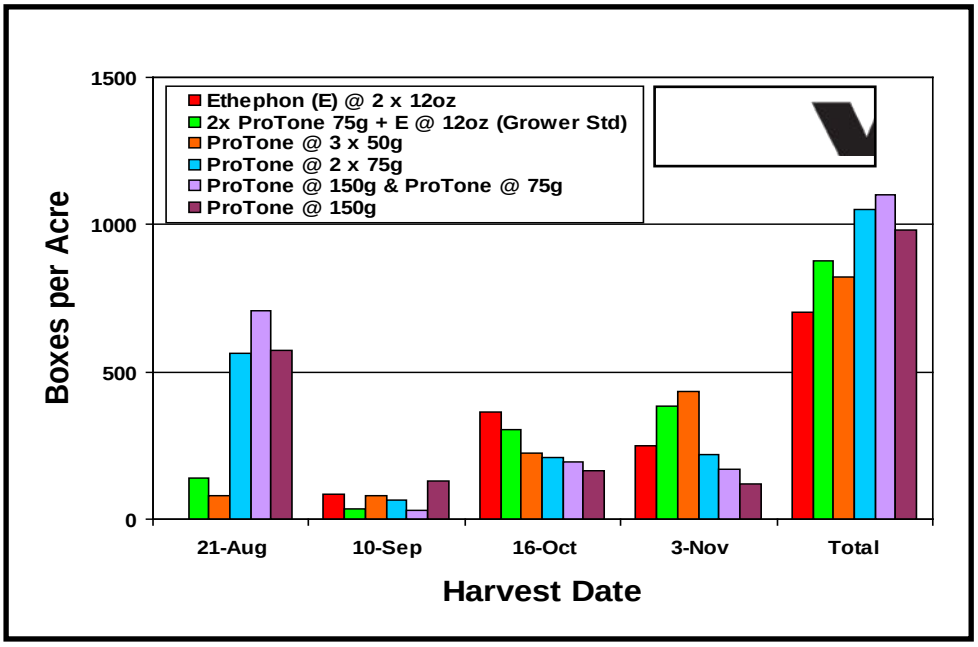

Figure 2. Yield of Crimson Seedless tables grapes (Kingsburg R) following different treatment strategies with S-ABA (ProTone) compared to a standard ethephon coloring program in Kingsburg, CA.

Table 1. Value analysis comparing S-ABA (ProTone) to a standard ethephon coloring program on Crimson Seedless table grapes in Kingsburg, CA.

		Ethephon[a] @ 2 x 12oz		ProTone[b] @ 150g	
Harvest Date	Price USD/ 19lb box	Boxes/Acre	Gross Income/Acre	Boxes/Acre	Gross Income/Acre
21-Aug	$16.00	0	$0	574	$9,184
10-Sep	$16.00	86	$1,376	128	$2,048
16-Oct	$16.00	362	$5,792	164	$2,624
3-Nov	$16.00	251	$4,016	118	$1,888
TOTAL		699	$11,184	984	$15,744

[a] Ethephon applied on July 28 and Aug 13, 2009.

[b] ProTone applied on July 14, 2009, one week following veraison, 50% berry softening.

Late in the season it is not uncommon for fruit to achieve marketable sugar levels, but lack sufficient color to be harvested. This situation occurred in a Flame Seedless vineyard, when the temperatures became extremely hot late in the season and the fruit did not "finish" for harvest. Historically, this vineyard has been difficult to color and VBC has worked extensively with the grower to improve his harvest yields. During the 2009 EUP season when ProTone was available for sale, the grower purchased product and treated this entire block, along with ethephon. The "new" grower standard became a combination of ProTone and ethephon. Following multiple harvests of the block the only remaining fruit were in the adjacent research rows. The fruit in these rows were high in sugar, still firm, but had not completely colored. On September 1, ProTone was applied at 150 g AI/acre. Ten days later the fruit had colored sufficiently to be commercially harvested (Figure 3). S-ABA (ProTone) increased the total yield for these treatments significantly over the "new" standard coloring program. Financial analysis showing the increased returns following this late season "rescue" treatment are shown in Table 2.

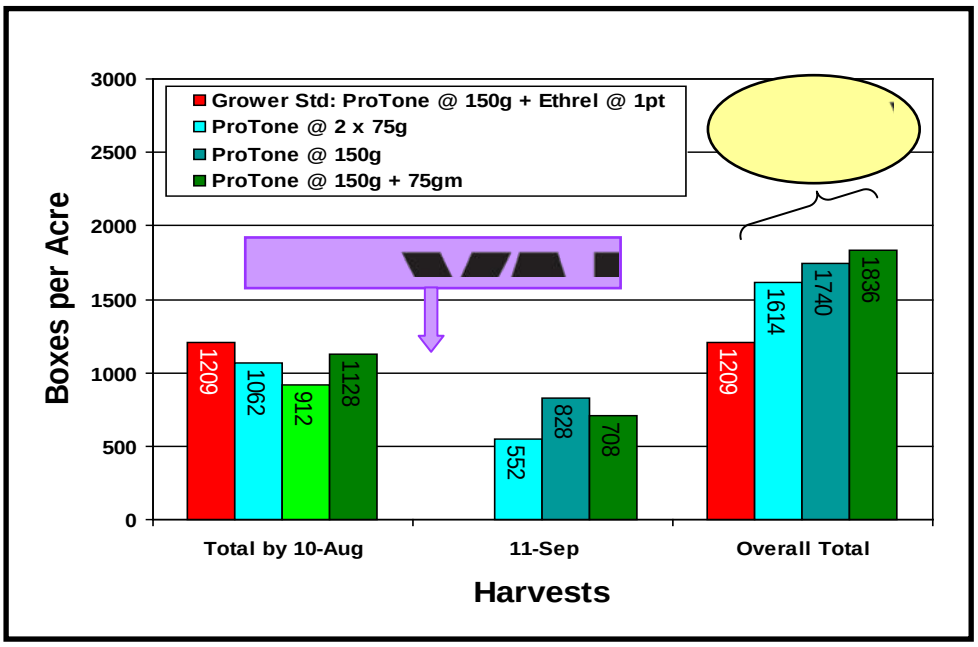

Figure 3. Yield of Flame Seedless tables grapes following a late season "rescue" treatment with S-ABA (ProTone) compared to a standard ethephon coloring program in Kingsburg, CA.

Table 2. The added value of an S-ABA (ProTone) late season "rescue" application when applied over a ProTone plus ethephon coloring program on Flame Seedless table grapes in Kingsburg, CA.

ProTone Treatment	Boxes per Acre	Value (USD) per Acre @ $20/box
3 x 50 g	**90**	**$1,800**
2 x 75 g	**405**	**$8,100**
150 g	**531**	**$10,620**
150 g + 75 g	**627**	**$12,540**

During 2009, large scale grower trials were conducted in the table grape growing regions of California, using conventional vineyard application equipment. They were successful in demonstrating the commercial feasibility of using S-ABA (ProTone™) as a color enhancing product for red table grapes.

The field data confirmed a wide application window in which S-ABA (ProTone) can be used from veraison to late in the harvest season to increase harvestable yields.

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VARIOUS GROWTH REGULATORS AS POTENTIAL ABSCISSION AGENTS FOR SOME SEEDLESS TABLE GRAPE CULTIVARS FOR FRESH-CUT PRODUCTS

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INTRODUCTION

In Apulia region (Southern Italy) table grape is cultivated on 45.000 hectares (70% of the whole country) with a yield of 950.000 tons (ISTAT 2009). The crisis of the table grape market in the last years requires to lower the production costs and find new market strategies to keep the sector competitive. In the last years in Italy, a decrease (-8%) of table grape consumption was observed whereas fresh-cut products (especially vegetables) showed an interesting increased consumption. It is worth pointing out the remarkable surplus value of such products. Today Italy is the second country in Europe, after UK, for consumption of fresh-cut products. In these perspectives, table grape as fresh-cut fruit could be offered in supermarkets as well as in vending machines located in schools and offices at a valuable price.

Plant growth regulators (PGRs) are largely used in agriculture and may facilitate the process to obtain table grape as fresh-cut fruit; some are actually used for the production of seedless table grape, such as gibberellins (Sachs e Weaver, 1968; Wolf et al., 1991) and in general to improve quality parameters (Yahuaca et al., 2001; Cantin et al., 2007; Peppi et al., 2007; Peppi and Fidelibus, 2008). Limited studies, to our knowledge, have been conducted to test the effects of PGRs on grape berry abscission in seedless table grape cultivars (Fidelibus et al., 2007; Ferrara et al., 2008; González-Herranz et al., 2009). The final step of the whole process would involve a possible mechanical harvesting similarly to what done for wine grapes.

The objective of this work was to verify the efficacy of some PGRs to reduce the fruit detachment force (FDF) few days after the treatment in order to obtain single berries without pedicel (with/without mechanical harvest) to be marketable as fresh-cut fruits.

MATERIALS AND METHODS

Vineyard sites and experimental design. The experiment was carried out in Apulia in 2009. The trial was performed in two commercial table grape vineyards, located near Castellaneta Marina (Vineyard 1) in the Taranto province, and near Adelfia (Vineyard 2), in the Bari province. In Vineyard 1, Crimson seedless and Thompson seedless, in Vineyard 2, Regal seedless and Crimson seedless were tested, respectively. All the grapevines were trained to a overhead system ('tendone'); the cultural practices including leaves removal, bunches and berries thinning were carried out according to local protocols. For each cultivar, a randomized block design was used with three blocks and 24 treatments plus one control consisting of water with the wetting agent. Treatments consisted of 24 different solutions made up of eight PGRs: abscisic acid (ABA), 0.1, 0.5, 1 mM; benzyladenine (BA), 0.18, 0.91, 1.82 mM; ethephon (Eth), 6, 10, 20 mM; forchlorfenuron (CPPU), 0.04, 0.2, 0.4 mM; gibberellic acid (GA_3), 0.03, 0.12, 0.3 mM; methyl jasmonate (MeJa), 1, 10, 20 mM; naphtaleneacetic acid (NAA), 0.053, 0.53, 1.06 mM, and naphtaleneacetamide (NAD), 0.43, 0.86, 2.16 mM. All treatments were replicated three times (three grapevines per treatment), with the exception of the control which was replicated six times (six grapevines).

On the basis of results in our previous studies by using various PGRs and times of application (Ferrara et al., 2008; personal communications), in this experiment the bunches were sprayed with the solutions by

using a manual pump with care to wet whole bunches only when the fruits reached sufficient soluble solids (at least 16 °Brix) for harvest.

Ten bunches from each vine were selected and three berries from each bunch (top, middle and bottom section) were detached by using a force gauge. The force required (N) was recorded as fruit detachment force (FDF) both the same day of the treatment and at harvest, seven days after the treatment. Successively, the berries were placed in plastic bags and stored in a portable ice box to be carried in the laboratory where to be visually checked for integrity of the berry, presence/absence of the pedicel, integrity of (dry) stem scar**.**

Statistical analysis. Analysis of variance (ANOVA) was performed at the 0.01 P level and the mean values obtained for the different treatments were statistically compared to the control treatment by using the Dunnett's test.

RESULTS AND DISCUSSION

Vineyard 1. The reduction of the FDF was significant in both cultivars, Thompson seedless and Crimson seedless, but only with two PGRs, MeJa and Eth. The other PGRs did not significantly affect berry abscission. In particular, FDF was reduced from 6.65 N (control) to 1.99 N (MeJa 20 mM) in the case of Thompson seedless; for Crimson seedless FDF was reduced from 7.94 N (control) to 6.65 N (Eth 20 mM) and 6.08 N (Eth 10 mM), respectively. Berries abscised after the treatment with MeJa and Eth presented a dry scar at the abscission zone (pedicel/fruit interface). We did not observe canopy damages, probably because only bunches were sprayed with the solutions having care not to wet the canopy.

Vineyard 2. In this experiment the same two PGRs significantly affected berry abscission. The reduction of the FDF (control, 6.31 N) in Regal seedless was significant when treated with Eth 20 mM (3.12 N) and MeJa 20 mM (4.64 N). In Crimson seedless the reduction of FDF from the control value (6.77 N) was significant with Eth 10 mM (5.05 N) and MeJa 20 mM (2.83 N). Berries abscised after the treatment with both MeJa and Eth presented a dry, corky scar at the abscission zone (pedicel/fruit interface).

In conclusion, the treatments with MeJa and Eth at the highest concentrations promoted the loosening of mature grape berries whereas the other PGRs tested did not induce significant reductions of the FDF. Moreover, detached berries showed dry stem scars which is the most positive and desired response, especially for the successive processing steps towards the final goal: fresh-cut fruits. In the case of Thompson seedless, loosening occurred within very few days after treatment and vines could be harvested very quickly by using an appropriate harvesting machine.

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