"Influence of cluster-directed applications of potassium salts and other compounds before harvest on postharvest quality and decay of table grapes."

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Abstract

Cluster-directed applications of potassium (K) appear to bea practical tool to manage the harvest date and quality of many table grape cultivars.In general, potassium applications after veraisonincrease soluble solids, berry firmness, and often increased the color (hue angle) of colored varieties (**see table below**).In prior work, Ksprays significantly improved firmness and soluble solids contents of 'Redglobe' berries treated 5 times between berry set and harvest. Effects were evident at harvest and after storage for 10 weeks. In 2009 and 2010, we found early sprays were much less effective and only veraisonand later K treatments were needed; in 2010, those very close to harvest were omitted since most soluble solid increases occurred early in veraison and in some tests near-harvest applications left visible salt deposits on berries. In 2009 and 2010, many K compounds (K citrate, K phosphite, K phosphate, K silicate, K bicarbonate, and K nitrate) were applied to 'Redglobe' and the largest, but relatively modest, increases in soluble solids were caused K metalosate, K sorbate, or K bicarbonate, which were generally similar to each other. In terms of stimulating sugars accumulation, the response of 'Redglobe' to potassium applications was less than that of some other cultivars.In 2010, most K-treated grapes, which were treated only twice (once at the onset of veraison and again 2 weeks later) were of harvestable color and maturity 1 to 2 weeks before those untreated. K treatment increased the firmness of ethephon-treated 'Flame Seedless' grapes, but K partially inhibited the color enhancement ethephoncaused when applied alone and berry size was reduced. Negative aspects of K application occurred with some cultivars. 'Crimson Seedless' developed more soft-tip, the K responses in some vineyards

were modest, late applications should be avoided because they can leave visible residues, and a minor reduction in berry size occurred in some cultivars. Benefits exceeded these problems with most cultivars, however, and generally included increased berry firmness, soluble solids content, and color intensity. K-sorbate, inexpensive, readily available, and listed as exempt from residue tolerances by the USEPA, has fungicide activity and reduced postharvest gray mold significantly in repeated tests.K metalosate, a plant nutrient product, had similar effects on berry quality, but its influence on postharvest gray mold is not known.

Summary table. Influence of two potassium metalosate(or where indicated with potassium sorbate or bicarbonate) cluster-directed sprays applied at the onset of veraison and again 10-14 days later in 2010 on the soluble solids content and color of table grapes.The berries were significantly firmer in every test and smaller in some tests. See report for rates, timing, and test locations.

	Soluble solids (^{o}Brix)			Color (hue)*	
Variety (Date)	Control	Potassium	Change	Control	Potassium
Autumn Royal	15.5	20.3	+4.8	…	…
Summer Royal	18.2	20.0	+1.8	…	…
Scarlet Royal	18.1	21.8	+3.7	25.4	23.0
Sweet Scarlet	16.6	19.3	+2.7	34.7	25.1
Redglobe (Kingsburg K sorbate)	16.4	17.4	+1.0	22.9	23.2
Redglobe (Kingsburg K bicarbonate)	16.4	18.1	+1.7	22.9	22.7
Redglobe (Kearney Ag Center)	15.8	17.8	+2.0	39.3	19.2
Flame Seedless	17.2	19.6	+2.4	38.1	36.8

*Lower number indicates more red in color. Hue of cultivars blue-black in color not measured.

There was insufficient space in this report to include some earlier work with K nutrition. For example, we found K nutrition was adequate and normal (between 2-3% petiole content) in a ‘Redglobe’ vineyard that responded to K applications after veraison.This was done to determine if K cluster applications were compensating for inadequate K content in this vineyard, and they were not.

Test #1.Responses of many newer cultivars to potassium (“K”) metalosate applications. Cluster-directed sprays of Kmetalosatewere done at California State University Fresno (CSUF) vineyard. Cultivars included ‘Summer Royal’, ‘Sweet Scarlet’, ‘Ruby Seedless’, ‘Crimson Seedless’, and ‘Autumn Royal’. At CSUF, four replicate plots of three vines each were used. A solution containing 1.3 g of Kmetalosate per L of water was prepared, with 0.35 ml of B1956 surfactant per L. This was applied by spraying the solution into the clusters to run-off. The grapes were treated two times: at the onset of veraison and two weeks later. A sample of 100 berries per replicate was used

for quality: 1) berry firmness and size; 2) berry color; 3) average berry weight; 4) soluble solids ("SS"); 5) titratable acidity ("TA"); and 6) K content.

The response of some cultivars to K metalosate was readily apparent soon after it was applied, and it affected many quality parameters measured after harvest, in particular color and soluble solids and K contents **(Table 1).** In every case, the soluble solids content was increased by the K metalosate treatments, and in most cases, the color was significantly deeper (lower hue number). The influence of potassium on firmness was to increase it or not change it, with the exception of 'Ruby Seedless', which was softer. However, none of the firmness measurements were significantly different from each other. 'Ruby Seedless' berries in this vineyard were very small, and the appearance of K-treated 'Ruby Seedless' grapes was poor in this trial, with many smaller and softer grapes. 'Ruby Seedless' should be evaluated elsewhere. Last year in a plot near Delano where we applied Ksorbate, we found an increased incidence of 'soft tip', a disorder of 'Crimson Seedless', and we again saw K treatment increase the incidence of 'soft tip' in 2009 at CSUF. The severity of the soft tip symptoms among 'Crimson Seedless' grapes was high and objectionable. Some 'soft tip' occurred on 'Sweet Scarlet' Kmetalosate treated in 2009, but the severity of the symptoms was low.

Test #2.The effect of application timing on the response of the grapes to K cluster sprays. Cluster-directed sprays of Ksorbate were applied at the UC Kearney AgriculturalCenter (KAC) in Parlier. At KAC, six replicate plots of one vine each were used –all that were available for our work at this location. The cultivar was 'Redglobe'. A solution containing 5 g of Ksorbate per L of water was prepared, with 0.35 ml of B1956 surfactant per L. This was applied by spraying the solution into the cluster to run-off. The grapes were treated with one of the following three regimes: 1) a water-treated control; 2) K sorbatewas applied twice before veraison ("Early");or 3)K-sorbate was applied twice after veraison ("Late"). Soluble solids, pH, titratable acidity, and K content were determined repeatedly after K sorbate sprays. At harvest, a sample of 100 berries per replicate was used for quality: 1) berry firmness and size; 2) berry color; 3) average berry weight; 4) soluble solids; 5) titratable acidity; and 6) K content.

Cluster-directed sprays of Ksorbate applied at the UC KAC in Parlier in the schedule in **Fig. 3**.The purpose for this test was to determine the effect of application timing on the response of the grapes to K cluster sprays. The grapes were treated with one of the following three regimes: 1) a water-treated control; 2) Ksorbate was applied twice before veraison ("Early"); or 3)Ksorbate was applied twice after veraison ("Late"). Soluble solids, pH, titratable acidity, and K content were determined, some repeatedly after K sorbate sprays (**Fig. 3, Fig. 4**). The 'Late' regime, where only two applications were made after the onset of veraison, increased soluble solids, improved berry firmness and berry color, and berry size was not altered. The 'Early' regime did improve berry soluble solids and color modestly, but not firmness.

Test #3.The interaction of ethephon and K metalosate and K sorbate on the quality of 'Flame Seedless'. This test was conducted in a vineyard near Arvin.Treatments included water, ethephon alone, Ksorbate alone, Ksorbate + ethephon, potassium metalosate, Kmetalosate + ethephon. All were applied first at 5% berry color and again 5 to 7 days later. Rates of potassium compounds were 1.3 g K actual per L (2.1 lbs/acre actual K). Ethephon was applied at 0.24 pt per acre. At harvest, a sample of 100 berries per replicate was used for quality: 1) berry firmness and size; 2) berry color; 3) average berry weight; 4) soluble solids; and 5) titratable acidity.

In the Arvin test with 'Flame Seedless' grapes (**Table 7**), K treatments increased soluble solids compared to water or ethephon-treated grapes. Combining K + ethephon treatments also resulted in increased soluble solids compared to water or ethephon alone. K content of the grapes was not altered by any treatment. The juice titratable acidity was occasionally lower, but not significantly so, after K or ethephon treatment. The juice pH was higher, often significantly so, after K or ethephon treatment. K treatments increased firmness compared to water or ethrel-treated grapes. Combining K + ethephon treatments increased berry firmness compared to ethephon alone. The color of ethephon-treated grapes was darker (lower 'L') and more red (lower hue), but the saturation ('C') of the color was less than the other treatments. The Kmetalosate treatment alone did not alter color from the water-treated, and it reduced ethephon effectiveness more than Ksorbate. The Ksorbate treatment alone did not alter color from the water-treated, but it only slightly reduced ethephon effectiveness. Berry size and weight was reduced somewhat by most of the K treatments.The best combination treatment in this experiment was ethephon + Ksorbate, because the soluble solids and firmness were higher than ethephon alone, the berry size was only slightly reduced (0.5 g). The most significant problem was the reduction in berry size in this test.

Test #4.Comparison of many potassium salts in a single vineyard. In a vineyard near Kingsburg, seven potassium salts and one calcium salt were applied twice: K bicarbonate, K metalostate, K sorbate, K citrate, K phosphate, K phosphite, K silicate, and K nitrate with an untreated controls.All K treatments containedequimolar concentrations of K (1.3 g potassium per L). Each solution contained 0.35 ml of B1956 surfactant per L. Soluble solids, pH, titratable acidity,and K content were determined repeatedly after K sorbate sprays. Fruit were harvested when the control treatment reached maturity (>16.5% soluble solids). Quality measurements recorded at harvest included fruit color, soluble solids, pH, titratable acidity, berry weight, firmness, K content, and berry diameter. Sugar analysis by HPLC and K localization by SEM X-ray analysis was conducted using berries from this experiment.

In the 'Redglobe' vineyard near Kingsburg, Fresno County, where this test was conducted, the variation among plots was low, the crop load was high, and the response of the grapes to Ksorbate was very modest although in prior seasons the response to this salt and Kmetalosate was significant as it was in another 'Redglobe' vineyard in Kern County used in prior years (**Table 5 and 6**). New in 2011 was that K bicarbonate caused a markedly higher increase in SS. Bi-weekly measurements of the soluble solids of berries within the water-treated control clusters and those treated with Ksorbate provides

some insight into why the response measured at harvest was small **(Table 5).** Soluble solids increased markedly by the K compared to the control, and the maturity of these grapes was about 7 days ahead of the controls. Of the seven K salts applied (K bicarbonate, K metalostate, K sorbate, K citrate, K phosphite, K phosphate, K silicate, K nitrate), the highest soluble solids contents, firmness, and best color were associated with K bicarbonate followed by K metalosate or K sorbate. There were some significant differences in the quality of the grapes among the salt solutions. K treatments made the berries firmer but often slightly smaller in size. Color, TA, and pH were not altered by these treatments. Potassium content of the berry juice was increased by the K applications in this test.

Test #5.Antifungal activity of Ksorbate in vineyard applications to control decay in subsequent cold storage. In this experiment, conducted at USDA in Parlier, a 'Thompson Seedless' vineyard was used in afungicide test, where six replicate plots of five vines each in a latin square design was used. A 10 kg sample of clusters was harvested from each plot. In this vineyard, the increase in soluble solids was modest when measured at harvest (1.2^{o}Brix in both years).Ksorbate, applied at 0.5% wt/vol to run off, was applied four times and compared in effectiveness to a four application fungicide program that employed Scala (pyrimethanil), Switch (cyprodinil and fludioxonil), Pristine (pyraclostrobin and boscalid), and Elevate (fenhexamid), all at their label maximum rates. The test was done in 2009 and repeated in 2010. After harvest and 5 weeks of storage at 1^{o}C, control of decay by potassium sorbate was significant but inferior to the fungicide program in 2009 but equal in effectiveness in 2010:

	Gray mold (%)		Other decay (%)	
	2009	2010	2009	2010
1 Control	15.2 a	24.2 a	1.9 a	5.0 a
2 Potassiumsorbate	4.9 b	6.9 b	1.4 a	4.2 a
3 Fungicides	1.1 c	4.7 b	1.1 a	4.1 a

Test #6.Influence of potassium treatment on berry sugar and potassium contents.HPLC analysis of the juice prepared from samples from two 'Redglobe' vineyards (one near Kingsburg, the other in Parlier) that had four cluster directed applications of 0.5% wt/volKsorbate applied from veraison to three weeks before harvest revealed the soluble solids increase was due to an increase in both glucose and fructose contents. The increase was sufficient to account for the increase in soluble solids content. SEM and x-ray analysis was applied to determine the distribution and concentration of potassium within 'Redglobe'. Initial results showed the natural K content was distributed within the hypodermis, 5 to 7 cell layers from the surface. After K treatment, its concentration was greatly increased and primarily found closer to the berry surface.

Conclusions:

This research has provided compelling evidence that K applications after fruit set may be a practical tool to improve the color, soluble solids content, and firmness of many table grape cultivars. Together with the prior seasons' results, it provides useful but negative information regarding the lack of influence of other compounds applied to clusters, such as calcium,had on berry quality.

- Cluster-directed applications of K could be used to obtain earlier maturity as measured by color or soluble solids contents.For example, earlier harvest is feasible if soluble solids content attained minimum maturity 1 to 2 weeks earlier as a consequence of K treatment.

- The number and timing of K applications was reduced to twice in our tests with good results; the first application at the onset of veraison, and again about 2 weeks later.

- Cluster-directed applications of K could be used to retain a higher crop load, since it increased soluble solids and color. For example, if soluble solids were increased from 18 to 20^{o}Brix by potassium treatment, it is conceivable a crop load 10% larger in size could be retained.

- Interactions of cluster-directed applications of K with other plant growth regulators may exist – for example, in our testsethephon (Ethrel)and Ksorbateapplications to 'Flame Seedless' had firmer berry than ethephon alone and were higher is soluble solids, and color development was improved but less than ethephon alone. However, K sorbate treatments markedly reduced berry size in this test.More work is needed in this subject.

- The newer cultivars 'Autumn Royal' 'Summer Royal', Scarlet Royal' and 'Sweet Scarlet' all responded well to Ksorbate applications – they were higher in soluble solids and firmer in every case, and berry size reductions were small or absent.

- 'Flame Seedless' were markedly smaller and 'Crimson Seedless'grapes had higher rates of soft tip, so use of cluster-directed applications of potassium need to be done with care on these cultivars. More work is needed with this cultivar.

- K sorbate reduced postharvest decay modestly in some tests and may be a good choice for some vineyards for this reason. K sorbate is listed by the USEPA as a FIFRA sec 25(b) minimum risk pesticide; its exemptions include residue tolerances and some safety equipment requirements. K metalosate was not included in these tests and should be tested in this role.

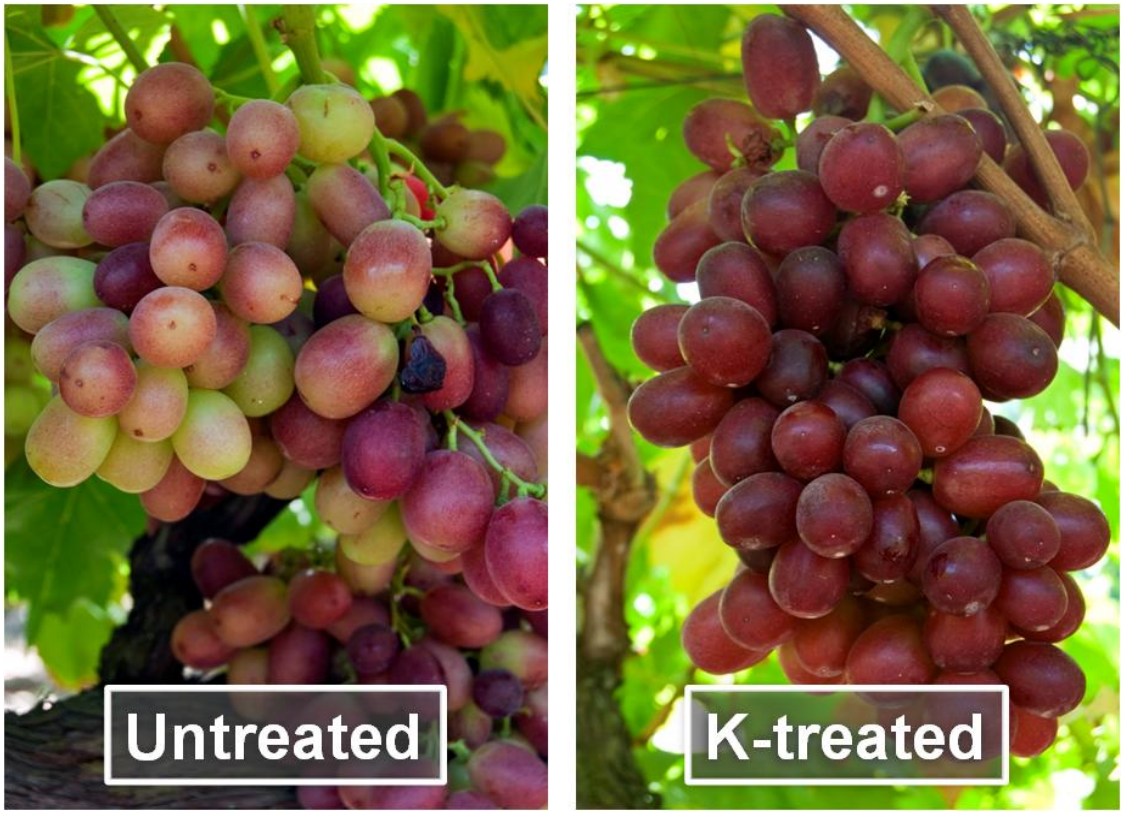

Figure 1. Appearance of ‘Sweet Scarlet’ table grapes at harvest on Aug 5, 2009, after four applications of potassium metalosate.Soluble solids untreated were 16.0% and those potassium-treated were 19.5%.

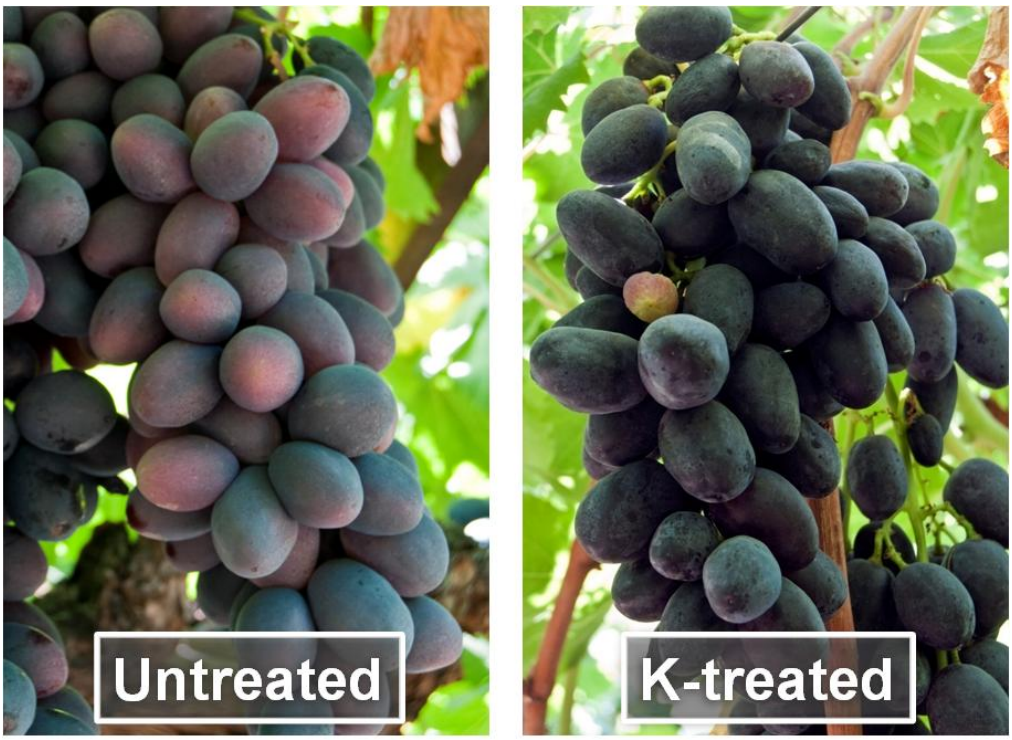

Figure 2. Appearance of ‘Autumn Royal’table grapes on Aug 18, 2009, after three applications of potassium metalosate. Soluble solids of the untreated grapes were 15.2% and thoseof the potassium-treated grapes were 20.2%.

Figure 3. Appearance of ‘Flame Seedless’table grapes at harvest on July 5, 2009, after no treatment (left) or four applications of potassium sorbate (right).Soluble solids of the untreated grapes were 16.4% and those of potassium-treated grapes were 18.4%.

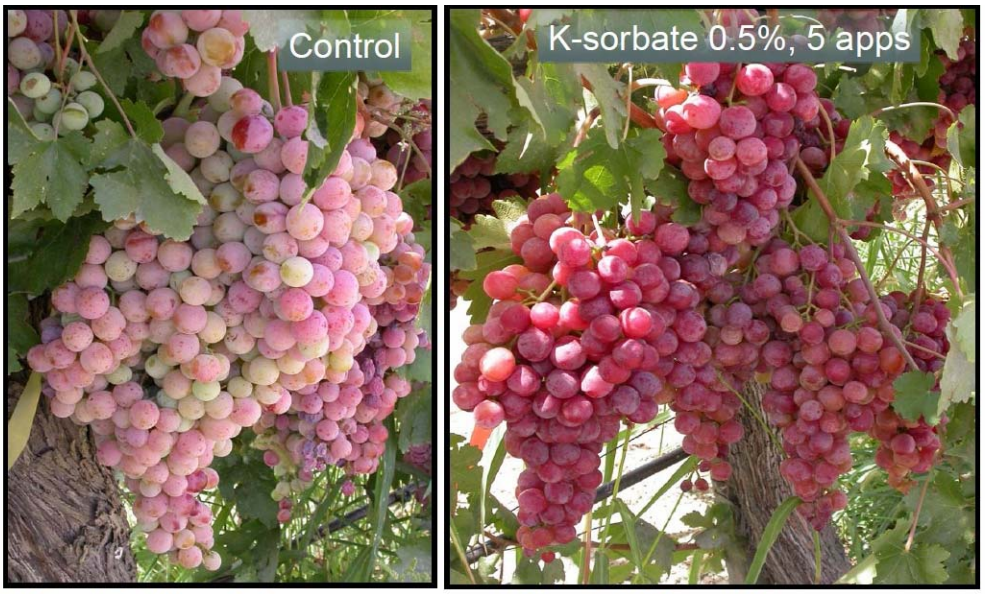

Figure 4. Appearance of 'Redglobe'table grapes at harvest on August 19, 2008, after four applications of potassium sorbate at Kearney Agricultural Center. In 2009, the appearance of the grapes was similar.

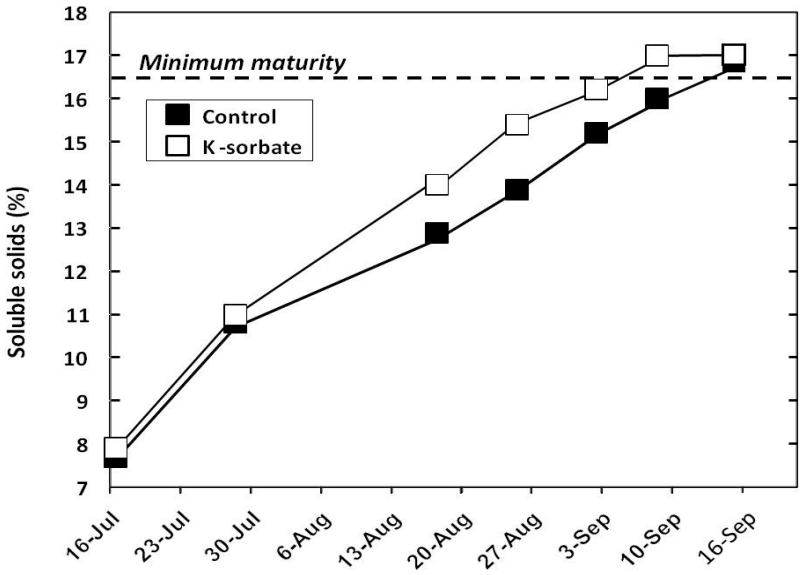

Figure 5. Soluble solids content of 'Redglobe' table grapes after the onset of veraison. Potassium sorbate ('K-sorbate; 0.5% wt/vol) was sprayed into clusters on June 2, June 23, July 28, and August 19, 2009. Each value is the mean of five replicate samples, each containing 25 berries.The grapes were harvested September 17, 2009.

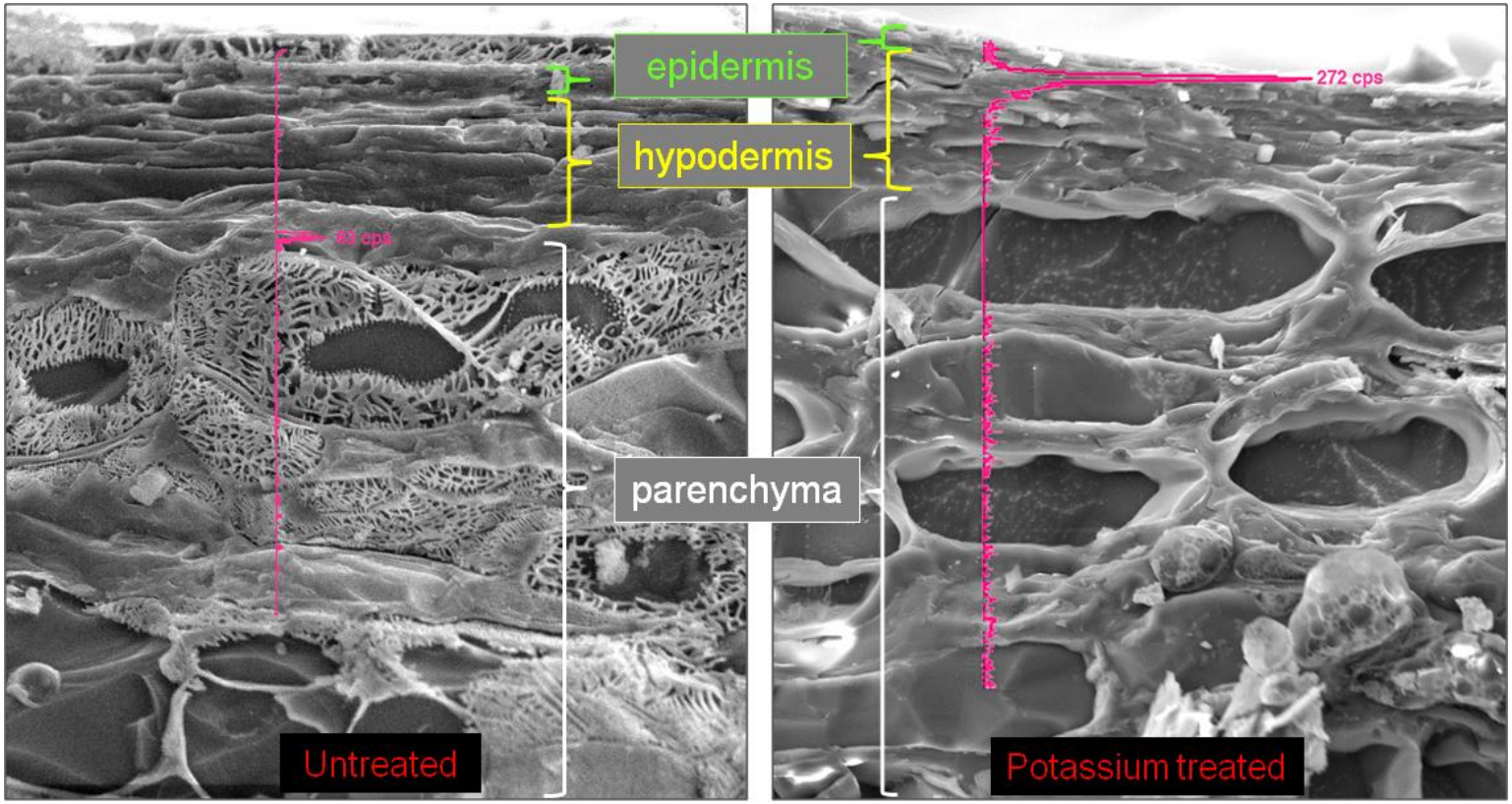

Figure 6. Potassium distributionwithin 'Redglobe' table grapes after the onset of veraison. Potassium sorbate ('K-sorbate; 0.5% wt/vol) was sprayed into clusters on June 2, June 23, July 28, and August 19, 2009. Red line indicates potassium content. In untreated grapes, potassium was located near the bottom of the hypodermis, in potassium treated grapes, most potassium was located in layers 3 to 5 of the hypodermis.

Table 1. Influence of two potassium salt solution applications (beginning of veraison and 2 weeks later) on the quality of two cultivars blue-black in color (’Autumn Royal’ and ’Summer Royal’) and two cultivars red in color (‘Scarlet Royal’ and ’Sweet Scarlet’) grown at California State University Fresno (2010). Dates of potassium application: July 21 (beginning of veraison) and August 11, 2010. Each was applied to run-off into clusters at 1.3 grams actual potassium per liter. Each value is the mean of a 50-100 berry sample from each of plot of 5 vines arranged in a randomized complete block design. SS = percent soluble solids, K = berry potassium content in ppm fresh weight. [a] Sample dates = Jul 27, Aug 4, Aug 9, Aug 16 and harvest [b] Sample dates =Jul 27, Aug 3, Aug 9 and harvest [c] Sample dates =Jul 1, Jul 7, Jul 13, Jul 20, Jul 26 and harvest [d] Sample dates =Jul 27, Aug 3, Aug 9, Aug 16 and harvest

		First sample date				Second sample date				Third sample date				Fourth sample date				Fifth sample date			
Variety	Treatment	SS	K	pH	TA	SS	K	pH	TA	SS	K	pH	TA	SS	K	pH	TA	SS	K	pH	TA
Autumn Royal[a]	Untreated	11.4	852	3.3	9.0	12.7	1240	3.5	8.7	14.1	1220	3.7	4.7	15.5	1140	3.9	4.9				
	K metalosate	13.6	1050	3.4	8.6	15.6	1280	3.7	6.8	18.2	1420	3.8	5.2	20.3	1480	4.0	4.8				
	Sig.	**0.000**	**0.018**	**NSD**	**NSD**	**0.000**	**NSD**	**NSD**	**NSD**	**0.000**	**0.002**	**NSD**	**NSD**	**0.000**	**0.004**	**NSD**	**NSD**				
Scarlet Royal[b]	Untreated	14.8	874	3.4	9.3	16.2	1140	3.5	9.1	18.1	1560	3.7	6.6								
	K metalosate	17.0	1020	3.5	9.8	19.1	1240	3.6	8.8	21.8	1700	3.8	6.5								
	Sig.	**0.000**	**0.028**	**NSD**	**NSD**	**0.000**	**NSD**	**NSD**	**NSD**	**0.000**	**0.026**	**NSD**	**NSD**								
Summer Royal[c]	Untreated	10.5	912	2.9	18.5	13.3	1180	3.0	12.9	14.6	986	3.2	8.60	16.6	1240	3.4	7.1	18.2	1280	3.5	6.3
	K metalosate	10.4	954	2.8	18.6	14.8	1300	3.1	13.3	16.6	1400	3.3	9.1	18.8	1340	3.5	7.3	20.0	1440	3.6	6.4
	Sig.	**NSD**	**NSD**	**NSD**	**NSD**	**0.027**	**0.162**	**NSD**	**NSD**	**0.016**	**0.001**	**NSD**	**NSD**	**0.047**	**NSD**	**NSD**	**NSD**	**0.051**	**NSD**	**NSD**	**NSD**
Sweet Scarlet[d]	Untreated	12.9	840	3.4	6.1	14.0	1120	3.5	5.8	15.5	1380	3.7	4.3	16.6	1300	3.8	4.1				
	K metalosate	14.8	936	3.4	6.4	16.5	1360	3.6	6.4	18.3	1580	3.8	4.6	19.3	1720	3.9	4.1				
	Sig.	**0.006**	**0.050**	**NSD**	**NSD**	**0.000**	**0.000**	**NSD**	**NSD**	**0.000**	**0.003**	**NSD**	**NSD**	**0.000**	**0.001**	**NSD**	**NSD**				

Table 2. Influence of potassium salt solution applications (beginning of veraison and 2 weeks later) on the quality of two cultivars blue-black in color (’Autumn Royal’ and ’Summer Royal’) and two cultivars red in color (‘Scarlet Royal’ and ’Sweet Scarlet’) grown at California State University Fresno (2010) and harvested at commercial maturity. See Table 1 for dates of potassium application and rates of maturity before harvest.

								Berry color		
	SS	TA	pH	K content	Firmness	Diameter	Berry wt	L	C	hue
’Summer Royal’ (Blue-black in color) July 26, 2010										
Control	18.2 a	6.3	3.5	1280 a	324 a	21.7 a	6.2 a	26.5 a	1.7 a	304.8 a
Potassium	20.0 b	6.4	3.6	1440 b	341 b	21.2 b	5.9 b	25.3 b	1.1 b	268.8 b
‘Scarlet Royal’ (Red in color) Aug 9, 2010										
Control	18.1 a	6.6	3.7	1560 a	401 a	24.5 a	9.5 a	32.5 a	11.4 a	25.4
Potassium	21.8 b	6.5	3.8	1700 b	458 b	23.6 b	8.8 b	30.6 b	12.7 b	23.0
’Autumn Royal’ (Blue-black in color) Aug 16, 2010										
Control	15.5 a	4.9	3.9	1140 a	458 a	23.7	9.2 a	28.3 a	3.4 a	342.0
Potassium	20.3 b	4.8	4.0	1480 b	506 b	23.3	9.1 a	27.0 b	2.1 b	342.0
’Sweet Scarlet’ (Red in color) Aug 16, 2010										
Control	16.7 a	4.0	3.8	1300 a	506 a	24.1 a	8.8 a	35.4 a	12.6 a	34.7 a
Potassium	19.3 b	4.0	3.9	1720 b	532 b	23.2 b	7.8 a	32.1 b	13.4 b	25.1 b

Values followed by unlike letters indicate they are significantly different by Tukey’s HSD (P = 0.05). In columns where values are not followed by the letters the observations do not differ significantly. Observations include soluble solids as determined with an electronic refractometer (SS), titratable acidity in grams per L of berry juice (TA), berry juice pH, berry firmness as determined the force required in grams to cause 1 mm deflection, diameter of the berry in mm, berry weight in grams, and berry color where L = lightness/darkness, higher number = lighter; C = chroma or color saturation, higher number = more saturated, and hue angle, where a lower number = more red in color with red cultivars.

Table 3. Influence of "early" or "late" potassium sorbate applications to 'Redglobe' table grapes on their soluble solids contents at Kearney Agricultural Center in Parlier, CA, in 2010. The solution contained 5 g or potassium sorbate plus 0.3 ml Latron B1956 surfactant per L. The solution was applied through a pump sprayer directly into the clusters to run-off. Treatments were applied to 5 plots of one vine each. Each value is the mean of a 50 berry sample from each plot.

	Potassium sorbate application dates				Soluble solids content dates			
	Jun7[a]	Jun 21[b]	Jul 8[c]	Jul 22[d]	Jul 19	Aug 10	Aug 19	Sept 1
Control	no	no	no	no	10.5	14.2	14.8	15.8 a
KSorb ("Early")	yes	yes	no	no	10.1	14.6	15.4	16.4 ab
KSorb ("Late")	no	no	yes	yes	12.1	15.5	16.6	17.8 b

[a]Fruit set, 4-5 mm in size[b]Fruit set + 2 weeks, fruit 12 mm in size[c]Beginning of verasion[d] Middle of verasion

Table 4. Influence of "early" or "late" potassium sorbate applications to 'Redglobe' table grapes on their quality at harvest on September 1, 2010 at Kearney Agricultural Center in Parlier, CA, in 2010. The solution of potassium sorbate was applied as described in Table 5. Treatments were applied to 5 plots of one vine each. Each value is the mean of a 50 berry sample from each plot.

								Berry color		
	SS	TA	pH	K content	Firmness	Diameter	Berry wt	L	C	hue
Control	15.8 a	3.59	3.62	1110	294 b	23.0 a	7.30 a	39.9 a	9.8 a	39.3 a
KSorb ("Early")	16.4 ab	3.63	3.70	1033	267 a	23.5 b	7.70 a	37.8 b	10.2 a	29.9 a
KSorb ("Late")	17.8 b	3.45	3.71	1113	305 c	23.2 ab	7.44 a	34.0 c	10.8 b	19.2 b

Values followed by unlike letters indicate they are significantly different by Tukey's HSD (P = 0.05). In columns where values are not followed by the letters the observations do not differ significantly. Observations include soluble solids as determined with an electronic refractometer (SS), titratable acidity in grams per L of berry juice (TA), berry juice pH, berry firmness as determined the force required in grams to cause 1 mm deflection, diameter of the berry in mm, berry weight in grams, and berry color where L = lightness/darkness, higher number = lighter; C = chroma or color saturation, higher number = more saturated, and hue angle, where a lower number = more red in color.

Table 5. Influence of two potassium salt solution applications on the quality of 'Redglobe' grapesgrown near Kingsburg (2010). Dates of potassium application: July 21 (beginning of veraison) and August 11, 2010. Each was applied to run-off into clusters at 1.3 grams actual potassium per liter. Each value is the mean of a 50-100 berry sample from each of plot of 3 vines arranged in a randomized complete block design. SS = percent soluble solids, K = berry potassium content in ppm fresh weight.

	Aug 3		Aug 11		Aug 25		Sept 8	
Treatment	SS	K	SS	K	SS	K	SS	K
Untreated	11.3 ab	668 a	12.8 a	962 a	14.5 a	1120 ab	16.4 a	1240 ab
K-bicarbonate	12.2 b	660 a	13.4 a	942 a	16.5 c	1220 c	18.1 b	1360 b
K-metalosate	11.9 ab	662 a	12.8 a	926 a	15.6 abc	1140 b	17.3 ab	1240 ab
K-sorbate	11.4 ab	704 a	12.7 a	906 a	15.9 bc	1220 b	17.4 ab	1280 ab
K-citrate	10.9 a	696 a	12.2 a	950 a	14.3 a	1060 a	16.5 a	1200 ab
K-phosphate	11.6 ab	684 a	13.2 a	898 a	15.6 abc	1060 a	17.5 ab	1220 ab
Maniplex -K	11.6 ab	662 a	12.5 a	910 a	15.3 abc	1040 a	17.0 ab	1220 ab
K-silicate	11.4 ab	668 a	12.7 a	910 a	15.0 ab	1080 ab	16.7 a	1200 ab
K-nitrate	11.0 a	658 a	12.4 a	849 a	14.4 a	1034 a	16.2 a	1080 a

Table 6. Influence of potassium salt solution applications on the quality of 'Redglobe' grapesgrown near Kingsburg (2010). Dates of potassium application: July 21 (beginning of veraison) and August 11, 2010. Each was applied to run-off into clusters at 1.3 grams actual potassium per liter. Each value is the mean of a 50-100 berry sample from each of plot of 3 vines arranged in a randomized complete block design. All measurements were made on grapes harvested September 8, 2010. SS = percent soluble solids, pH = undiluted berry juice pH, TA = titrable acidity as grams per L in berry juice, K = berry potassium content in ppm fresh weight, Firmness = grams to cause a 1 mm deflection, Dia = diameter in millimeters, Wt = grams per berry, L = lightness, darkness (higher number = darker), C = chroma or color saturation (higher number = deeper color), hue = angle in degrees (lower value indicates more red in color). Values within columns followed by unlike letters differ significantly by Tukey's HSD ($P \leq 0.05$). Values not followed by letters were not significantly different.

Treatment	SS	pH	TA	K	Firmness	Dia	Wt	L	C	hue
Untreated	16.4 a	3.92	3.51	1240 ab	322 ab	27.8 ab	13.2 cd	32.4 b	11.2 a	22.9
K-bicarbonate	18.1 b	3.93	3.76	1360 b	374 de	26.8 d	11.9 ab	32.2 b	12.9 c	22.7
K-metalosate	17.3 ab	3.92	3.53	1240 ab	354 d	27.1 cd	12.3 abc	31.8 ab	12.2 b	22.7
K-sorbate	17.4 ab	3.87	3.83	1280 ab	360 de	26.8 d	11.6 a	32.1 b	12.1b	23.2
K-citrate	16.5 a	3.85	3.58	1200 ab	318 a	27.4 bc	12.6 bcd	31.9 b	11.4 a	22.7
K-phosphate	17.5 ab	3.89	3.37	1220 ab	336 bc	27.5 bc	12.7 bcd	31.3 a	12.0 b	22.7
Manniplex -K	17.0 ab	3.91	3.48	1220 ab	352 cd	26.9 d	11.9 ab	32.2 b	12.0 b	23.8
K-silicate	16.7 a	3.92	3.31	1200 ab	332 ab	27.7 b	12.9 cd	32.0 b	12.1 b	22.3
K-nitrate	16.2 a	3.90	3.38	1080 a	327 ab	28.2 b	13.3 d	32.0 b	11.4 a	23.6

Table 7. 'Flame Seedless' grape quality at harvest (July 14, 2010) after applications of water, ethephon alone, potassium sorbate alone, potassium sorbate + ethephon, potassium metalosate, potassium metalosate + ethephon. All were applied first at 5% berry color and again 5 to 7 days later. Rates of potassium compounds were 1.3 g K actual per L (2.1 lbs/acre actual K). Ethephon was applied at 0.24 pt per acre.

						Color				
Treatment	Soluble solids	K	Titr.acids	pH	Firmness	L	C	hue	Berry dia.	Berry wt.
Water	18.4 a	910	6.40	3.49 a	471 a	33.3 d	12.7 c	38.1 cd	20.2 d	4.4 ab
Ethephon	17.2 a	933	6.13	3.60 c	462 a	29.1 a	10.8 a	24.7 a	20.5 e	4.6 a
K- metalosate	19.2 b	925	6.56	3.53 ab	513 b	32.2 b	12.7 c	40.7 d	19.3 ab	3.7 c
K-metalosate + Ethephon	19.4 b	945	5.94	3.59 c	505 b	32.5 bc	13.6 d	37.7 cd	19.1 a	3.6 c
K-sorbate	19.6 b	927	6.19	3.50 ab	540 c	32.9 cd	13.7 d	36.8 c	19.4 bc	4.1 bc
K-sorbate + Ethephon	19.6 b	990	6.08	3.58 bc	498 b	29.0 a	11.9 b	30.9 b	19.5 c	3.9 c

Material rates: Potassium sorbate $C_6H_7KO_2$, 26% K, formulation rate 8.1 lbs/acre; Potassium metalosate 20% K, formulation rate 10.6 lbs/acre). Ethrel (ethephon 240 g/L) formulation rate was 1 pt per acre.