CALIFORNIA RAISIN MARKETING BOARD
Annual Report for 2009 Research

I. Project Title: Advancing maturity of raisin cultivars using potassium sprays applied to fruit just prior or during the ripening phase.

II. Principal Investigator: **William L. Peacock**, UC Cooperative Extension, Viticulture Farm Advisor, emeritus, Visalia, CA 93292; fax 559/798-0398; office phone 559/260-6119; WLPeacock@ucdavis.edu.

Cooperators: **Joseph L. Smilanick**, USDA-ARS, Research Plant Pathologist USDA ARS San Joaquin Valley Agricultural Sciences Center 9611 S. Riverbend Ave., Parlier, CA 93648 fax 559 /596 2791 office phone 559 /596 2810 Joe.smilanick@ ars.usda.gov.

III. Summary:

Stated objectives are to advance Thompson Seedless maturity, raisin quality, and raisin nutrition (K content) using potassium sprays applied to foliage/fruit during the lag and ripening phases of fruit development.

Three Thompson Seedless raisin vineyards were used in this study: two in the Kingsburg area and one near Woodlake. None of these vineyards was deficient in K. Raisins were tray dried at the Kingsburg sites and dried-on-vine at Woodlake.

Albion Metalosate® Potassium 0-0-24 was the potassium fertilizer used in this research.

Summary of results:

a) Fruit maturity (^{o}brix) was significantly advanced by potassium applied during the period from mid-July to early-August at all three vineyards [concentrate sprayer (1½ lbs. K/Acre) or dilute application fruit-only (1 ½ lb. K/50 gallons)]:
   - Kingsburg-N vineyard (concentrate spray): + 2.3 ^{o}brix;
   - Kingsburg-S vineyard (concentrate spray): + 0.9 ^{o}brix;
   - Woodlake vineyard (dilute cluster-only spray): + 1.6 ^{o}brix.

The average increase for all three sites was 1.6 ^{o}brix. This represents 1½ to 2 weeks advancement in maturity. Raisin quality correspondingly improved. At the Woodlake vineyard, potassium application increased B&better from 78% to 92%. Sub-standard was lowered from 2.6% to 0.8%. K application had no effect on berry weight.

b) Potassium applied in mid-July and early-August was more effective than when K was applied at veraison.

c) Positive responses occurred regardless of application method: concentrate spray or cluster-only dilute spray.

d) Applying K with a single application was equally effective as multiple applications - when same total K applied.

e) Potassium application elevated the concentration of K in raisins by 9%. This has positive implications on the nutritional value of raisins.

f) Potassium application elevated the concentration of boron (B) in fruit (other minerals were unaffected). One of the biochemical roles of B in higher plants is to facilitate the transport of sugars through membranes. This finding suggests that K may indirectly advance fruit ripening by facilitating the flux of B into fruit which in turn aids transport of sugars.

Potassium sprays have been shown to advance color development in Redglobe and other pigmented table grape cultivars (Smilanick), but the mechanism for this response is a mystery. The pigments of grapes are anthocyanidins modified by attachment of a molecule of glucose (anthocyanins). B may be involved in the transport of sugars into epidermal cells and this sugar is then used for pigment synthesis.

Anthocyanins are water-soluble vacuolar pigments responsible for the violet, purple, red, and scarlet colors. They are produced from carbon and other photo assimilates imported into the berry by the phloem, and all enzymes necessary to produce pigments from imported sugar are found in the berry skin of grapes.

g) A study of the interactions of K, B, and fruit maturity will be added as an additional objective for research in 2010. Differentiating the accumulation of B in epidermis and fruit pulp will be important.

IV. Objective(s) and Experiments Conducted to Meet Stated Objective(s):

Objectives are to advance Thompson Seedless maturity, raisin quality, and raisin nutrition (K content) using potassium sprays applied to fruit during the lag and ripening phases of fruit development. Our goal is to advance raisin maturity by one week or more.

Three Thompson Seedless raisin vineyards were used in this study: two in the Kingsburg area and one near Woodlake. A complete nutritional screening (macro-, micro-, and intermediate-nutrients) of petiole and leaf blade tissue was done at all sites - both during bloom and at veraison. Tissue analysis indicated vineyards were adequately supplied with all nutrients with one exception: the Kingsburg N site was low in both boron and zinc. Raisin fruit samples were taken at the Woodlake site and analyzed for the following elements: N, S, P, K, Mg, Ca, Na, Fe, Al, Mn, B, Cu, Zn, and Mo.

The two Kingsburg sites are identified as Kingsburg N and Kingsburg S. Identical experiments (design, treatments, and sampling time) were conducted at these sites. Experiments were designed as completely randomized blocks with 3 blocks and five treatments.

Albion Metalosate® Potassium 0-0-24 was the potassium fertilizer used in this research. Treatments were as follows: 1: Control; 2: K applied July 1 (1.5 lbs. K per acre with concentrate sprayer); 3: K applied July 16 (1.5 lbs. K per acre with concentrate sprayer); 4: K applied August 1 (1.5 lbs. K per acre with concentrate sprayer); 5: K applied three separate times – July 1, July 16, August 1 (0.5 lbs. K per acre with concentrate sprayer). Plots consisted of three, 80 vine rows. Data was collected on the center row. Statistical analysis was by ANOVA and $L.S.D._{05}$ was used to separate means. Raisins were tray dried.

The Woodlake site was designed as a completely randomized block design with four treatments and three blocks. Treatments included 1: Control; 2: K applied July 5 (1.5 lbs K per 50 gallons dilute spray clusters only); 3 K applied July 18 (1.5 lbs K per 50 gallons dilute spray clusters only); 4: K applied July 5 and July 18 (1.5 lbs K per 50 gallons dilute spray clusters only). Plots consisted of five vines. Data was collected of the two center vine sections. Raisins were dried-on-vine.

At both Kingsburg sites, sprays were applied with an Air-O-Fan vineyard sprayer applying 1.5 lbs of K (or 0.5 lbs.) in 50 gallons per acre. At the Woodlake site, clusters only were hand sprayed until run-off using a hand-wand and with solution concentration of 1.5 lbs. K (or 0.5 lbs.) in 50 gallons water.

Berry weight and soluble solids (^{o}brix) were measured early- and mid-August by collecting 100 berries from each plot (sampling most clusters in the plot). Berries were weighed and then fruit macerated, filtered, and ^{o}brix measured using hand refractometer.

Raisin quality was measured at the Woodlake site. Raisins were dried on the vine by cutting canes on August tenth. Head fruit was harvested and hung on trellis seven days later. Raisins harvested from experimental plots were thoroughly mixed and a sub-sample collected for raisin quality measurements. Samples were sent to the USDA dried fruit laboratory analysis for measurement of raisin quality (% moisture, %BorB, and %SSTD). A sub sample of raisin was collected for analysis of the following elements (N, S, P, K, Mg, Ca, Na, Fe, Al, Mn, B, Cu, Zn, and Mo).

V. Summary of Major Research Accomplishments and Results (by Objective):

The nutritional statuses of the three experimental vineyards were determined by taking tissue samples (petioles and blades) at bloom and again at veraison (early July). The results of these screenings are shown in Table 1. All experimental sites were adequately supplied with nutrients including K; however, Zn and B levels were low at Kingsburg N.

Fruit maturity (^{o}brix) was significantly advanced by potassium applied during the period from mid-July to early-August in all three vineyards [concentrate sprayer (1 ½ lbs. K/Acre) or dilute application fruit-only (1 ½ lb. K/50 gallons)]:

- Kingsburg-N vineyard (concentrate spray): + 2.3 ^{o}brix;
- Kingsburg-S vineyard (concentrate spray): + 0.9 ^{o}brix;
- Woodlake vineyard (dilute cluster-only spray): + 1.6 ^{o}brix.

The average increase for all three sites was 1.6 ^{o}brix. This represents a 1 ½ to 2 weeks advancement in maturity. Raisin quality correspondingly improved. At the Woodlake vineyard, potassium application increased B&better from 78 to 92%. Sub-standard was lowered from 2.6% to 0.8%., Table 7.

Potassium applied in mid-July and early-August was more effective than application at veraison, Table 4.

Positive responses occurred with different application methods. At both Kingsburg sites, sprays were applied with an Air-O-Fan vineyard sprayer with 50 gallons per acre. At the Woodlake site, clusters-only were hand sprayed until run-off using a hand-wand. Positive results occurred with both methods, Tables 2 to 4.

Advancement in fruit maturity occurred regardless of whether 1 ½ pounds of K was applied as a single application (July 1, 16, or August 1) or multiple applications applying ½ pound of K on each of the three dates, Tables 2, 3.

Potassium sprays increased the concentration of K in raisins (fruit) by 9%, Table 6. This has positive implications for treatment effects on the nutritional value of raisins.

Potassium application during the late stages of fruit ripening also elevated the concentration of boron (B) in raisins, Table 6. One of the biochemical roles of B in higher plants is to facilitate the transport of sugars through membranes. This finding suggests that K may indirectly advance fruit ripening by facilitating the flux of B into fruit which in turn aids transport of sugars into fruit.

Potassium sprays have been shown to advance color development in Redglobe and other pigmented table grape cultivars (Smilanick), but the mechanism for this response is a mystery. The pigments of grapes are anthocyanidins modified by attachment of a molecule of glucose (anthocyanins). Anthocyanins are water-soluble vacuolar pigments responsible for the violet, purple, red, and scarlet colors. They are produced from carbon and other photo assimilates imported into the berry by the phloem, and all enzymes necessary to produce pigments from imported sugar are found in the berry skin of grapes.

B may be involved in the transport of sugars into epidermal cells and this sugar is then used for pigment synthesis. The major anthocyanins commonly found in *Vitis vinifera* grape berries consist of the 3-monoglucosides and 3-p-coumarylglucoside derivatives of the following five pigments: cyanidin, peonidin, delphinidin, petunidin, and malvidin.

Potassium did not increase the flux of other minerals into fruit: Nitrogen (N), Sulfur (S) Phosphorous (P), Magnesium (Mg), Calcium (Ca), Sodium (Na), Iron (Fe), Aluminum (Al), Manganese (Mn), Copper (Cu), Zinc (Zn) and Molybdenum (Mo).

VI. Outside Presentations of Research:

No publications at this early stage of research. Publication in popular press, industry, and university newsletters (Grape Notes) will be forth coming during the second year of research.

VII. Research Success Statements:

This research has shown that K applications to vines during fruit ripening can advance sugar accumulation by 1 to 2 weeks. The research has also provided an insight on the physiological and biochemical reasons for this response.

The implications of this for industry follow:

- Thompson Seedless raisin quality and yield are enhanced.
- Advanced maturity of Thompson Seedless improves the candidacy of this cultivar for dried-on-vine raisin production.
- Improves mineral nutrition of raisins.
- Provides better understanding of the biochemistry involved in fruit ripening.

Table 1. Nutritional evaluation of experimental vineyards.

Sampled at Bloom

Vineyard	Potassium (% K)) Petioles	Potassium (% K)) Blades	Nitrogen (% N) Petioles	Nitrogen (% N) Blades	Nitrate Nitrogen (ppm (NO_3-N)) Petioles	Nitrate Nitrogen (ppm (NO_3-N)) Blades
Kingsburg N	2.23	0.98	0.97	3.52	1157	144
Woodlake	2.41	1.06	1.71	3.38	1326	84

Sampled at Veraison

Vineyard	Potassium (K) (% K) Petioles	Potassium (K) (% K) Blades	Nitrogen (% N) Petioles	Nitrogen (% N) Blades	Nitrate Nitrogen (ppm NO3-N) Petioles	Nitrate Nitrogen (ppm NO3-N) Blades
Kingsburg N	1.90	0.71	0.93	3.36	1464	124
Kingsburg S	1.33	0.56	0.81	3.11	865	137
Woodlake	2.00	0.95	0.90	3.31	935	182

Sampled at Bloom

Vineyard	Phosphorus (% P)) Petioles	Phosphorus (% P)) Blades	Magnesium (%Mg) Petioles	Magnesium (%Mg) Blades	Calcium (% Ca) Petioles	Calcium (% Ca) Blades
Kingsburg N	0.48	0.31	0.79	0.33	1.77	2.32
Woodlake	0.35	0.24	0.55	0.30	1.37	1.73

Sampled at Veraison

Vineyard	Phosphorus (% P)) Petioles	Phosphorus (% P)) Blades	Magnesium (%Mg) Petioles	Magnesium (%Mg) Blades	Calcium (% Ca) Petioles	Calcium (% Ca) Blades
Kingsburg N	0.58	0.32	0.96	0.34	2.20	2.25
Kingsburg S	0.37	0.25	0.98	0.35	2.21	2.42
Woodlake	0.41	0.31	0.78	0.37	1.99	2.44

Table 1. Nutritional evaluation of experimental vineyards - continued.

Sampled at Bloom

Vineyard	Boron (B ppm) Petioles	Boron (B ppm) Blades	Zinc (Zn ppm) Petioles	Zinc (Zn ppm) Blades	Manganese (Mn ppm) Petioles	Manganese (Mn ppm) Blades
Kingsburg N	25	57	17	36	21	62
Woodlake	33	39	26	19	66	72

Sampled at Veraison

Vineyard	Boron (B ppm)) Petioles	Boron (B ppm)) Blades	Zinc (Zn ppm) Petioles	Zinc (Zn ppm) Blades	Manganese (Mn ppm) Petioles	Manganese (Mn ppm) Blades
Kingsburg N	50	66	30	18	74	60
Kingsburg S	44	59	31	15	71	53
Woodlake	40	58	34	23	22	55

Table 2. Thompson Seedless fruit maturity as affected by K sprays at the Kingsburg N vineyard.

Treatment	Sampled 8/4 (^{o}brix)	Sampled 8/17 (^{o}brix)
Control	18.3	21.3 a
K applied July 1 (1.5 Lbs. K per acre: Albion K Metalosate)	18.3	22.6 ab
K applied July 16 (1.5 Lbs. K per acre: Albion K Metalosate)	18.6	23.0 ab
K applied August 1 (1.5 Lbs. K per acre: Albion K Metalosate)	19.1	23.5 b
K applied July 1, July 16, Aug. 1 (0.5 Lbs. K per acre: Albion K Metalosate)	18.6	23.6 b
Least Significant Difference (L.S.D. $_{.05}$)	n.s.	1.9

1. Means with uncommon letters are significantly different at 5%.

Table 3. Thompson Seedless fruit maturity as affected by K sprays at the Kingsburg S vineyard.

Treatment	Sampled 8/4 (^{o}brix)	Sampled 8/17 (^{o}brix)
Control	17.8	19.3 a
K applied July 1 (1.5 Lbs. K per acre: Albion K Metalosate)	17.8	19.6 ab
K applied July 16 (1.5 Lbs. K per acre: Albion K Metalosate)	17.9	20.0 ab
K applied August 1 (1.5 Lbs. K per acre: Albion K Metalosate)	17.9	20.1 b
K applied July 1, July 16, Aug. 1 (0.5 Lbs. K per acre: Albion K Metalosate)	17.8	20.2 b
Least Significant Difference (L.S.D. $_{.05}$)	n.s.	0.8

1. Means with uncommon letters are significantly different at 5%.

Table 4. Thompson Seedless fruit maturity as affected by K sprays (Combined data from Kingsburg N and S vineyards)

Treatment	Sampled 8/4 (^{o}brix)	Sampled 8/17 (^{o}brix)
Control	18.0	20.3 a
K applied July 1 (1.5 Lbs. K per acre: Albion K Metalosate)	18.1	21.1 ab
K applied July 16 (1.5 Lbs. K per acre: Albion K Metalosate)	18.3	21.5 b
K applied August 1 (1.5 Lbs. K per acre: Albion K Metalosate)	18.5	21.8 b
K applied July 1, July 16, Aug. 1 (0.5 Lbs. K per acre: Albion K Metalosate)	18.2	21.9 b
Least Significant Difference (L.S.D. $_{.05}$)	n.s.	0.9

1. Means with uncommon letters are significantly different at 5%.

Table 5. Thompson Seedless fruit maturity as affected by K sprays at the Woodlake site.

Treatment	Sampled 7/29 (^{o}brix)	Sampled 8/6 (^{o}brix)
Control	17.5 a [1]	19.8 a
K applied July 5 (1.5 Lbs. K per acre: Albion K Metalosate)	18.1 a	20.2 a
K applied July 18 (1.5 Lbs. K per acre: Albion K Metalosate)	19.5 b	21.6 b
K applied July 5 & July 18 (0.5 Lbs. K per acre: Albion K Metalosate)	18.0 a	20.5 a
Least Significant Difference (L.S.D. $_{.05}$)	1.1	1.0

1. Means with uncommon letters are significantly different at 5%.

Table 6. Potassium and Boron concentration in raisins (12% moisture) as affected by K sprays - Woodlake,

Treatment	Potassium (K %)	Boron (B ppm)
Control	1.06 a [1]	18a
K applied July 5 (1.5 Lbs. K per acre: Albion K Metalosate)	1.09 a	20 b
K applied July 18 (1.5 Lbs. K per acre: Albion K Metalosate)	1.16 b	21 b
K applied July 5 & July 18 (0.5 Lbs. K per acre: Albion K Metalosate)	1.04a	19 a
Least Significant Difference (L.S.D. $_{.05}$)	0.07	1.9

1. Means with uncommon letters are significantly different at 5%.

Table 7. Raisin quality as affected by K sprays - Woodlake.

Treatment	B&Better (%)	Substandard (%)
Control	78 a[1]	2.6 a
K applied July 5 (1.5 Lbs. K per acre: Albion K Metalosate)	86 ab	1.1 ab
K applied July 18 (1.5 Lbs. K per acre: Albion K Metalosate)	88 b	1.0 b
K applied July 5 & July 18 (0.5 Lbs. K per acre: Albion K Metalosate)	92 b	0.8 b
Least Significant Difference (L.S.D. $_{.05}$)	10	1

1. Means with uncommon letters are significantly different at 5%.

Table 8. Nutrient concentration in raisins (12% moisture) harvested at Woodlake vineyard (values = average of all plots).

N (%)	S (%)	P (%)	K (%)	Mg (%)	Ca (%)	Na (ppm)
0.54	0.04	0.12	1.09	0.04	0.07	18.20

Fe (ppm)	AL (ppm)	Mn (ppm)	B (ppm)	Cu (ppm)	Zn (ppm)	Mo (ppm)
29.68	0.35	3.08	18.24	2.55	2.29	0.04