CORRECTION OF POTASSIUM DEFICIENCY IN PRUNES USING POTASSIUM CHLORIDE AND GYPSUM

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Introduction:

Potassium (K) deficiency is widespread in prunes grown in California and has a dramatic effect on fruit quality and production. Correction of potassium deficiency is one of the most costly cultural expenses for prune growers. Currently, prune growers correct potassium deficiency with mass applications of up to 2000 lbs. of potassium sulfate (K_2SO_4) or potassium chloride (KCl) per acre, annual applications of 300-500 lbs. per acre per year of the same materials acre, or 3 to 5 foliar sprays per year of potassium nitrate.

Positively charged K ions are fixed near the soil surface by negatively charged soil particles, limiting K movement into the root zone. Surface applications of K are banded in large amounts in order to overcome the cation exchange capacity of the soil and allow the K to move into the root zone. Calcium (Ca) from Gypsum (CaSo4) application has been shown to displace K from soil particles (Carlson et al, 1974). Using gypsum to leach K past the soil surface could reduce the amount of K time needed for correction of K deficiency.

Potassium deficiency has also been correlated to high magnesium soils and soils with a low calcium to magnesium ratio (Carlson and Rosen, 1983). Syed-Omar and Sumner (1991) found that applications of gypsum displaced both potassium and magnesium, with magnesium being more susceptible to displacement than potassium. Therefore, gypsum may move potassium into the soil profile while removing magnesium from the root zone, making potassium uptake more efficient. Since gypsum is cheaper than potassium, the costs of correcting potassium deficiency may be lowered over time by using potassium more efficiently and correcting calcium to magnesium ratios.

Procedure:

A 7-year-old prune orchard in the Capay district north of Hamilton City was selected for this trial. The treatments were set up in a randomized complete block design with 5 single tree replicates. Eight treatments were applied in December of 1999 and the materials and rates per tree are listed below:

1) 1.6 lb. KCl + 3.2 lb. $CaSO_4$
(2) 3.2 lb. KCl + 3.2 lb. $CaSO_4$
(3) 6.4 lb. KCl + 6.4 lb. $CaSO_4$
(4) 1.6 lb. KCl

(5) 3.2 lb. KCl
(6) 6.4 lb. KCl
(7) 6.4 lb. $CaSO_4$
(8) Untreated control

Treatments were applied in a band on each side of the tree (3-4′ from the trunk). Leaf samples were collected in May, June, and July and analyzed for N, K, Ca, Mg, S, and Cl. Soil samples were collected in July from directly under the application sites from 0-3″,3-6‴,6-12″ and 12-18″ soil depth and analyzed for total K, Ca, and Mg.

Results and Conclusions:

Figure 1 shows leaf K levels for four of the treatments (with the lowest and highest rates; treatments #3, 6, 7, and 8). Only four treatments are shown to improve readability of the graphs. Figures 2, 3, and 4 show soil nutrient levels (Ca, Mg, and K) for the same four treatments. Table 1 gives leaf nutrient levels (K, Ca, Mg, S, and Cl) for all the treatments, and Table 2 gives soil nutrient levels for all of the treatments. Significant differences between leaf nutrient levels were found only between leaf potassium levels during the first sample date, where the high rate of K and gypsum was significantly higher than the untreated control, the high rate (6.4 lb/tree) of gypsum without K, and the middle rate (3.2 lb/tree) of K without gypsum. The high and low rate (1.6 lb/tree) of K without gypsum, and the combinations of K and gypsum were significantly higher than the untreated control only. Numerically there appears to be a trend towards increased potassium leaf levels with the addition of gypsum, and lower levels of leaf sulfur, calcium and magnesium.

Soil analysis showed potassium was lower at the surface when gypsum was added with potassium chloride, which was expected due to displacement by the calcium. The addition of gypsum did not appear to increase potassium at lower depths. Potassium did not appear to leach below 12″ during the duration of the study, and appeared to only leach past the 6″ depth when applied at the high (6.4 lb/tree) rate, with or without gypsum. Calcium and magnesium levels were shown to increase with the application of gypsum alone, especially at the soil surface. The addition of potassium increased calcium and magnesium levels at the lower depths (under 6″). It appears from this study that potassium was more effective in displacing calcium and magnesium than calcium was at displacing potassium. The addition of gypsum, however, did seem to increase the uptake of potassium, as it appears that the gypsum did succeed in leaching potassium from the top 3″ of the soil.

Further research is necessary to follow the movement of K, Ca and Mg within the root zone and to determine the effect of the treatments on leaf K levels under repeat applications.

References:

Carlson, R.M., J.R. Buchanan, T.E. Kapustka, and K. Uriu. 1974. Displacement of Fertilizer Potassium in Soil Columns with Gypsum. Journal of the American Society of Horticultural Science. 99(3):221-222.

Carlson, R.M. and C.J. Rosen. 1983. Cation Interactions in Potassium Nutrition. Proceedings of the 1983 California Plant and Soil Conference. American Society of Agronomy. Jan. 26-28, 1983. 115-118.

Syed-Omar, S.R. and M.E. Sumner. 1991. Effect of Gypsum on Soil Potassium and Magnesium Status and Growth of Alfalfa. Communications in Soil Science and Plant Analysis. V2(19/20): 2017-2027.

Figure 1. Leaf K (%)

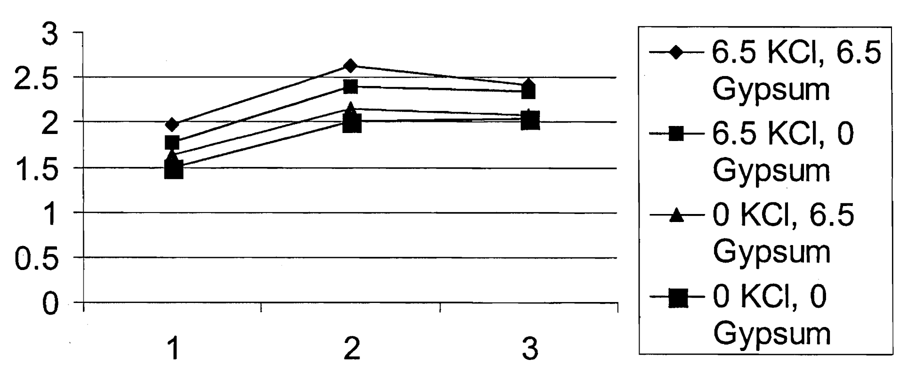
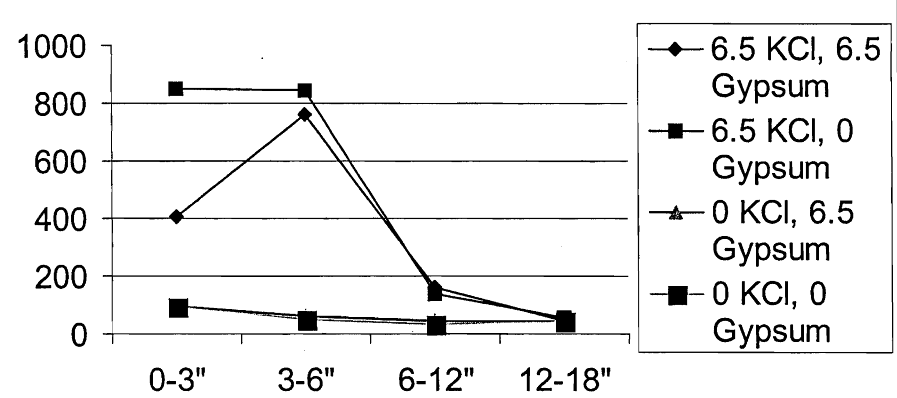


Figure 2. Soil Potassium (ppm)



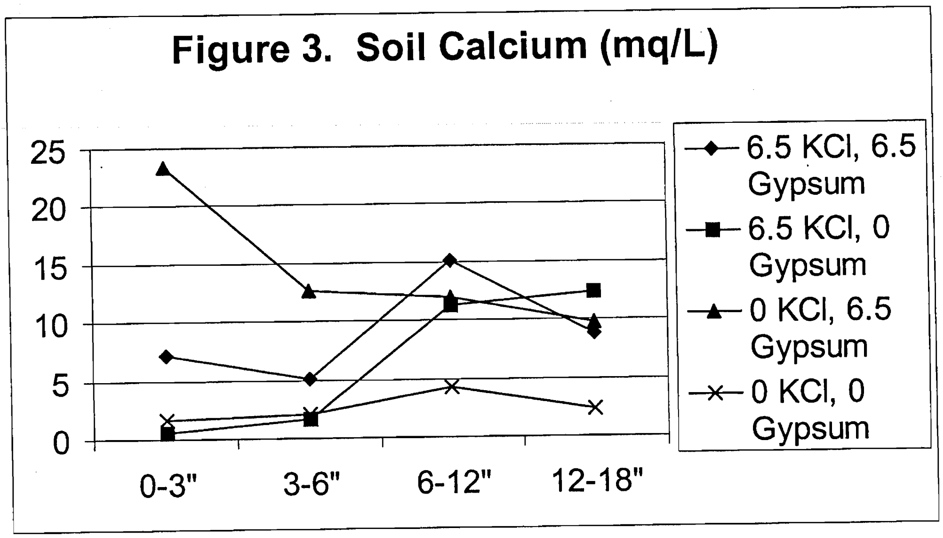


Figure 3. Soil Calcium (mq/L)
25
20
15
10
5
0
0-3"
3-6"
6-12"
12-18"
6.5 KCl, 6.5 Gypsum
6.5 KCl, 0 Gypsum
0 KCl, 6.5 Gypsum
0 KCl, 0 Gypsum

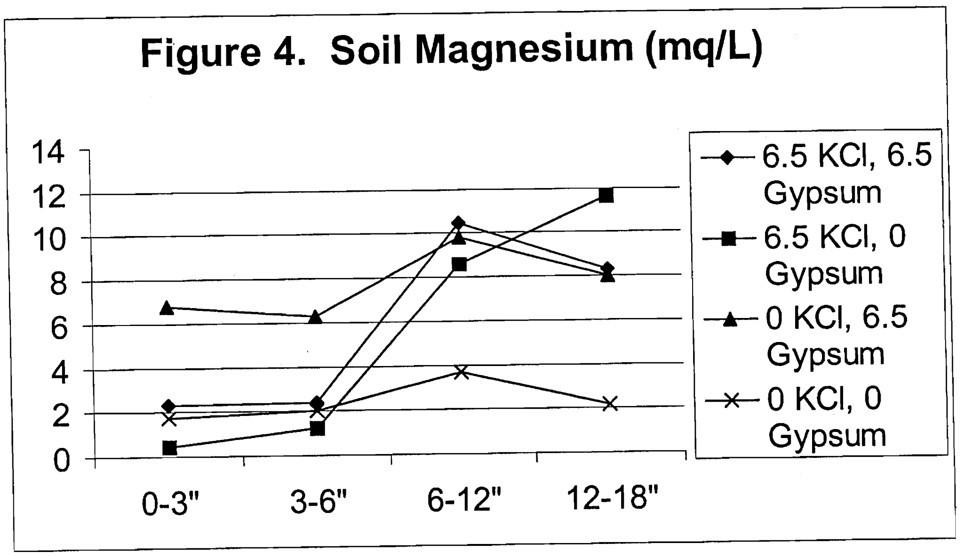


Figure 4. Soil Magnesium (mq/L)
14
12
10
8
6
4
2
0
0-3"
3-6"
6-12"
12-18"
6.5 KCl, 6.5 Gypsum
6.5 KCl, 0 Gypsum
0 KCl, 6.5 Gypsum
0 KCl, 0 Gypsum

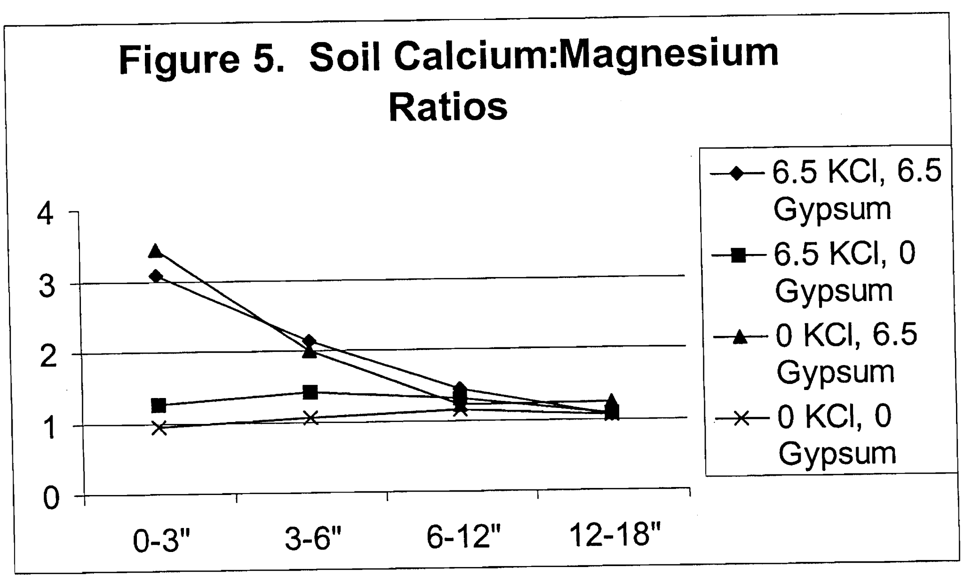


Figure 5. Soil Calcium:Magnesium Ratios
4
3
2
1
0
0-3"
3-6"
6-12"
12-18"
6.5 KCl, 6.5 Gypsum
6.5 KCl, 0 Gypsum
0 KCl, 6.5 Gypsum
0 KCl, 0 Gypsum

Table 1. Leaf Nutrient Levels

KCl	CaSO4	% N	% K	S (ppm)	% Ca	% Mg	% Cl
05/05/2000							
3.22	3.22	3.13	1.77	BC 1888	1.25	0.39	0.02
1.61	3.22	3.43	1.74	BC 1970	1.30	0.42	0.02
3.22	0	3.34	1.62	AB 1914	1.30	0.40	0.03
6.45	0	3.36	1.77	BC 2026	1.38	0.43	0.03
6.45	6.45	3.38	1.96	C 1992	1.34	0.41	0.02
1.61	0	3.41	1.81	BC 1968	1.39	0.44	0.02
0	0	3.24	1.49	A 1950	1.31	0.40	0.02
0	6.45	3.22	1.63	AB 1858	1.19	0.38	0.02
		NS		NS	NS	NS	NS
06/05/2000							
3.22	3.22	3.09	2.36	1962	1.84	0.51	0.03
1.61	3.22	3.13	2.38	2026	1.88	0.53	0.03
3.22	0	3.06	2.19	1966	1.89	0.53	0.04
6.45	0	3.25	2.39	2074	1.85	0.53	0.04
6.45	6.45	3.25	2.62	2074	1.92	0.54	0.03
1.61	0	3.03	2.41	2032	1.98	0.56	0.03
0	0	3.06	2.01	1978	1.85	0.51	0.03
0	6.45	3.12	2.15	1956	1.83	0.51	0.03
		NS	NS	NS	NS	NS	NS
07/07/2000							
3.22	3.22	2.19	2.23	1848	1.93	0.48	0.02
1.61	3.22	2.34	2.31	2016	1.96	0.51	0.02
3.22	0	2.40	2.09	1890	2.01	0.52	0.02
6.45	0	2.35	2.35	1984	1.92	0.50	0.03
6.45	6.45	2.25	2.41	1896	2.01	0.49	0.03
1.61	0	2.32	2.05	1916	2.11	0.54	0.02
0	0	2.30	2.05	1892	1.99	0.51	0.02
0	6.45	2.30	2.08	1874	1.91	0.50	0.02
		NS	NS	NS	NS	NS	NS

Table 2. Soil Nutrient Analysis

#KCl/tree	#Gyp/tree	depth	Ca meq/L		Mg meq/L		X-K ppm		Ca: Mg ratio	
3.22	3.22	0-3"	4.1	ABC	2.0	BCD	396.6	BC	2.03	B
1.61	3.22	0-3"	6.6	BC	2.8	D	259.0	B	2.48	B
3.22	0	0-3"	1.0	A	0.9	AB	526.2	C	1.22	A
6.45	0	0-3"	0.5	A	0.4	A	850.6	D	1.22	A
6.45	6.45	0-3"	7.1	C	2.3	CD	404.2	C	3.13	C
1.61	0	0-3"	1.5	AB	1.3	ABC	405.0	C	1.14	A
0	0	0-3"	1.6	AB	1.7	BCD	96.2	A	1.00	A
0	6.45	0-3"	23.4	D	6.8	E	92.4	A	3.39	C
3.22	3.22	3-6"	6.3	C	4.0	C	324.0	B	1.80	CD
1.61	3.22	3-6"	5.5	BC	3.5	BC	214.8	AB	1.60	BC
3.22	0	3-6"	3.0	ABC	2.5	ABC	288.8	AB	1.20	AB
6.45	0	3-6"	1.7	A	1.2	A	842.6	C	1.60	BC
6.45	6.45	3-6"	5.1	ABC	2.4	ABC	759.4	C	2.20	D
1.61	0	3-6"	4.2	ABC	3.5	BC	232.8	AB	1.00	A
0	0	3-6"	2.1	AB	2.0	AB	48.8	A	1.00	A
0	6.45	3-6"	12.6	D	6.3	D	61.4	A	2.00	CD
3.22	3.22	6-12"	11.1	C	9.7	C	53.8	A	1.18	AB
1.61	3.22	6-12"	11.5	C	9.9	C	61.6	A	1.16	AB
3.22	0	6-12"	7.7	B	6.4	AB	51.6	A	1.17	AB
6.45	0	6-12"	11.2	C	8.6	BC	139.0	B	1.33	BC
6.45	6.45	6-12"	15.1	D	10.5	C	158.4	B	1.49	C
1.61	0	6-12"	7.1	AB	6.3	AB	73.8	A	1.12	A
0	0	6-12"	4.2	A	3.7	A	33.0	A	1.13	A
0	6.45	6-12"	11.9	CD	9.8	C	41.8	A	1.32	BC
3.22	3.22	12-18"	6.4	BC	7.1	CD	55.4	NS	0.90	NS
1.61	3.22	12-18"	5.2	AB	5.1	BC	64.4		1.02	
3.22	0	12-18"	4.9	AB	5.0	BC	60.2		0.98	
6.45	0	12-18"	12.4	E	11.6	E	54.8		1.07	
6.45	6.45	12-18"	8.8	CD	8.3	D	46.2		1.06	
1.61	0	12-18"	4.3	AB	4.4	AB	54.6		0.97	
0	0	12-18"	2.3	A	2.2	A	43.0		1.04	
0	6.45	12-18"	9.8	DE	8.0	D	47.2		1.22	