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Potassium Fertigation Improves Soil K Distribution, Builds Pistachio Yield and Quality

Available soil potassium rapidly depletes in postachio orchards where it is not applied, adversely affecting pistachio yield and quality.

Summary: *Potassium (K) distribution in the soil profile is characterized by decreasing soil K content with depth. We initiated a three-year study to soil apply K through a micro-sprinkler in pistachio orchards to see if it would benefit yields and crop quality and restore these K-depleted soils. Subsequent observations showed that K content increased significantly throughout the 0 to 30-inch soil profile, even though movement of surface-applied K in the soil profile was slow. Thus, more K accumulated in the fruit and leaves of the pistachio trees, appreciably improving pistachio yield and quality.*

In California, distribution of applied K and balance of K in the soil profile of pistachio orchards have never been addressed. Traditionally, soil K status and K fertilization requirements have been evaluated on the basis of ammonium (NH_4) extractable K (referred to as exchangeable K in the remainder of this article).

Soil samples are frequently taken from a 0 to 6-inch depth. However, this approach to soil K analysis may not be suitable for irrigated pistachio, since root distribution and soil moisture regime may not be well represented by exchangeable K. In micro-sprinkler-irrigated orchards, K availability in the surface soil may change rapidly due to fluctuating soil moisture in response to wetting and drying during summers, a process that may enhance soil K fixation.

To accurately diagnose soil K deficiency and determine K fertilization requirements, a three-year study (1996-1998) was initiated in two commercial pistachio orchards to determine the distribution of applied K and soil K balance in the soil profile. The orchards were located in Yolo and Madera, California, with the following characteristics or setups at the time.

*Soil exchangeable **K*** in the 0 to 6-inch layer of soil was 156 ppm and 97 ppm, respectively.

Plant density was 247 trees per acre in both orchards.

Soil texture was silt loam at the Yolo site and sandy loam at Madera.

Fertilization. Potassium was applied annually at one-month intervals from May to August at rates of 0, 1.1, 2.2, and 3.3 lbs/tree/year as potassium sulfate (K_2S0_4) via a specially designed fertigation system. Equal rates of nutrients other than K were applied to all treatments.

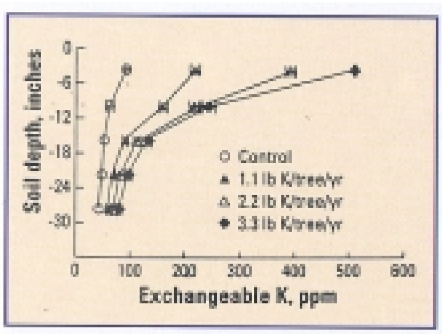

Figure 1. K distribution in the soil profile after three years of K fertilization at various rates, Madera orhard, Zeng, et al., University of California.

Plots consisting of five adjacent trees were arranged in a randomized complete block design with five replications.

Soil samples were collected in the fertigated zone in 6-inch increments from the 0 to 30-inch profile before and after the experiment to determine soil K distribution and balance after three years of K fertilization.

Soil K increases

Initially, the soils had low exchangeable K, suggesting the need to apply K for adequate K supply to the trees. Potassium fertilization significantly increased soil exchangeable K over the control (Figures 1 and 2). When K was applied at the rate of 2.2 lbs/tree/year, exchangeable K in the surface 12-inch depth more than tripled following three years of K fertilization. In contrast, soil K declined sharply in control plots, resulting in further soil K depletion.

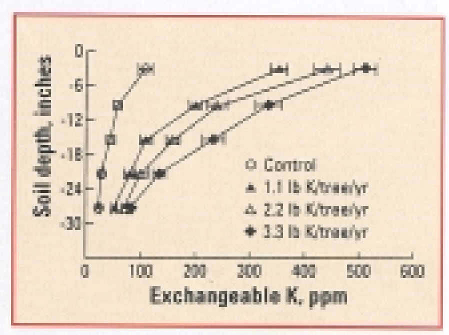

Figure 2. K distribution in the soil profile after three years of K fertilization at various rates, Yolo orhard, Zeng, et al., University of California.

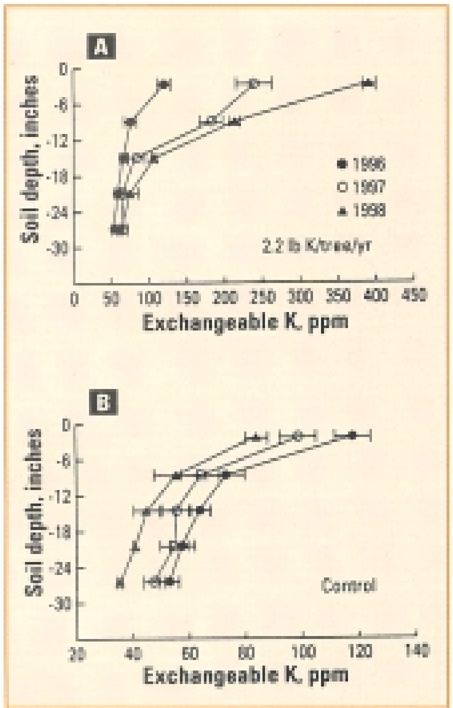

Figure 3. Changes of soil exchangeable K in soil profile with (A) and without K fertilization (B) Madera orhard, Zeng, et al., University of California.

K in soil profile

Soil K content decreased with depth in both soils. In K-treated plots, K applied to the soil surface moved downward in the soil profile, resulting in significantly higher soil K content than in control plots (Figures 3 and 4).

As K input increased, more K moved to deeper soil depths. Soil K content was significantly higher in the surface soil than in the subsoil, suggesting that the majority of applied K was held in the surface soil and that downward movement was slow. Slow downward movement of applied K may be partially attributed to net upward flux of soil water in the soil profile as a result of high evapotranspiration in summer.

Buffering capacity

The magnitude of soil K increases and movement of surface-applied K fertilizers were greater in the Madera than in the Yolo soil. The differences can be explained by the differential potential buffering capacity for soil K *(PBCk,* data not shown). The Yolo soil, which has abundant vermiculite and montmorillonite clays, had a higher ***PBCk*** value than the Madera soil, which has primarily kaolinite clay.

Soil K balance

Potassium fertilization significantly influenced soil K balance. Without it, exchangeable K in the 0 to 30-inch depth decreased by 0.37 and 0.34 lb/tree in the Madera and Yolo soils, respectively, resulting in depletion of soil available K.

In contrast, after three years of K fertilization, there was a net increase of exchangeable K from 0.38 to 1.56 lbs/tree in the Madera soil (Table 1) and 0.21 to 1.19 lbs/tree in the Yolo soil (Table 2), leading to soil K accumulation.

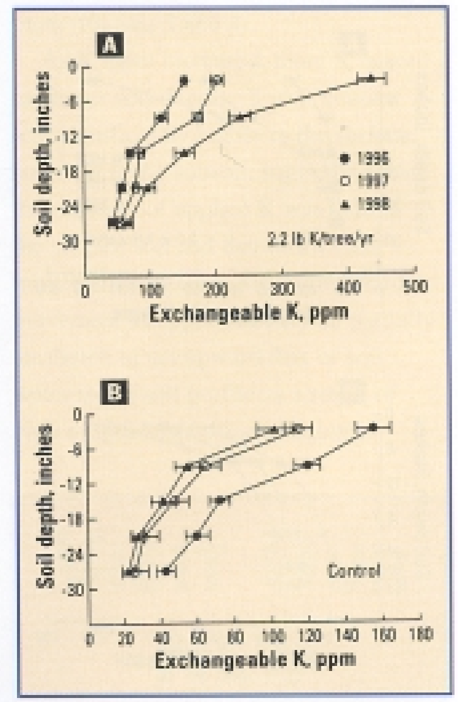

Figure 4. Changes of soil exchangeable K in soil profile with (A) and without K fertilization (B) Yolo orhard, Zeng, et al., University of California.

Pistachio trees accumulated significantly more K in K-treated plots than in control plots (Tables 1 and 2).

K accumulated in the fruit and leaves of the control trees at Madera was 2.05 lbs/tree and 1.65 lbs/tree at Yolo.

K accumulated in the fruit and leaves of the K-treated trees was 2.85 to 4.16 lbs/tree at Medera and 2.40 to 3.07 lbs/tree at Yolo.

Higher K accumulation in fruit and leaves is a result of increased K concentration and increased crop yield in K-treated plots (data not shown).

Table 1. Soil K balance (lb/tree) in 0 to 30-inch profile after three years of K fertilization, Madera orchard, Zeng, et al., University of California.

3-year K input lb/tree	Change in K lb/tree	K accumulation in fruit and leaves lb/tree	Soil K balance lb/tree
0.0	-0.37	2.05	-1.68
3.3	0.38	2.85	0.07
6.6	1.08	4.16	1.36
9.9	1.56	4.13	4.21

Table 2. Soil K balance (lb/tree) in 0 to 30-inch profile after three years of K fertilization, Yolo orchard, Zeng, et al., University of California.

3-year K input lb/tree	Change in K lb/tree	K accumulation in fruit and leaves lb/tree	Soil K balance lb/tree
0.0	-0.34	1.65	-1.32
3.3	0.21	2.40	0.69
6.6	0.70	2.90	3.01
9.9	1.19	3.07	5.64

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