CALIFORNIA

Effects of Potassium Fertilization on Soil Potassium Distribution and Balance in Pistachio Orchards

By David Qiupeng Zeng, Patrick H. Brown, and Brent A. Holtz

This study was conducted from 1996 to 1998 in two commercial pistachio orchards to determine the distribution of applied K and the soil K balance in the soil profile. In California, the distribution of applied K and K balance in the soil profile of pistachio orchards have never been addressed. Traditionally, soil K status and K fertilization requirements are 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 to a 0 to 6 inch depth. 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 microsprinkler-irrigated orchards, K availability in the surface soil may change rapidly due to fluctuating soil moisture in summer in response to wetting and drying, a process that may enhance soil K fixation.

Potassium (K) fertigation by microsprinkler significantly increased soil K content throughout the 0 to 30 inch soil profile in the three-year study. Available soil K was rapidly depleted where K was not applied, but increased for all K treatments. Yield and quality of pistachios were appreciably improved by K fertilization as reported in the previous issue of *Better Crops with Plant Food*, 1999, No. 3, pp. 10-12.

The orchards in the study were located in Yolo and Madera, California, where the initial soil exchangeable K in 0 to 6 inches of soil was 156 and 97 parts per million (ppm), respectively. The plant density was 247 trees/A in both orchards. Soil texture was silt loam and sandy loam in the Yolo and Madera orchards, respectively. Potassium was applied annually at one-month intervals from May to August at the rates of 0, 1.1, 2.2, and 3.3 lb K/tree/year as potassium sulfate (K_2SO_4) via a specially designed fertigation system. Equal rates of nutrients other than K were applied to all treatments. Individual plots consisting of five adjacent trees were arranged in a randomized

TABLE 1. Soil K balance (lb K/tree) in 0 to 30 inch profile after three years of K fertilization in the Madera soil.

3-yr K input, lb/tree	ΔK, lb/tree	K accumulation in fruit and leaves, %	Soil K balance, lb/tree
0	-0.37 d	2.05 c	-1.68 c
3.3	0.38 c	2.85 b	0.07 c
6.6	1.08 b	4.16 a	1.36 b
9.9	1.56 a	4.13 a	4.21 a

*Values with different letters are significantly different at P≤0.05.

TABLE 2. Soil K balance (lb K/tree) in 0 to 30 inch profile after three years of K fertilization in the Yolo soil.

3-yr K input, lb/tree	ΔK, lb/tree	K accumulation in fruit and leaves, %	Soil K balance, lb/tree
0	-0.34 d	1.65 c	-1.32 c
3.3	0.21 c	2.40 b	0.69 c
6.6	0.70 b	2.90 a	3.01 b
9.9	1.19 a	3.07 a	5.64 a

*Values with different letters are significantly different at P≤0.05.

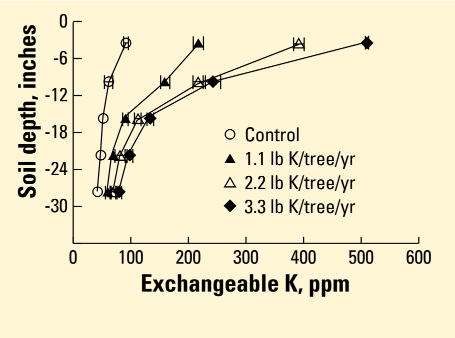

Figure 1. Potassium distribution in the soil profile after three years of K fertilization at various rates in the Madera orchard. Each value is the average of five repli cates ± standard error.

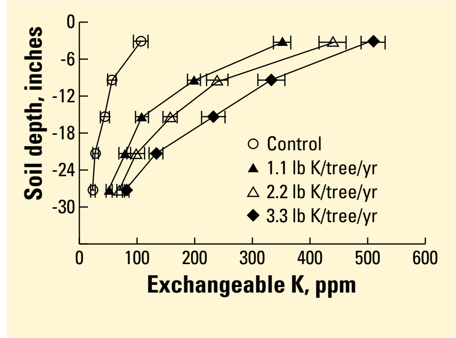

Figure 2. Potassium distribution in the soil profile after three years of K fertilization at various rates in the Yolo orchard. Each value is the average of five replicates ± standard error.

complete block design with five replications.

Soil samples were collected in 6-inch increments from the 0 to 30 inch profile in the fertigated zone before and after the experiment to determine soil K distribution and balance after three years of K fertilization based on mass balance of exchangeable K in the 0 to 30 inch profile: Soil K balance = 3-year K inputs - ΔK - crop K accumulation.

Crop K accumulation was estimated as the amount of K accumulated in fruits and leaves, and ΔK represents the net change of exchangeable K in the 0 to 30 inch profile in the fertigated zone. A negative soil K balance suggests that K was released from non-exchangeable forms while a positive balance indicates conversion of applied K to non-exchangeable forms.

Potassium Fertilization Increases Soil Available K

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 a rate of 2.2 lb K/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.

Distribution of Applied 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 evaportranspiration in summer.

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 (PBC^k, data not shown). The Yolo soil, which has abundant vermiculite and montmorillonite clays, had a higher PBC^k 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 K/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 exchange-

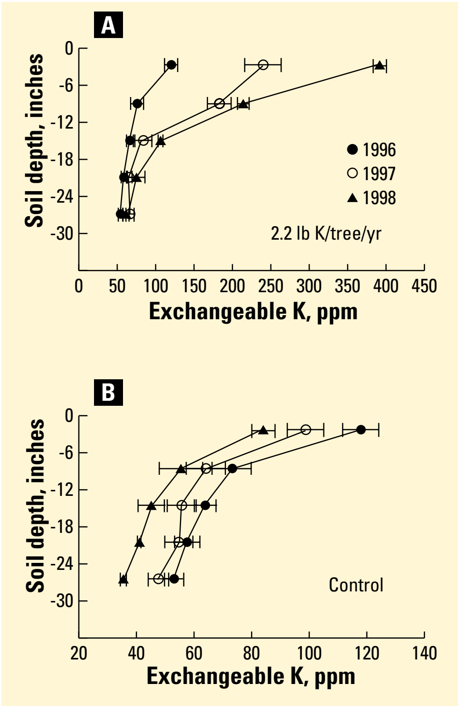

Figure 3. Changes of soil exchangeable K in soil profile with time with (A) and without (B) K fertilization in the Madera orchard. Each value is the average of five replicates ± standard error.

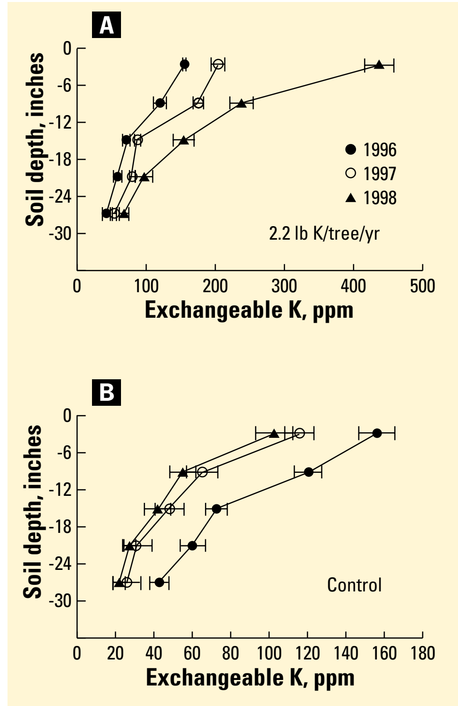

Figure 4 Changes of soil exchangeable K in the soil profile with time with (A) and without (B) K fertilization in the Yolo orchard. Each value is the average of five replicates ± standard error.

able K of 0.38 to 1.56 lb K/tree in the Madera soil (**Table 1**) and 0.21 to 1.19 lb K/tree in the Yolo soil (**Table 2**), leading to soil K accumulation.

Pistachio trees accumulated significantly more K in K-treated plots than in control plots (**Tables 1** and **2**). The control trees accumulated 2.05 and 1.65 lb K/tree in fruit and leaves in the Madera and the Yolo soils, respectively. Trees receiving K fertilizer accumulated 2.85 to 4.16 lb K/tree in the Madera soil and 2.40 to 3.07 lb K/tree in the Yolo soil. 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).

Conclusions

Potassium distribution in the soil profile is characterized by decreasing soil K content with depth. Potassium fertilization significantly increased soil K content throughout the 0 to 30 inch soil profile, even though the movement of surface-applied K in the soil profile was slow. More K was accumulated in the fruit and leaves in pistachio trees treated with K. Soil K balance data showed that without K fertilization, soil available K was rapidly depleted. To accurately diagnose soil K deficiency and to determine K fertilization requirements in pistachio, it is important to examine K status in the irrigated soil profile. BC

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