Potassium Fertilization and Diagnostic Criteria for Pistachio Trees

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Although fertilizers in general have played an important role in California pistachio production, K fertilization has been largely ignored. Limited use of K could be partially attributed to: a) a scarce knowledge of K requirement and lack of documented K effects on improving nut yield and quality in pistachio; and b) the out-of-date view that California soils are not K-deficient and can supply adequate quantity of K for pistachio production. Consequently, K deficiency has occurred and affected the productivity of pistachio trees in many orchards. If K fertilizers are not adequately applied to replenish the soil K pools, K deficiency is expected to increase in severity and extent.

Potassium (K) fertilization of pistachio trees in the Central Valley of California substantially increased both nut yield and quality during a three-year study. Results indicated that the presently suggested leaf K critical level of 1.0 percent should be increased to 1.7 percent or higher.

This study was designed to determine the effects of K fertilizer, applied at the rates of 0, 120, 240, and 360 lb K_2O/A on leaf K concentration, nut yield, and quality of pistachio. Three field experiments were conducted from 1996 to 1998 on mature 'Kerman' pistachio trees in three commercial orchards located in Madera, Yolo, and Orland, CA. Available soil K in the surface 0 to 6 inches of soil was 82, 97, and 125 parts per million (ppm), respectively. Potassium was applied annually as potassium sulfate (K_2SO_4) via a specially designed fertigation system.

In pistachio, K deficiency is characterized by smaller, upward curling leaves with scorched leaf margin. The symptoms appear first on older leaves and those adjacent to the maturing fruits.

Potassium Fertilization Increases Leaf K

Pistachio trees exhibit highly dynamic seasonal K fluctuations (**Figure 1**). During spring flush from April to May, K demand is relatively low, and K uptake from the soil is minimal. Leaf K concentration during spring flush is usually below 1.0 percent. As fruit development proceeds, leaf K concentration increases dramatically, with the most significant increase occurring from July to September, the peak nut-fill period when the K demand and accumulation in the maturing nuts are maximal. Leaf K concentration declines rapidly after harvest in September, suggesting the translocation of leaf K to perennial tree organs to build the tree K storage pool.

Potassium fertilization improved K nutrition in the pistachio trees, with leaf K concentration being significantly higher in the K-treated trees than in the control trees not treated with K. However, the difference in leaf K concentration was not significant among the three K application rates, i.e., 120, 240, and 360 lb K_2O/A, except in the

Madera orchard where leaf K concentration was significantly higher in trees receiving 360 lb K_2O/A compared to those receiving 120 lb K_2O/A (data not shown).

Potassium Fertilization Increases Nut Yield

Average nut yield in control plots not receiving K fertilizers was 1,223, 1,934, and 1,963 lb/A in the Yolo, Madera, and Orland orchards, respectively (**Figure 2**). In contrast, when K was applied at the rate of 120 to 240 lb K_2O/A, the trees yielded 1,567 to 1,823 lb/A in the Yolo orchard, 2,806 to 3,179 lb/A in the Madera orchard, and 2,619 to 3,126 lb/A in the Orland orchard. With a further increase of annual K fertilization to 360 lb K_2O/A, the average nut yield was 1,695, 2,802, and 2,659 lb/A in the Yolo, Madera, and Orland orchards, respectively, which is a decrease of nut yield compared to 240 lb K_2O/A. This yield decrease was significant (at $P \leq 0.05$) in the Madera and Orland orchards, but not in the Yolo orchard. Reduced nut yield at high rates of K fertilization may be associated with reduced leaf calcium (Ca) and magnesium (Mg) concentrations, both of which were below the optimal ranges, suggesting potential antagonisms among K, Ca, and Mg (data not shown).

Fertilization Increases Nut Quality

The percentage of split, blank, and stained nuts and 100-nut weight are the major quality criteria used to grade pistachio nuts. It is desirable to produce a high percentage of split nuts and a high 100-nut weight, but low percentages of blank and stained nuts. **Figure 3** shows that the K-treated trees produced a significantly higher percentage of split nuts, higher 100-nut weight, and a significantly lower percentage of blank and stained nuts than in the control trees not receiving K. This clearly demonstrates improved nut quality due to K fertilization. However, there were no significant differences in these quality parameters among the treatments receiving K fertilization. Increased percentage of split nuts and nut weight are indicative of enhanced nut filling, probably due to enhanced photosynthesis and

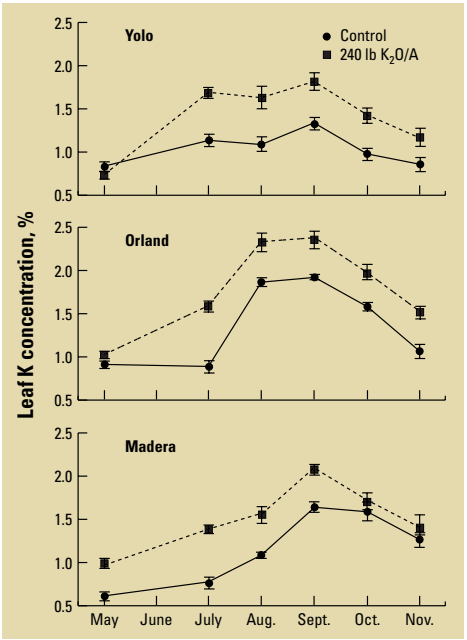

Figure 1. Seasonal variation in leaf K concentration in pistachio in 1998 in three orchards. Each value is the mean ± standard error of 5 replicates.

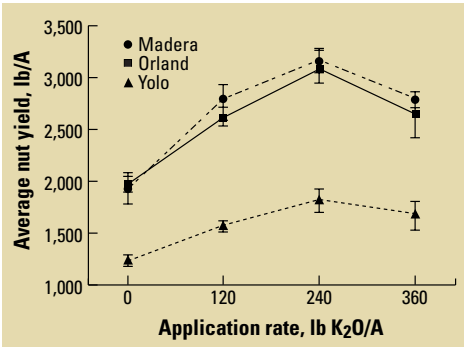

Figure 2. Yield of in-shell nut (average of 3 years) as affected by K applied at various rates in pistachio. Each value is the mean ± standard error of 5 replicates.

photoassimilate transport to the developing nuts when K fertilizer is applied. Nut staining is caused by fungal diseases, i.e., *Botroyspheria* and *Alternaria*, as pistachio trees are highly susceptible to fungal infections in orchards with high humidity. Reduced nut staining in the K-treated trees

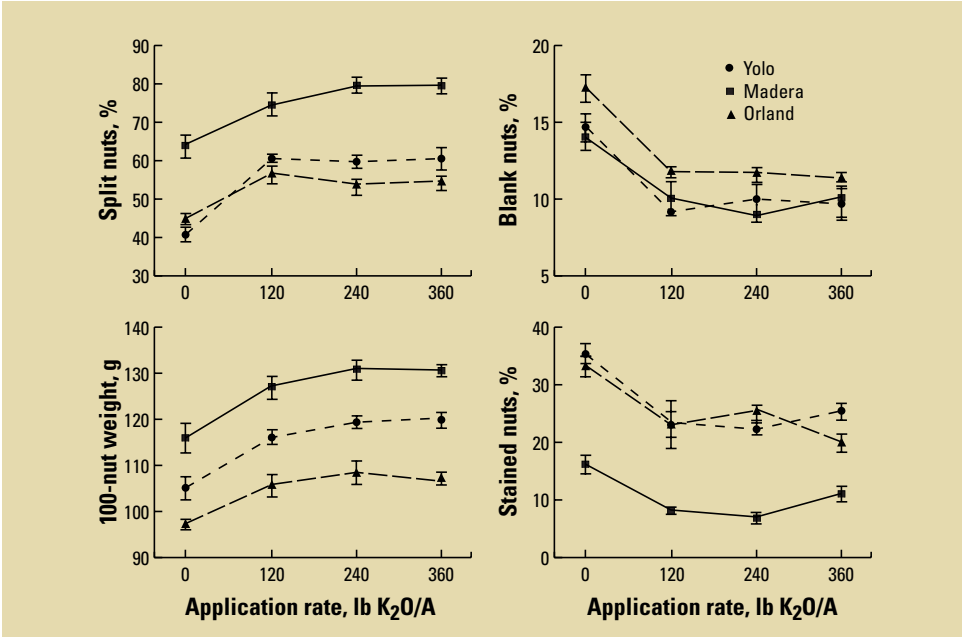

Figure 3. Potassium application improves pistachio nut quality. Each value is the average of 5 replicates ± standard error.

indicates that K may help build resistance of pistachio trees to diseases.

The Diagnostic Criteria for K Nutrition

In this study, the marketable, in-shell nut yield and leaf K concentration during the nut-fill period were averaged over three years for each orchard to perform a regression analysis at $P \leq 0.05$. The maximum nut yield ($Y_{100\%}$), 95 percent of the maximum yield ($Y_{95\%}$), and their corresponding leaf K concentrations ($K_{100\%}$ and $K_{95\%}$) were calculated. Researchers often use $Y_{95\%}$ as the reference point to diagnose nutrient status (sufficient vs. deficient) and refer to it as the critical leaf value. There was a significant, positive correlation between nut yield and leaf K concentration during nut fill in pistachio. Maximum nut yield ($Y_{100\%}$) was 1,844, 3,228, and 2,769 lb/A, with corresponding leaf concentration ($K_{100\%}$) being 2.03, 1.96, and 2.29 percent in the Yolo, Madera, and Orland orchards, respectively. The $K_{95\%}$ at $Y_{95\%}$ was 1.67, 1.69, and 2.02 percent in these three orchards, respectively. These results indicate that the presently suggested critical leaf K value of 1.0 percent, which was developed based on the expression of visual deficiency symptoms in the leaf, is too low to predict the K fertilization requirements for optimal pistachio production and that new K diagnostic criteria associated with optimal yield levels should be adopted.

Conclusions

Potassium fertilization increased leaf K concentration, nut yield, and quality in pistachio. The critical leaf K value for 95 percent maximum yield is 1.67 to 2.02 percent. It is recommended that K fertilizers be applied at the rate of 120 to 240 lb K_2O/A in California pistachio production. BC

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