CALIFORNIA

Phosphorus and Potassium Nutrition of Pistachio Trees as Affected by Alternate-Bearing

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The large amount of woody biomass of mature trees (branches, trunk, roots) makes it difficult to assess the magnitude and dynamics of nutrient uptake and over-winter storage. The situation is further complicated by alternate fruit bearing, because differential crop load influences the pattern of nutrient uptake and usage.

Pistachio trees are highly alternate bearing, with an on-year followed by an off-year. Heavy fruiting has been shown to depress root growth in many tree crops, but little is known about the relationship between root growth and nutrient uptake in mature trees. Many researchers have assumed that nutrient uptake and root growth are concurrent processes, with increased root growth resulting in greater nutrient uptake. This hypothesis, however, has not been adequately tested. An understanding of the effects of alternate nut bearing on nutrient uptake and root growth is a prerequisite to developing best management practices for pistachio fertilization.

An experiment was conducted to evaluate the effects of alternate bearing on root growth and P and K nutrition of pistachios in the San Joaquin Valley of California. On-year trees yielded approximately 2,400 lb/A, while off-year yields were 800 lb/A.

Pistachio trees are highly alternate bearing, with a heavy cropping year (on-year) followed by a light cropping year (off-year). Uptake and partitioning of phosphorus (P) and potassium (K) among tree parts were determined during nut fill (late May to early September). Although root growth was reduced during nut fill in on-year trees compared with off-year trees, there was no relationship between root growth and the uptake of P or K from the soil. This indicates that sink (nut) demand rather than root growth regulates the uptake of P and K.

Root Growth

Roots from 12 trees were counted every two weeks between fruit set and leaf senescence (April 15 to November 15). Root growth was determined by counting white (actively growing) roots growing up against root observation boxes installed in the herbicide strip in the microjet spray zone.

Root growth varied seasonally and was influenced by alternate bearing (**Figure 1**). On-year trees initiated root growth earlier in the spring than off-year trees and produced three times more roots during spring flush than off-year trees, measured three weeks following anthesis (April 22). On-year trees, however, produced significantly fewer white roots during nut growth (June 16) compared with off-year trees. During nut growth and development, root growth rates and elongation were significantly depressed in on-year vs. off-year trees (data not shown). This research supports previous studies with other fruit tree species that heavy fruiting reduces root growth.

Nutrient Uptake

To assess the effects of alternate bearing on P and K uptake in pistachio trees, six trees (three on-year and three off-year) were excavated following spring growth flush

(May 24), and another six were excavated following nut fill (September 8). The trees were separated into various fractions (leaves, fruit, trunk, branches, and roots) and were weighed and analyzed for P and K. Total annual P and K uptake was determined by the difference in the total tree P and K contents between the September and May tree excavations dates.

Root observation boxes among pistachio trees allowed counting of actively growing roots from April to November. However, researchers found no relationship between root growth and uptake of P and K from the soil.

Heavy cropping increased nutrient uptake, particularly in the case of K (**Figure 2**) compared to the alternate light crop. Pistachio trees took up over 200 lb K_2O/A during the on-year as compared to only 70 lb during the off-year...about three times more. Fourteen percent more P was taken up in on-year vs. off-year trees. The large increase in K uptake may reflect the role it plays in sugar transport which includes: 1) binding to carboxylates and transport (mainly as K_2-malate) in the phloem to fruits and roots and 2) acting as an osmoticum to develop pressure gradients in the phloem for the transport and storage of sugars.

The increase in P and K uptake occurred despite the fact that root growth was significantly reduced in on-year vs. off-year trees. On-year trees had four times fewer white roots growing against the root boxes during the nut fill period than off-year trees, yet K uptake was triple in the on-year trees. For the decoupling between root growth and nutrient uptake to occur, the rate of nutrient uptake per unit of root length in fruiting trees must be higher than that of non-fruiting trees. Simulation models have shown that doubling root uptake kinetics (activity) is as effective as doubling root growth in increasing nutrient uptake. Thus, increases in the rate of nutrient uptake by roots can compensate for a lack of root growth.

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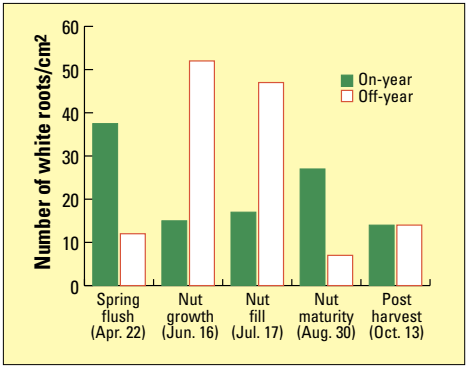

Figure 1. Effects of alternate-bearing on the number of observed white roots during the various growth phases.

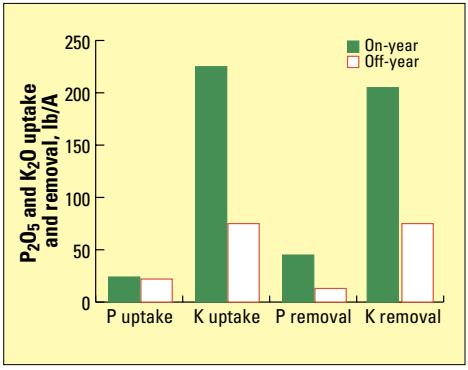

Figure 2. Uptake of P and K during the nut fill period (May 24 to September 8) and removal of P and K in nuts and abscised leaves in on-year and off-year trees.

nutrients requires reducing losses to the environment and to weeds. Weeds, like crops, respond positively to increased soil fertility. In a worst-case scenario, crop yields may actually decrease as fertilizer rates increase if weeds have access to the added fertility.

Further research will be conducted to develop agronomic practices that simultaneously reduce weed populations and result in optimal crop yields. A greater understanding of how N and P placement affects crop-weed competition should lead to a clearer interpretation of why differences occurred among previous studies. In addition, it could lead to the development of fertilization strategies, such as timing and placement of nutrients, that reduce weed interference with crops. BC

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*P and K Nutrition of Pistachio Trees...**(continued from page 19)*

Nutrient Removal

Almost all of the K taken up by the on-year trees was subsequently removed in fruit and abscised leaves during late summer and fall (**Figure 2**). This indicates that little K was stored over winter and that substantial quantities of K must be present in the soil during heavy cropping years to avoid K deficiency. In contrast, P removal was double that of P uptake during the on-year, indicating that much of the P demand was met by redistribution from storage. Phosphorus, therefore, can be stored in perennial tree parts and used the following year, but little K appears to be stored and used in the subsequent year.

The pronounced effect of alternate fruit bearing on tree P and K demand and capacity for uptake has important implications for fertilizer management. The greatest amount of soil P and K uptake occurred during the nut fill period in on-year trees. Thus, P and K must be available in the soil at this time. How much P and K to apply, however, depends on management considerations such as method of application, soil test values, and tree density, as well as tree physiological considerations such as nutrient status and potential crop yield.

Summary

We examined interrelationships among crop load, P and K uptake, and root growth in mature pistachio trees that characteristically bear heavy (on-year) nut crops in alternate years. Uptake and partitioning of P and K among tree parts were determined during nut fill (late May to early September). Although root growth was reduced during nut fill in on-year trees compared with off-year trees, there was no relationship between root growth and the uptake of P or K from the soil. Our data support the hypothesis that sink demand rather than root growth regulates the uptake of P and K in pistachio trees. BC

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