PHYSIOLOGICAL ASSESSMENT OF POTASSIUM CRITICAL VALUE IN ALMONDS

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Introduction

Potassium (K) is an essential plant nutrient removed from the orchard in large amounts in the almond crop. Increasing average yields due to refinements in pollination, irrigation and other management variables, coupled with long term cultivation on sandy soils has apparently reduced soil K reserves in much of the almond acreage in California. Some discussion with respect to the adequacy of current UC leaf K guidelines. The experimental foundation for the current guidelines is not clear, and a reassessment of K critical values - i.e., the leaf K conc. below which yields are affected adversely - is underway in a currently-funded Almond Board project (Brown and Weinbaum, Proj. No. 99-PB-00). Results of that study suggest that yields were not impacted significantly for two years following imposition of potassium stress (i.e., withholding K fertilization, and that yield decline was not conspicuous until leaf K concn. dipped below 1.1% in July spur leaf samples (non-fruiting spurs). It would appear desirable to maintain leaf K concentrations in the 1.4 to 1.6% dry weight range.

Background

Brown and Weinbaum's study indicated that percentage fruit set and nut size were not impacted by K deficiency which resulted in yield decline. Fruit are borne primarily on spurs in mature almond trees. We suspected, therefore, that the yield decline in K-deficient trees resulted from a reduction in the number of flowers per tree, and the reduction in flower number per tree may have resulted from reduced vegetative growth and an associated reduction in spur renewal and/or an increase in spur mortality.

We hypothesized that K deficiency may reduce photosynthesis and, as a result, reduce spur and shoot growth. Shoot and spur growth occur primarily in the early part of the growing season (March to early May). Early-season vegetative growth is thought to be dependent upon stored carbohydrate which, in turn, is dependent upon late-season photosynthesis which occurs after growth has slowed down for the season. To maintain yields in mature trees, a population of viable fruit-bearing spurs must be maintained. This may result from the combination of spur replacement and the delay of spur mortality. Previous work indicates that at least 40%-50% of the spurs may die within 4-5 years.

Objectives

Our objectives were to assess relationships between photosynthesis and yield reduction in K-deficient almond trees. Previous observations suggested some premature i.e., early-season, defoliation in the low K trees, and this may contribute to a reduction in the photosyntheticallyactive leaf canopy per tree and reduced storage of carbohydrates that overwinter and are available to support bloom and early vegetative growth in the spring. Thus, the first objective was to determine if canopy light interception differed among trees receiving differing amounts of K fertilizer over the previous three years. A second objective was to determine whether the relationship between leaf K concentrations may be used to develop a physiologically – based K critical value in almonds.

Procedures

Differential K fertilizer application rates (O, 200, and 800 pounds K per acre) over a three year period resulted in a range of leaf K concentrations between 0.5% and 2.0%. Leaves were sampled in July from fruiting and non-fruiting spurs on 15 trees encompassing the range of leaf K concentrations.

The relationship between tree leaf K concentrations and carbon gain was assessed in two ways:

1. TREE K STATUS. Leaf K concentrations were determined in July using standard analytical procedures. Forty leaves per tree (20 leaves from fruiting and 20 leaves from non-fruiting spurs) were sampled from 15 different trees.

2. PHOTOSYNTHETIC RATES. The effect of tree K status on photosynthetic rates were assessed on April 25, May 31, July 31, and August 10 (postharvest). Five leaves per tree were measured between 11 AM and 1 PM on cloudless days. Photosynthesis rates were measured with a CIRAS portable infra-red gas analysis system on well-exposed leaves on spurs attached to large fruiting branches.

3. LIGHT INTERCEPTION. Measurement of light interception at the orchard floor was used to resolve possible differences in foliage density between low K and high K trees as a result of differences in the amount of premature defoliation. Thus, greater light interception may indicate a greater leaf area in the tree canopy. Reduced leaf area may indicate reduced growth i.e., fewer nodes and leaves, smaller leaves and/or premature defoliation.

Results

TREE K STATUS. After several years of differential K application rates, leaf K concentrations in non-fruiting spurs varied significantly (Table 1), and ranged from 0.7 to 1.7%. Irrespective of K availability (i.e., K fertilizer application rates), leaf K concentrations were invariably lower on fruiting spurs than on non-fruiting spurs.

PHOTOSYNTHESIS. Leaf photosynthetic rates on non-fruiting spurs were not consistently related to K application treatments or leaf K concentration that season. The July data in Figure 1 are representative of the measured relationship between leaf photosynthesis and leaf K concentrations between 0.5% and 2.1%.

LIGHT INTERCEPTION. There was a significant positive linear trend of light interception and leaf K concentration. Thus, light interception appeared to be less in low K than in high K trees

(Figure 2) and it is likely that this reflects a somewhat lower canopy photosynthetic capacity of the low K trees.

Discussion

The lack of any correlation between the leaf K concentration of non-fruiting spurs, individual leaf photosynthetic rates on those spurs, and the yield reduction which occurred in trees with July leaf K concentrations below 1.1%K indicated the individual leaf photosynthesis was not coupled directly to the yield reduction. The somewhat lower light interception in low K trees is consistent with some premature defoliation on low K trees and a possible decrease in leaf size-especially on fruiting spurs. This may have lead to a somewhat reduced whole canopy rate of photosynthesis since canopy photosynthesis is generally highly correlated with canopy light interception. However this may not be the primary factor determining yield loss in K deficient trees. Brown and Weinbaum could not document a reduction in vegetative growth and spur renewal on low K trees, however, they reported increased mortality in a segment of the population of fruiting spurs which bore two or more fruit per spur. The lower leaf K status of heavily fruiting spurs and the heavy local fruit demand for potassium resulted in nearly complete preharvest defoliation of those spurs. We suggest, therefore, that the factors which contribute to yield reduction in low K trees are the following: a) heavy crop loads which increases tree demand for potassium, b) low K availability leading to local K stress and premature defoliation on heavily-cropping spurs, and finally c) death of those highly fruitful spurs and the resultant reduction in the number of viable spurs in subsequent years.

Table 1. Effects of K application on leaf K concentration and yield in 2000[z].

Treatment	Leaf K (% of dry weight)		Yield
(lbs. K/acre)	(fruiting spurs)	(non-fruiting spurs)	(meat lbs./acre)
000	0.5	0.7	2280
200	0.9	1.2	2650
500	1.0	1.4	2660
800	1.3	1.7	2640
	**	**	*

[z]Application of treatments began in 1998.
[*] Denotes significant differences among treatment means at $p<0.05$.
[**] Denotes significant differences among treatment means at $p<0.01$.

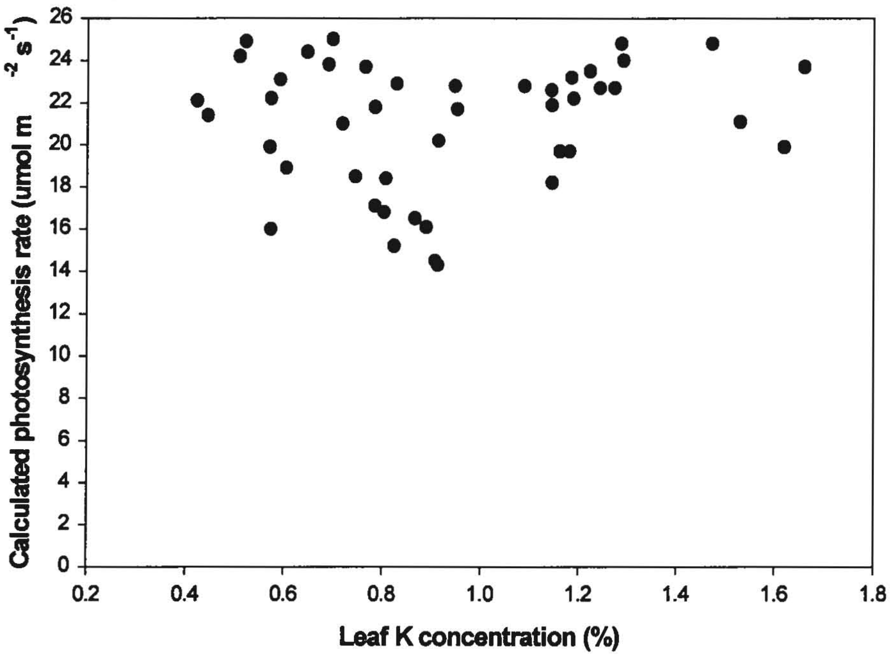

Figure 1. Almond leaf photosynthesis rates in response to leaf K concentration. Photosynthesis was measured during mid-morning and leaf K concentration was determined on composite leaf samples including the leaf involved in the photosynthesis measurement and four adjacent leaves on the same spur.

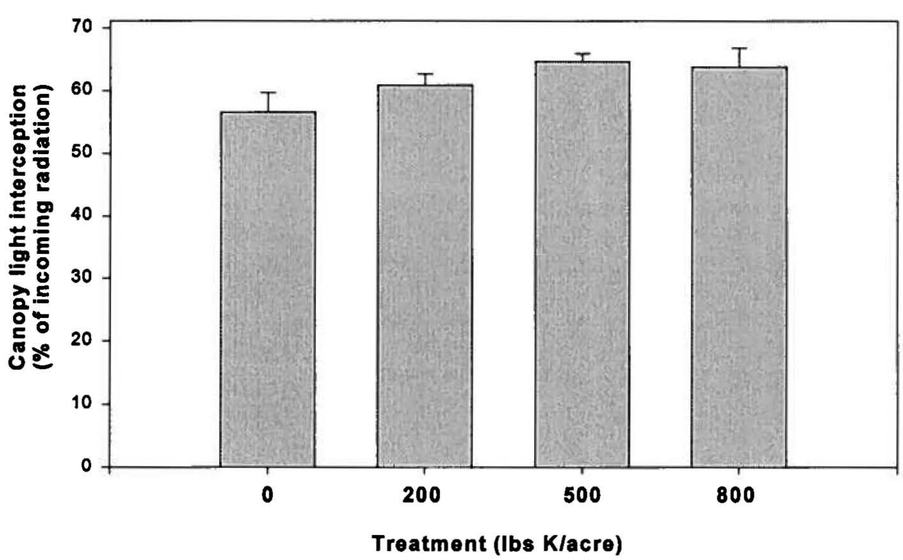

Figure 2. Canopy light interception of trees that have received differing amounts of K fertilization over the past four years. Measurements were made at mid-day under three trees per treatment.