PRELIMINARY STUDIES ON THE USE OF RUBIDIUM AS A POTASSIUM TRACER IN PRUNES.

F. Niederholzer
R. Rosecrance

PROBLEM AND ITS SIGNIFICANCE

Potassium (K) is an essential nutrient, vital to the health of a mature, cropping prune orchard. Potassium fertilizer is significant annual expense for prune growers, and research to improve K fertilizer use efficiency should benefit prune growers. Unfortunately, a non-radioactive tracer for K research (such as ^{15}N used in nitrogen studies) does not exist. Changes in leaf nutrient concentrations don't always match changes in plant nutrient content, because fruit and woody tissue also contain significant amounts of essential nutrients. So, using leaf analysis for a particular nutrient doesn't always reflect the activity of that nutrient in the entire plant. Without a tracer to follow current fertilizer uptake, researchers must rely on destructive, whole tree sampling to measure differences in tree K absorption. This approach is expensive and time consuming. Tree crop K research would benefit from the development of new approaches to studying K uptake and movement in the tree and/or orchard.

Rubidium (Rb) is an element in the same chemical family as K, and has similar chemical properties. Rubidium has been used as a K analog in agricultural and natural ecosystems research for many years. It does not function exactly like K in plants and animals, but is non-toxic, relatively inexpensive and behaves similarly.

Rubidium occurs naturally in soils in amounts that are just a fraction of K content. In contrast, fertilizer K contains very little Rb, so changes in plant K to Rb ratios have been used as a means of measuring changes in fertilizer K content of plants – both trees and annuals.

We propose research to test the feasibility of using Rb in prune orchards as a tool to assess root system activity at different times of the year and in different locations in the soil. In addition, we will evaluate the potential for use of K/Rb ratios in future K research.

Objectives:

1) Learn how to use Rb in experiments in prune orchards.

2) Evaluate the possibility of using a Rb to track K movement in the soil and tree.

PROCEDURES

An experiment was set up in a commercial prune orchard in Sutter County to test Rb as a K tracer. The experiment will test the hypothesis that adding gypsum to a band of K sulfate fertilizer applied to the soil under prune trees in the late fall or winter can increase Rb content in the tree. Twenty, 15-year-old, similarly sized 'French' prune trees were selected by visual inspection. Five trees were fertilized with K + Rb at a rate equivalent to 400 pounds of K sulfate per acre. Seven percent of the fertilizer was applied as Rb sulfate (100 grams/tree). Five other trees were treated with the same amount of K+Rb, and granular gypsum equivalent to 1000 pounds per acre was applied over the top of the K. Five other trees received just gypsum and no K. Five additional trees were identified as untreated control trees and received no fertilizer.

Leaves, 30 per sample, were taken from bearing spurs, non-bearing spurs, and shoots from all 20 trees on September 1, 2010 – the day before harvest. Leaves were kept on ice, transported to the lab, leaf area was determined, leaves were rinsed in tap water, and then oven dried at 55^{o}C. Leaf K and Rb concentrations were determined via lab analysis, and leaf K and Rb contents were determined using specific leaf weights (leaf weight per unit area).

In 2010, the study orchard was not thinned. Total crop fresh weight from each tree, including field screened fruit, was measured at harvest. Three to four pound fresh weight subsamples were dried at the Sunsweet dryer in Gridley. Total crop dry weight was then determined from dry away ratio and total fresh weight. Fruit size distribution was determined from each dried subsample by 1) screening and 2) direct weight of individual fruit. Fruit mesocarp was cut from the pit after drying and submitted for analysis for K and Rb.

In spring, 2011, the study orchard was thinned. Since there was no difference in leaf K or Rb between bearing and non-bearing spurs in 2010, in 2011, no effort was made to sample specific spur types (bearing or non-bearing. On July 19, 2011, 30 leaves from bearing and non-bearing spurs were sampled, stored, processed and analyzed as in 2010. Whole tree yields were taken for each of the 20 trees in the experiment at harvest as in 2010. Fruit flesh analysis results have not yet been received.

RESULTS AND DISCUSSION

In 2010, Rb levels in different leaf samples followed a similar pattern as K levels (Table 1). Spur leaf samples showed K and Rb levels roughly double those of upright, vertical shoots.

In 2010 or 2011, K treatments did not significantly change total dried fruit yield /tree or the percent A+B screen fruit (Tables 2 and 3). In addition, K treatments did not alter leaf K levels in either year (Tables 2 and 3) or "A screen" dried fruit flesh K concentrations in 2010 (Table 2).

Application of 100 grams of Rb per tree in December, 2009 doubled leaf rubidium levels compared with trees not receiving rubidium in 2010 and 2011, and significantly increased fruit flesh rubidium levels in 2010 compared with trees not receiving K+Rb (Tables 2 and 3).

Addition of gypsum to K+Rb fertilizer did not affect dry fruit yield, dried fruit size, or leaf rubidium levels compared with fertilized (K+Rb) trees that didn't receive gypsum. However, adding gypsum to K+Rb fertilizer did significantly increase A screen fruit flesh rubidium levels in 2010 compared with other treatments (Tables 2 and 3). Because all K+Rb fertilized trees had similar dry fruit yield and trees treated with K+Rb+gypsum contained more Rb than K+Rb treated trees (Table 2), it is possible that adding gypsum with K fertilizer increases the current season uptake of K by mature prune trees compared to tree receiving K fertilizer without gypsum amendments.

The amount of Rb recovered in prune trees following the application of 100 gms (1/4 lb/tree) of rubidium sulfate/tree appears to be very small. In heavily cropping prune trees, fruit can contain up to 75% of total tree K content, and roughly 90% of fruit K is in the flesh (mesocarp). Assuming that two thirds of the tree Rb content is in the fruit, and most of the Rb (like K), in the fruit is in the flesh -- and using the fruit dry weight and flesh ppm Rb values in Table 2, it appears very probable that less than 1% of the Rb applied to the soil in December, 2009 was contained in the tree at harvest in September, 2010. If Rb is a 1:1 analog for K in prunes and soil, these data translate to a very inefficient recovery of fall applied soil K fertilizer in prune trees the year after harvest. While this is a preliminary experiment and the status of Rb as a K analog in Sacramento Valley soils needs more complete evaluation, given the high cost/acre of soil applied potassium fertilizer in prune production, these results are thought provoking and suggest more research on the topic of K fertilizer use efficiency in prune production is needed.

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Table 1. The influence of leaf location and/or spur cropping status on leaf potassium or rubidium concentration -- on a dry weight basis -- in ‘French’ prune. Samples were taken on September 1, 2010.

Treatments	% Leaf K	ppm Leaf Rb
Bearing spur leaves	**1.66 a**	**12 a**
Non-bearing spur leaves	**1.61 a**	**11 a**
Vertical shoot leaves	**0.75 b**	**7 b**

Table 2. Affect of addition of potassium, potassium + gypsum or gypsum to the soil under mature ‘French’ prune trees in December, 2009 on crop yield/tree (pounds dry weight), % A+B screen fruit, %leaf K, ppm leaf Rb and Rb fruit flesh (mesocarp) in 2010. Treatment details appear in the text. Data followed by the same letter are not significantly different (95% certainty) than other values in that same column.

Treatments	Dried fruit/tree (lbs)	% A+B screen per tree	% Leaf K*	Leaf Rb* ppm	“A” screen Fruit flesh K (%)	“A” screen Fruit flesh Rb (ppm)
Control	**68 a**	**81 a**	**1.5 a**	**4 a**	**0.94 a**	**5 a**
Gypsum only	**49 a**	**84 a**	**1.4 a**	**5 a**	**0.92 a**	**7 a**
Potassium only*	**57 a**	**91 a**	**1.7 a**	**11 b**	**0.94 a**	**13 b**
Gypsum + potassium*	**58 a**	**91 a**	**1.5 a**	**12 b**	**0.92 a**	**19 c**

*Non-bearing spur leaves, sampled September 1, 2010

Table 3. Affect of potassium alone, potassium + gypsum or gypsum alone applications in December, 2009 on crop yield per try (pounds dry weight), % A+B screen fruit, leaf K, and leaf Rb in 2011. Treatment details appear in the text. Data followed by the same letter are not significantly different (95% certainty) than other values in that same column.

Treatments	Total crop dry wt/tree (lbs)	% A+B screen per tree	% Leaf K*	Leaf Rb* ppm
Control	**33.2 a**	**99 a**	**1.7 a**	**5 a**
Gypsum only	**37.7 a**	**97 a**	**1.7 a**	**7 a**
Potassium only*	**43.0 a**	**97 a**	**1.6 a**	**13 b**
Gypsum + potassium*	**50.5 a**	**96 a**	**1.6 a**	**14 b**

*Bearing and non-bearing spur leaves, sampled July 19, 2011