Exploring Agrotechnical and Genetic Approaches to Increase the Efficiency of Zinc Recovery in Peach and Pistachio Orchards

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Introduction:

Zinc (Zn) is an essential plant micronutrient, and Zn deficiency is widespread causing economic losses throughout the world. Among fruit crops, pecan, peach, citrus and avocado seem to be particularly sensitive to Zn deficiency. The need to investigate alternative strategies to improve tree response to Zn applications has been voiced widely because there are impediments to Zn recovery by trees following either soil or foliar applications. Also, the potential for contaminating soils with excess Zn applications has been receiving increased attention in recent years. In California, soil alkalinity limits the availability of zinc in the root zone, and the limited mobility of foliar-applied zinc in pistachio and perhaps other species, may be attributed partially to the high binding capacity of leaf tissue for zinc. We have proposed a multi-faceted approach to improve Zn recovery by trees whether applied to soil or foliage. We have focused on peaches and pistachios. Peaches are so prone to Zn deficiency, especially on Nemaguard rootstock, that yearly applications are basically a standard practice, even in orchards showing no deficiency symptoms. Pistachio orchard recommendations for alleviating Zn deficiency are greater than for any other fruit or nut crop (40 lbs zinc sulfate/acre), so the potential for soil contamination is high.

Although we have tried both soil-applied and foliar treatments, our emphasis has been on soil applications since this should provide for a more permanent solution to Zn deficiency. In his review of Zn in horticultural crops in 1999, Swietlik concluded that foliar sprays provide only temporary relief and do not correct Zn deficiency in the roots. Past recommendations for soil applications have often been in excess of several hundred pounds per acre, which could lead to soil contamination problems. In order to substantially reduce these rates we have taken advantage of soil chemical reactions and root functions to increase Zn uptake efficiency.

Statement of Objectives:

1.) Assess the feasibility of alternative zinc application methodologies to increase the efficiency of zinc recovery by using soil applications to acidify and stimulate root proliferation in a limited portion of the soil volume.
2.) Evaluate the potential of using zinc efficient cover crops to mobilize soil zinc and make it more available to tree roots.
3.) Evaluate an experimental peach rootstock that appears to have greater capacity for zinc uptake from soil than rootstocks currently in commercial usage.
4.) Compare the efficiency of zinc uptake into the woody tissues of peach trees before, during and after leaf abscission in the fall.
5.) Evaluate the distribution of zinc throughout young peach trees (especially to the roots) from a fall foliar application.

Executive Summary:

Several approaches to improving zinc uptake efficiency have been evaluated in this project. The first approach was to make Zn much more available to peach trees by acidifying a small portion of the root zone using soil sulfur. Decreasing the pH by just one unit makes Zn^{+2} about 100 times more available. We tried the technique with both mature peach trees and with newly planted trees using "root bags" placed in the planting hole. We have been successful at increasing the leaf level of other metals, including iron, copper and particularly manganese. However, we were only able to increase leaf Zn levels when large amounts of zinc sulfate were added with the soil sulfur. Thus, at this point, this approach does not appear to be very economical or practical.

A second approach was to plant barley directly under some Springcrest peach trees showing minor symptoms of Zn deficiency. Barley and other graminaceous species are very efficient at taking up Zn and Fe under conditions where these metals are low in the soil. They do this by releasing molecules called phytosiderophores that help extract these nutrients from the soil. When another crop is planted with the barley, its Zn and Fe uptake can also be improved if its roots are in close proximity to the barley roots. This experiment also failed to produce positive results. There was a modest improvement in iron nutrition but no effect on zinc.

Finally, we are in the middle of a series of foliar experiments using ^{68}Zn. These trials involve mature trees, small potted trees, greenhouse seedlings and Arabidopsis plants (a well studied plant used for many plant physiology experiments). The overall goal of these experiments is to determine the best material, timing, application method and additive for applying zinc to peach and pistachio trees. The results will be presented in detail in the 2007 annual report.