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Towards Development of Foliar Fertilization Strategies for Pistachio to Increase Total Yield and Nut Size and Protect the Environment

A proof-of-concept project

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INTRODUCTION

Foliar fertilization in crop production is encouraged. Replacing soil-applied fertilizer, at least in part, with foliar-applied fertilizer contributes to fertilizer best management practices (BMPs) by reducing the potential for accumulation of nutrients in soil, run-off water, surface water (streams, lakes and the ocean), and groundwater (drinking water supply), where they can contribute to salinity, eutrophication and nitrate contamination in the case of N, all of which have serious consequences on human health and the environment.

When successful, foliar fertilization provides the nutrients required for photosynthesis and other important metabolic functions directly to the leaves to prevent restrictions in carbon fixation, metabolism and plant productivity. Even a transient or incipient deficiency needs to be corrected quickly. The longer the tree's nutrient status remains at the low end or below the optimal range at key stages of tree phenology, the greater the negative effects on the current year's yield and next year's bloom. Thus, foliar fertilization, which has the potential for being a rapid and efficient method for improving crop nutrient status during periods of high nutrient demand or when soil conditions render soil nutrients less available to the plant, could have a positive impact on yield.

For pistachio, potential yield benefits to be derived from foliar fertilization have yet to be fully realized. Like other deciduous fruit crops, pistachio reproductive growth commences prior to vegetative shoot extension and leaf expansion. Thus, foliar fertilization strategies at early stages of tree phenology by default target reproductive structures, which are typically small. Despite this, bloom sprays of boron, zinc and urea applied to apple or pear increased fruit set and yield (Bajter and Thompson, 1949; Righetti, n.d.; Stover et al., 1999). In the case of pistachio, boron applied in the late dormant stage (just prior to bud swell to 20% bud break) increased 3-year cumulative yield by 20% and reduced blanking as well as non-splits to further increase yield (Brown et al., 1995). The effect on yield of applying urea-N and zinc sprays (individually or in combination, including boron) to pistachio trees at this time remains to be determined. A further difficulty is that pistachio leaves, like those of many other crop plants, have a thick waxy cuticle known to compromise uptake of some foliar-applied nutrients once the leaves mature (Kallsen, 2007). The following critical questions related to nutrient uptake by pistachio leaves remain unanswered. Can a sufficient amount of fertilizer be taken up when leaves are 2/3 expanded (and still have a thin cuticle) to provide a yield benefit? Will including urea as a “carrier” in the fertilizer spray sufficiently increase nutrient uptake by mature pistachio leaves to enhance yield?

Past research has documented that properly timing foliar fertilizer applications to key stages of crop phenology, when nutrient demand is likely to be high or when soil conditions are known to restrict nutrient uptake (e.g. spring), can successfully increase yield and grower net income, typically with only one application for both evergreen and deciduous tree crops. Examples include: a single winter prebloom foliar application of low-biuret urea increased flower number, total yield and pounds total soluble solids per acre of Valencia orange (Albrigo, 1999); a bloom spray of boron increased fruit set and yield of pear (Batjer and Thompson, 1949); four potassium nitrate sprays increased yield, fruit size, early harvest and grower income of ‘Sunburst’ tangerine (Boman, 2002); a fall canopy application of boron to preload the tree increased fruit set and yield of Italian prune (Chaplin et al., 1977); boron sprays to avocado inflorescences at the cauliflower stage of development increased the number of pollen tubes that reached the ovule, ovule viability and yield (Jaganath and Lovatt, 1998); winter prebloom sprays of low-biuret urea increased yield of navel orange, whereas low-biuret urea applied at maximum peel thickness increased the yield of commercially valuable large size navel orange fruit (Lovatt, 1999); prebloom foliar-applied boron, zinc and urea increased yield of ‘Empire’ and ‘MacIntosh’ apples (Stover et al., 1999). The 20% increase in pistachio yield achieved over 3 years with foliar B fertilization was of significant economic benefit (Brown et al., 1995).

OBJECTIVES

The goal of our research is to obtain a positive effect on fruit set and yield, nut quality (increased percent split nuts, reduced percent aborted and blank nuts), and retention of floral buds for next year’s crop with properly timed foliar fertilization to achieve an increase in marketable yield that will increase grower net profit. We will test the capacity of three foliar fertilization strategies to successfully supply key essential nutrients at phenological stages of high nutrient demand as discussed below.

1. Strategy 1 - Application of foliar fertilizer boron (B), zinc (Zn) and urea (N) to emerging inflorescences to enhance flower nutrient levels (ovary and/or pollen) to increase fruit set. Despite uptake of only small amounts of nutrients, prebloom foliar applications of these elements have been shown to increase yield in other deciduous tree crops (Cowgill and Compton, 1999).
2. Strategy 2 - Apply foliar fertilizer at 1/2 to 2/3 leaf expansion when leaves have a wax cuticle thin enough for nutrient uptake and sufficient surface area that the amount of nutrient taken up is large enough to enhance tree performance.
3. Strategy 3 - Investigate urea as a carrier to increase K and N uptake prior to and during kernel filling when all but the most current pistachio leaves have fully developed wax cuticles. Urea improved the uptake and efficacy of benzyladenine when hardened pistachio leaves were treated in June and July (Lovatt et al., 2006). Researchers and growers report its use in foliar treatments (Righetti, n.d.).
4. Disseminate a cost:benefit analysis to growers.

DESCRIPTION

Strategy 1. Application of foliar fertilizer to emerging inflorescences to enhance flower nutrient levels (ovary and/or pollen) to increase fruit set. Despite uptake of only small amounts of nutrients, prebloom foliar applications of boron (B), zinc (Zn) and urea (N) have been shown to increase yield in other deciduous tree crops.

1. N [6 lb/acre, urea (46% N, 0.25% biuret)].
2. 1 combined with Zn [5 lb/acre, $ZnSO_4$ (36% Zn)] to test the capacity of urea to increase Zn uptake.
3. Treatments 2 and 4 combined.
4. [5 lb/acre, Solubor (20.5% B)], industry standard applied late February to early March (Brown et al. 1995).

Comparison of the effects of these treatments will resolve whether trees require N at this time and whether urea enhances Zn and B uptake.

Strategy 2. Apply foliar fertilizer at 1/2 to 2/3 leaf expansion when leaves have a wax cuticle thin enough for nutrient uptake and sufficient surface area that the amount of nutrient taken up is large enough to enhance tree performance.

1. Zn [2 lb/acre, $ZnSO_4$ (36% Zn)]. This strategy is currently practiced within the industry, but no data exist to support a yield benefit.
2. N [6 lb/acre, urea (46% N, 0.25% biuret)] to determine if a sufficient amount of N can be taken up at this stage to have a positive impact on fruit retention and yield, nut quality and retention of buds for next year's crop.
3. Treatments 1 and 2 combined. Comparison of treatment effects will resolve whether urea increases Zn uptake and whether Zn and/or N increase fruit retention and yield, nut quality and retention of buds for next year's crop.

Strategy 3. Investigate urea as a carrier to increase K and N uptake prior to and during kernel filling when all but the most current pistachio leaves have fully developed wax cuticles.

1. K [10 lb/acre, KTS (0-0-25-17S)].
2. [10 lb/acre, KNO_3 (13-0-38)].
3. [6 lb/acre, urea (46% N, 0.25% biuret)].
4. 1 and 3 combined. Comparison of treatment effects on yield will determine whether urea increases K uptake and whether trees need only K or benefit from added N and/or S at this time.

At the specified stages of tree phenology, foliar fertilizers were be applied in 100 gallons of water (maximum) per acre (industry standard) to 15 individual tree replications per treatment (including an untreated control) in a randomized complete block in a commercial 'Kerman' pistachio orchard owned by Paramount Farming company and located in Kern County, California. The experiment will be conducted for 2 years. Applications were made using a three-point Myers mini-sprayer producing strong canopy movement and a very fine droplet size. Sets of buds in the four quadrants of the trees receiving prebloom sprays were covered just prior to fertilizer application, uncovered 24 hours later and the resulting flowers collected one week later for nutrient analysis. Sets of leaves in the four quadrants of each tree to be sprayed were protected from fertilizer spray at the time of application, uncovered 24 hours later and collected one week after fertilizer application. Leaves will also be collected at the standard time for nutrient analysis and just prior to harvest to determine if foliar-applied fertilizers increased leaf nutrient concentrations, for how long and if to a level sufficient to "preload" the tree for the following spring bloom. One branch (bearing fruit) in each of the four quadrants of each treated tree will be tagged and the initial number of floral buds per branch counted just prior to foliar fertilizer application. The final number of floral buds will be determined just prior to harvest to quantify treatment effects on bud retention. In spring the following year, return bloom (inflorescence number) will be determined on the tagged shoots. At commercial harvest, yield per tree and split nuts, kernel weight, aborted nuts and blank nuts (dry weight) per 20 lb sample will be determined by a commercial packinghouse belonging to Paramount Farming Company.

RESULTS AND DISCUSSION

The start of this experiment was delayed until January 1, 2011. Thus far, we have obtained an excellent orchard located in Lost Hills managed by Paramount Farming Company. Paramount generously harvested more than 600 trees and provided us the yield data per tree. We used these data to select 165 uniform trees to include in our experiment. The experiment has been laid out and all foliar fertilizer treatments have been applied. In addition, all flower and leaf samples for nutrient analyses have been collected, washed, dried, processed and sent to the University of California (UC) Division of Agriculture and Natural Resources Analytical Laboratory at UC-Davis. The first harvest has been organized and is currently scheduled for some time in October. Arrangements have been made with Paramount Farming Company for collecting fruit quality samples for each data tree and for commercial processing of the fruit samples in Paramount's packinghouse with evaluation according to Paramount Farming Company's commercial standards.

ACCOMPLISHMENTS

All foliar fertilizer applications were applied at the correct stage of tree phenology and all flower bud and leaf samples for nutrient analyses were collected according to the prescribed schedule without deviation. The Year 1 harvest will occur in October 2011. Thus, it is too early in the research to report preliminary findings or make recommendations.

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