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Salinity Tolerance in Avocado

Report for Project Year 2

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Benefit to the Industry

Avocado trees are highly susceptible to salt damage, but are frequently grown in areas where irrigation water contains high levels of sodium chloride. Resulting problems associated with high soil salinity and chloride toxicity include reductions in fruit yield and tree size, lowered leaf chlorophyll content, decreased photosynthesis, poor root growth, and leaf scorching. In California, this problem is becoming increasingly common as the cost for high quality irrigation water has increased and growers leach their soil less frequently, or are forced to rely on saline groundwater for their irrigation water supply, the proposed research is aimed at identifying and ranking salinity tolerant rootstocks that may be used to improve avocado production under saline conditions.

Objectives

Examine the relative salinity tolerance of avocado root stocks that may be used for production of avocado with saline irrigation waters, or that may be used in the plant breeding program for selection of root rot resistant and salt tolerant root stock material for future release to the industry.

Introduction

Although there are only a few rootstocks that have been directly compared for salinity tolerance to date, earlier data has suggested that salt tolerance is greatest in West Indian rootstocks and poorest in the Mexican rootstock cultivars (Embleton, et al., 1955; Ben-Ya'acov, 1970; Gustafson et al., 1970). In southern California, West Indian rootstocks have not been used in breeding programs because of their poor cold tolerance. However, several West Indian varieties have been identified by Israeli researchers as having excellent salinity tolerance, and after further testing in our screening evaluation may be incorporated into the avocado breeding program at UCR.

Physiological mechanisms of salt tolerance include a number of plant responses that have been characterized in various model plant species, but not I avocado. As a general principal, high sodium is thought to displace calcium from the root cell walls, which causes leakage of potassium and other plant metabolites form the root (Spiegel et al., 1987). As reviewed by Kafkafi and Bernstein (1977), maintenance of adequate potassium concentrations and the proper potassium/sodium ratios in cells is necessary for cellular function under saline conditions (Greenway and Munns, 1980). This idea is further supported in experiments with mung bean in which calcium additions were shown to reverse the inhibition of root elongation by NaCl and to maintain high potassium levels in the roots (Nakamura et al., 1990). In lime trees, resistance to salinity is associated with chloride exclusion and high selectivity of the roots for potassium as opposed to sodium (Storey and Walker, 1987). All of these data together suggests that maintenance of high potassium and calcium concentrations in the rooting zone may help to offset the effects of salinity. The effects of calcium on maintaining root membrane integrity are particularly intriguing since calcium also reduces Phytophthora root rot, and thus suggests a possible explanation for failure in Phytophthora resistance of the normally resistant Thomas rootstock in saline soils.

Methods

The screening protocol employs a hydroponic sand culture system that we have set up in the greenhouse to maintain trees under fixed salinity levels. One year old Hass avocado trees grafted on to the selected rootstocks are planted in five gallon containers in sand medium. The trees are watered four times daily with a modified Hoagland nutrient solution pumped into the sand tanks and drained back into the solution reservoirs. Salinity treatments are the same as those used by Mickelbart and Arpaia (1997) at salt levels (NaCl) of 1.5 (control, 3.0, 4.5, and 6.0 dS m-1). If we identify rootstocks that are particularly resistant to salinity damage, we will increase the salt levels to an appropriate level that will test the full extent of salt tolerance of these specific cultivars.

Results and Discussion

While eventually we plan to study the basis for salinity tolerance in superior avocado rootstocks, the immediate objective of this research is to provide the avocado industry with information on which rootstocks are most tolerant to high chloride conditions. To this end, we have established a large screening facility in two greenhouses located at the university of California campus. These facilities include two separate hydroponic systems for sand culture of 240 trees. Each experiment requires approximately 18 months to two years to complete from time of grafting until the end of the experiment. After the trees are grafted with Hass avocado shoots, at least three months are required before the seedlings have generated enough roots to transplant them into the sand medium containers where they are subjected to the salinity treatments. Approximately 3 to 6 months are required at this second step for the trees to produce sufficient roots before imposition of the salinity treatments. When the treatments are begun, 2 months are required to ramp up the salinity levels to the highest levels, after which the trees are monitored for another 6 months to obtain growth data and information on their leaf tissue contents and physiological parameters such as photosynthetic rates and leaf water potentials Each greenhouse experiment involves 4 salinity levels with 10 replicate trees per treatment for a total of 129 trees. Because a control is required (Duke 7), only two varieties can be screened at a time, which are compared to the control.

This year, we have started the first greenhouse trial with Hass on Duke 7 and two of the Israeli rootstocks that are purported to have high salt tolerance. We have also finished constructing a second greenhouse hydroponic facility that will enable us to double our capacity for 5 new rootstocks per year. To increase the throughput, grafted trees have been ordered or are already potted in the greenhouse so that they can be transplanted into the screening system as soon as the first experiments are taken down.

An initial observation is that Hass trees grafted on Duke 7 are leafing out much faster than Hass grafted on the two Israeli rootstocks. Trees on these latter rootstocks are producing flowers, but have not yet begun shoot extension and full leaf development. This has introduced a confounding factor in our experiment, since Duke 7 trees are producing more roots and bigger trees earlier which will influence salt tolerance and transpiration rates. If the Israeli rootstock trees do not catch up in the next month, this should be controlled by pruning to bring all of the trees to the same size before the salinity treatments are begun.

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