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Rootstock Screening and Salinity Management in Avocado

New Project: Year 1

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Benefit to the Industry

This project will provide avocado growers with information on which rootstocks are most useful for production of avocado on saline soils. Identification of rootstocks that can be incorporated into the breeding program will eventually allow growers to use irrigation water having a higher salinity content that is currently used for avocado production. As water costs increase and growers rely increasingly on saline water for irrigation, this will permit use of higher salinity water with lesser damage to the trees and concomitant reductions in crop yield. Research on the interrelationship of tree responses to salinity management through improved irrigation practices is expected to provide fundamental information that will lead to development of integrated management practices that are critical to long term viability of the avocado industry in California.

Methods

The research is focusing on two field trials that were established at the Miller and Stehly Orchards. The experiment located at the Miller Orchard near Santa Barbara is comparing Hass and Lamb Hass scions on 7 rootstocks. In this study, we are analyzing the leaf chloride contents, growth, and yields of the trees to evaluate rootstock performance and interactions with different scions. The second experiment, which is located at the Stehly Orchard, is comparing 10 rootstocks grafted with Hass. This latter experiment is the site of a new experiment, described in our proposal, in which we are examining soil plant water relations to determine possible differences in the ability of the rootstocks to extract water from the soil during soil drying cycles as the water becomes increasingly concentrated with salts. This will provide practical information on irrigation frequency intervals that are necessary to supply water and prevent desiccation that leads to leaf burn.

Progress: November 2005 -September 2006

Miller Experiment

The trees at Miller's are now three years old, and are beginning to yield fruit. In March 2006, measurements were made of the tree canopy volume and fruit number per tree. The data below provide our measurements for canopy volume and fruit yield at the Miller Orchard. As shown in the Table 1, both tree growth and yield were highly variable. There was no significant difference between Hass and Lamb Hass scions on the different rootstocks (data not shown). While there are no statistical differences, comparisons of the values suggest that Toro Canyon is performing the best at this time with respect to both canopy volume and yield. PP-14, PP4, and Toro Canyon had similar canopy volumes with 22 cubic feet. The standard deviation for canopy volume was relatively high, which reflects differences in soil quality and slope across the orchard. DUSA trees are an anomaly in this experiment in that they were planted approximately later than the other rootstocks and were thus disadvantaged from the start of the experiment. We will continue to monitor tree performance in this experiment, and will measure leaf sodium and chloride contents in Sept 2006.

Table 1. Rootstock evaluations for three year old trees at Miller Orchard near Santa Barbara. Data collected March 2006.

Rootstock	Canopy Volume	Fruit / Tree
Dusa	8 (4)*	0.5 (1)
Latas	14 (9)	11 (16)
PP-14	23 (10)	16 (15)
PP-24	18 (3)	14 (14)
PP-4	22 (6)	14 (18)
Thomas	18 (6)	13 (13)
Toro Canyon	22 (10)	28 (15)

*Values in parentheses represent 1 standard deviation

Stehly Experiment

The field trial at the Stehly Orchard is our primary experiment for this research investigating salinity tolerance in avocado rootstocks. The original experiment was set up to compare the best rootstocks previously identified from Menge's breeding program and the Israeli VC rootstocks, along with Duke 7 and Zentmyer as controls. In addition to evaluating tree performance, we have now set up an experiment to examine plant-soil-water relations and the ability of the rootstocks to extract water at different EC values.

The layout of the experiments is shown in Figure 1. There are 200 trees in the field trial with 20 replicates for each of the 10 rootstocks. The trees are arranged in a block design with each block consisting of individuals of the 10 rootstocks. The trees were planted in May 2004 and are now 3 years old. There are substantial differences in the tree performance under the highly saline conditions as indicated by differences in growth. Figure 2 shows the tree canopy volumes as of July 18, 2006 for the different rootstocks that are being tested. Among the rootstocks in this trial, VC 801 and VC 207 are the best performing in comparison to the Duke 7 control. This is in line with our previous trial which indicated superior performance for these rootstocks under saline conditions.

Figure 1. Plot design for screening of salinity tolerance in 10 selected rootstocks. Experiment is located at the Stehly Orchard near Valley Center, south of Highway 76.

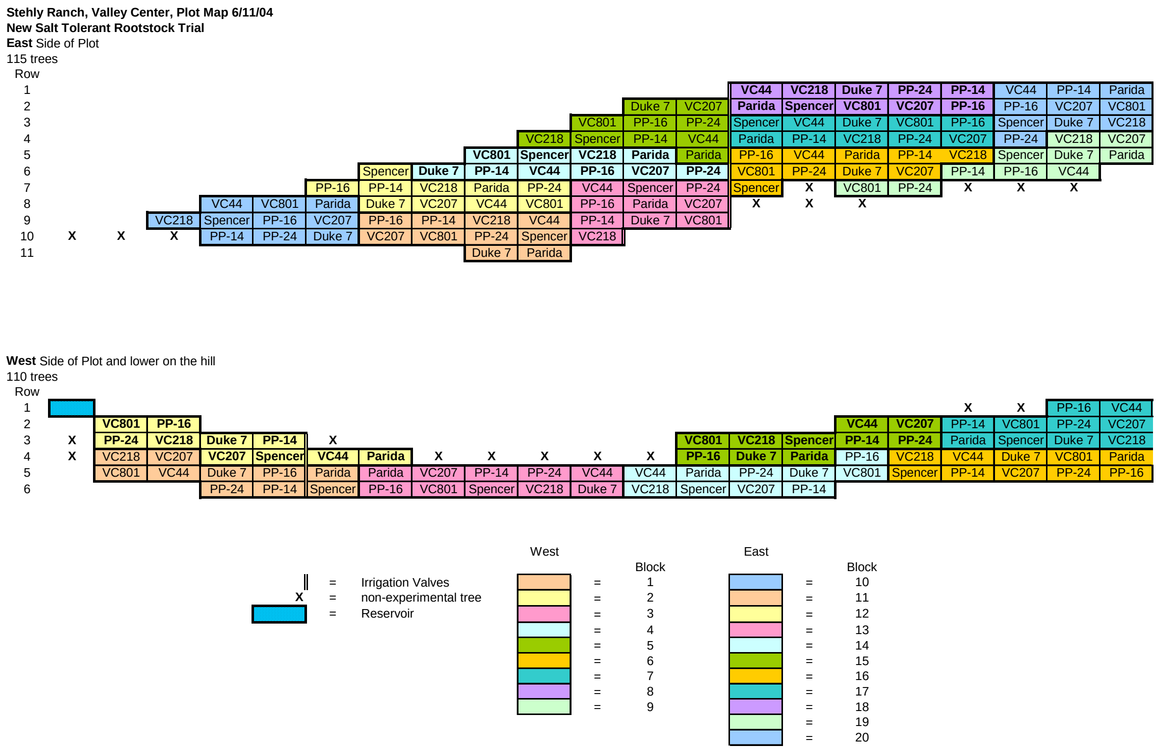
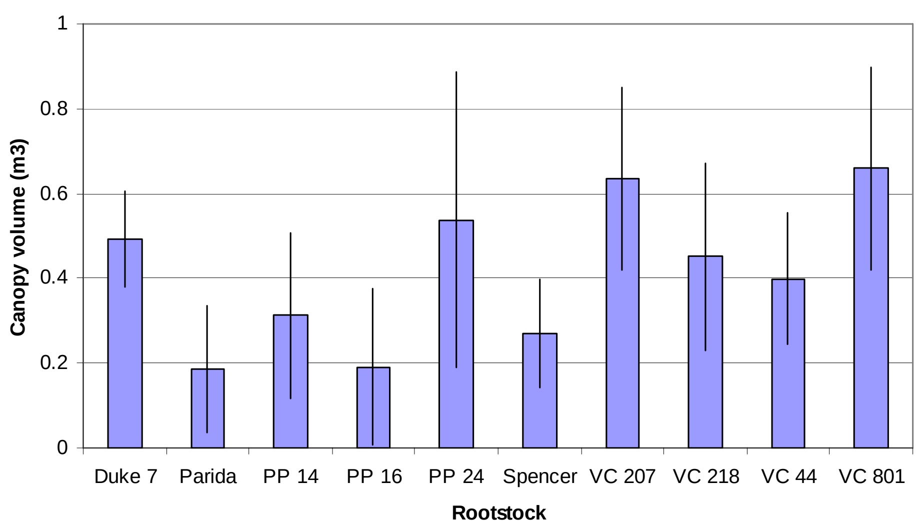


Figure 2. Canopy volumes for rootstocks under evaluation for salinity tolerance and water use efficiency at the Stehly Orchard. Trees measured on July 18, 2006. Vertical bars are 1 standard deviation. Letters indicate statistical difference (P>0.05)



Our previous data suggested that avocado cannot take up water when the soil EC reaches ca 4 dS m^{-1}. However, this estimate was made by examination of data collected from three points in the field and did not specifically compare different rootstocks. In the new experiment, we have carefully monitored a set of 50 trees (10 different rootstocks in 5 replicate blocks) to measure the water availability, salinity, and chloride contents under each tree.

Irrigation of the trees was begun in mid April, and over the summer of 2006, soil water availability was maintained between 0 and 50 centibars by irrigation with 3 hour applications of water biweekly or as needed to maintain water availability in the desired range. The salinity of the irrigation water was measured biweekly and had EC values ranging between 1.8 and 2.3. Analysis of the chloride levels in the irrigation water showed that this particular water supply contained very high levels of chloride for avocado production, ranging between 12 and 14 meq (434 to 490 ppm). These levels are 4 to 5 times greater than the 100 ppm value that has been recommended as a maximum for avocado.

Soil salinity and chloride levels were determined by removal of soil cores from a 0 to 15 cm depth at the base of each tree at each sampling date, which were then brought to the laboratory and analyzed immediately thereafter by insertion of soil pore water extraction tubes that use a vacuum to draw pore water through a 2 mm diameter ceramic tube (Minirhizons). The pore water extraction tubes can purportedly be used in the field, but in our experience were found to be fragile and were better used in the laboratory, which allowed the soil pore water to be extracted overnight and acquisition of a sufficient volume for analysis of salinity and chloride content. At each sampling date, 50 samples were processed. All together, the results showed that soil salinity was highly variable across the field, reflecting variation that occurs with respect to water infiltration, slope, and water delivery patterns with the mini-sprinkler irrigation that varies from tree to tree. Soil salinity measurements determined using the vacuum soil pore water extractors measured between 2.5 to 2.8 dS m^{-1}. The chloride levels in the soil pore water were approximately twice as high as that of the irrigation water (18 – 22 meq), which is expected due to the concentration of salts in the soil water as the soil dries.

Comparison of Rootstock-Plant-Soil Water Relations. Plant water relations are a major contributing factor in the development of leaf burn which is the major visible symptom of salt damage to the leaf tissues. Previous studies by us with greenhouse grown trees, and in the field by Embleton (personal communication) have shown that trees can have very high levels of chloride in the leaf tissues with no symptoms of leaf burn if they are kept well watered and do not experience water stress. We are thus very interested in whether the rootstocks being evaluated here vary in their abilities to provide water to the leaves and how this may be affected by soil salinity levels.

To examine this question, we have carried out preliminary studies to measure the leaf water potentials of the 50 test trees using a Scholander pressure bomb. Leaf water potentials were measured predawn (2 to 4 AM) to determine the water levels after resupply of water from the roots to the leaves at night when the leaf stomata are closed and the trees have fully recovered from desiccation. Other measurements were made a midday (11 AM to 1 PM) to determine the leaf water stress encountered during the day. Presumably, rootstocks that are more effective in delivering water will result in a lower leaf water potential at midday, with the caveat that all plants will reach a maximum leaf water potential that triggers stomatal closure and any further water loss.

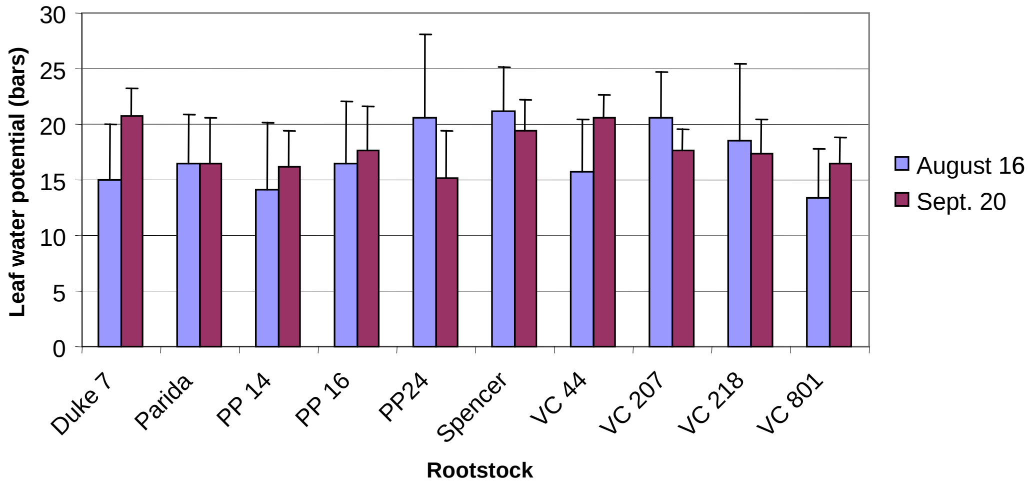


Figure 3. Leaf water potential at midday for Hass scions on avocado rootstocks differing in salinity tolerance.

Our results from these preliminary studies show that at predawn, leaf water potentials are remarkably consistent across all rootstocks and measure between -5 to -6 bars. At midday leaf water potentials increase to -15 to -20 bars, with maximum values occurring at approximately -25 bars. A complicating factor is that water demand by the scion is also affected by leaf surface area, such that trees that have low numbers of leaves due to poor growth on salinity intolerant rootstocks may not desiccate as fast as trees with a large canopy and high leaf surface area. Our initial comparisons across the rootstocks suggests that the most salinity tolerant rootstock, VC 801, may be superior for delivery of water to the scion due to the fact that it had the lowest leaf water potential and highest leaf area. However, further detailed studies are required to better examine this aspect of salinity tolerance and its variation with respect to different rootstocks. These may be examined in 2007 as described in our grant proposal for continuing this project.

Tree leaf samples will be collected at the end of September and will be analyzed for chloride and sodium, at which time we will also remeasure canopy volumes. We will also be cooperating with Dr. Greg Douhan to evaluate salinity tolerance in other avocado rootstock outplantings that were begun by Dr. Menge, and that are being continued by Dr. Douhan. Results of the leaf tissue analysis will be available in the winter of 2007 after the samples have been processed, and the data are analyzed.