Rootstock Selections for Improved Salinity Tolerance of Avocado

Continuing Project; Year 5 of 6

David Crowley[1], Woody Smith[1], MaryLu Arpaia[2]
[1]Dept of Environmental Sciences, University of California, Riverside, CA 92521
[2]Kearney Agricultural Center, 9240 S. Riverbend Ave. Parlier, CA 93648

Benefit to the Industry

Avocado trees are susceptible to salinity. Symptoms include leaf scorch and decreased tree productivity. As the cost for irrigation water continues to increase, and growers increasingly rely on saline groundwater supplies, there has been an increasing need to identify salt tolerant rootstocks that may be used for saline soils. This research is aimed at evaluating recently introduced salt tolerant rootstocks for use with 'Hass' avocado, and is also comparing these new rootstocks with the commercial and newly developed rootstock materials from the UCR rootstock breeding program.

Objectives

1. To compare the salinity tolerance of currently used and newly developed *Phytophthora* root rot resistant rootstocks in a screening system, which will allow us to recommend specific rootstocks that can be used by avocado growers in California.

2. Identify new rootstocks that can be incorporated into the ongoing breeding program at UCR for selection of *Phytophthora* resistant, salinity tolerant plant material.

Introduction

Avocado trees are 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 has 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. Although there are only a few California-derived rootstocks that have been directly compared for salinity tolerance to date, field observations have 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 rootstock selection programs. However, several West Indian varieties have been identified as salinity tolerant. With further testing, some of these West Indian rootstocks may prove to be useful for saline soils, or may be incorporated into the avocado rootstock breeding program.

The research reported here is comparing the salt tolerance of avocado rootstocks that are already in commercial use or that are potential candidates for release to the public, along with several salinity tolerant selections that have been identified by researchers in Israel. Approximately 20 rootstocks from Israel have been imported into the United States, most of which are still in quarantine, but that will be available for research in the next two years. During the past 5 years, we have been conducting a series of screening trials in the greenhouse using a hydroponic culture system that allows us to adjust the salinity levels. The focus of this research has been on resistance to elevated chloride, with all of the trees being grown at the same total salt concentration. Results that are reported here summarize the data from the greenhouse experiment for six different rootstocks, all of which were compared to Duke 7, which was used as a control in each of the various experiments. In this manner, we not only obtained chloride uptake data for Hass avocado on these rootstocks, but are also able to compare the relative uptake of chloride across all of the separate experiments. This year, two more rootstocks have been included in the analysis, and there is one more experiment that is still ongoing in the greenhouse for which data will be available next year.

Due to the lengthy amount of time that is required to propagate the grafted rootstocks and the amount of time required to conduct these experiments, we have decided this year to implement a field study that will evaluate all of the available rootstocks even before they have been through the greenhouse screening process. This field experiment has been established at a large commercial orchard in Pauma Valley, California where the electrical conductivity (EC) of the irrigation water is typically around 2.5. This is well above the level at which avocados typically experience leaf burn and thus will provide highly relevant field data on chloride uptake, as well as data on the growth and yields for Hass avocado when grafted on these rootstocks. In this report, we also describe the layout of this field experiment which was planted this spring. The leaf tissue samples for the first year are now being analyzed, after which we will release the data for the first year later in the fall of 2001. This is a long term experiment that will require several years of observation and analyses. In addition to leaf tissue analyses, we are also following the soil moisture and EC of the soil solutions across the field plot which is laid out in 5 replicate blocs. Because of the labor intensive nature and high cost of the field experiment, we plan to focus our efforts in the future on the field experiment and will finish our greenhouse screening experiments with the trees that are being studied this year.

Materials and Methods

Plant materials. All of the experiments for both greenhouse screening and the field experiment are using 'Hass' avocado scions that has been grafted on to selected rootstocks from Israel or that have shown promise in the avocado root rot screening program. Except for a few trees that are being included in additional treatments to examine field grafting, all of the trees used in the main greenhouse and field experiments were propagated by Brockaw Nursery using the nurse seed method. This method employs a constriction ring that is used to slowly restrict development of roots from the nurse seed and force transition to growth on the test rootstock. To assure that the trees are established completely on the test rootstock by the time of the experiments, the roots from the nurse seed are being physically clipped after one year, after which the trees are allowed to grow for another 6 months on the test rootstock. This procedure was essential to avoid confounding effects caused by chloride uptake by the nurse seed roots.

The hydroponic screening system in the greenhouse study consists of 120 5-gallon containers that are hooked in line into a re-circulating irrigation system that automatically delivers nutrient solution and salt treatments to the trees four times a day. The nutrient solution consists of a modified Hoagland's nutrient solution. There are 12 replicate trees per treatment, with Duke 7 grafted trees included as a control in each experiment. The salinity treatments are designed to mimic typical irrigation water in Southern California, as described in the USDA handbook (USDA 1954; see also http://www.ussl.ars.usda.gov/hb60/hb60.htm), but are lower in carbonate, which interferes which pH control and trace metal availability. The principal cations are calcium, sodium, magnesium, and potassium. The anions include sulfate, nitrate, and chloride. Calcium and sodium are adjusted along with chloride and sulfate to provide different levels of chloride. Total salinity is maintained at a constant value of 3 dS/M (TDS 2000 ppm) with chloride adjusted to 2, 4, 8, and 16 meq/L. Parameters being measured include shoot and root growth, trunk diameter, and tissue contents of Na, Cl, K, Ca, and metals.

In the field experiment, we have established a rootstock comparison trial at the Stehly ranch, which is located off of Highway 76 near Pauma Valley in San Diego County. The first phase of our field experiments at the Stehly ranch was established in June 2001. The site that was allocated for this experiment is on the side of a hill adjacent to an irrigation water supply in which the EC is routinely measured between 2.0 and 2.5. All of the trees are grafted with Hass, except for a small group of Israeli rootstock trees that will be field grafted with Hass once they are established. Since the plot is located on a hill, the experimental design was laid out as a randomized block design, in which there are 4 replicate trees of each rootstock in each of the 5 blocks. The blocks were laid out horizontally along the sloop to capture variability that may be expected due to water runoff and differences in soil texture along the slope gradient. Each of the trees is being watered by mini-sprinkler irrigation. The field experiment is being continuously monitored for soil water content and each block contains replicate extraction tubes for collection of the soil water for EC determinations. Soil water status is being monitored at 6, 12, and 24 inches using 2 replicate irrometers per block. The data are collected via data loggers. The rootstocks that are being tested in this field experiment are listed in Table 1.

Table 1. Rootstocks included in the field experiment planted in June 2001.

Duke 7	Thomas pp#6628	Toro Cyn. #5642
VC 218	VC 225	VC 256
VC 801	PP5 UCR	Latas
Evstro	PP4UCR	

Results and Discussion

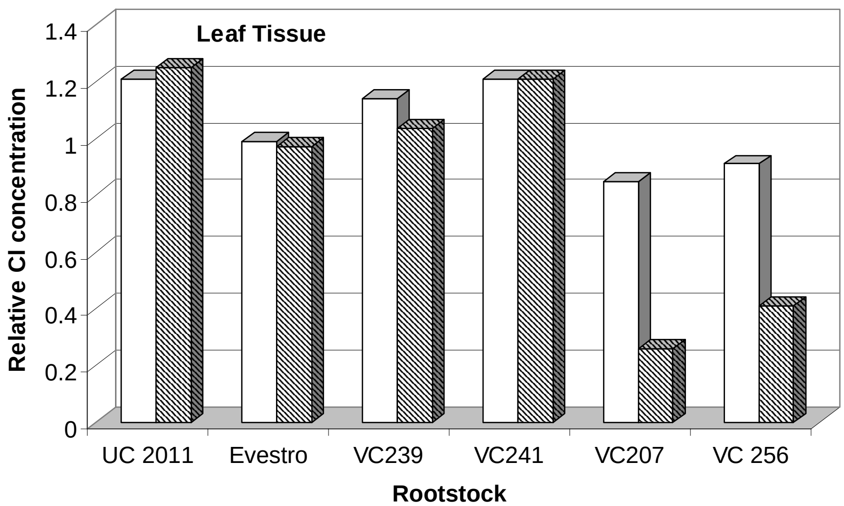
Leaf tissue analysis for chloride accumulation in 'Hass' grafted to the all of the rootstocks tested to date are shown in Table 2. Since these rootstocks were tested in a series of trials over several years, the chloride responses were compared to that of Duke 7, which was included in all of the experiments. Data for Duke 7 in Table 2 are for 1 representative year. Similar values were obtained for this rootstock in other years.

To compare rootstocks across experiments, the results were also analyzed by comparing their relative uptake to the Duke 7 control in each experiment. These data are expressed as the relative chloride uptake, with a value of 1 being equivalent to the chloride accumulation by Duke 7 (Fig. 2). A value less than 1 is interpreted as a decrease in chloride accumulation as compared to Duke 7, whereas a value greater than 1 means the trees took up more chloride than Duke 7.

Table 2. Leaf and root chloride concentrations (ppm) for Hass avocado seedlings grown on selected rootstocks.

Plant Part	Rootstock	Cl conc in Nutr. Soln (meq/L)	
		2	8
Leaves	Duke 7	24	109
	VC 239	28	112
	VC 241	30	112
	VC 207	13	24
	VC 256	14	39
	Evestro	21	104
	UC 2011	26	134
Roots	Duke 7	179	240
	VC 239	171	213
	VC 241	251	419
	VC 207	272	339
	VC 256	262	400
	Evestro	216	383
	UC 2011	201	334

Figure 2. Leaf tissue chloride contents for Hass avocado on selected rootstocks as compared to Duke 7.



The data for relative chloride uptake show that there are significant differences in chloride accumulation by the leaves of the 'Hass' scions grafted on to VC 239 and VC 241 as compared to Duke 7 when grown at chloride levels of 2 and 8 meq /L. When grown at relatively low chloride levels at 2 meq/L, VC 207 and VC 256 accumulated 20% less chloride in the leaves. When grown at high chloride levels of 8 meq / L, leaf chloride levels were 75% lower in VC 207 and 60% lower in VC 256 as compared to Duke 7. Among the other rootstocks tested, UC 2011 and VC 241 were inferior to Duke 7 in terms of chloride accumulation, whereas Evestro and VC 239 were nearly identical to Duke 7.

When the roots were analyzed to determine the relative accumulation of chloride by the roots as compared to Duke 7, the data revealed that both of the rootstocks that had decreased leaf chloride concentrations had elevated chloride concentrations in the roots. These data suggest that the basis for salinity tolerance provided by these rootstocks involves differential partitioning of salt to the roots and scions.

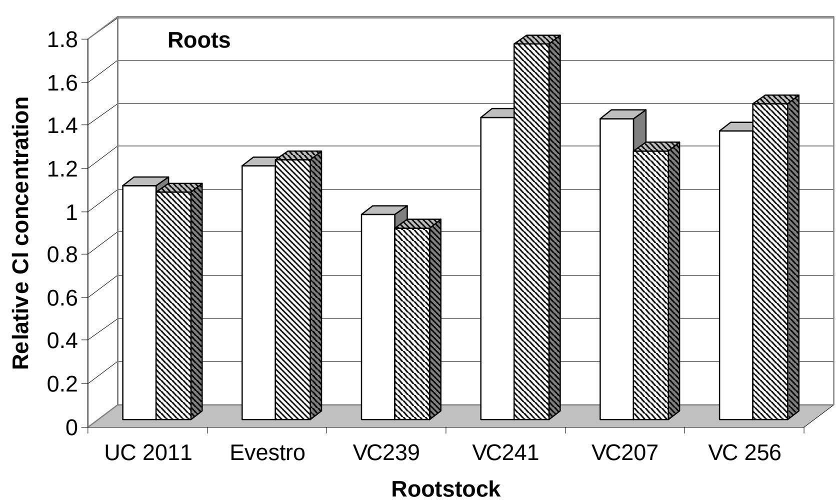


Figure 3. Root tissue chloride contents test rootstocks as compared to Duke 7. Trees were grown in hydroponic sand cultures in the greenhouse in solutions contained 2 and 8 meq/L chloride at EC 3.0.

Summary

Two West Indian rootstocks VC 207 and VC 256 have been identified that have significantly greater salinity tolerance as compared to Duke 7. Further evaluation of these and other rootstocks is now underway in a field trial that was established this year. Results of these experiments will provide valuable information on which rootstocks are most productive under saline conditions, and will help to identify materials that will be included in the avocado breeding program.

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