In: M. L. Arpaia and R. Hofshi (eds.), Proceedings of Avocado Brainstorming. Session 4. Salinity Management. Pages 78-80. October 27-28, 1999. Riverside, CA. Hofshi Foundation. http://www.avocadosource.com.

ROOTSTOCK SELECTIONS FOR IMPROVED SALINITY TOLERANCE OF AVOCADO

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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 better 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. Another factor that further contributes to salinity problems is the use of mulch and other soil organic matter amendments that are used to improve soil fertility and disease management, but which release salts as they decompose. Lastly, root damage and increased leakage of root exudates from salt affected roots is speculated to cause increased susceptibility to *Phytophthora* root rot, which is reported to be more severe in saline soils.

Although there are only a few rootstocks, in the US, that have been directly compared for salinity tolerance (Oster and Arpaia, 1991; Micklebart and Arpaia, 1995), field observations in California and in Israel 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 breeding programs because of their putative 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 rootstock-breeding program at UCR. On a more temporary basis, a recent study also has shown that there is considerable variation in salt tolerance among Mexican and Mexican-Guatemalan rootstocks, which might be useful for immediate improvement of avocado culture on saline soils.

Physiological mechanisms of salt tolerance include a number of plant responses that have been characterized in various model plant species, but not in 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 from the root (Spiegel et al., 1987). As reviewed by Kafkafi and Bernstein (1997), 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 root 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.

In our research we are currently examining rootstocks for their relative salinity tolerance. This involves both field studies and greenhouse experiments using 'Hass' on to selected rootstocks from Israel or those have shown promise in the avocado root rot screening program of Dr. John Menge. The hydroponics screening system in the greenhouse study consists of 120 5-gallon containers that are hooked in line into a recirculating irrigation system that automatically delivers nutrient solution and salt treatments to the trees 4 times a day. The nutrient solution consists of a modified Hoagland's nutrient solution, which is pH buffered with MES, and contains carefully controlled trace metal concentrations employed a chelator buffered system. 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, but are lower in carbonate, which interferes with 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 with chloride adjusted to 2, 4, 8, and 16 meq/L. If we identify rootstocks that are particularly resistant to the effects of high salinity, we will increase the salt levels to an appropriate level that will test the full extent of salt tolerance of these more tolerant selections. Parameters being measured include net CO_2 assimilation, shoot growth, trunk diameter, final biomass at harvest, and tissue contents of Na, Cl, K, Ca, and metals. Photosynthesis measurements are also being made using a portable CO_2 analyzer.

Results for chloride accumulation by rootstocks tested in 1999 are shown in Figure 1. These data reveal that there are significant differences in chloride accumulation by Hass avocado grafted on to VC 239 and VC 241 as compared to Duke 7 when grown at intermediate levels of chloride at 4 and 8 meq /L concentration. Decreased chloride accumulation was also observed for VC 239 at 16 meq/L, whereas, VC 241 was not different from Duke 7 at this high concentration. Possibly selectivity of the root membranes for chloride in VC 241 manifested at low concentrations is overwhelmed at high chloride levels. Other parameters to be considered are differences in shoot growth when grafted on to the different rootstocks. In the greenhouse, shoot biomass production was approximately one-half that observed for Duke 7 at all chloride concentrations. Results of field trials will allow us to determine whether these same patterns are observed in orchard conditions.

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