Potential for Utilizing Blended Drainage Water for Irrigating West Side, San Joaquin Valley Pistachios

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Introduction

Pistachios can be grown in microclimates with combinations of heat, and poor soil and water quality not favorable to all tree crops. For example the lower West Side of the San Joaquin Valley, where high quality (surface) irrrigation water is expensive and ground or reclaimed (drainage) water is low quality. If irrigation costs in this area could be decreased by using poor quality ground or drainage water, production would be more economical. The West Side of the San Joaquin Valley not only historically has higher yields but also is less favorable for development of the foliar fungal diseases that can decimate pistachio production. Therefore, any factor that renders pistachio production more economical in this region would be a great benefit.

Our 1999 greenhouse trial demonstrated pistachios are potentially among the most salt tolerant of the tree nut crops. However, a ten month controlled greenhouse trial with two-year-old nonbearing, budded, seedling rootstocks and a field trial with mature bearing trees are completely different situations. The long-term field trial with mature bearing trees is an attempt to corroborate the salinity potential demonstrated in the earlier greenhouse trials. A field trial is particularly important because the effects of sustained salinity are often slow to develop and can be subtle.

There are two ways saline irrigation can harm a plant. The first is by osmotic influences. The second is by specific–ion toxicities. The former is more difficult to detect than the latter.

Osmotic effects are the more common way salts in irrigation water reduce plant growth and yield. Normally the concentration of solutes in root cells is higher than that in soil water. This difference in osmotic potential allows water to move freely into the plant root. But, as the salinity of soil water increases, the difference decreases, initially making the soil water less available to the plant. To prevent salts in the soil from reducing the soil water availability to the plant, the plant cells must adjust osmotically. They must either accumulate salts, or synthesize organic compounds, generally sugars or organic acids, that raise the osmotic level of the plant root cells. This osmotic adjustment through the acquisition or synthesis of new cellular constituents allows the plant roots to compete more effectively for the available soil water. However, this synthesis process also uses energy that would otherwise be used for plant growth. The net result is a smaller plant that appears otherwise healthy. Some plants are more efficient at osmotic adjustment, or at excluding salt, and are therefore more salinity tolerant.

Specific-ion toxicities occur when chloride, boron or sodium ions in the soil water are absorbed by, and accumulate, within the plant, generally in stems or leaves. The most common manifestation of specific ion toxicity is marginal and tip leaf burn.

The objective of this long-term field trial (1994-2002) is to determine the relative salinity tolerance limits of the four commercial pistachio rootstocks in a mature production situation. Based on the earlier greenhouse trial, all four rootstocks tolerate irrigation with water up to 8dS/m. The unit, dS/m, is a measure of electrical conductivity (EC) of a solution. Generally, EC in dS/m X (640-840) = total dissolved salts (TDS) ppm. The range of salinities used in this experiment ranged from 0.75 to 12 dS/m, or 480 to 11,040 ppm TDS.

Results

The larger rootstock trial that contains this rootstock salinity trial was planted in 1989 and reached full bearing in 1998. The salinity treatments commenced in 1994. By 1998, when the trees were full bearing, the soil water extract levels were reflective of the irrigation water salinity. Figure 1 shows eight sequential seasons of irrigation with 0.75 through 8.0 dS/m water had no significant effect on marketable yield. Irrigation water at 12 dS/m produced generally insignificant decreases in marketable yield of trees on all four rootstocks. However, trees on UCB-1 rootstocks appeared to be most adversely affected. This contradicts the greenhouse trial in which Atlantica was the most saline tolerant rootstock followed by the two interspecific hybrids, UCB-1 and PGII, and PGI was the most saline sensitive rootstock.

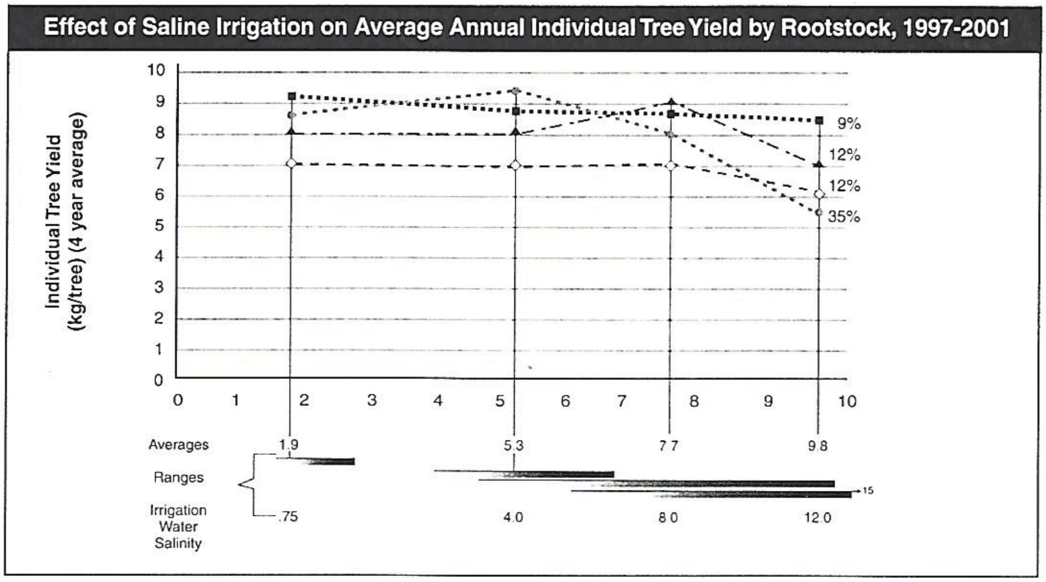

Figure 1. This graphically demonstrates the effect of salinity on average annual yield, 1997-2001, of individual trees on all four rootstocks. This graph corroborates the greenhouse study demonstrating irrigation water up to 8 dS/m, which produces an average root zone salinity of 7.7 dS/m, has no effect on marketable yield of trees on any rootstock. However, and again consistent with the greenhouse trial, all four rootstocks produced decreased yields when irrigation water salinity was 12 dS/m and soil salinity averaged 9.8 dS/m.

Trees on PGI rootstocks averaged a 9% decrease in yield between control and the12 dS/m irrigation treatment. Trees on PGII and Atlantica had an average 12% decrease in yield between the control and the 12 dS/m treatment. Trees on UCB-1 rootstocks averaged a 35% decrease in yield between the control and the 12 dS/m treatments. It appears irrigation water higher than 8 dS/m will produce yield decreases in trees on all rootstocks.

Annual leaf analyses since 1994 have found no significant differences in macronutrients, or the micronutrients of interest; boron, sodium or chloride. No salinity treatment, with any rootstock is producing consistently visible specific-ion damage of the leaves.

Finally, tree water status by both midday bagged leaf water potential measurements and stomatal conductance indicated none of the saline irrigation treatments have produced tree water stress.

However, an accounting of water applied, evaporated from soil surface, available in the soil, and transpired through the tree 1998 through 2000 suggested the 4, 8 and 12 dS/m treatments were resulting in significantly decreased tree water use. This suggested either the trees were becoming significantly more efficient in their water use or that the roots were obtaining fresh water elsewhere. To eliminate the latter possibility 2.5 m plastic screens were sunk around the trees in the winter of 2000/01. In digging the trenches some roots were ripped, indicating some root proliferation outside the saline zone. However, this possibility is now eliminated. More neutron probe tubes were installed to better monitor soil moisture.

Tree and soil water measurements in 2001 reveal no significant differences in tree water use among those irrigated with water at 8 dS/m or less. Trees on all four rootstocks, when irrigated with 12 dS/m water, had significantly decreased tree water use. However, even these trees were not stressed.

In summary, trees on all four rootstocks, irrigated with 4 to 8 dS/m water produced yields equal to those of control trees irrigated with 0.75 dS/m water. All of the trees on all rootstocks transpired normal amounts of water, and had normal tree water and nutrient status. Only trees irrigated with 12 dS/m water are demonstrating some insignificant decreases in yield. However, none of the trees had measurably compromised tree water status.

Conclusions and Practical Application

Results thus far indicate trees on all four rootstocks are tolerant of irrigation water salinity up to 8 dS/m, or 7,620 ppm TDS. These results demonstrate trees on all four rootstocks can tolerate a soil water EC up to 9.8 dS/m, 9,016 ppm TDS, with boron, sodium and chloride as the major ions. Pistachios can be safely, and profitably, grown in soil and using irrigation water with these salinity levels.

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