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Avocado response to salinity and potential management practices

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Let me first just introduce myself. My name is Steve Grattan, and I'm a plant water relations specialist at UC Davis. I have been working with salinity and salinity management, crop salinity relations, probably for almost twenty-five years, if you count graduate school. So, I'm starting to become somewhat of an old-timer.

Now, admittedly my experience with avocados doesn't go beyond guacamole. I have been asked to chair the session mainly because of my experience with salinity and in hopes that I can keep a non-partial discussion going among the people that have considerable experience working with salinity and avocados.

The salinity panelists members come from all over the world. We've got Gary Bender, who is a farm advisor in San Diego County. We have Nirit Bernstein from the Volcani Center in Israel. Ricardo Cesped, who was recently a graduate student at UCR, and is now at Rutgers, New Jersey. Myself, whom I've introduced. Emi Lahav who has quite a bit of experience in Israel, along with Avraham Meiri both at the Volcani Center. Michael Mickelbart is at Lincoln University in New Zealand (currently at Purdue University, Indiana). Andreas Neahaus is from the University of Western Australia. Yosef Shalhevet, another person with considerable amount of experience over the years from the Volcani Center in Israel. Don Suarez is the Director of the U.S. Salinity Laboratory in Riverside, California and Miriam Zilberstaine, from the Department of Agricultural and Rural Studies, Israel.

This session's panelists are Nirit Bernstein, Ricardo Cesped, Mary Lu Arpaia, Michael Mickelbart, and Miriam Zilberstaine.

What I'd like to do is just provide some very basic, general information about salinity and crop response. This may sound pathetically simple to some of the people that have considerable experience with salinity. On the other hand, we want to make sure that people are on the same page.

I want to thank the Los Angeles County Sanitation District that was very generous in a contribution to help sponsor this meeting. At the same time, I didn't want to exclude all other ones, too. When you're registering, there's an acknowledgement page, or poster, acknowledging all the people that have made contributions to this workshop. And, in particular for the salinity session, I guess, Calleguas Watershed Association has made substantial contributions, which is appreciated, as is the United Water Conservation District. So, again, thanks for all those that have participated in supporting this workshop.

Some of the things that you'll be hearing are about salinity; you'll be hearing about composition, you'll be hearing about different ions. Basically, when we're talking salinity, we're talking about six major salinities and constituents that are in play for the bulk of the salinities and media (Figure 1). You've got three major cations, which are sodium, calcium, and magnesium, and you have three major anions, which are chloride, sulfate, and bicarbonate.

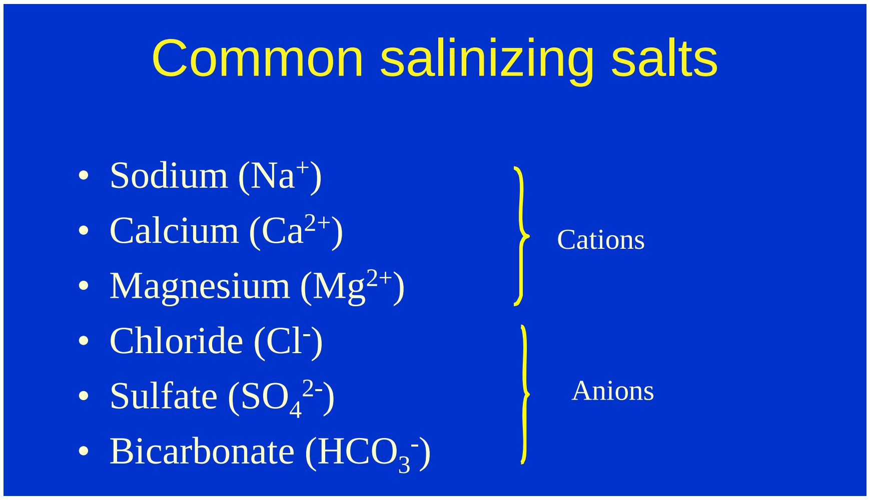

Figure 1: *List of common salinizing salts.*

Now, the anions and the cations have to be in equivalent concentrations in the solution, but what varies is the concentration of the total salts, and also, the ratios of these various constituents. And it's hoped that during this discussion a lot of these issues will be brought up. Not just the concentration of all these, but also the relative composition of these solutions, which also could have a profound effect on avocado.

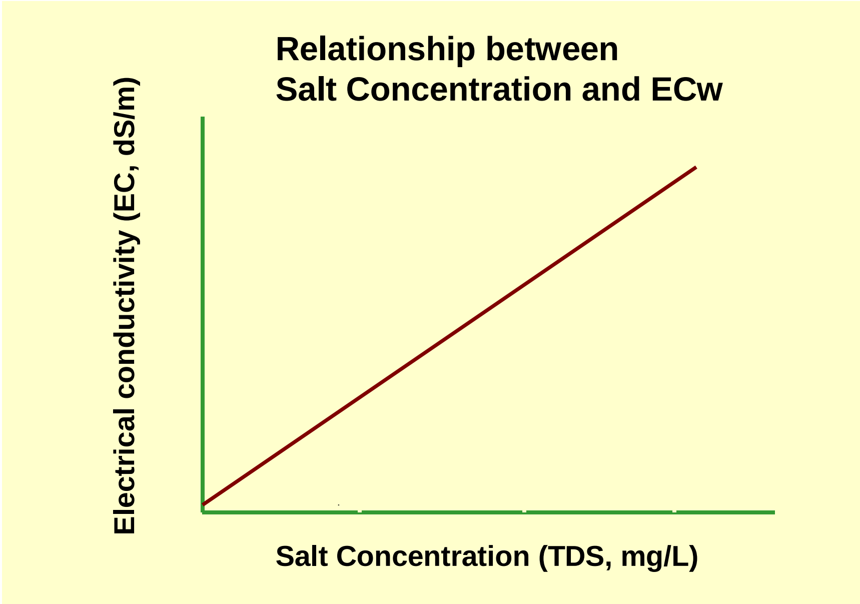

Figure 2: *Graphed relationship between salt concentration and ECw.*

There are two terms that describe salinity. One is electrical conductance, and the other is total dissolved solids. And as you can see, there's a nice linear relationship between electrical conductivity and salt concentration (Figure 2). When you get a lab report back from a commercial lab, salt is expressed sometimes in TDS, sometimes you'll see electrical conductivity, sometimes you'll see them both, sometimes you'll see specific conductance. Generally, the term a lot of us will prefer to use here today is electrical conductivity.

Why? Well, there are a couple of important reasons. One, it's a measurement you can make from the irrigation water supply, or a saturated soil paste. It's something that you can get as an instantaneous reading, and you don't have to either analyze everything in the world in the solution or make inferences to what the total dissolved solids are. The second reason is that our salinity tolerance base is based on electrical conductivity. That's an important reason why we use that term.

It's also important to understand that there are a couple of different ways in which salt impacts crops, whether it is trees or annual crops. One is osmotic effects, and one is specific ion or toxic ion effects. The reason I'm introducing this is because sometimes that's confused. There are two different ways that the tree is being impacted.

What exactly is an osmotic effect? Osmotic effect is an effect on the tree based on the total concentrations of these constituents. As long as there are no extreme ratios of different types of salts, the plants will tend to experience a reduction in growth, from just the total amount of salts that it's experiencing Figure 3). This reduction is an overall reduction in plant growth, number of leaves, and leaf size. This is what we call, an **osmotic effect**.

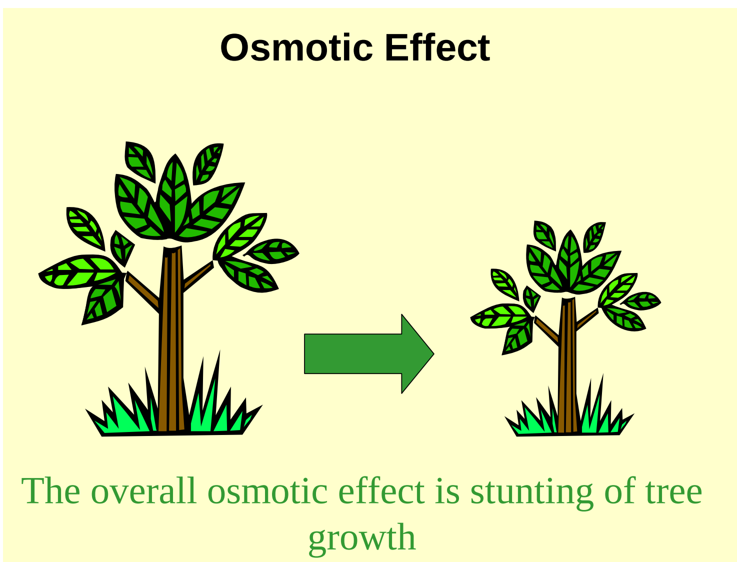

Figure 3: *Depiction of osmotic effect on tree growth.*

The osmotic effect is what we call a toxic ion effect (Figure 4). For a toxic ion effect, we're usually thinking of a few different constituents: sodium, chloride, and boron. Today you'll hear quite a bit of discussion on chloride, and probably sodium, but with specific ion toxicity, what you've got is the constituents in the soil water, both sodium and chloride, and also boron if that's an issue. The rootstock has a profound influence on being able to either exclude or include the uptake of these particular constituents.

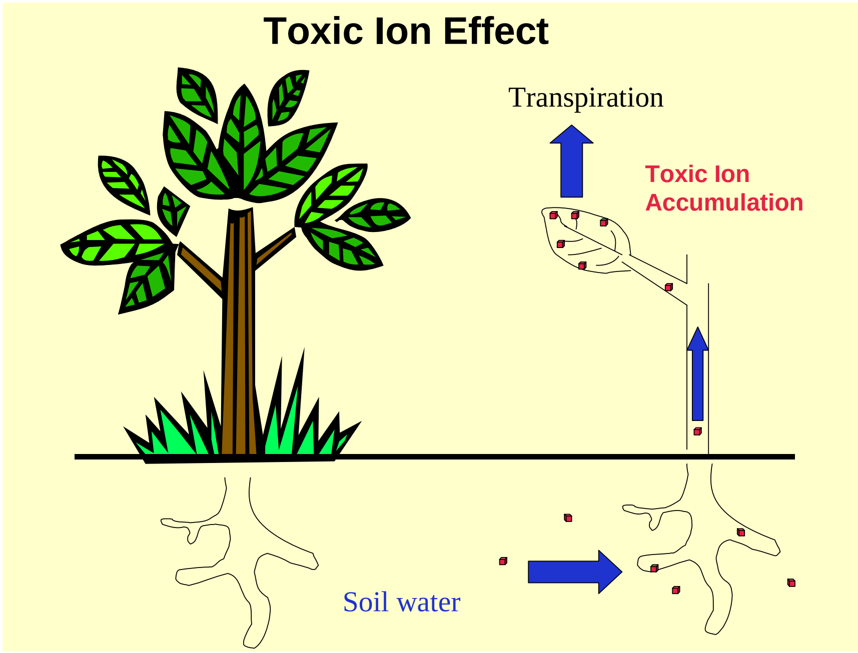

Figure 4: *Depiction of toxic ion effect on plants.*

These constituents can move in the transpiration stream and get deposited in the leaf as it ages. The older leaves are almost always the ones affected first. Why? Because they have the longest history of transpiration, the amount of water that actually moves to the leaf's surface. So, older leaves have the tendency to show injury first. Also, they show injury on the tips and the margins, particularly for chloride injury. Sodium toxicity often has been described in avocados as being blotchy types or spherical type injury that can occur in-between the leaf veins.

There's another thing that I think is important for today's discussion, and that is that these two different effects, osmotic effects and specific ion effects, may not necessarily play, be in the driver's seat at the same time for a particular given year. It may be, at least for some trees, that in early years, when the trees are young, you may have osmotic effects dominating, and then as you advance through the years, it could be that specific ion toxicities start becoming perhaps more damaging than the osmotic effect itself. And, hence, some of those trees that are completely "fried", as some people mentioned earlier today (Figure 5).

I have put a graph together just showing what we know with the different tree crops, and where does avocado fit in this whole picture. (Figure 6) This is a picture showing yield potential on the y-axis as a function of increasing salinity in the crop root zone. What this shows is that all crops can tolerate some maximum level of salinity, and when salinity goes beyond that, yields drop off more or less in a linear fashion.

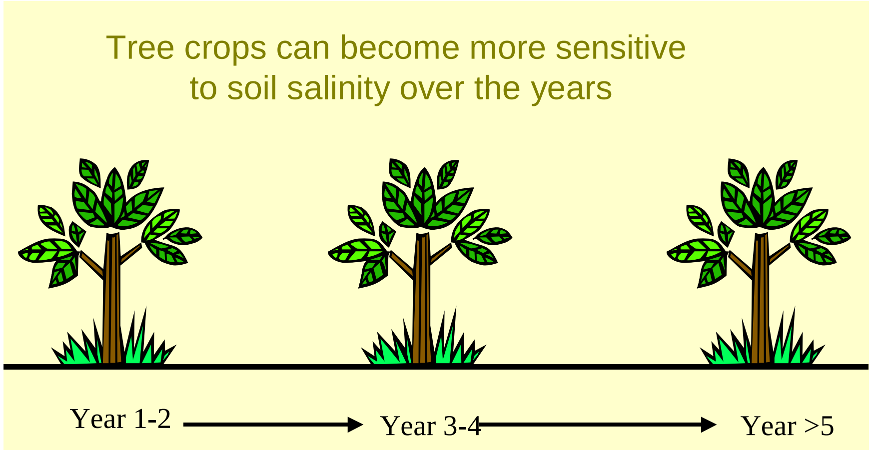

Figure 5: *Diagrammatic representation of the cumulative effects of salinity. Osmotic effects tend to dominate in the early years whereas specific ion toxicities dominate in later years.*

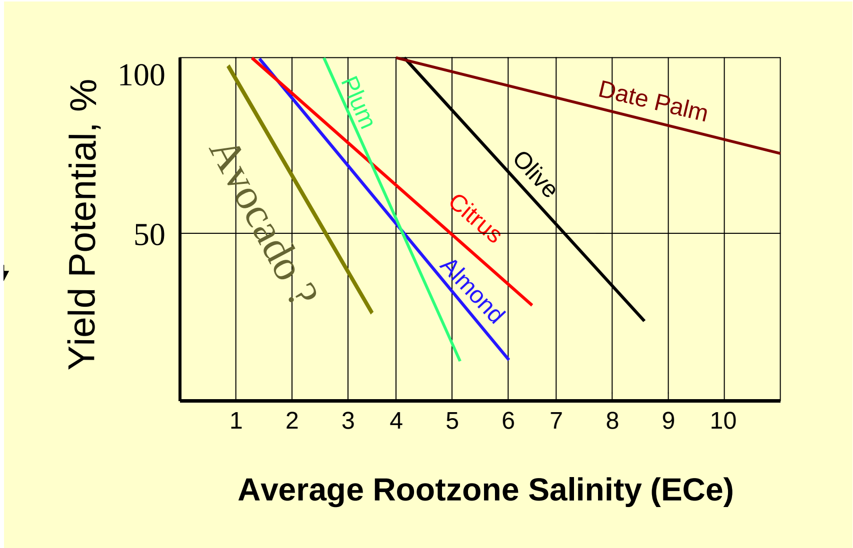

Figure 6: *The relationship between increasing rootzone salinity (ECe) and the effect of salinity of yield potential for different tree crops. Note that avocado is the most sensitive tree crop depicted.*

We have fairly good values for salinity coefficients for these other crops. When we talk about salinity coefficients, we're talking about two different things. One is the **threshold value**, that's the maximum concentration of salts a particular crop can withstand before yields decline. The other salinity coefficient is the **slope**. The steeper the slope, the more rapidly crop yields decline with increase in salinity beyond the threshold.

So in this particular case, you've got some of these world record holders like date palm that are very tolerant, and I put a question mark with avocado because we don't really know where that fits in. A lot of the research was conducted in the 1950's, and there are some inferences that the crop is in fact very sensitive.

There's been a lot more research conducted over the past ten years – and that's the importance of the salinity panel here, is to be able to share that information and hopefully we can shed light on being able to figure out exactly where that may fit. And that it's going to vary somewhat, depending on the rootstock, and Mexican rootstocks are going to tend to be more sensitive than those on the West Indian rootstocks.

Therefore, I tried to put together some goals (Table 1). I'm hoping to accomplish in this workshop, and I'm hoping when the panelists are talking they can have these kinds of questions in mind, and the audience as well. These are very simplistic questions, but sometimes the answers may not be as simplistic.

Table 1. Goals of workshop

- Can reclaimed waste-water be used for irrigation of avocado? If so, what are the upper limits for EC, Cl, or Na?
- Do salinity (osmotic) and specific-ion damage (ie Chloride and sodium) contribute to avocado's extreme sensitivity to salinity? If so, which process is more damaging?
- What is the long-term feasibility of shifting to more salt-tolerant rootstocks?
- What irrigation management strategies can be adopted in avocado orchards to optimize their response to irrigation with poor quality water?

We're hoping to address the issue with reclaimed waste water. There have been experiences both in Israel and in California with using such water. The question is, how feasible is it? And if so, what are the upper limits of EC, chloride and sodium that one can tolerate and still be using this source as irrigation water?

Do salinity, and, in other words, osmotic effects and specific ion damage, contribute to avocado's extreme sensitivity to salinity, and, if so, is one really in the driver's seat more so than the other? Hopefully, we'll get some sort of questions regarding that. And what is the long-term feasibility of shifting to more salt-tolerant rootstocks? And here you've got orchards that already have certain rootstocks. It's not a simple process of pulling them out. But, in terms of water quantity and water quality, water quality is not going to be getting better in the future. Avocado is a crop that's very sensitive to salinity, and most of the water qualities in Southern California are already at that threshold level or beyond. And so, therefore water management and salinity management are very critical.

It's also important to look at what irrigation management strategies could be adopted in avocado orchards to optimize their response to irrigation water. Okay, these are simple questions, but we want to be able to get, hopefully by the end of today, a little bit more concrete answers regarding this.

We're going to have some presentations that vary in length from short, five minutes ones, in some cases, to maybe a little bit longer, up to fifteen minutes. With the primary goal to stimulate discussions, essentially be the seed information for you to think about to help generate questions, not only amongst panelist members, but also interact with the audience and panelist members as well.

The first we've got are Mary Lu Arpaia and Mike Mickelbart who are going to give a short presentation of some of their findings. The topic's going to be a summary of salinity studies examining various avocado rootstocks. This morning the basic emphasis is going to be looking at the avocado rootstocks and salinity tolerance. So if we could kind of keep the discussions mainly with regards to avocado rootstocks.