# Development of Pistachios with Saline Irrigation Water and Regional Salt Tolerance in Pistachio Production Fields


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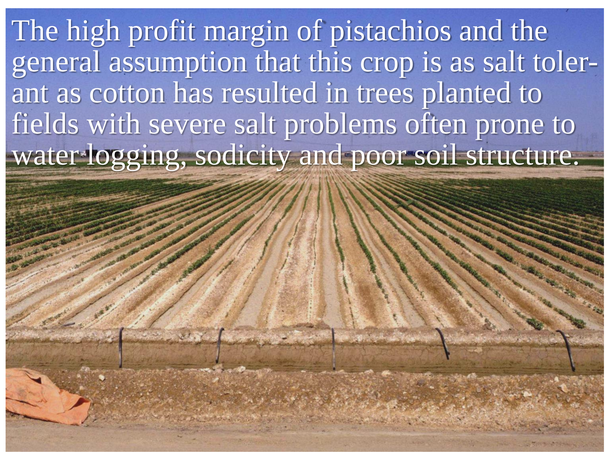
## Abstract

The published and currently accepted root zone salinity threshold for California pistachios of 9.4 dS/m ECe with an 8.4% relative yield decline above that level was developed from a small plot study for 8th through 13th leaf yields in northwestern Kern County from 1997-2002. A second large scale study applied fresh and saline irrigation treatments (0.5 to 5.2 dS/m EC) from planting through 10th leaf yields. Average 2011-14 root zone salinity ranged from 2.5 to 13.2 dS/m and caused a significant edible in shell yield reduction of 108 to 264 kg/ha (~3.1% decline) depending on rootstock in the combined 4 year yield for every unit EC (dS/m) increase over 5 to 6 ds/m. A greatly expanded salinity survey including 9 commercial fields (9th – 13th leaf) in western Kern County with more than 130 individual tree data points ranging from an average root zone salinity of 1.4 to 22.3 dS/m resulted in a similar yield reduction of 48 kg/ha edible in shell for one season for every unit EC above 5 to 6 dS/m.



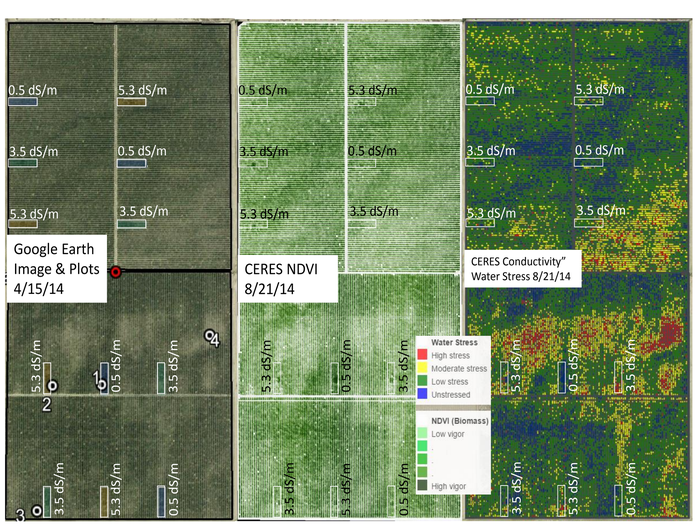




Fig 2. Comparison of a Google Earth aerial image (4/15/14) to CERES Imaging color enhanced NDVI and Water Stress, (Conductance) images from 8/21/14.

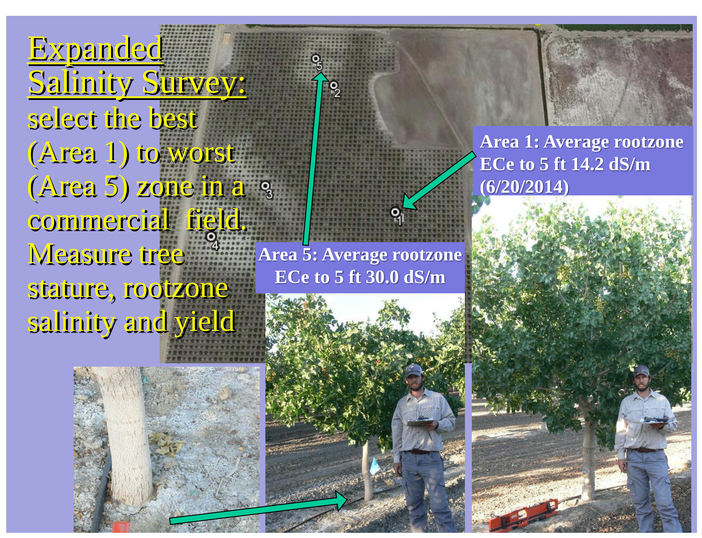



Fig. 3. Example of field impacted by variable salinity and resulting differential in tree size after 11 years.

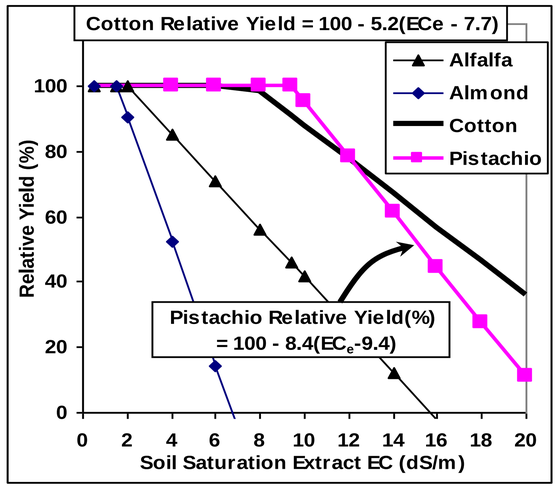




Fig 1. Currently accepted pistachio salt tolerance curve compared to cotton, alfalfa and almond (Sanden and Ferguson, 2004)

## Introduction

The very high threshold salinity generated by the earlier small plot study by Sanden and Ferguson (2004) seemed to concur with other sand tank studies (Fardooel, 2001 and Ferguson, et. al, 2002) where woody shoot growth was not reduced, given non-limiting water availability, until root zone salinity exceeded 12 dS/m. However, none of these trials exposed trees to real field soil conditions of elevated irrigation water salinity starting with planting and following through to tree maturity. A large-scale field trial utilizing sub-surface drip tape in a commercial 125.6 ha development was established in 2004 to answer this question.

## Objectives

- Determine the impact of differential irrigation water salinity on the growth and eventual yield of a newly planted pistachio orchard.
- Create a revised pistachio salt tolerance curve if warranted.
- Assess the feasibility of interplanted cotton using subsurface drip tape as a cash crop between juvenile pistachios (grower objective, data not presented).

## Experimental/Field Design

: In 2004, twelve 7.9 ha test plots were set up in two adjacent 62.8 ha fields to test the use of saline water for commercial-scale development of a new pistachio orchard inter-planted with cotton using shallow (10 inch depth) sub-surface drip tape. The fields were well reclaimed (soil EC 1.57 dS/m to 1 m) and had good drainage.

**Irrigation Treatments:**

| | | |
|---|---|---|
| **Aqueduct** | **0.5 dS/m** | **0.3 ppm B (fresh)** |
| **Blend** | **3.5 dS/m** | **6.0 ppm B (moderate)** |
| **Well** | **5.3 dS/m** | **11 ppm B (saline)** |

The above irrigation treatments are the average water salinity applied for the last 11 years. The highest salinity treatment is more than 4 times as saline as most irrigation waters currently used in the SJV. The field was planted to solid pima cotton in 2004. In 2005, pistachio rootstocks (PG1 and UCB1) were planted in March, 5.2 m apart on a 6.7 m row spacing and inter-planted with four 0.96 m rows of pima cotton. Pistachios were budded with a Kerman scion in July. With minimal rainfall the entire acreage is given a 100 to 200 mm pre-irrigation with canal water in January or February. In-season irrigation is scheduled to meet crop ET in the fresh water treatment and provide leaching in the saline water treatment. Cotton was inter-planted only in 2005 and 2006. The grower stopped all Westside cotton production after 2006 due to the severe shortage and high price of canal water. Increasing salinity of the original well water to 9 dS/m by 2010 necessitated blending with some fresh water to maintain the 5.3 dS/m "Well" treatment. Trunk circumference and canopy volume measurements were taken every fall. Leaf tissues and rootzone soil samples to a 1.5 m depth were taken in July and analyzed for nutrient and salt concentration. Nut yield and quality was measured starting with 7th through 10th leaf (2011-14). Nine additional pistachio fields with salt affected areas were hand harvested in selected areas in 2014 and yields correlated to rootzone salinity.

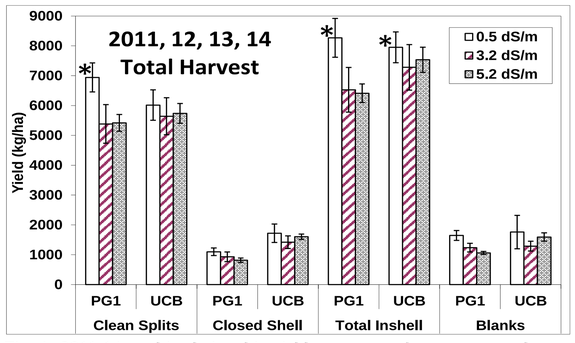



Fig. 4. 2011-14 combined pistachio yield components by treatment and variety with standard error bars. (* significantly different, P<0.05)

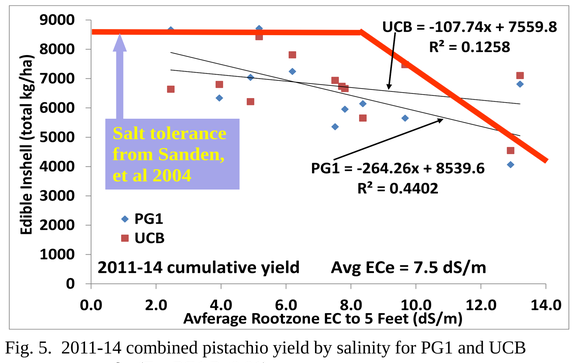



Fig. 5. 2011-14 combined pistachio yield by salinity for PG1 and UCB rootstocks (For PG1 P<0.01)

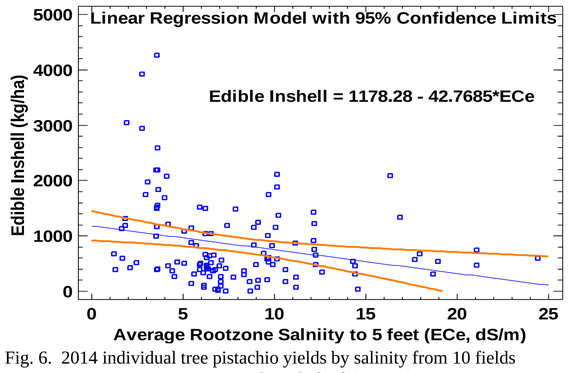



Fig. 6. 2014 individual tree pistachio yields by salinity from 10 fields in western Kern County. 9th-13th leaf (P<0.01).

## Results and Discussion

PG1 rootstock circumference showed a significant 7% decrease at the end of 4th leaf while UCB was unaffected. Starting the end of the 5th leaf UCB also showed a significant decrease. At the end of 10th leaf there is a significant 12% reduction for PG1 and 7% reduction for UCB for both the 3.5 and 5.3 dS/m irrigation compared to the 0.5 dS/m water. Photoshop pixel counts of the volume of green foliage down the row showed a reduction of 19.6 and 7.1% smaller canopy for the 3.5 and 5.3 dS/m irrigation, respectively, compared to the 0.5 dS/m irrigation water. NDVI estimates from 2012 and 2014 indicate a 10-12% canopy size decrease for saline irrigation treatments.

Reduction in pistachio nut yield from saline water was not statistically significant for either the first or second year harvests, but the combined 2012-13, single year 2013 and 2011-14 total yield showed a significant reduction from saline irrigation water of 600 to 1,700 kg/ha total inshell (Fig.4). Split nut yield was reduced by 22% for PG1 and 9% for UCB.

## Conclusion

Of greatest and most practical interest is the yield regression as a function of rootzone salinity. Figure 5 shows that the 4 year yield is significantly reduced as average rootzone salinity increases above an EC of 5 to 6 dS/m – not the 9.4 dS/m originally found by Sanden and Ferguson in 2002. This figure shows superior yield for PG1 over UCB under low salt conditions but says that PG1 has a 264 kg/ha yield penalty for every dS/m increase in salinity while the slope of decline for UCB is only 108 kg/ha for each dS/m increase.

Survey work was expanded to 9 other pistachio fields (ages 9th to 13th leaf) with 3 to 5 areas selected per field to represent the range of lowest to highest salinity, tree stature and yield in that field (Figure 3). The final objective being a salt tolerance/yield loss curve with more points (130 including the Starrh field) and broader application across the region. Figure 6 corroborates the long-term Starrh findings for declining yield with increasing salinity above 6 dS/m (statistically significant P<0.01). However, when analyzed on a "relative yield" per field basis (the traditional way to express salt tolerance) – with 100% in a given field being the highest yielding area for that field -- the trend disappears and becomes insignificant. The problem with this approach is that even the best area in a more saline field (i.e. 100% for that field) was worse than the worst area of a "good" field.


**Literature cited**

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