Site Selection: Location Evaluation, Modification, Water Quality, Salinity Management and Reclamation

Advances in Pistachio Production – Short course

Mae Culumber
Nut Crops Advisor, Fresno

What to evaluate?

Pistachio Crop: Life cycle, water use, rooting characteristics, spacing, canopy structure, harvest requirements, field traffic.

Land: cost, soil texture, drainage chemistry and amendments.

Development: Cost of land leveling, irrigation system, energy, irrigation method, distribution, frequency, pressure regulation, filtration, durability, monitoring, maintenance/repairs.

Water supply: reliability, cost, chemistry, amendments.

Evaluate potential for:
- Uniformity
- Rapid maturity
- Quality/nut size
- High yield
Where to start
UNIVERSITY OF CALIFORNIA COOPERATIVE EXTENSION
2019
SAMPLE COSTS TO ESTABLISH and PRODUCE
PISTACHIOS
SAN JOAQUIN VALLEY - SOUTH

Where to start

$15,000/acre ground, no amendments needed + 5% simple interest over 10 years = $7,500

FINAL COST $22,000/ac or...

$7,000/acre ground
- Year 1: 1.5 t/ac Sulfur $800
- Year 2 thru 10: $300/yr
- Extra acid and gypsum through the system $3,000 (Simple interest, 10 yrs @ 5% $3,500)
- Year 7 - 10:
  - 1000 lb/ac cumulative yield loss compared to other ground $2,400

FINAL COST $19,400/acre

“Expensive” ground

“Inexpensive” ground

Capital Investment Concerns

Expensive” ground
- $15,000/acre ground, no amendments needed + 5% simple interest over 10 years = $7,500
- FINAL COST $22,000/ac or...

Inexpensive” ground

$7,000/acre ground
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- Year 7 - 10:
  - 1000 lb/ac cumulative yield loss compared to other ground $2,400

FINAL COST $19,400/acre

Cost Comparison for 150 Acres @ 121 trees/ac (18 x 20 foot spacing)

EVALUATION COST:
- Four zones–1, 2, 3 & 5 foot
  - Soil analyses 1,000
  - Water analysis 50
  - Backhoe 500
  - Consultant 600
- TOTAL $2,150

ORCHARD COST:
- 18,150 trees, stake, bud, train @ $12/tree 217,800
- Irrig System @ $1,500 225,000
- Land @ $10,000 1,500,000
- TOTAL $1,942,800

0.11% of initial capital.
Assessment of historical images

- Is the “problem” soil or management related?
- Images over areas already developed into permanent crops can provide an idea.

https://casoilresource.lawr.ucdavis.edu/soilweb-apps/
SoilWeb Earth in Google Earth

Or another software that can process .kmz files

Google Earth version easier manipulation of images and provides a timeline of historical imagery.

Not as complete as the Soilweb survey

https://casoilresource.lawr.ucdavis.edu/soilweb/apps/
How does the Lethent Clay Loam compare with the Calfax soil series?

Web soil survey data may not match ground observations. Web soil survey data may not match ground observations –

<table>
<thead>
<tr>
<th>Depth Range (in)</th>
<th>Horizon Designation</th>
<th>% Clay</th>
<th>% Sand</th>
<th>% Organic Matter</th>
<th>pH by water extraction</th>
<th>Sat. Hydraulic Conductivity (mm/hr)</th>
<th>EC (μS/m)</th>
<th>SAR (%)</th>
<th>Carbonates (% of &lt; 2 mm)</th>
</tr>
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<tbody>
<tr>
<td>0 - 2</td>
<td>A</td>
<td>25</td>
<td>23</td>
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<td>7.4</td>
<td>10.8</td>
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<td>3</td>
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<tr>
<td>3 - 12</td>
<td>B</td>
<td>23</td>
<td>22</td>
<td>0.5</td>
<td>7.4</td>
<td>10.8</td>
<td>10</td>
<td>18</td>
<td>3</td>
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<td>12 - 24</td>
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<td>18</td>
<td>0.3</td>
<td>7.7</td>
<td>7.2</td>
<td>12</td>
<td>20</td>
<td>3</td>
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<tr>
<td>24 - 36</td>
<td>B</td>
<td>22</td>
<td>18</td>
<td>0.3</td>
<td>7.7</td>
<td>7.2</td>
<td>12</td>
<td>20</td>
<td>3</td>
</tr>
<tr>
<td>36 - 60</td>
<td>B</td>
<td>20</td>
<td>16</td>
<td>0.2</td>
<td>7.7</td>
<td>7.2</td>
<td>11</td>
<td>20</td>
<td>8</td>
</tr>
</tbody>
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</thead>
<tbody>
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<td>A</td>
<td>35</td>
<td>36</td>
<td>2.0</td>
<td>7.9</td>
<td>10.1</td>
<td>6.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3 - 12</td>
<td>B</td>
<td>32</td>
<td>36</td>
<td>1.4</td>
<td>8.4</td>
<td>10.5</td>
<td>6.0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>12 - 24</td>
<td>B</td>
<td>30</td>
<td>45</td>
<td>0.8</td>
<td>8.6</td>
<td>5.5</td>
<td>12</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>24 - 36</td>
<td>C</td>
<td>23</td>
<td>36</td>
<td>0.3</td>
<td>8.0</td>
<td>5.5</td>
<td>12</td>
<td>15</td>
<td>2.0</td>
</tr>
<tr>
<td>36 - 60</td>
<td>C</td>
<td>27</td>
<td>23</td>
<td>0.7</td>
<td>7.7</td>
<td>3.5</td>
<td>5.0</td>
<td>15</td>
<td>0.5</td>
</tr>
</tbody>
</table>
Soil Profile

- Survey
  - Backhoe pits
  - Augering
  - Push probe

Analysis:

<table>
<thead>
<tr>
<th>SP (saturation %)</th>
<th>48</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>8.2</td>
</tr>
<tr>
<td>ECe</td>
<td>6.0 dS/m</td>
</tr>
</tbody>
</table>

How to do it

SOIL PROFILE
Sampling scheme for variable 160 acres

- Use soil probe or auger to composite sample 0-1 & 1-2 foot depths from at least 8 holes 50 feet apart for each soil type.

- Put at least one backhoe pit to 6 feet in each 40 acres of one soil type. Take deeper samples from pits.
How to do it

SOIL PROFILE
BACKHOE PITS
• SHOVEL
• GEOLOGIST HAMMER/PICK
• MEASURING TAPE
• CLIPBOARD
• BUCKETS/BAGS

How to do it
COLLECTING SAMPLES
@ DEPTH IN SOIL PITS
**How to do it**

Record depths of layers, texture, lime, hardpans, rooting, drainage

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**What to evaluate?**

**SOIL QUALITY**

- Texture
- Structure
- Permeability
- Stratification
- Drainage
- Salinity/Fertility

---

**How to do it**

**SOIL TEXTURE**

Making a soil “ribbon” test from a moistened ball.
What to evaluate?
SOIL PROFILE

- STRUCTURE

SOIL PROFILE -- STRUCTURE

What to evaluate?
SOIL PROFILE

- PERMEABILITY
PERMEABILITY

- Measure infiltration
- Deep rip before planting
- Calcium supplying amendments
- Organic matter
- Cover crops

Pick irrigation system that matches soil infiltration!!!
2.5”/week peak season

What to evaluate?

SOIL PROFILE

- Texture
- Structure
- Permeability
- Stratification
- Drainage
- Salinity/Fertility

SOIL PROFILE
Fine sandy silt layer with high alkalinity and poor structure at the 34 to 44-inch depth may impede root development between 2 layers of clay loam. Slip plowing below this depth is advisable.

**What to evaluate?**

**SOIL PROFILE**

- Monitoring well to determine shallow water table depth

**DRAINAGE**

- Perching inclusions
- Actual Water Table
- Confining Clay Layer
What to evaluate?

Depth to perched water and localized salinity

What to evaluate?

SOIL PROFILE

• TEXTURE
• STRUCTURE
• PERMEABILITY
• STRATIFICATION
• DRAINAGE
• SALINITY/FERTILITY

Submit soil and water samples to a CERTIFIED ag lab

Different labs have different formats. Use one lab with consistent, quality results and a format you understand.
What to evaluate?

**SALINITY CONCERNS**

- Increasing Amount

4.5 to 6 dS/m EC irrigation water may not be sustainable for long-term productivity if salinity challenges are coupled with poor drainage.

**SAFETY ZONE**

- Toxicity Threshold

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**Relationship between ETa and Yield**

Each point is a bi-annual cycle

- Yield vs ETa

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What to evaluate?

**SALINITY CONCERNS**

- Total salinity (EC, TDS), pH
- Specific Ions: Boron, sodium, chloride
- Sodium Adsorption Ratio (SAR<sub>water</sub>)
- Exchangeable Sodium % (ESP<sub>soil</sub>)

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Relative yield of alfalfa, cotton, almond, and pistachio as a function of soil ECe.

Cotton Relative Yield = 100 - 5.2(ECe - 7.7)

Pistachio Relative Yield = 100 - 8.4(ECe - 9.4)

Salt increases osmotic potential, costing the plant energy and interfering with water uptake and limits critical processes like cell expansion for germination and shoot growth.

CLASSIC GUIDELINES
### Table 1: Guidelines for Interpretation of Water Quality for Irrigation

<table>
<thead>
<tr>
<th>Potential Irrigation Problem</th>
<th>Degree of Restriction on Use</th>
<th>None</th>
<th>Slight to Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salinity (affects crop water availability)</td>
<td>ECw (dS/m)</td>
<td>&lt; 0.7</td>
<td>0.7 – 3.0</td>
<td>&gt; 3.0</td>
</tr>
<tr>
<td></td>
<td>TDS (mg/l)</td>
<td>&lt; 450</td>
<td>450 – 2000</td>
<td>&gt; 2000</td>
</tr>
<tr>
<td>Infiltration (affects infiltration rate of water into the soil; evaluate using ECw and SAR together)</td>
<td>Ratio of SAR/ECw</td>
<td>&lt; 5</td>
<td>5 – 10</td>
<td>&gt; 10</td>
</tr>
<tr>
<td>Specific Ion Toxicity (sensitive trees/vines, surface irrigation limits)</td>
<td>Sodium (Na⁺) (meq/l)</td>
<td>&lt; 3</td>
<td>3 – 9</td>
<td>&gt; 9</td>
</tr>
<tr>
<td></td>
<td>Chloride (Cl⁻) (meq/l)</td>
<td>&lt; 4</td>
<td>4 – 10</td>
<td>&gt; 10</td>
</tr>
<tr>
<td></td>
<td>Boron (B) (mg/l)</td>
<td>&lt; 0.7</td>
<td>0.7 – 3.0</td>
<td>&gt; 3.0</td>
</tr>
</tbody>
</table>

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#### Infiltration Response to SAR and EC<sub>irr</sub>


Impact of pH on micronutrient availability and emitter clogging.

- **6.5 OPTIMAL pH 7.5**
  - Mo deficiency
  - Low Ca
  - High Fe, Mn, emitter clogging
  - Lime precip
  - Chlorosis
  - Fe, Zn, Cu, Mn deficiency

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**DEVELOPING NEW PISTACHIO PLANTINGS USING SALINE WATER?**
Establishing pistachios interplanted in Pima cotton using drip tape and saline water. 

(1st leaf, 8/2/05)

Blend (50/50) 

EC = 3.0 dS/m 
Na = 12.1 meq/l 
Cl = 16.9 meq/l 
B = 6.0 ppm

Belridge Well 
EC = 5.4 dS/m 
Na = 23.0 meq/l 
Cl = 33.5 meq/l 
B = 11.1 ppm

Marginal burn was seen on most leaves 
9-1 West Compare

Blend (30% Well, 70% Aqueduct) 
EC = 3.2 dS/m 

Well (60% Well, 40% Aqueduct) 
EC = 5.2 dS/m

2009-13 rootstock growth decreased 7 to 10% from well water 

Trees planted March 5-11, 2005. Irrigation salinity impact statistically significant
### Tree leaf tissue responses

<table>
<thead>
<tr>
<th>NO₃-N (ppm)</th>
<th>NH₄-N (ppm)</th>
<th>PO₄-P (ppm)</th>
<th>K (%)</th>
<th>Na (ppm)</th>
<th>Cl (%)</th>
<th>B (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rootstock Leaves 9/15/05 Pistachio 2005</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acid</td>
<td>150</td>
<td>580</td>
<td>1.02</td>
<td>222</td>
<td>0.27</td>
<td>194</td>
</tr>
<tr>
<td>50/50 Acid</td>
<td>126</td>
<td>545</td>
<td>1.06</td>
<td>220</td>
<td>0.27</td>
<td><strong>492</strong></td>
</tr>
<tr>
<td>Well</td>
<td>148</td>
<td>500</td>
<td>1.08</td>
<td>314</td>
<td><strong>0.38</strong></td>
<td><strong>673</strong></td>
</tr>
</tbody>
</table>

Critical levels of specific ions in leaf tissue (For August tissue samples prior to harvest.)

<table>
<thead>
<tr>
<th>Specific Ion</th>
<th>Levels in Leaf Tissue Degree of toxicity</th>
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<tbody>
<tr>
<td>Chloride (%)</td>
<td>&lt; 0.2 – 0.3 &gt; 0.3</td>
</tr>
<tr>
<td>Boron (mg/l)</td>
<td>&lt; 300 – 700 &gt; 800</td>
</tr>
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</table>

Salt added to crop rootzone from start of project

<table>
<thead>
<tr>
<th>Irrigation Treatment (avg dS/m)</th>
<th>2005</th>
<th>2008</th>
<th>2011</th>
<th>2013</th>
<th>Total</th>
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<td>1.742</td>
<td>6.8</td>
<td>1535</td>
<td>33</td>
<td>3,387</td>
<td>215.8</td>
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<tr>
<td>Blend (3.2)</td>
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<td>8,570</td>
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<td>8,185</td>
<td>41</td>
<td>40,838</td>
<td>247.9</td>
</tr>
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<td>Well (5.2)</td>
<td>12</td>
<td>14,782</td>
<td>9.6</td>
<td>13,296</td>
<td>35</td>
<td>48,596</td>
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1Irrigation inches for total tree spacing, salt totals (lb/ac) calculated for a 9.5 foot wide subing area centered on the tree row. Assumes 640 ppm soluble salt = 1 dS/m and a 5 ac-ft depth of soil = 20 million lbs.

2Maximum increase in soil saturated paste EC for a 5 foot rootzone with no precipitation of salts and no leaching past the 5 foot depth.

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July 2014 aerial of southern half of trial. White boxes are the 40 tree harvested plots.
Yields declined 3.0% PG1 and 1.4% UCB for every additional unit increase in ECe above 5-6 dS/m after a 10-year study of trees planted into saline soil.

**How to do it**

Leaching calculations for composite pit samples

<table>
<thead>
<tr>
<th>Depth</th>
<th>SP</th>
<th>pH</th>
<th>EC</th>
<th>Ca</th>
<th>Mg</th>
<th>Na</th>
<th>SAR</th>
<th>ESP</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1'</td>
<td>40</td>
<td>7.9</td>
<td>5.5</td>
<td>34.2</td>
<td>4.6</td>
<td>21.7</td>
<td>4.9</td>
<td>5.7</td>
</tr>
<tr>
<td>1-2'</td>
<td>45</td>
<td>8.0</td>
<td>6.7</td>
<td>26.8</td>
<td>4.3</td>
<td>39.6</td>
<td>9.6</td>
<td>11.4</td>
</tr>
<tr>
<td>2-3'</td>
<td>45</td>
<td>8.0</td>
<td>7.3</td>
<td>25.7</td>
<td>4.4</td>
<td>51.8</td>
<td>13.6</td>
<td>15.8</td>
</tr>
</tbody>
</table>

Guidelines to evaluate orchard soils and water supplies for excess salinity for mature pistachio trees

Degree of restriction for pistachios

<table>
<thead>
<tr>
<th>EC (dS/m) of:</th>
<th>None</th>
<th>Increasing</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. root zone</td>
<td>&lt; 6</td>
<td>6 - 8</td>
<td>&gt; 8-12</td>
</tr>
<tr>
<td>Irrigation water</td>
<td>&lt; 4</td>
<td>4 - 8</td>
<td>&gt; 8-12</td>
</tr>
</tbody>
</table>

Average salinity = 6.5 dS/m

**How to fix it**

FIX: Monitor soil EC, calculate reclamation leaching
**How to do it**

How to fix it

> WATER QUALITY – Soil structure may suffer with Well 1 quality.

**Analysis:**

<table>
<thead>
<tr>
<th></th>
<th>Well 1</th>
<th>Well 2</th>
<th>Well 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>8.4</td>
<td>7.4</td>
<td>7.4</td>
</tr>
<tr>
<td>ECw</td>
<td>1.0 dS/m</td>
<td>0.5 dS/m</td>
<td>5.8 dS/m</td>
</tr>
<tr>
<td>Ca</td>
<td>0.5 mg/l</td>
<td>1.2 mg/l</td>
<td>28.5 mg/l</td>
</tr>
<tr>
<td>Mg</td>
<td>0.1 mg/l</td>
<td>1.0 mg/l</td>
<td>15.3 mg/l</td>
</tr>
<tr>
<td>Na</td>
<td>9.4 meq/l</td>
<td>2.5 meq/l</td>
<td>23.9 meq/l</td>
</tr>
<tr>
<td>HCO₃⁻</td>
<td>4.2 meq/l</td>
<td>1.6 meq/l</td>
<td>1.5 meq/l</td>
</tr>
<tr>
<td>CO₃²⁻</td>
<td>1.0 meq/l</td>
<td>&lt;0.1 meq/l</td>
<td>&lt;0.1 meq/l</td>
</tr>
<tr>
<td>Cl</td>
<td>4.6 meq/l</td>
<td>2.0 meq/l</td>
<td>36.9 meq/l</td>
</tr>
<tr>
<td>SO₄²⁻</td>
<td>0.1 meq/l</td>
<td>0.9 meq/l</td>
<td>24.0 meq/l</td>
</tr>
<tr>
<td>B</td>
<td>0.7 mg/l</td>
<td>0.3 mg/l</td>
<td>11.0 mg/l</td>
</tr>
<tr>
<td>NO₃⁻</td>
<td>5.2 mg/l</td>
<td>0.6 mg/l</td>
<td>8.0 mg/l</td>
</tr>
<tr>
<td>SAR</td>
<td>17.5</td>
<td>2.4</td>
<td>5.4</td>
</tr>
<tr>
<td>SARadj</td>
<td>16.6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**FIX:** Inject acid. 200 - 500 lb/ac-ft H₂SO₄

(Use Excel Program for weights of sulfuric and nitric acid required to neutralize HCO₃ and release Ca from lime.)

**Fine, ball-milled reclaimed sulfur applied @ 1.5 t/ac**

2-foot banded application:

= 15 t/ac to reduce pH in tree row

Incorporated with bent 15” furrowing shovel welded to 30” chisel shank and sunk into slip trench
Incorporation to 28” depth

Soil analyses from composite sample of Auger & Backhoe treatments prior to planting and end of first season

Finally, what about ground prep and deep tillage?
How to do it

**STRATIFICATION**

How to fix it

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**Treatments:**

1. **Auger only:** no deep tillage. Row marked with furrowing shovel, sulfur applied and incorporated with second pass of same shovel. Standard 3-point hitch auger to be used at planting same as all other treatments.

2. **Slip plow** (standard tillage for whole project): one slip plow pass down the tree row with a 15-inch shoe penetrating 42 to 50 inches.

3. **Triple slip:** slip plow treatment down tree row (as above) with an additional pass 6 feet on either side. A final fourth pass repeated down the center (tree row) pass to achieve a 52-inch penetration and further fracture the profile.

4. **Backhoe to 7 feet**: 3' wide x 7' trench

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**Effect of Pre-plant Tillage on Pistachio Development Under Drip Irrigation (planted 2006)**

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Rootstock circumference: No significant differences after 8 seasons

- Auger
- Chisel
- Slip 1x
- Slip 3x
- Backhoe

(Backhoe is subset of triple slip treatment. Differences are not statistically significant.)

What to evaluate?

Pistachio Crop:
Life cycle, water use, rooting characteristics, spacing, canopy structure, harvest requirements, field traffic

Land:
cost, soil texture, drainage chemistry and amendments

Development:
Cost of land leveling, irrigation system, energy, distribution, frequency, pressure regulation, filtration, durability, monitoring, maintenance/repairs,

Water supply: reliability, cost, chemistry, amendments
THANK YOU!

QUESTIONS?