Evaluation of the Multiple Benefits of Nitrogen Management Practices in Walnuts
Parry Klassen
CURES
Study Overview

- Walnut Orchard located east of Ceres (Stanislaus County)
- 2-year study
  - 2016-2017 crop years

**Project Technical Consultant**

- MLJ Environmental, Davis
- Performed lysimeter installation, data gathering and analysis
Project Objectives

#1: Identify management practices implemented to reduce nitrogen moving past the root zone in two walnut orchards

#2: Determine the amount and timing of nitrogen moving through the root zone following adequate rain to saturate soils

#3: Identify benefits of implemented management practices
   a. Cost savings (reduced water use, reduced fertilizer use)
   b. Groundwater protection

#4: Determine if additional practices could be implemented to further reduce nitrogen moving past the root zone

#5: Disseminate results to growers of walnuts
Efficient Nitrogen Management
Applying the 4 R’s Principles

- Apply at the **Right Time**
- Apply the **Right Rate**
- Use the **Right Source**
- Apply in the **Right Place**
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Analyses</th>
<th>Distribution</th>
<th>Collection depth</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pore water</td>
<td>Nitrate as N</td>
<td>15 locations per block</td>
<td>4 feet (2016, 2017), 10 feet (2017)</td>
<td>1 rain event, 6 irrigation events</td>
</tr>
<tr>
<td>Irrigation water</td>
<td>Nitrate as N</td>
<td>Groundwater and surface water</td>
<td>NA</td>
<td>As needed to characterize nitrate applied.</td>
</tr>
<tr>
<td>Soil cores</td>
<td>Nitrate as N, C:N ratio, % moisture</td>
<td>8 random locations per block</td>
<td>2 foot intervals to 10 feet (5 samples per 10-foot core)</td>
<td>2 in 2016, early season and late season; 1 in 2017, early</td>
</tr>
<tr>
<td>Solvita Labile Ammino-N (SLAN)</td>
<td>Nitrogen mineralization potential</td>
<td>8 random locations per block (Sub-sampled from soil cores)</td>
<td>2-4 foot interval (variable based on results)</td>
<td>2 in 2016; early season and late season; none in 2017</td>
</tr>
<tr>
<td>Tissue (nut and hull only)</td>
<td>Total nitrogen, % moisture</td>
<td>10 random locations in east and west block</td>
<td>NA; samples collected from multiple trees within the grid square</td>
<td>Annually, just prior to harvest.</td>
</tr>
<tr>
<td>Soil volumetric water content</td>
<td>% VWC</td>
<td>5 random locations per block</td>
<td>2 feet, 4 feet</td>
<td>Continuous logging; 15-minute interval</td>
</tr>
</tbody>
</table>
Walnut Orchard

- Located in Stanislaus County near Ceres
- Chandler walnut cultivar on black walnut rootstock
- 20 yrs old with replanting as needed for losses from disease (bacterial canker)

- East block (4.09 acres)
  - 170 trees/acre
  - Each tree irrigated with one 10.3 gal/hr microsprinkler

- Center block (3.50 acres)
  - 108 trees/acre
  - Each tree irrigated with one 19.6 gal/hr microsprinkler

- West block (2.34 acres)
  - 108 trees/acre
  - Each tree irrigated with one 19.6 gal/hr microsprinkler
Treatments

- **2016**
  - 2 blocks: West and East
  - 4 ft. lysimeters only

- **2017**
  - 3 blocks: West, Center and East
    - An improved understanding of the irrigation system resulted in sub-dividing the West Block into the West and Center Blocks
  - 4 ft. and 10 ft. lysimeters sampled
  - Locations of tissue sample collection, and moisture sensors remained the same
East Block: 4.09 acres
West Block: 2.34 acres  Center Block: 3.50 acres
(blue outline)

West Block: 94.1 m x 251.4 m = 5.84 acres
Soil Cores

- Collected in May and November 2016, March 2017
- Five 10 ft cores from each block
  - Divided into 2 ft sections
- Characterized for texture by section
- Measured concentration of NO$_3$-N
Walnut orchard - soils

- Hanford fine sandy loam
- Tujunga loamy sand
- Sand lens of more compacted material approximately 10 cm thick is found between 150 and 300 cm below ground surface across some of both blocks
- Depth to groundwater is 40 m
## Irrigation Water Analysis Report for Nitrate

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Nitrate ($\text{NO}_3^-$) ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>63</td>
</tr>
<tr>
<td>II</td>
<td>48</td>
</tr>
<tr>
<td>III</td>
<td>2</td>
</tr>
<tr>
<td>IV</td>
<td>38</td>
</tr>
<tr>
<td>V</td>
<td>63</td>
</tr>
</tbody>
</table>
Observations from 2016
Changes made in 2017

2016 Observations

• Fertilization by banded applications followed by flood irrigation
• Flood irrigation events were causing considerable nitrate movement to four feet: was it from just previous nitrogen application or the combination of all previous applications?
• Grower wondered what was going on below our 4 ft lysimeters

2017 Changes

• Grower agreed to delay flood irrigation until after fertilization was complete
  • Fertilizer applied by sprinkler fertigation
• Added 10’ deep lysimeters to measure nitrate movement below active root systems
Walnut orchard - irrigation and fertilizer 2016

- Combination of microsprinkler using groundwater and flood irrigation using surface water
- **Fertilizer** - 150 lbs/acre in three 50 lb/acre applications
  - Urea-ammonium nitrate solution fertilizer (UAN 32) used for all fertilizations
- Combination of fertigation and banded applications
- Fertigation combined with normal irrigation events
  - Concentration of NO$_3$ during fertigation events - 515 mg/L NO$_3$-N
- Banded applications prior to flood irrigation
- Tissue testing in early July indicated no need for additional applications
Walnut orchard - irrigation and fertilizer 2017

- Fertilizer applications by fertigation only
- Flood irrigation during non-fertilization events
- Fertilizer - 150 lbs/acre in three 50 lb/acre applications
  - Urea-ammonium nitrate solution fertilizer (UAN 32) used for all fertilizations
  - Fertigation combined with normal irrigation events
    - Concentration of NO₃ during fertigation events - 515 mg/L NO₃-N
  - Tissue testing in early July indicated no need for additional applications
Results 2016 - soils

Non-detects as missing data
GLM ANOVA results:
No significant difference between grids
No significant difference between months
No significant interaction

<table>
<thead>
<tr>
<th>Date</th>
<th>NO$_3$-N (mg/kg), West Block</th>
<th>NO$_3$-N (mg/kg), East Block</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>2.818</td>
<td>5.387</td>
</tr>
<tr>
<td>November</td>
<td>4.210</td>
<td>4.818</td>
</tr>
</tbody>
</table>

Non-detects as 0 mg/kg
GLM ANOVA results:
No significant difference between grids
No significant difference between months
No significant interaction

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<th>NO$_3$-N (mg/kg), East Block</th>
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<tbody>
<tr>
<td>May</td>
<td>2.325</td>
<td>4.175</td>
</tr>
<tr>
<td>November</td>
<td>3.928</td>
<td>2.650</td>
</tr>
</tbody>
</table>
Soils

- Paired t-test indicates **no differences** between May and November concentrations of nitrate from same grid cells
- Non-detects treated as missing

<table>
<thead>
<tr>
<th>Mean NO3-N (mg/kg) May</th>
<th>Mean NO3-N (mg/kg) November</th>
<th>Wilcoxon Signed-Ranks</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.625</td>
<td>5.000</td>
<td>t = -0.384, p = 0.70</td>
</tr>
</tbody>
</table>

- Non-detects treated as 0 mg/kg

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<tr>
<th>Mean NO3-N (mg/kg) May</th>
<th>Mean NO3-N (mg/kg) November</th>
<th>Wilcoxon Signed-Ranks</th>
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<tr>
<td>3.25</td>
<td>2.33</td>
<td>t = 1.597, p = 0.11</td>
</tr>
</tbody>
</table>
Year 1 Results (2016)

Pore Water Nitrogen from 4 Foot Lysimeters After Fertilizer Application

Fertilization Application
- Fertigation
- Flood

Nitrogen (mg/L)
Year 2 Results (2017)
Summary of Findings

- Flood irrigations moved applied nitrogen beyond the root zone
  - Sprinkler irrigations levels were less dramatic (but still resulted in nitrate detections above 10 mg/l N mcl)

- Split applications of N were not significant improvement
  - May have been caused by injecting N at beginning of irrigation set
Questions?

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