Nitrogen Management Training
for Certified Crop Advisers

MODULE 4

Irrigation and
Nitrogen Management

Larry Schwankl, PhD
UC Cooperative Extension, Kearney Ag Extension Station

Allan Fulton
UCCE Farm Advisor, Tehama, Glenn, Colusa, and Shasta Counties
Irrigation and Nitrogen Management

Successful nitrogen management depends on efficient irrigation water management:

- Nitrate is mobile and moves with water.
- You can apply the right amount of N in the root zone, but N can leach past the root zone unless the correct amount of water is applied at the correct time.
- Inefficient irrigation may result in N-deficient crops and potentially add nitrates to groundwater.
Irrigation Efficiency

• Measure of how much of the applied water goes to “reasonable and beneficial uses”.
  • The major beneficial use is to supply plant water needs and grow productive crops.
  • Other beneficial uses include salt leaching and frost protection, but both of these can lead to N leaching if not carefully done.

• Non-beneficial uses or losses are:
  • Deep percolation below root zone except the amount needed to manage salinity
  • Tailwater runoff that is not reused
Irrigation Efficiency: Calculation

\[
\text{Beneficially-Used Water} = \frac{\text{Irrigation Efficiency (%)} \times \text{Total Water Applied}}{100}
\]

• What is a realistic efficiency?

  70% minimum eventually required by regulations
  
  85-90% is an impressive efficiency to target
Irrigation Efficiency

Different people arrive at different estimates for Irrigation Efficiency. Why?

Field scale – vs – Watershed or basin scale

Single irrigation – vs – Sum of several irrigations in a season
How Do We Become More Efficient Irrigators?
Achieving Efficient Irrigation

Where to begin:

• Use readily available information to look for situations where the choice of crop, soils, and irrigation method do not match up well.
  – Fertilizer bills
  – Electricity, fuel, and water bills
  – Production history
Soil texture and its influence on leaching

1. Sprinkler
2. Drip and microsprinkler
3. Flood
4. Furrow

Less chance of leaching

Greater chance of leaching
Infiltration and N Leaching

- Both “light” and “heavy” soil types can have a wide range of soil intake rates.

- Soil moisture, soil mineralogy, soil structure, and tillage are key elements.
How Do We Become More Efficient Irrigators?
Know how much water to apply
Irrigation Scheduling

- Determining how much water to apply
  - Quantify how much water has been used by the crop since the previous irrigation or rainfall
  - When the correct amount of water is applied at the proper time, potential for deep percolation and leaching of nitrate is minimized.
Irrigation Scheduling: Soil Monitoring Approach

There are numerous soil moisture monitoring techniques, devices, and services available to growers.

“Feel Method,” squeeze soil in hand to estimate its moisture level.

Sophisticated devices continuously monitor soil moisture and upload data to online databases growers can check.
**Irrigation Scheduling: Soil Monitoring Approach: Drawbacks**

- Most soil monitoring techniques tell when to irrigate, but not all provide how much to irrigate.

- Effectiveness is subject to representative placement of sensors and good understanding of the crop root zone.
Irrigation Scheduling: Plant Monitoring Approach

- Monitoring the plant itself for signs of water stress

- Relatively new approach, equipment and knowledge still developing
Irrigation Scheduling: Plant Monitoring Approach: Drawbacks

- **Limited information**, available for some crops & not for others
  - Interpreting pressure bomb readings and crop stress levels for most CA crops is unexplored

- Methods tend to be **labor intensive** – working toward automation

- Crop stress and readings tell you **when** to irrigate (plant is stressed) but not **how much**
  - How much water is needed can be learned with experience or by coupling plant monitoring with other approaches (i.e. ET)
Irrigation Scheduling: Weather Monitoring Approach

- Climatic conditions drive the water use of plants.
- Monitor the weather and use it to estimate crop water use (evapotranspiration).
Irrigation Scheduling: Weather Monitoring Approach

California has the CIMIS network to provide weather information and estimates of Reference Crop ET (ET of pasture grass).
Irrigation Scheduling: Weather Monitoring Approach

- Relates estimate to irrigation system design and performance
- Tells us both *when* and *how much* to irrigate
How Do We Become More Efficient Irrigators?
Apply the correct amount of water with a good irrigation system
Sound Irrigation System Design Concepts

• Ability to measure applied water and thus control leaching

Our ability to manage water improves if we have the ability to measure it.
Sound Irrigation System Design Concepts

How much water is being applied? Measure with a flow meter

Saddle Propeller Meter, the most common type of flow meter, attached by cutting through the pipe. It is sufficiently accurate for agricultural purposes.

Saddle propeller meter attached to pipe
Sound Irrigation System Design Concepts

How much water is being applied? Measure with a flow meter

Electronic flow meter, known as a MagMeter. It is a very accurate type of meter, but locating it near elbows and forks can alter pressure and decrease accuracy.

Debris in water can hinder propeller meters; installations with weeds and trash in the water need special flow meter devices.
Sound Irrigation System Design Concepts

How much water is being applied? Irrigation system evaluation

Water application rate and uniformity
Irrigation System Evaluation: Application Rate

A measure of the field-wide water application rate

- Most easily measured in pressurized irrigation systems
- Relates to how deep water (and nitrogen) will penetrate the crop root zone depending on the irrigation set time

![Soil Nitrate Nitrogen (NO3-N) Concentration](image.png)

<table>
<thead>
<tr>
<th>Soil Depth (inches)</th>
<th>Site 1</th>
<th>Site 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>21</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>42</td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td>84</td>
<td>84</td>
<td>84</td>
</tr>
<tr>
<td>126</td>
<td>126</td>
<td></td>
</tr>
</tbody>
</table>

Soil Nitrate Nitrogen (NO3-N) (ppm)
Rapid Assessment

Step 1

Determine soil moisture depletion since last irrigation (ET)

Table CWU-8. Corn (Planted May 1) ET (in/day)

<table>
<thead>
<tr>
<th>Location</th>
<th>Madera</th>
<th>Merced</th>
<th>Stockton</th>
<th>Modesto</th>
<th>Parlier</th>
<th>Visalia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr 1-15</td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>Apr 16-30</td>
<td>0.05</td>
<td>0.05</td>
<td>0.04</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>May 1-15</td>
<td>0.14</td>
<td>0.14</td>
<td>0.13</td>
<td>0.14</td>
<td>0.14</td>
<td>0.14</td>
</tr>
<tr>
<td>May 16-31</td>
<td>0.24</td>
<td>0.24</td>
<td>0.23</td>
<td>0.23</td>
<td>0.24</td>
<td>0.24</td>
</tr>
<tr>
<td>Jun 1-15</td>
<td>0.30</td>
<td>0.30</td>
<td>0.28</td>
<td>0.28</td>
<td>0.29</td>
<td>0.29</td>
</tr>
<tr>
<td>Jun 16-30</td>
<td>0.30</td>
<td>0.27</td>
<td>0.28</td>
<td>0.28</td>
<td>0.27</td>
<td>0.29</td>
</tr>
<tr>
<td>July 1-15</td>
<td>0.28</td>
<td>0.27</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.27</td>
</tr>
<tr>
<td>July 16-31</td>
<td>0.20</td>
<td>0.19</td>
<td>0.19</td>
<td>0.18</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>Aug 1-15</td>
<td>0.13</td>
<td>0.13</td>
<td>0.07</td>
<td>0.13</td>
<td>0.13</td>
<td>0.14</td>
</tr>
<tr>
<td>Aug 16-31</td>
<td>0.13</td>
<td>0.13</td>
<td>0.07</td>
<td>0.13</td>
<td>0.13</td>
<td>0.14</td>
</tr>
<tr>
<td>Sept 1-15</td>
<td>0.13</td>
<td>0.13</td>
<td>0.07</td>
<td>0.13</td>
<td>0.13</td>
<td>0.14</td>
</tr>
<tr>
<td>Sept 16-30</td>
<td>0.13</td>
<td>0.13</td>
<td>0.07</td>
<td>0.13</td>
<td>0.13</td>
<td>0.14</td>
</tr>
<tr>
<td>Oct 1-15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>24.88</td>
<td>24.59</td>
<td>22.52</td>
<td>23.51</td>
<td>24.03</td>
<td>24.64</td>
</tr>
</tbody>
</table>
Rapid Assessment

Step 2

Measure Flow and Determine how much water has been applied (flow rate)

- Flow meters the best way - on all pumps
- Irrigation District information
- Pump test - discharge will change (often a lot) if groundwater level changes.
Rapid Assessment

Step 2

Measure Flow and Determine how much water has been applied (inches)

\[ D = \frac{(Q \div 449) \times T}{A} \]

\[ D = \text{inches of water applied} \]
\[ Q = \text{gpm (gallons per minute) flow rate} \]
\[ T = \text{hours irrigation set time} \]
\[ A = \text{acres in irrigation set} \]

*If flow is measured in cfs, no need to divide by 449 in equation*
Rapid Assessment

Step 3  Is the risk of deep percolation high?

Compare the amount applied to the amount used since last irrigation.

- Leaching is likely to occur when runoff is minimal and applied water is “much” greater than crop use.
Irrigation System Evaluation: Irrigation Uniformity

A measure of how evenly water is applied to the field

- Given as percentage with 100 % being perfect
- Various measures including Distribution Uniformity (DU), Coefficient of Uniformity (CU), and Emission Uniformity (EU).
- Knowing the general concept is more important than the details about the different measurement methods of irrigation uniformity.
Importance of Irrigation Uniformity

• Poor irrigation uniformity means that portions of the field are getting less water than others.

• Most growers do not want to under-irrigate even a portion of the crop, so they irrigate to make sure the area receiving the least water gets enough.

• Some portions of the field receive too much water. Too much water leads to deep percolation losses (leaching of water). If nitrate is in the soil profile, it can be leached with the water.

• Poor irrigation uniformity makes N leaching more likely.
Importance of Irrigation Uniformity

Average DUs by Irrigation Method
MIL 2002-2011

- Micro-Sprinkler: 125
- Micro-Drip: 83
- Impact: 76
- Rotator: 92
- Flood: 58
- Hand Move: 39
- Wheel Line: 55
- Center Pivot: 60
- # of Evals
- Average DU

Tehama County Resource Conservation District
Types of Irrigation Systems
Surface Irrigation

Furrow and border strip irrigation
Surface Irrigation: Furrow Irrigation Example

1. Water flows field top to bottom in furrow irrigation. Blue segment represents water on field surface; pink is infiltration.

2. More water has infiltrated at field head, where it has been present the longest.
Water is run off the field tail to allow enough to infiltrate there to satisfy the crops’ needs. The runoff should be collected and reused.

End of irrigation event. Water has infiltrated field tail, and field head has received excess. This water goes to deep percolation, leaching any N present.
Surface Irrigation: Recognizing Non-Uniform Flood or Furrow Irrigation

Total time water ran on an irrigation set \[= \text{Advance Ratio}\]
Time it takes water to reach end of field

\[
\frac{398 \text{ minutes}}{158 \text{ minutes}} = 2.5
\]

Advance Ratio > 2 indicates reasonable uniformity
Surface Irrigation: Improvement with High Flow Rates

Water losses can be from deep percolation and tailwater runoff.

Losses from deep percolation and tailwater runoff are competing outcomes of surface irrigation management:

• Design steps that improve irrigation uniformity and reduce deep percolation probably increase tailwater runoff
• Design steps to reduce tailwater runoff probably cause more deep percolation and risk of N leaching
Shortening field length gets water across the field more quickly, resulting in less deep percolation.
**Surface Irrigation: Improvement with Shortened Field Length**

**Example**

- Reduce field length
  - Often the most effective option
  - Also often the least popular option

<table>
<thead>
<tr>
<th>Irrigation</th>
<th>1250’ Field</th>
<th>2-600 ‘ Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount</td>
<td>9.1”</td>
<td>5.4”</td>
</tr>
</tbody>
</table>

![Diagram showing comparison between 1250’ and 2-600’ field lengths with irrigation amount]
Surface Irrigation: Improvement with Increased Field Slope

Example

<table>
<thead>
<tr>
<th>slope</th>
<th>Irrigation</th>
<th>Applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.001</td>
<td></td>
<td>5.1”</td>
</tr>
<tr>
<td>0.002</td>
<td></td>
<td>4.8”</td>
</tr>
</tbody>
</table>
Surface Irrigation: Improvement of Border Check Irrigation

Increase the flow per foot of border check

Field Study: Usually run 2 valves per check; make checks half as wide and run 1 valve at a time → more flow per foot of check width

<table>
<thead>
<tr>
<th>Irrigation Applied</th>
<th>Wide check (200’)</th>
<th>Narrow check (100’)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5.1”</td>
<td>4.3”</td>
</tr>
</tbody>
</table>
Surface Irrigation: Improvement with Torpedoes

Using a torpedo gets water across the field more quickly, resulting in less deep percolation.
**Surface Irrigation:** Improvement with Torpedoes Example

**Field study:** Newly cultivated furrows, some “torpedoed” and some not

<table>
<thead>
<tr>
<th>Torpedoed Furrow</th>
<th>Non-torpedoed Furrow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation Water</td>
<td>9.4”</td>
</tr>
<tr>
<td>Applied</td>
<td>12.9”</td>
</tr>
</tbody>
</table>
Collecting and reusing tailwater runoff makes the best use of expensive and limited irrigation water.

Water is collected and carried to a sump pump by underground pipelines, where it is pumped to a standpipe for use.

A small pond is used to collect tailwater, which is then pumped back to the head of the field using a sump pump.
Surface Irrigation: What if these options for improvement are not practical or effective?

- A change in irrigation method may be needed
  - Possibly target specific irrigation events (pre-irrigation of row crops)
  - Alternatively, make a wholesale change in methods
  - Often there will be a corresponding improvement in crop productivity when poorly performing irrigation systems are improved
Pressurized Irrigation

• Reduce the inherent control of the soils on irrigation efficiency
• Invest in irrigation hardware and sound irrigation system design to gain more management control of applied water
Pressurized Irrigation: Sprinkler

• How can sprinkler system performance be improved?
  • Know the **application rate**
    • We provide water use information in units of “inches of water use (per day or per week.......)”
    • Need to know the system application rate (in/hr) in order to know how long to run the system
Pressurized Irrigation: Sprinkler Application Rate

Calculating system application rate:

\[
i \text{ (in/hr)} = \frac{96.3 \times \text{(nozzle discharge in gpm)}}{\text{Spacing along lateral (ft.)} \times \text{Spacing between laterals (ft.)}}
\]
**Pressurized Irrigation: Sprinkler Application Rate**

Nozzle Discharge:

<table>
<thead>
<tr>
<th>Pressure (psi)</th>
<th>(\frac{3}{32})</th>
<th>(\frac{1}{32})</th>
<th>(\frac{1}{8})</th>
<th>(\frac{5}{32})</th>
<th>(\frac{11}{64})</th>
<th>(\frac{3}{16})</th>
<th>(\frac{13}{64})</th>
<th>(\frac{7}{32})</th>
<th>(\frac{15}{32})</th>
<th>(\frac{1}{4})</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>1.17</td>
<td>1.60</td>
<td>2.09</td>
<td>2.65</td>
<td>3.26</td>
<td>3.92</td>
<td>4.69</td>
<td>5.51</td>
<td>6.37</td>
<td>7.32</td>
</tr>
<tr>
<td>25</td>
<td>1.31</td>
<td>1.78</td>
<td>2.34</td>
<td>2.96</td>
<td>3.64</td>
<td>4.38</td>
<td>5.25</td>
<td>6.16</td>
<td>7.13</td>
<td>8.19</td>
</tr>
<tr>
<td>30</td>
<td>1.44</td>
<td>1.95</td>
<td>2.56</td>
<td>3.26</td>
<td>4.01</td>
<td>4.83</td>
<td>5.75</td>
<td>6.80</td>
<td>7.86</td>
<td>8.97</td>
</tr>
<tr>
<td>35</td>
<td>1.55</td>
<td>2.11</td>
<td>2.77</td>
<td>3.50</td>
<td>4.31</td>
<td>5.18</td>
<td>6.21</td>
<td>7.30</td>
<td>8.43</td>
<td>9.69</td>
</tr>
<tr>
<td>40</td>
<td>1.66</td>
<td>2.26</td>
<td>2.96</td>
<td>3.74</td>
<td>4.61</td>
<td>5.54</td>
<td>6.64</td>
<td>7.80</td>
<td>9.02</td>
<td>10.35</td>
</tr>
<tr>
<td>45</td>
<td>1.76</td>
<td>2.39</td>
<td>3.13</td>
<td>3.99</td>
<td>4.91</td>
<td>5.91</td>
<td>7.03</td>
<td>8.30</td>
<td>9.60</td>
<td>10.99</td>
</tr>
<tr>
<td>50</td>
<td>1.85</td>
<td>2.52</td>
<td>3.30</td>
<td>4.18</td>
<td>5.15</td>
<td>6.19</td>
<td>7.41</td>
<td>8.71</td>
<td>10.10</td>
<td>11.58</td>
</tr>
<tr>
<td>55</td>
<td>1.94</td>
<td>2.64</td>
<td>3.46</td>
<td>4.37</td>
<td>5.39</td>
<td>6.48</td>
<td>7.77</td>
<td>9.12</td>
<td>10.50</td>
<td>12.15</td>
</tr>
<tr>
<td>60</td>
<td>2.03</td>
<td>2.76</td>
<td>3.62</td>
<td>4.50</td>
<td>5.65</td>
<td>6.80</td>
<td>8.12</td>
<td>9.56</td>
<td>11.05</td>
<td>12.68</td>
</tr>
<tr>
<td>65</td>
<td>2.11</td>
<td>2.88</td>
<td>3.77</td>
<td>4.76</td>
<td>5.87</td>
<td>7.06</td>
<td>8.45</td>
<td>9.92</td>
<td>11.45</td>
<td>13.21</td>
</tr>
<tr>
<td>70</td>
<td>2.19</td>
<td>2.99</td>
<td>3.91</td>
<td>4.96</td>
<td>6.10</td>
<td>7.34</td>
<td>8.78</td>
<td>10.32</td>
<td>11.95</td>
<td>13.70</td>
</tr>
<tr>
<td>75</td>
<td>2.27</td>
<td>3.09</td>
<td>4.05</td>
<td>5.12</td>
<td>6.30</td>
<td>7.58</td>
<td>9.08</td>
<td>10.66</td>
<td>12.32</td>
<td>14.19</td>
</tr>
</tbody>
</table>

Note: Metric conversions: 1 gal = 3.785 l; 1 in = 2.54 cm; 1 psi = 6.89 kPa.
Pressurized Irrigation: Sprinkler Application Rate

Nozzle Size (diameter):

Where to find this information?

1. Engraved on side of brass/steel nozzle

2. For a worn nozzle, compare opening with drill bit sizing

3. Plastic sprinklers often color coded by manufacturer
Pressurized Irrigation: Sprinkler Application Rate

Determining Pressure:

Pressure gauge with Pitot tube attached (above), inserted into sprinkler opening (left)
# Pressurized Irrigation: Sprinkler Application Rate

## Determining Pressure (another method):

### R10 Plate/Nozzle Options and Flow Performance in GPM and LPH

<table>
<thead>
<tr>
<th>Plate Series</th>
<th>Plate Options</th>
<th>Recommended Nozzles</th>
<th>PSI</th>
<th>BAR</th>
<th>BAR</th>
<th>BAR</th>
<th>BAR</th>
<th>BAR</th>
<th>BAR</th>
<th>BAR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>25</td>
<td>30</td>
<td>35</td>
<td>40</td>
<td>45</td>
<td>50</td>
<td>1.75</td>
<td>2</td>
</tr>
<tr>
<td>P2 9° Red</td>
<td>18-20'</td>
<td>Lt. Blue #40</td>
<td>—</td>
<td>—</td>
<td>.28</td>
<td>.30</td>
<td>.32</td>
<td>.34</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>(5.5-6.1 m)</td>
<td>Lt. Purple #45</td>
<td>.29</td>
<td>.32</td>
<td>.35</td>
<td>.37</td>
<td>.39</td>
<td>.42</td>
<td>66.4</td>
<td>71.3</td>
</tr>
<tr>
<td></td>
<td>(36-58 cm)</td>
<td>Dk. Green #50</td>
<td>.36</td>
<td>.39</td>
<td>.43</td>
<td>.46</td>
<td>.48</td>
<td>.51</td>
<td>82.3</td>
<td>87.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.35 10FC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P4 9° White</td>
<td>18-22'</td>
<td>Dk. Green #50</td>
<td>—</td>
<td>—</td>
<td>.43</td>
<td>.46</td>
<td>.48</td>
<td>.51</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>(5.5-6.7 m)</td>
<td>Lt. Yellow #55</td>
<td>.44</td>
<td>.48</td>
<td>.52</td>
<td>.55</td>
<td>.59</td>
<td>.62</td>
<td>101</td>
<td>107</td>
</tr>
<tr>
<td></td>
<td>(36-61 cm)</td>
<td>Lt. Red #60</td>
<td>.51</td>
<td>.56</td>
<td>.61</td>
<td>.65</td>
<td>.69</td>
<td>.73</td>
<td>117</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td></td>
<td>.50 10FC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P4 15° Orange</td>
<td>23-25'</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>(7.0-7.6 m)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>40-50&quot;</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>(102-127 cm)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Within the recommended pressure range of 25-50 PSI (1.75-3.25 BAR), the .35 10 FC flow control nozzle is flow regulating within a flow range of no more than 0% greater and 10% less than the nominal flow of .35 GPM (79.5 LPH).

Within the recommended pressure range of pressure range of 25-50 PSI (1.75-3.25 BAR), the .5 10 FC flow control nozzle is flow regulating within a flow range of no more than 0% greater and 10% less than the nominal flow of .5 GPM (114 LPH).
Pressurized Irrigation: Sprinkler Application Rate

Calculating Application Rate Rate (another method):

1. Time how long it takes to fill pale of known volume

2. This is the application rate in gpm

3. Plug into formula to get application rate in in/hr
Pressurized Irrigation: Sprinkler Application Uniformity

• How can sprinkler performance be improved?
  • Determine and improve sprinkler application uniformity
Pressurized Irrigation: Sprinkler Application Uniformity

Determining uniformity with a catch can test. A consultant or mobile team can be hired to conduct this type of test and provide suggestions for improvement.
Pressurized Irrigation: Microirrigation Application Uniformity

• Irrigation uniformity can be a problem with microirrigation systems too.

• What causes non-uniformity?
  • Poor microirrigation system design – pressure differences too great
Pressurized Irrigation: Microirrigation Application Uniformity

Pressure differences cause changes in rates of discharge, affecting uniformity:

The discharge from a drip emitter is shown on the Y-axis. As pressure increases (X-axis), so does discharge.

Similar to the drip emitter, the microsprinkler flow rate represented here increases as pressure increases.
Pressurized Irrigation: Microirrigation Application Uniformity

How do system designers address pressure differences that cause non-uniformity?

Pressure-compensating (PC) drippers (left) and microsprinklers (right) are used to equalize discharge when pressure is not constant.
What causes non-uniformity?

Maintenance problems

Clogging can lead to serious non-uniformity problems. Almost all clogging problems can be solved or prevented with good filtration and routine maintenance.
Pressurized Irrigation: Microirrigation Application Uniformity

Maintenance Tips:

Clean and flush filters regularly

Automatic backflush system

Flush lines regularly

Silt and clay are small enough to make it through filters but often settle in the lateral lines of drip tape and tubing.
Pressurized Irrigation: Microirrigation Application Uniformity

Maintenance Tips:

Monitor for leaks and breaks

Check lines for chemical clogging at least twice per season

Many of the most successful microirrigation system users check for leaks and breaks every time the system is turned on. This picture shows where a microsprinkler has been broken off.

Check for bacteria or calcium buildup around emitters and nozzles. Surface waters are prone to organic problems (above right), and groundwater is more prone to chemical precipitation problems (above left).
Fertigation
Accounting for N in Irrigation Water

• Converting between Nitrate and Nitrate-N
  • Nitrate reported as: nitrate (NO$_3^-$) or as nitrate-N (NO$_3^-$-N)
    
    \[ \text{ppm (NO}_3^\text{-}) = \text{ppm (NO}_3^\text{-N}) \times 4.43 \]
    \[ \text{ppm (NO}_3^\text{-N}) = \text{ppm (NO}_3^\text{-}) \div 0.23 \]

• Converting from ppm in irrigation water to lbs/ac-in
    \[ \text{ppm (NO}_3^\text{-}) \times 0.052 = \text{lbs N / ac-in} \]
    \[ \text{ppm (NO}_3^\text{-N}) \times 0.23 = \text{lbs N / ac-in} \]

• Converting from ppm in irrigation water to lbs/ac-ft
    \[ \text{ppm (NO}_3^\text{-}) \times 0.62 = \text{lbs N / ac-ft} \]
    \[ \text{ppm (NO}_3^\text{-N}) \times 2.79 = \text{lbs N / ac-ft} \]
Fertigation in Surface and Pressurized Systems

• Source of nutrients (very often N) through fertigation

• Fertigation (with anhydrous ammonia and UAN) is commonly used in sprinkler and microirrigation, but is also done in flood irrigation
Fertigation in Surface Systems

Infiltration rate of soil controls uniformity:

![Graph showing infiltration rate over time]

- **Initial rate**: 5.0 inches/hour
- **Basic rate**: 0.10 inches/hour

Time, hours: 0, 1, 2, 3, 4, 5
Fertigation in Surface Systems: Example

Irrigation started with clean water

Distance along field - feet
Fertigation in Surface Systems: Example cont’d.

Liquid sulfur drip started when fresh water advance at 750’. Sulfur begins to quickly move down the furrow.
Fertigation in Surface Systems: Example cont’d.

Clean water advance at 800’
Injected material advance at 500’

Liquid sulfur dripping

Distance along field - feet
Liquid sulfur drip was started when fresh water advance was at 750’. Sulfur “caught up” by 850’.
**Fertigation in Surface Systems: Flood Irrigation Example**

<table>
<thead>
<tr>
<th>Fertigation Added:</th>
<th>Nitrogen Applied (lbs/ac)</th>
<th>Uniformity of application</th>
</tr>
</thead>
<tbody>
<tr>
<td>During entire irrigation</td>
<td>242</td>
<td>+</td>
</tr>
<tr>
<td>When freshwater advance to 75% of field length</td>
<td>86</td>
<td>++</td>
</tr>
<tr>
<td>When freshwater advance to 85% of field length</td>
<td>31</td>
<td>++++</td>
</tr>
</tbody>
</table>

*field length = 1200’, avg. irrig. amt = 7.1”*  

Improved the uniformity of fertilizer application and allowed a smaller amount to be applied per irrigation.
Goals:

• Material injected into the drip system should be applied as evenly (uniformly) as water applied by the system. It takes time for water and injected chemical to move through a drip irrigation system.

• Target fertilizer in the root zone where crop can use it
Fertigation in Pressurized Systems: Uniformity

- Trees & vines: injections should last at least 1 hour for uniform application, and at least 1 hour of clean water irrigation should follow so that all fertilizer is delivered to the crop.

- Row crop drip: injections should be at least 2 hours in length, and there should be at least 2 hours of clean water irrigation following injection.
Fertigation in Pressurized Systems: Orchard Uniformity Example

Water / chemical travel times through the pipelines and drip lateral lines for several vineyard and orchard field sites:

<table>
<thead>
<tr>
<th>Site</th>
<th>Mainline and Submain</th>
<th>Lateral Line</th>
<th>Total Travel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Travel Time (min.)</td>
<td>Length (ft)</td>
<td>Travel Time (min.)</td>
</tr>
<tr>
<td>1</td>
<td>22</td>
<td>1000</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>1500</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>65</td>
<td>5000</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
<td>1400</td>
<td>30</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>700</td>
<td>25</td>
</tr>
<tr>
<td>6</td>
<td>17</td>
<td>800</td>
<td>28</td>
</tr>
</tbody>
</table>
Fertigation in Pressurized Systems: Root Zone Targeting Example

When during the irrigation do you inject (for different soil types)?

- **Loam**
  - 2 hour injection near start of 27 to 36 hour Irrigation.
  - N levels elevated at 30 in.
  - N confined to top 10 in.

- **Surface Drip**

- **Silt Loam**
  - 2 hour injection near start of 27 to 36 hour Irrigation.
  - N levels elevated at 30 in.
  - N confined to top 6 in.

(Blaine Hanson, “Fertigation with Microirrigation”)
Fertigation in Pressurized Systems: Root Zone Targeting Example

*Microsprinklers

When during the irrigation do you inject?

(Blaine Hanson, “Fertigation with Microirrigation”)
Other Issues Faced by California Growers
Salinity

- It is a fact that leaching is necessary to sustain crop production where salinity approaches crop tolerance. This is considered a beneficial water use.
- How do we leach to manage root zone salinity without leaching nitrogen fertilizers?
Salinity: Tips for Leaching Salts and Not Nitrate

- Leaching is not necessary every irrigation or perhaps even every season but only when crop tolerances are approached.

- Periodic soil and irrigation water testing will help determine when and how much leaching is needed.

- The amount of applied water must exceed ET, and the soil water content must exceed field capacity for leaching to occur.

- Leaching is most efficient in the winter when land is fallow or crops are dormant and should not coincide with critical periods of nitrogen uptake and fertilization.
Rainfall

- Rainfall can be a source of water for leaching.
- We have little control over the amount and timing of rainfall.
- Can we control the N available to be leached at the time of rainfall?
  - Coordinate timing of N fertilizers with the period of highest crop demand
  - Apply reasonable rates for crop production levels
  - Minimize amount of N in the root zone going into the rainy season
University of California

Nitrogen Management Training
for Certified Crop Advisers

Course materials available at:
cciwr.ucanr.edu/NitrogenManagement

Contributing partners:

University of California
Agriculture and Natural Resources
web: ucanr.edu
Twitter: @ucanr

California Institute for Water Resources
University of California
Agriculture and Natural Resources
web: ciwr.ucanr.edu
Twitter: @ucanrwater

California Department of Food & Agriculture (CDFA)
web: www.cdfa.ca.gov
Twitter: @CDFAnews

California Association of Pest Control Advisers (CAPCA)
web: capca.com

University of California
Agriculture and Natural Resources