Irrigation Distribution Uniformity
*From design to maintenance – why care?*

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Tehama, Glenn, Colusa, and Shasta Counties

Topics:

• DU … What is it?
• Why care?
• What causes low DU?
• Effective management practices
Irrigation Distribution Uniformity (DU) - Simple Concept

Important to the bottom line:
• water demand
• energy demand
• nitrogen use efficiency
• uniform orchard production and tree health
• efficiency - production per unit water, land, and energy
Irrigation uniformity...

Has a big impact on water use and yield. Measure your distribution uniformity and improve it!
Measuring DU is simpler with drip and micro sprinkler (Example: system pressure (psi) data Tehama County Mobile Irrigation Lab)
Measuring system pressures – simpler than measuring flows

Pressure gauge and pitot tube
Calculating water emission rates based on pressure measurements:

<table>
<thead>
<tr>
<th>Plate Series</th>
<th>Plate Options</th>
<th>Recommended Nozzles</th>
<th>PSI</th>
<th>BAR</th>
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<tbody>
<tr>
<td>P2</td>
<td>9° Red</td>
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<td>—</td>
<td>—</td>
<td>.28</td>
<td>—</td>
<td>.30</td>
<td>—</td>
<td>.32</td>
<td>—</td>
<td>.34</td>
<td>—</td>
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<td>.32</td>
<td>.35</td>
<td>.37</td>
<td>.39</td>
<td>.42</td>
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<td>.43</td>
<td>.48</td>
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<td>87.2</td>
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<td>Dk. Green #50</td>
<td>.36</td>
<td>.39</td>
<td>.43</td>
<td>.46</td>
<td>.48</td>
<td>.51</td>
<td>.46</td>
<td>.48</td>
<td>.51</td>
<td>—</td>
<td>—</td>
<td>93.4</td>
<td>99.4</td>
<td>104</td>
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<tr>
<td></td>
<td>9° Red</td>
<td>.35 10FC</td>
<td>—</td>
<td>—</td>
<td>.43</td>
<td>.46</td>
<td>.48</td>
<td>.51</td>
<td>—</td>
<td>—</td>
<td>93.4</td>
<td>99.4</td>
<td>104</td>
<td>108</td>
<td>112</td>
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<td>9° White</td>
<td>Dk. Green #50</td>
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<td>—</td>
<td>.43</td>
<td>.46</td>
<td>.48</td>
<td>.51</td>
<td>—</td>
<td>—</td>
<td>93.4</td>
<td>99.4</td>
<td>104</td>
<td>108</td>
<td>112</td>
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<td></td>
<td>9° White</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>
<td>114</td>
<td>120</td>
<td>125</td>
<td>131</td>
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<td></td>
<td>9° White</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>
<td>133</td>
<td>141</td>
<td>147</td>
<td>154</td>
<td>161</td>
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<td></td>
<td>15° Orange</td>
<td>.50 10FC</td>
<td>—</td>
<td>—</td>
<td>.43</td>
<td>.46</td>
<td>.48</td>
<td>.51</td>
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<td>—</td>
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<td>99.4</td>
<td>104</td>
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<td>112</td>
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</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).
Going the extra mile – actually measuring flows

Tehama County Mobile Irrigation Lab
Field Team
Approximating DU

\[
\text{Distribution Uniformity (DU)} = \frac{\text{Average emission rate for low quartile of pressure measurements in orchard}}{\text{Average emission rate for all pressure measurements in whole orchard}}
\]
Sidebar: Approximating Hourly Rate of Water Application to Schedule Irrigation Duration and Frequency

- Determine average emission rate from drip or microsprinklers
- Count number of drippers or (micro)sprinklers per acre
- Know 1.0 acre-inch volume of water equals 27,154 gallons

**Calculation for Drip and Microspinklers rated in gph:**

\[
\text{Average Emission Rate (gph)} \times \frac{\text{Number of drippers or microsprinklers per acre}}{27,154} = I \text{ (inch/hour)}
\]

**Calculation for sprinklers and mini-sprinklers rated in gpm:**

\[
\text{Average Emission Rate (gpm)} \times \frac{\text{Number of (mini)sprinklers per acre} \times 60}{27,154} = I \text{ (inch/hour)}
\]
Why Care about DU?

Example: Target application 1.0 inch water

DU = 90% 1.12"

DU = 70% 1.42"
### Why Care about DU?

**Example:** Target application 1.0 inch water

<table>
<thead>
<tr>
<th>DU</th>
<th>Water Applied High ¼ of orchard</th>
<th>Water Applied Low ¼ of orchard</th>
<th>Difference across one irrigation</th>
<th>Difference thirty irrigation cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>1.12</td>
<td>0.90</td>
<td>0.22</td>
<td>6.6</td>
</tr>
<tr>
<td>80</td>
<td>1.27</td>
<td>0.80</td>
<td>0.47</td>
<td>14.1</td>
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<tr>
<td>70</td>
<td>1.42</td>
<td>0.70</td>
<td>0.72</td>
<td>21.6</td>
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</tbody>
</table>
## Why Care about DU?

Example: Target 1.0 inch of water in low ¼ of orchard using a micro sprinkler system with 0.05 inch/hr application rate

<table>
<thead>
<tr>
<th>DU</th>
<th>Hours to apply 1” low ¼ of orchard</th>
<th>Total hours thirty irrigation cycles</th>
<th>Hours irrigation (pump) time increased between DU’s</th>
<th>Relative Increase %</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>20</td>
<td>600</td>
<td>Reference Point</td>
<td>----</td>
</tr>
<tr>
<td>90</td>
<td>22</td>
<td>660</td>
<td>60</td>
<td>10</td>
</tr>
<tr>
<td>80</td>
<td>24</td>
<td>720</td>
<td>120</td>
<td>20</td>
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<tr>
<td>70</td>
<td>26</td>
<td>780</td>
<td>180</td>
<td>30</td>
</tr>
</tbody>
</table>
Who Should Care?

Micro Irrigation DU's of Almonds by ITRC Ranking Method
(103 Evaluations) MIL 2002-2014

1 in 3 systems

Average System Age (years)

- Excellent: 6.2 years
- Good: 6.7 years
- OK: 7.3 years
- Low: 8.7 years
- Poor: 10.4 years
Factors Affecting DU?

When designing a system:

– Drip emitter, microsprinkler, or mini sprinkler features
– Pressure regulation or flow compensation
– Lateral lines – material, size, length, placement
– Mainline and sub-main pipe sizes
– Filtration and back flush system
– Pumping plant performance
– Ability to measure system flow and pressure

– Balancing these factors with cost
Factors Affecting DU – Understand Emission Device

Non-pressure compensating drip emitter

Pressure compensating drip emitter
Factors Affecting DU – Understand Emission Device

Non-pressure compensating micro sprinkler

Pressure compensating micro sprinkler
Factors Affecting DU – Pressure Regulation and Flow Compensation

Pressure regulating valves

Pressure reducing regulators
Factors Affecting DU - Mainline, lateral line materials, placement, sizes, and lengths

Materials = Durability
Placement = Exposure to damage
Size/Length = Pressure and flow distribution. Water hammer.

Source: http://www.rainbird.com/landscape/resources/FrictionLossCharts.htm
Factors Affecting DU- Filtration and Back Flushing

Types of Filters:

- Pressurized screen or disk filter
- Centrifugal sand separator
- Sand media filter

Back flushing:

- Automated
  - Pressure differential
  - Clock
- Manual
### Factors Affecting DU - Filtration and Back Flushing

#### Table 1. Relative microirrigation system clogging potential of irrigation water

<table>
<thead>
<tr>
<th>Water characteristics</th>
<th>Minor</th>
<th>Moderate</th>
<th>Severe</th>
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</thead>
<tbody>
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<td>suspended solids (ppm)</td>
<td>&lt; 50</td>
<td>50–100</td>
<td>&gt; 100</td>
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<tr>
<td>pH</td>
<td>&lt; 7.0</td>
<td>7.0–8.0</td>
<td>&gt; 8.0</td>
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<tr>
<td>total dissolved solids (ppm)</td>
<td>&lt; 500</td>
<td>500–2,000</td>
<td>&gt; 2,000</td>
</tr>
<tr>
<td>electrical conductivity (dS/m)</td>
<td>&lt; 0.8</td>
<td>0.8–3</td>
<td>&gt; 3</td>
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<tr>
<td>manganese (ppm)</td>
<td>&lt; 0.1</td>
<td>0.1–1.5</td>
<td>&gt; 1.5</td>
</tr>
<tr>
<td>iron (ppm)</td>
<td>&lt; 0.2</td>
<td>0.2–1.5</td>
<td>&gt; 1.5</td>
</tr>
<tr>
<td>hydrogen sulfide (ppm)</td>
<td>&lt; 0.2</td>
<td>0.2–2.0</td>
<td>&gt; 2.0</td>
</tr>
<tr>
<td>bacterial population (number per ml)</td>
<td>&lt; 10,000</td>
<td>10,000–50,000</td>
<td>&gt; 50,000</td>
</tr>
</tbody>
</table>

*Source: Bucks and Gilbert 1979; Nakayama and Bucks 1991.*
Filtration Guidelines
Many options are available for filtration. Guidelines developed by the industry are shown in Table 6.

References

<table>
<thead>
<tr>
<th>Flow rate (gpm)</th>
<th>Concentration</th>
<th>Filtration*</th>
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<tbody>
<tr>
<td></td>
<td>Organic</td>
<td>Inorganic</td>
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<td>&lt; 50 gpm</td>
<td>L</td>
<td>L</td>
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<td></td>
<td>L</td>
<td>M</td>
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<td>50 to 200 gpm</td>
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<td>&gt; 200 gpm</td>
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<td>M</td>
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<td>H</td>
<td>H</td>
</tr>
</tbody>
</table>

Source: Bruce 1985.

Key:
L = less than 5 ppm
M = 5–30 ppm
H = more than 50 ppm
A = pressurized screen or disk filter
B = suction screen filter
C = centrifugal sand separator
D = gravity flow screen filter
E = sand media filter

Note:
* Letter sequence indicates the sequence of the filters: C+E means a centrifugal separator followed by a sand media filter.
Factors Affecting DU – Pumping Plant Design: Adequate Supply and Pressure as Groundwater Levels Change

- Ground Surface
- Static or Standing Water Level
- Ground Water
- Pumping Water Level
- Pump
- Motor
- Pump Head
- Discharge Pressure Gauge
- Discharge Pipe
- Pumping Lift
Factors Affecting DU – Ability to Measure Flow and Pressure

Self-flushing end caps
As the system ages: plugs, leaks, and breaks occur.

Photos: By Kevin Greer and Allan Fulton.
Keys to maintaining high DU’s (what works well)

• Check often (quick check at start up, thorough check including **hose flushing** monthly or more often, **check pressure regulator valves**)
• Balanced and sufficient pressures
• Be cautious with system additions or modification
• Maintenance - sprinkler and emitter types – must match
• Maintenance - nozzle sizes – must match
• Maintenance – Clean filters, keep in good condition
• Maintenance – fix breaks and leaks
• Maintenance - chemigation
Suggestions for Chemigation

**Biological plugging**
- Good filtration lessens chemigation
- Three effective methods
  - Chlorination with pH adjustment
  - Copper products
  - Ozone

**Chemical precipitate plugging**
- Add acids to neutralize alkalinity
- Amount of acidification depends on water quality and acid strength
- Usually lower pH to 4 to 7 range
- Exercise caution
  - Personal safety
  - Corrosive and other damage

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**Graph 1:** pH Effect on Hypochlorous Acid Concentration

- pH Range: 4.5 to 10
- Hypochlorous Acid Concentration (%)

**Graph 2:** Titration curve for urea sulfuric acid (15% urea, 49% sulfuric acid)

- pH Range: 4 to 8
- Gallons of acid per acre-foot of irrigation water

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To conclude about Distribution Uniformity (DU)

Important to the bottom line:
- water demand
- energy demand
- nitrogen use efficiency
- uniform orchard production and tree health
- efficiency - production per unit water, land, and energy

AN ONGOING BATTLE OVER TIME!

http://micromaintain.ucanr.edu/Solutions/
THANK YOU!