Irrigation Efficiency on small farms and gardens.

Dean Moberg
USDA – NRCS
Welcome and introductions

Monet, *Haystacks*
Irrigation as a system

Hardware.
Soil.
Plants.

Escher, Waterfall
Irrigation as a system

*Hardware.*

*Soil.*

*Plants.*
Hardware

- Flood
- Sprinkler
- Micro
Hardware

- Flood
- Sprinkler
- Micro
Sprinkler benefits

- Can be portable
- Cooling
- Frost protection
Sprinkler drawbacks

- Uniformity difficult
- Affected by wind
- Wet foliage
- High energy cost
- Smaller sets

Scott and Cory, 1957
Sprinkler tip 1: overlap

Close to 100% sprinkler overlap is important for good water application uniformity.
Sprinkler tip 2: pressure

Low

Correct

Smesrud et al., 1997
Sprinkler tip 3: maintenance
Micro (drip) benefits

- Less waste
- Uniform
- Low labor
- Dry foliage
- Less bacteria on fruit?
Micro drawbacks

• Hard to see clogs and leaks
• Animal damage
• Hard to “catch up”
Micro tip 1: good filtration
Micro tip 2: regular flush
Irrigation as a system

$\textit{Hardware.}$

$\textit{Soil.}$

$\textit{Plants.}$
Available water, simplified

Figure 1. Soil-Bottle Analogy.
Web Soil Survey

Free, fun, easy

http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
<table>
<thead>
<tr>
<th>Map unit symbol</th>
<th>Map unit name</th>
<th>Rating (centimeters per centimeter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7B</td>
<td>Cascade silt loam, 3 to 7 percent slopes</td>
<td>0.19</td>
</tr>
<tr>
<td>7C</td>
<td>Cascade silt loam, 7 to 12 percent slopes</td>
<td>0.19</td>
</tr>
<tr>
<td>16C</td>
<td>Delena silt loam, 3 to 12 percent slopes</td>
<td>0.20</td>
</tr>
</tbody>
</table>
Volunteer needed
Available Water

- Field capacity
- Available water
- Wilting coefficient
- Unavailable water

Water content (cm/m of soil)

Sand | Sandy loam | Loam | Silt loam | Clay loam | Clay
Irrigation as a system

*Hardware.*

*Soil.*

*Plants.*
Western Oregon Irrigation Guides

Mario Hess, Jason Smesrud, and John Selker

The Western Oregon Irrigation Guides were developed to aid growers in this region with irrigation management and scheduling for common irrigated crops. Guides presently available are listed below.

The detailed guides are provided in Adobe Acrobat format. This requires your browser to have an Acrobat Reader plug-in. If you don’t already have this plug...

<table>
<thead>
<tr>
<th>Blueberry</th>
<th>Leafy Green</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broccoli</td>
<td>Orchard</td>
</tr>
<tr>
<td>Bulb Onion</td>
<td>Peppermint</td>
</tr>
<tr>
<td>Caneberry</td>
<td>Potato</td>
</tr>
<tr>
<td>Carrot</td>
<td>Squash</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>Strawberry</td>
</tr>
<tr>
<td>Cucumber</td>
<td>Sweet Corn</td>
</tr>
<tr>
<td>Green Bean</td>
<td>Table Beet</td>
</tr>
</tbody>
</table>

Additionally, the Background & References Guide provides further information and tips concerning irrigation in Western Oregon.

http://bioe.oregonstate.edu/Faculty/selker/wo_irrigation_guide.htm
Blueberries have most of their effective rooting system in the upper 18 inches of soil. Since they are relatively shallow-rooted, blueberries are subject to drought injury. A uniform and adequate supply of moisture is essential for optimum growth. In most areas of Western Oregon, irrigation is required to maintain adequate soil moisture from mid-June to mid-September. The demand for moisture is greatest from the time of fruit expansion until harvest. July and August are the lowest rainfall months and this is the period when the developing fruit produces the greatest plant water demand. This is also the period when floral initiation for next year’s crop begins. If soil moisture is lacking at this time, a reduced set of buds will occur. Some cultivars are sensitive to fruit cracking. However, with a continuous supply of moisture, the fruit skin remains elastic and cracking is less likely to occur. Cracking often occurs after a period of drought. Fruit growth is slowed and the skin becomes less elastic. Then, if precipitation or a period of high humidity occurs, the fruit flesh swells faster than the skin can accommodate and the skin splits. Fruit may also shrivel under periods of water stress. Growers should be aware however that excessive, standing water in blueberry fields can reduce root growth and promote root diseases like phytophthora.

The peak water use for blueberry is approximately 0.25 and 0.23 inches per day for July and August, respectively.

On the back side of this page is a worksheet to aid in calculating irrigation schedules for blueberries. These calculations are most straightforward for those using side-roll, hand-move, or solid set sprinkler irrigation. For those with linear move or center pivot systems, all information applies except for the set time, which must be gauged to the tower travel speed. For basic schedule information, sprinkler nozzle diameters, operating pressures, and spacing and soil type must be known. To more accurately describe individual systems, the uniformity coefficient of the system and available water capacity of your soil is also needed. This worksheet was designed to be progressed through sequentially starting with item a). Equations listed under item headings use item letters for reference. Although the rooting depth is already supplied in the worksheet, if you have reason to believe your site is an exception (e.g., shallow restrictive layer), this may be altered. Evapotranspiration rate estimates for the growing season are listed in the worksheet.

References

Note: For additional background information and references, see “Western Oregon Irrigation Guides: Background and References.”
From blueberry guide

- Effective root depth = 18 inches
- Maximum allowable depletion = 50%
Available water, simplified

Figure 1. Soil-Bottle Analogy.
Total available water

\[ AW/\text{inch} \times \text{root depth} \times \text{MAD} \]

\[ 0.20 \frac{\text{in}}{\text{in}} \times 18 \text{ in} \times 50\% = 1.8 \text{ in} \]
Total available water

\[ \frac{AW}{\text{inch}} \times \text{root depth} \times \text{MAD} \]

\[ \frac{0.20}{\text{in}} \times 18 \text{ in} \times 50\% = 1.8 \text{ in} \]

Your available water calculation will depend on your soil and crop.
Evapotranspiration (ET)

Peak ET for blueberries = 0.25 in/day
**Irrigation Schedule Worksheet: Blueberry**

**A. Determine Irrigation Interval**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Allowable Deficit [pct]</td>
<td>b. 10</td>
</tr>
<tr>
<td>Effective Rooting Depth [in]</td>
<td>c. 18</td>
</tr>
<tr>
<td>Peak ET [in/day]</td>
<td>d. 0.25</td>
</tr>
<tr>
<td>Maximum Irrigation Interval [days]</td>
<td>e.</td>
</tr>
<tr>
<td>Your Irrigation Interval [days]</td>
<td>f.</td>
</tr>
</tbody>
</table>

Note: Should be equal to or shorter than e.

**B. Determine Combined Efficiency**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniformity Coefficient</td>
<td>g.</td>
</tr>
<tr>
<td>Combined Efficiency</td>
<td>h.</td>
</tr>
</tbody>
</table>

$h = \left[ 0.9183 \times \left( \frac{gf}{0.6327} \right) \right] \times 100$

**C. Determine Depth of Irrigation**

<table>
<thead>
<tr>
<th>Month</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth of Irrigation per Set [in]</td>
<td>0.02</td>
<td>0.14</td>
<td>0.22</td>
<td>0.20</td>
<td>0.23</td>
<td>0.18</td>
</tr>
</tbody>
</table>

**D. Determine Set Time**

<table>
<thead>
<tr>
<th>Application Rate [in/hr]</th>
<th>Measure or see Tables 3 and 4 below to determine your application rate.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation Set Time [hr]</td>
<td>i.</td>
</tr>
</tbody>
</table>

**Table 1**

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>AWC [in/hr]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandy</td>
<td>0.07 to 0.10</td>
</tr>
<tr>
<td>Sandy Lean</td>
<td>0.09 to 0.15</td>
</tr>
<tr>
<td>Loam</td>
<td>0.14 to 0.19</td>
</tr>
<tr>
<td>Clay Loam</td>
<td>0.17 to 0.22</td>
</tr>
<tr>
<td>Clay</td>
<td>0.20 to 0.30</td>
</tr>
</tbody>
</table>

**Table 2**

<table>
<thead>
<tr>
<th>Irrigation System</th>
<th>Uniformity Coefficient (*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid set</td>
<td>70</td>
</tr>
<tr>
<td>Hand mow or Set-25</td>
<td>82</td>
</tr>
<tr>
<td>First or Linear Move</td>
<td>65</td>
</tr>
<tr>
<td>Offset Manged Hopper</td>
<td>50</td>
</tr>
</tbody>
</table>

**Table 3**

<table>
<thead>
<tr>
<th>Pressure</th>
<th>Discharge [gpm]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1/16</td>
</tr>
<tr>
<td>35</td>
<td>1.5</td>
</tr>
<tr>
<td>40</td>
<td>1.6</td>
</tr>
<tr>
<td>45</td>
<td>1.7</td>
</tr>
<tr>
<td>50</td>
<td>1.8</td>
</tr>
<tr>
<td>55</td>
<td>1.9</td>
</tr>
</tbody>
</table>

**Table 4**

<table>
<thead>
<tr>
<th>Sprinkler Spacing [ft]</th>
<th>Application Rate [in/hr]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>20</td>
<td>0.21</td>
</tr>
<tr>
<td>30</td>
<td>0.21</td>
</tr>
<tr>
<td>40</td>
<td>0.21</td>
</tr>
<tr>
<td>50</td>
<td>0.21</td>
</tr>
</tbody>
</table>

(*) If your sprinkler spacing/discharge combination falls into gray shaded area, use uniformity coefficient from the right, also gray shaded column. Otherwise use values from the left column.
Login
Using your AgWeatherNet account.

Username: 
Password: 
Remember me □
Login

Forgot Username?
Forgot Password?

Register
In order to use the irrigation scheduler, please register for an AgWeatherNet account which can be used to log in.

Privacy  About Us  Contact Us
Log In  Desktop Website  Help

http://weather.wsu.edu/ism/index.php?m=1
Add New Field

Help

☐ Check box to start with existing field:

Name: Example
Year: 2015
Network: AgriMet (WA, OR, ID, NV, MT)
Station: Forest Grove, OR
Crop: Blueberries
Soil: Silt Loam

Add Field

Add/Delete Fields

Privacy  About Us  Contact Us
Logout  Desktop Website  Help
Add New Field
A new field has been added to the database.

Add irrigation events in the 'Daily Budget Table' using the 'Edit' button for that date.

The 'Soil Water Chart' shows your soil water content over time.

You can make changes to the default values using the 'Field Settings' button below.
Root Depth on  
Start Date: 36 in

Maximum Managed Root Zone  
Depth: 48 in

Root Depth on  
Start Date: 18 in

Maximum Managed Root Zone  
Depth: 18 in
Soil Water Dashboard

Field: Example, 2015; Blueberries

This Morning’s Soil Water
Deficit: 0 in.
Days Until Water Stress: 31
Today’s Irrigation: 0.00 in.
I Irrigated Today: in.

Green is good. Crops increasingly stressed below green.

Save

Dashboard
<table>
<thead>
<tr>
<th>Date</th>
<th>Water Use (in)</th>
<th>Rain &amp; Irrig (in)</th>
<th>Avail. Water (%)</th>
<th>Water Deficit (in)</th>
<th>Edit Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>03/27</td>
<td>0.03</td>
<td>0.00</td>
<td>99.3</td>
<td>0</td>
<td>Edit</td>
</tr>
<tr>
<td>03/28</td>
<td>0.03</td>
<td>0.01</td>
<td>98.8</td>
<td>0</td>
<td>Edit</td>
</tr>
<tr>
<td>03/29</td>
<td>0.03</td>
<td>0.00</td>
<td>98</td>
<td>0.1</td>
<td>Edit</td>
</tr>
<tr>
<td>03/30</td>
<td>0.03</td>
<td>0.00</td>
<td>97.2</td>
<td>0.1</td>
<td>Edit</td>
</tr>
<tr>
<td>03/31</td>
<td>0.02</td>
<td>0.16</td>
<td>100</td>
<td>0</td>
<td>Edit</td>
</tr>
<tr>
<td>04/01</td>
<td>0.02</td>
<td>0.09</td>
<td>100</td>
<td>0</td>
<td>Edit</td>
</tr>
<tr>
<td>04/02</td>
<td>0.03</td>
<td>0.00</td>
<td>99</td>
<td>0</td>
<td>Edit</td>
</tr>
</tbody>
</table>

Forecast: Mar 27, 2015
## 7-Day Daily Budget Table

**Field:** Example, 2015; Blueberries

<table>
<thead>
<tr>
<th>Date</th>
<th>Water Use (in)</th>
<th>Rain &amp; Irrig (in)</th>
<th>Avail. Water (%)</th>
<th>Water Deficit (in)</th>
<th>Edit Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>04/03</td>
<td>0.04</td>
<td>0.00</td>
<td>97.8</td>
<td>0.1</td>
<td>Edit</td>
</tr>
<tr>
<td>04/04</td>
<td>0.04</td>
<td>0.00</td>
<td>96.7</td>
<td>0.1</td>
<td>Edit</td>
</tr>
<tr>
<td>04/05</td>
<td>0.05</td>
<td>0.00</td>
<td>95.4</td>
<td>0.2</td>
<td>Edit</td>
</tr>
<tr>
<td>04/06</td>
<td>0.06</td>
<td>0.00</td>
<td>93.8</td>
<td>0.2</td>
<td>Edit</td>
</tr>
<tr>
<td>04/07</td>
<td>0.07</td>
<td>0.00</td>
<td>91.8</td>
<td>0.3</td>
<td>Edit</td>
</tr>
<tr>
<td>04/08</td>
<td>0.07</td>
<td>0.00</td>
<td>89.7</td>
<td>0.4</td>
<td>Edit</td>
</tr>
<tr>
<td>04/09</td>
<td>0.07</td>
<td>0.00</td>
<td>89.7</td>
<td>0.4</td>
<td>Edit</td>
</tr>
</tbody>
</table>
Soil Water Dashboard

Field: Example, 2015; Blueberries

This Morning's Soil Water
Deficit: 0 in.
Days Until Water Stress: 31
Today's Irrigation: 0.00 in.
I Irrigated Today: in.

Save

Green is good. Crops increasingly stressed below green.
Irrigation in the Pacific Northwest

Washington State University Extension

Home
Mobile
Irrigation Calculators
FAQs & Tutorials
Irrigation Resources
Washington Irrigation
Idaho Irrigation
Oregon Irrigation
Irrigation Links
About Us

http://irrigation.wsu.edu/index.php
Drip Line Rate

Use this form to calculate the water application rate of drip irrigation lines (tape, tubing) given the flow rate from individual emitters, the spacing of the emitters along the drip line, and the spacing between the drip lines.

Learn more about the units used on this page.

Emitter flow:

.53 gph

Emitter spacing along the line:

12 in

Distance between drip lines:

24 in

Calculate

Application Rate:

0.425 in/hr
Nozzle Flow Rate and Effective Application Rate

Nozzle Diameter: 
3 [16ths in]

Pressure: 
50 [psi]

Head Spacing: 
20 [ft]

Line Spacing: 
40 [ft]

Sprinkler Efficiency: 
70 [%]

[Calculate]

Nozzle Flow Rate: 
7.19 [gpm]

Effective Application Rate: 
0.606 [in/hr]
2.5" / 5 cans = 0.5" per 15 mins
Gadgets - atmometers

- “Reverse rain gauge”
- Estimates ET
Gadgets - tensiometer

- Measures true soil water tension
- Requires care, generally better for lighter soils that are kept fairly moist
Gadgets – granular matrix sensor

- Simple
- Measures electrical conductivity and converts to tension estimate
Gadgets – volumetric

- Volumetric data converts directly to inches water needed
- Higher cost
Gadgets – human hand

25-50% AWC

50-75% AWC

75-100% AWC

Typical silt loam shown
Gadgets – variable frequency drives

- Matches pump output (flow, pressure) to need.
- Saves energy.
- Only cost-effective in certain situations.
Staying legal

- Water rights specify how you may irrigate:
  - Rate (gallons per minute)
  - Total amount (inches per year)
  - Dates

- See watermaster for help:
  - 1400 SW Walnut St, Suite 240
  - Hillsboro, Oregon 97123
And justice for all

The U.S. Department of Agriculture (USDA) prohibits discrimination against its customers, employees and applicants for employment on the bases of race, color, national origin, age, disability, sex, gender identity, religion, reprisal, and where applicable, political beliefs, marital status, familial or parental status, sexual orientation, or all or part of an individual's income is derived from any public assistance program, or protected genetic information in employment or in any program or activity conducted or funded by the Department. (Not all prohibited bases apply to all programs and/or employment activities.)

Vonnoh, *Coquelicots*
And justice for all

The U.S. Department of Agriculture (USDA) prohibits discrimination against its customers, employees and applicants for employment on the bases of race, color, national origin, age, disability, sex, gender identity, religion, reprisal, and where applicable, political beliefs, marital status, familial or parental status, sexual orientation, or all or part of an individual’s income is derived from any public assistance program, or protected genetic information in employment or in any program or activity conducted or funded by the Department. (Not all prohibited bases apply to all programs and/or employment activities.)
Questions?
Rooting depth

- 40% extraction here
- 30% here
- 20% here
- 10%