SUSTAINABLE AGRICULTURE TECHNIQUES

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Strategies for Efficient Irrigation Water Use

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Figure 1. Furrow-irrigated onion grown at Ontario, Oregon, receives about twice as much water as the crop actually uses.

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When water is plentiful, growers usually schedule irrigation practices around other farming activities. For example, most growers change furrow irrigation sets at 12- to 24-hour intervals because this timing is convenient and uses labor efficiently. However, long irrigation sets can waste water (Figure 1).

When water is in short supply, you need to rethink some practices to obtain maximum benefit from available water. After all, next to the land itself, water is a grower's second most important resource. It makes sense to exchange management and labor for water use efficiency.

Because irrigation districts must keep their systems charged with water, these practices have a greater impact as more growers use them.

Even when water is more plentiful, there are compelling reasons to use less. Excessive water use can waste soil and fertilizer in water runoff. Excessive irrigation results in deep percolation and leaching of nitrates, nitrites, and other farm chemicals. These contaminants contribute to the total daily load of chemicals carried by aquifers. Self regulation by growers typically benefits all parties interested in clean, plentiful water, including you and other growers. See Shock and Welch, 2011b, *TMDLs and Water Quality in the Malheur Basin: A Guide for Agriculture* (Sustainable Agriculture Techniques series, page 7).

Approaches to using less water

You can improve irrigation efficiency by irrigation scheduling, adopting practices such as deficit irrigation and conservation tillage, and installing more efficient irrigation systems. Sprinkler and drip irrigation systems are more efficient than furrow irrigation. Some of these strategies entail additional costs, but they can also lead to higher market value of crops.

Avoid over-irrigation

This sounds simple, but it isn't. Many growers err on the side of excess. Too much water has less visual impact than too little, but it wastes soil and fertilizer as well as water.

Eliminate deep watering of shallow-rooted crops such as onions and beans. Frequent, light irrigations help keep water and mobile nutrients in the root zone where plants can use them.

Schedule irrigations based on evapotranspiration (ET)

There is a seasonal demand pattern for water, which varies by crop. The optimal time to irrigate a particular field also depends on when the crop last received water and the soil water-holding capacity.

Use ET charts from the Bureau of Reclamation AgriMet system or other source. The charts show fairly accurate estimates of crop water use and can help you decide when and how to irrigate. (See Figure 2 for information about how to use these charts.)

Know the water-holding capacity of your soils. A sandy loam soil will not hold as much water as a silt loam; thus, it must be irrigated more frequently with less water per irrigation. Extra water is lost to runoff and deep percolation.

Schedule irrigations based on soil water content or soil water tension

Irrigation scheduling can be done based on soil water content or soil water tension.

Use soil-moisture monitoring equipment to measure how much moisture is in the soil. There are several types of sensors available. The soil water content sensors used most commonly in the Pacific Northwest are neutron probes and capacitance sensors. The most common soil water tension sensors are granular matrix sensors and tensiometers. These instruments, when used with ET charts, provide a fairly accurate estimate of irrigation needs.

Graph soil moisture readings. The most important aspect of soil-moisture monitoring is graphical presentation of the readings over time in order to improve your irrigation accuracy. Even if you measure soil moisture with a shovel and your fingers, you can graph the readings. Figure 3 shows a card used for recording soil water tension.

Figure 2. Using hypothetical AgriMet crop water use data.

1 ESTIMATED CROP WATER USE - JULY 16, 2012 ONTO												
2 CROP	3 START	4 DAILY CROP WATER USE-(IN) PENMAN ET - JULY				5 Daily Forecast	6 COVER DATE	7 TERM DATE	8 SUM ET	9 7 DAY USE	10 14 DAY USE
		12	13	14	15						
ONYN	401	0.32	0.3	0.29	0.31	0.32	710	820	20.6	2.16	4.3
POTS	501	0.33	0.32	0.3	0.32	0.34	610	820	19.7	2.3	4.28

(1) = Location of weather station: ONTO = Ontario, Malheur Experiment Station
(2) = Crop: ONYN = Onions; POTS = Shepody potatoes
(3) = Start date: Crop emergence date
(4) = Amount of water used by the crop each day for the past 4 days
(5) = Estimated water use for the date on the chart, i.e., July 16
(6) = Cover date: Date the crop reached full canopy
(7) = Term date: Date irrigation stops or crop is harvested
(8) = Sum ET: Total estimated water use from the beginning of the growing season to the current date
(9) = 7 day use: Prediction of water needed by crop for the next 7 days
(10) = 14 day use: Prediction of water needed by crop for the next 14 days

Grower_____________Field ID__________Soil Type___________ Month____Year____

Days

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
0																
10																
20																
30																
40																
50																
60																
70																
80																
90																
100																
110																
120																

Figure 3. Sample soil water tension recording card.

For more information on measuring soil moisture and using soil moisture observations to inform irrigation decisions, see Shock, et al., revised 2013b, *Irrigation Monitoring Using Soil Water Tension* (Sustainable Agriculture Techniques series, page 7).

Use deficit irrigation

Deficit irrigation is irrigation that applies less water than the crop needs for full development. Some crops lose little yield and quality with modest irrigation deficits, saving water. Deficit irrigation works with deep-rooted crops such as wheat and corn. Wheat and corn have been successfully grown with carefully controlled deficit irrigation, but they do lose test weight and yield. Know each crop's tolerance of drought stress, and irrigate accordingly.

Some plants handle drought stress much better than others, with yield and quality *positively* related to some water deficit during part of the growing season. Almonds, wine grapes, and alfalfa seed are such crops.

Sugar beets and alfalfa can extract moisture from a greater depth than most crops, so they can continue growth without irrigation as long as water reserves are available deeper in the soil profile.

Deficit irrigation is less successful with crops for which the proportion of the crop yield that is monetizable and/or the quality is depressed by water stress. Examples include potatoes and vegetable crops such as onions. Russet Burbank potatoes suffer greatly in quality when drought stressed, losing tuber grade and fry color consistency. Umatilla and Shepody potato varieties suffer less quality reduction than Russet Burbank, but still more than other crops. Total yield is reduced when Shepody and Umatilla Russet varieties are drought stressed. Potato plants can be stressed lightly very early, but not after setting tubers. Water stress on onions affects yield and grade and reduces the percentage of bulbs that have single centers.

For many seed and grain crops, water stress at the flowering stage is most damaging.

Plan your acreage under irrigation

Know the water-use requirements of the crops you intend to grow, and make sure you have enough water to get an economic yield. When water supplies are short, plant crops that require less water.

Figure 4. No-till wheat requires less fuel and water inputs.

Reduce irrigated acreage: Leave some ground idle, and apply the saved water to high-value crops.

Practice conservation tillage

Conservation tillage practices such as minimum tillage, no till, and strip till help conserve soil water. Tillage is reduced and crop residue from the previous crop is at least partially retained on the soil surface. The retention of crop residues reduces water loss from the soil to the air and cools the soil. Each time that the soil is tilled, it is exposed to drying; conversely, reductions in tillage help conserve soil water (Figure 4).

For strip tillage, cultivate only within the row zone and leave the inter-row zone undisturbed (Figures 5 and 6). This usually leaves at least 30 percent of the previous crop residue on the surface after planting. Soil infiltration capacity of the inter-row zone is increased, allowing water to go where it's needed. See Foley, et al., 2012b, *Making Strip Tillage Work for You: A Grower's Guide* (Sustainable Agriculture Techniques series, page 6).

Figure 5. Strip tillage saves water and helps protect sugar beet seedlings from being blown out of the soil by wind.

Figure 6. Strip tillage of beans for seed helps to conserve soil moisture and cools the soil.

Carefully manage surface irrigation

Surface irrigation systems are inherently inefficient. They bring a heavy flow of water in direct contact with your soil, dislodging soil particles. Fully surface irrigating a field from top to bottom often results in a field where the top is over-irrigated and the bottom is under-irrigated.

To save water with furrow irrigation, change irrigation sets soon after the water reaches the end of the furrow rather than at a specified time of day. Over-watering the top of the field stresses plants and causes nitrogen deficiency as nitrogen leaches below the root zone. Slightly drought stressing the bottom of the field often causes production losses similar to those caused by over-watering the top of the field. Mulch the bottom of the field with straw so the water that gets there soaks in.

Use PAM (polyacrylamide) or straw mulch to improve water infiltration in tight soils (those with a low water infiltration rate). See Iida and Shock, 2008, *Make Polyacrylamide Work for You!* (Sustainable Agriculture Techniques series, page 6).

Use sedimentation basins with pump-back systems to collect runoff and reuse it. Sometimes this involves pumping water to the top of the field or to the next field. Analyze the cost of pumping to see whether this strategy is effective. See Shock and Welch, 2011a, *Tailwater Recovery Using Sedimentation Ponds and Pumpback Systems* (Sustainable Agriculture Techniques series, page 6).

Use surge irrigation or at least use a modified surge program during the first annual furrow irrigation. The wetting-drying cycle of surge irrigation reduces water loss to deep percolation, which is particularly important on the first irrigation when the soil is friable and takes a lot of water. For a modified surge irrigation program, alternate siphon tubes between rows every couple of hours on the first irrigation. This method can save water and reduce nitrogen loss through leaching. See Shock and Welch, 2010, *Surge Irrigation* (Sustainable Agriculture Techniques series, page 6).

Figure 7. Sprinkler systems can apply less water per acre than furrow flood systems while fully meeting crop water needs.

Use alternate-row irrigation; irrigate one side of a bed on one irrigation and the other row or side on the next. This practice works well on crops that are less sensitive to moisture stress.

Another strategy is to irrigate only compacted rows; since water infiltrates wheel-traffic rows more slowly than soft rows, water is less likely to move below the root zone. Compact the soft, non-traffic rows in furrow-irrigated fields so their infiltration rate is similar to that of the wheel-traffic rows.

Consider switching to sprinkler irrigation or drip irrigation. Both allow you to manage water more efficiently and apply it to the depth needed (Figure 7). Both often increase yields.

Some crops might have more disease problems under sprinklers because the foliage stays wet. Also, there are increased power costs unless the water intake is high enough above the rest of your farm to allow you to set up a gravity flow system.

Drip irrigation can save a lot of water, in many cases 30 percent to more than half of the amount used for furrow irrigation. A drip irrigation system is costly to set up, but is practical for onions and promising for seed alfalfa. See Shock, revised 2013a, *Drip Irrigation: an Introduction;* Shock, et al., revised 2013c, *Drip Irrigation Guide for Onion Growers,* and Shock, et al., revised 2013e, *Drip Irrigation Guide for Potatoes* (Sustainable Agriculture Techniques series, page 7).

Maintain and update sprinkler and drip irrigation systems

The Malheur Experiment Station is investigating ways to leave the tape in the ground through several cropping cycles.

For more information

Websites

AgriMet—daily crop evapotranspiration (ET) estimates. http://www.usbr.gov/pn/agrimet/h2ouse.html

Efficient irrigation scheduling. http://www.cropinfo.net/irrigschedule.php

How to find irrigation information on the Internet. http://www.trickle-l.com/new/onthenet

Instrumentation for soil moisture monitoring. http://www.cropinfo.net/AnnualReports/1997/instrumentation.wq.php

NRCS irrigation information links. http://go.usa.gov/Kow

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The following Oregon State University Extension Service publications are available online or for purchase at *http://extension.oregonstate.edu/catalog/*.

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These and other Malheur Experiment Station publications, some in Spanish, are catalogued on the station's website at http://www.cropinfo.net/Publications.php

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