Summary: Irrigation Water Management during Drought Conditions

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Strategies to optimize water resources under limited water supply

It's important to assess the seasonal water needs of the plants you plan to grow. Once you know the water needs, we can determine how much land can be planted and get the crops to harvest. The land that is planted, you want to maximize production and profitability. Irrigation water allocations can be made to go further and grow more crops or more land by just increasing the irrigation efficiency. Also, increasing the water holding capacity of soil for longer term can help store more water in the soil. Many regions of California, even during periods of drought, get winter rains. These winter rains are very intense, it's important to infiltrate the water from these rains and store it in the soil and replenish the aquifer. Finally, it's important to think long term, and developing and using alternative water supplies.

Estimating the volume of water needed to irrigate a crop

The first step in managing water during a drought is estimating the volume of water needed to produce the crops planned for the growing season. This is a three-step process.

Step 1: Estimate preseason and in season crop water needs (pre irrigation, crop establishment, crop evapotranspiration (ET) (Table 1, 2, 3), salinity management).

Step 2: Estimate contribution from non-irrigation sources (rainfall, fog, perched water table, or soil moisture stored in the soil).

Step 3: Step 1 minus Step 2 value = volume of irrigation water needed to produce a crop.

Example estimating irrigation water requirement for an acre of broccoli:

Step 1.

Seasonal water needs	Inches
Preseason (prepare beds)	2.0
Crop establishment (after transplanting)	3.0
In-season (based on ET)	20.6
Total	**25.6**

Step 2.

Non-irrigation water sources	Inches
Change in available soil moisture	1.0
Rainfall	1.0
Fog	0.1
Shallow ground water	0.0
Total	**2.1**

Step 3. Seasonal water requirement = 25.6 – 2.1 inches = 23.5 inches.

Estimate of how many acres can be planted based on irrigation water available and seasonal crop water requirement

For example, if the water allocation is 200 ac-ft for the season, 200 ac ft ÷ 23.5 inches × 12 in/ft = 102 acres of broccoli.

Table 1. Crop evapotranspiration requirement in Sacramento Valley.

Crop	Irrigation Method	Season	ET Requirement (inches)
Pepper (red bell)	drip	May-Sept	22
Tomato (processing)	drip	May-Sept	23

Table 2. Crop evapotranspiration requirement in the interior valleys of the Central Coast.

Crop	Irrigation Method	Season	ET Requirement (inches)
Bok choy (greenhouse)	sprinkler	July-Sept	4
Broccoli	sprinkler	April-June	13
Broccoli	sprinkler	May-July	14
Broccoli	sprinkler	Sept-March	6
Cabbage	sprinkler	April-August	15
Cauliflower	sprinkler	March-June	13
Cauliflower	sprinkler	Nov-April	12
Celery	sprinkler/drip	May-August	14
Lettuce (iceberg)	sprinkler/drip	April-July	10
Lettuce (iceberg)	sprinkler/drip	June-August	8
Lettuce (iceberg)	sprinkler	June-August	9
Peppers (red bell)	drip	May-Sept	14
Spinach (baby)	sprinkler	May-Sept	4
Tomato (fresh market)	drip	June-Sept	16
Tomato (processing)	sprinkler/drip	May-Sept	18

Table 3. Crop evapotranspiration requirement in the coastal valleys of the Central Coast.

Crop	Irrigation Method	Season	ET Requirement (inches)
Broccoli	sprinkler	March-August	9
Broccoli	sprinkler	May-Sept	11
Broccoli	sprinkler	Sept-March	6
Brussels sprout	sprinkler	July-Dec	14
Cabbage	sprinkler	August-Oct	10
Cabbage	sprinkler	April-July	11
Cauliflower	sprinkler	March-June	7
Cauliflower	sprinkler	August-Dec	6
Celery	sprinkler/drip*	May-Sep	8
Lettuce (iceberg)	sprinkler/drip	Feb-May	5
Lettuce (iceberg)	sprinkler/drip	April-July	7
Lettuce (iceberg)	sprinkler/drip	June-August	6

Estimate of how many acres can be irrigated based on well/pump flow rate and peak water demand of crop

For example if well flow rate = 300 gallons per minute (gpm) at 40 psi (check the pump performance curve). A pump test gives the pump performance curve information (Figure 1).

Estimate of how many acres of broccoli can be irrigated based on well/pump flow rate and peak demand of crop

- Pump flow rate = 300 gpm
- Max ETc = 0.25 inches/day
- Sprinkler Application Uniformity (AU) = 0.75 (75%)

- Hours of operation = 12 hours per day × 6 days/week

Crop water requirement = 0.25 inches/day × 7÷ 0.75 = 2.33 inches/week/acre

2.33 inches/week × 27,154 gallons per acre-inch = 63,359 gal per acre per week

Pump capacity = 300 gal/min × 60 min/hr × 12 hr/day × 6 day/week = 1,296,000 gals/week

1,296,000 gal/week ÷ 63359 gal/acre per week = **20.5 acres can be irrigated by one well**

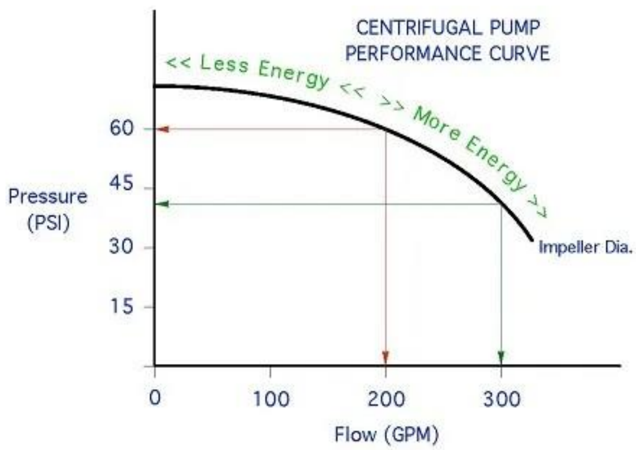

Figure 1: Centrifugal pump performance curve.

What if the water supply is not enough?

Farm the best fields and grow the most profitable crops. Look for fields with the most suitable soil types, uniform slope, good drainage, least weed pressure, highest fertility, and low soil borne disease pressure. Good field records can provide this information. Avoid fields with compacted or impermeable layers, excessive slope, or high salinity problems. Select higher yielding or shorter season varieties so they don't use as much water. Also, optimize your pest management and fertilizer program.

Conserve water by increasing irrigation efficiency

Increasing irrigation efficiency can help spread the water allocated over more acres. One way to do this is by improving the application uniformity of the irrigation system. Potential distribution uniformity for drip irrigation is 85-90% and for sprinkler irrigation system 75-80%. Drip irrigation system has the potential for high application uniformity, efficient salinity management, improved fertilizer management, and because it does not wet the leaves, you also get improved yield and crop quality.

How to conserve water or make it go further by increasing Irrigation Efficiency

Broccoli has an in season ETc of 13 inches. For sprinkler irrigation with an irrigation system distribution uniformity of 0.70 (70%) and leaching requirement of 10% (so salts don't build up in the soil), the water requirement for an acre of broccoli = 13 inches ÷ 0.70 ÷ (1 – (10%÷100%))

= 20.6 inches

When using drip irrigation, just by changing the distribution uniformity, you can decrease the amount of irrigation water needed. Drip irrigation with distribution uniformity of 0.90 (90%) and leaching requirement of 10%, the water requirement for an acre of broccoli = 13 inches ÷ 0.90 ÷ (1 – (10%÷100%)) = 16 inches. A water savings of 4.6 inches.

It is important to maintain the drip irrigation system in order to optimize the application uniformity of drip irrigation. Fix leaks, and if injecting fertilizers, especially organic fertilizers, the injection must be done before the irrigation filter to avoid plugging emitters. Optimize pressure and stay within the manufacturer recommendation, and optimize the irrigation system design to maintain uniform pressure throughout the field.

Pressure management is very critical for maximizing application uniformity of drip irrigation systems. Most drip irrigation systems work optimally at 8-12 PSI. Check the pressure of the drip system throughout the field. This can be done by installing pressure gauges. For example, install schrader valves and check pressure with the same pressure gauge so it's an effective comparison. Pressure regulators can help maintain the drip irrigation system pressure at the desired setting.

Sprinkler irrigation system application uniformity can be optimized by 1) making sure the nozzle size is uniform, check for mixed or different nozzle types and worn out nozzles; 2) management of pressure is critical, sprinklers don't operate effectively at too low pressures and at too high pressures is not good either; 3) optimize spacing of laterals, and 4) operate the sprinkler system at wind speeds less than 5 miles per hour; and 4) newer sprinkler head models provide higher application uniformity than brass impact type sprinkler heads.

Save water through improved irrigation scheduling

Irrigation system efficiency can also be improved by irrigation scheduling. There are different methods that can be used for scheduling irrigation applications – weather (ET) based, plant based, and soil based. Ideally, a combination of the three is probably the most effective. Soil moisture monitoring can be done by using soil tensiometers. It's best to use multiple rather than one tensiometer to determine soil moisture levels throughout the field.

Touch and feel method using a soil probe – the water doesn't go too far from the drip line, and soil probing gives you a good sense of where the water is located and how moist is the soil. Weather-based irrigation scheduling can be achieved by using the data from different California Irrigation Management Information System (CIMIS) stations located throughout the state. The CIMIS weather station provides the reference ET and you can calculate the crop ET. ETcrop = ETref × Kcrop, where Kc is the crop coefficient, and it can vary from 0.1 to 1.2.

CropManage, an online irrigation and nitrogen management decision support can also help you with irrigation scheduling. CropManage is a free irrigation tool developed by UCANR.

How often to irrigate

Frequency of irrigation depends on the weather (ET), water holding capacity of the soil (Table 4), root depth the volume of the crop is exploring, and threshold for maximum soil moisture depletion or when you are stressing the crop.

Table 4. Typical water holding capacity of soils of different textures.

Soil Texture	Field capacity (30 cbars)	Wilting point (1,500 cbars)	Available moisture
	inches of water per inch of soil depth		
Sand	0.10	0.04	0.06
Loamy sand	0.16	0.07	0.09
Sandy loam	0.21	0.09	0.12
Loam	0.27	0.12	0.15
Silt loam	0.30	0.15	0.15
Sandy clay loam	0.29	0.18	0.11
Sandy clay	0.28	0.15	0.13
Clay loam	0.32	0.18	0.14
Silty clay loam	0.36	0.20	0.16
Silty clay	0.40	0.20	0.20
Clay	0.40	0.22	0.18

Irrigation duration

Irrigation duration depends on nozzle size, system pressure, and spacing of sprinkler heads. Irrigation time (hrs) = Crop ET (in)/application rate (in/hr).

	Nozzle diameter (inches)				
	3/32	7/64	1/8	9/64	5/32
Pressure	Sprinkler application rate				
psi	inches/hour				
40	0.18	0.27	0.35	0.44	0.52
45	0.19	0.28	0.37	0.46	0.54
50	0.20	0.29	0.38	0.47	0.56
55	0.21	0.30	0.40	0.49	0.58
60	0.22	0.31	0.41	0.50	0.60
65	0.22	0.32	0.41	0.51	0.61
70	0.22	0.32	0.42	0.52	0.62

Figure 3. Application rate for solid-set sprinklers on a 30 ft x 30 ft grid.

Optimizing irrigations for stand establishment

Another way to spread the irrigation water on more land is by optimizing irrigation for establishing the crop. Over application of water has been commonly observed during crop establishment. Evaluate starting soil moisture content before first irrigation. If the soil is very moist, there is no need for irrigating for long durations, a couple of hours of sprinkler irrigation should suffice. Thereafter, apply no more than 2×ETo per irrigation, assure that sprinklers have a high application uniformity, and operate sprinklers under low wind conditions.

Maximize soil water holding capacity and rooting depth

Growing cover crops and adding organic amendments can improve the porosity of the soil. Deep tillage helps break up impervious soil layers. Maximizing crop rooting depth gives the crop access to soil water at higher soil depths.

Infiltrate stormwater runoff

Increasing infiltration of winter storm runoff can help store more water in the aquifer. Planting winter cover crops can help reduce storm run-off, prevent nitrate leaching, and build soil organic matter. Low-residue, short-term mustards cover crops planted in furrow systems that are tilled when 55-60 days old provides vegetation on the ground that helps with storm water infiltration during rain events. Cover crop research found that triticale and rye winter cover crops lead to infiltration of 90,000 – 110,000 gallons of water over the season, and also reduced top soil erosion.

Develop and use alternative water sources

With ongoing droughts, it is important to think long-term for developing and using alternative sources of water. Sewage water from urban areas goes through secondary and tertiary treatments and this recycled water is distributed through “purple pipes” to growers. On the Central Coast currently 17,000 acres are irrigated using recycled water. Recycled water has higher salinity and higher nitrogen content. Other growers are capturing tail water during the growing season. The tailwater, treated with chlorine, is used for germinating the crop or pre-irrigation. Growers don’t used the tail water for irrigating the crop during the growing season due to food safety concerns.