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Drought Tip: Drought Strategies for Table and Oil Olive Production

Olive (*Olea europaea L.*) is drought tolerant, and trees can survive on shallow soils with little supplemental water beyond winter rainfall.

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In California, the commercial productivity of olives relies on irrigation to maximize fruit yield and quality. Olives grown for table consumption must achieve maximum fruit size and yield, while olives grown for oil must maintain high yields without sacrificing oil quality. When olive trees are properly irrigated, trees will respond by maximizing shoot growth, crop set, fruit size, and oil content.

Olive Tree Development and Water Use

An understanding of critical periods for water availability to olive trees is important for strategizing in times of water shortages. Olive flower buds are formed beginning approximately 2 months before bloom, from mid-March to mid-May. This is an essential period for water availability in olives. Lack of water during flower bud differentiation affects the timing of bloom, number of blossoms, and the percentage of blossoms that are self-pollinating (Hartmann and Panetsos 1961). Olive shoot growth begins in the spring between February and April and continues through September if water is adequate. Shoot growth is important because next year's crop will be borne on the 1-year-old shoots. Too little water can inhibit shoot growth and reduce the crop set and yield in the following growing season (Goldhamer et al. 1993). Adequate water between August and harvest is necessary to produce larger and more profitable table olives (Goldhamer 1999). In contrast, fruit size is not critical in olives destined for oil, but the oil content in the fruit should be managed to maximize flavor. Research has shown this is best achieved by withholding some water during fruit development (Berenguer et al. 2006).

Irrigation Management Using Evapotranspiration

Research into irrigation management of olive trees has shown that using crop evapotranspiration (ET_c) is a reliable way to calculate the trees' water needs throughout the growing season. ET_c is a measure of the amount of water lost from evaporation from the ground plus the amount of water transpired by the tree. It depends on the weather conditions,

including temperature, humidity, and wind, as well as day length and orchard canopy cover. The goal when using ET_c to irrigate is to replenish the soil with the same amount of water lost to evapotranspiration: essentially, to irrigate at levels that match the trees' needs under the current weather conditions. This is the goal for effectively irrigating table olives to maximize production and value. However, optimal oil yield and quality can be achieved by irrigating less than full ET_c.

ET_c is calculated using a reference ET level (ET_0), which is calculated using a reference grass crop. Real-time ET_0 data are measured by California Irrigation Management Information System (CIMIS) stations around the state and are available online at www.cimis.water.ca.gov. Multiplying ET_0 by a crop-specific conversion factor (K_c) will give the crop's ET (ET_c):

$$ET_c = ET_0 \times K_c$$

The K_c for olive trees is 0.75 in a clean-cultivated orchard with 60% or greater shaded area (Goldhamer et al. 1994). Once the ET_c for a specific period is calculated, the proper amount of water can be applied to each tree. Average olive ET_c for the Sacramento Valley and San Joaquin Valley is shown in table 1. During winter months, rainfall may help fulfill the majority of the trees' water requirements. Auguring a hole at the beginning of the irrigation season will help determine the wetted depth and can serve as a guide to when irrigation should begin.

Table 1. **Olive water use (ET_c) in inches for mature trees in a clean-cultivated orchard with 60% or greater shaded area.**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sacramento Valley	0.92	1.22	2.14	3.41	4.60	5.51	6.36	5.47	4.07	2.69	1.19	0.75
San Joaquin Valley	0.78	1.22	2.49	3.68	5.00	5.81	6.35	5.51	4.09	2.60	1.12	0.60

Source: Beede and Goldhamer 2005.

Irrigation run times can be calculated for the type of irrigation system installed in the orchard. Irrigation management can be very effective using ET_c, assuming the irrigation system application rate is known (inches per hour or gallons of water per tree per hour) and diligence in following the current ET_c demands. Irrigation system upkeep is also vital to ensure that distribution rates are uniform across the orchard, so each tree is receiving the expected amount of water.

Deficit irrigation is the practice of irrigating a crop at less than the trees' full ET_c. Regulated deficit irrigation (RDI) is the practice of withholding water from the trees at a specific time during the growing season. In both oil and table olives, RDI strategies can lessen the impact of drought and limited water on olive quality and yield. Be aware, however, that water in excess of the water-holding capacity of the soil will eventually need to be applied (either through extra irrigation or rainfall) to leach soluble salts from the soil profile, especially if deficit irrigating with high-saline groundwater.

Table Olive Irrigation Management under Water Shortages

The key to optimizing profits in table olives is obtaining large fruit size and high fruit yield. When water is not a limiting factor, table olive size and yield can be optimized by irrigating at full ET_c (approximately 36 to 41 acre-inches per acre per year). The seasonal evapotranspiration may depend on tree size, light interception, and orchard floor vegetation. Efficient weed control is especially important during drought conditions, as ineffective weed control leads to increased evapotranspiration within an orchard.

Regulated deficit irrigation (RDI) may be used when a full water allocation is not available. The degree and best timing for RDI in table olives depends on the amount of water available. When 80% or more of the full crop ET_c is available, a moderate RDI irrigation strategy will conserve water while simultaneously protecting fruit size and yield. Irrigate at full ET_c until June, then irrigate at only 50% ET_c until mid-August (fig. 1). During this period, crop and shoot growth will slow relative to the growth observed on a fully irrigated tree. Reapply water at the full ET_c after

August 15. As the trees' water needs are met, olive fruit size will rapidly increase. Goldhamer (1999) found that irrigating using a moderate RDI approach will use approximately 21% (7 to 8 acre-inches per acre) less water without compromising fruit size, yield, or gross revenue.

When 60 to 80% of the full crop ET is available, a severe RDI strategy may be imposed. The severe RDI scheme uses approximately 40% (14 to 16 acre-inches per acre) less water; however, that water savings will be accompanied by approximately 10% reduction in yield and 25% reduction in gross revenue potential because of reduced fruit size. To impose severe RDI, irrigate at full ET from the beginning of the season until May 15. Irrigate 1 month at 50% ET (May 15 until June 15), then 2 months at 25% ET (June 15 until August 15), followed by 1 month at 50% ET (August 15 to September 15), before increasing back to full ET requirements (see fig. 1). Using a severe RDI approach will optimize profits at this level of water availability; however, multiple years at this level is not sustainable, as shoot growth and subsequent seasons' crop will suffer (Goldhamer 1999).

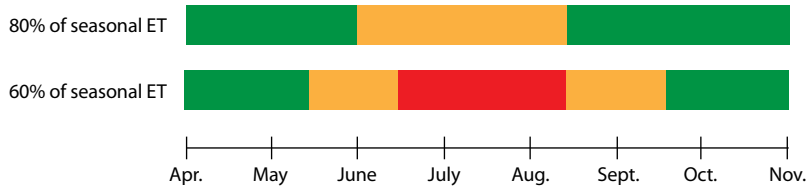

Figure 1. Timing of RDI regimes in table olives. Green bars indicate irrigation levels at 100% of the ET_c. Periods with yellow bars should be irrigated using 50% of the ET_c. Periods with red bars should be irrigated at 25% of the ET_c.

When less than 60% of full crop ET is available, severe effects to orchard growth and productivity can be expected. One strategy is to consider irrigating with an eye toward harvesting for oil production instead of table production; however, this is likely not an economically viable long-term (multiple-season) strategy. Be sure to focus on weed control to ensure that maximum water is available to trees. Plan on 2 years of normal irrigation before orchard production returns to pre-drought levels.

Oil Olive Irrigation Management under Water Shortages

The key to optimizing profits in super-high-density olive groves relies on producing optimal oil yield with the best flavor and quality characteristics while minimizing excess vegetative growth. Olives grown for oil do not need as much water as table olives. Oil yield and quality can be optimized by supplying enough water to match 70% of seasonal ET_c (25 to 29 acre-inches per acre). ET_c in oil olive groves may exceed 29 inches; however, too much water and fertilizer will cause super-high-density orchards to produce strong vegetative growth that will shade out the lower fruitwood and reduce bloom. Excessive vegetative growth is also undesirable for over-the-row harvesters used in super-high-density olive production because of interference with the harvester and increased damage to the olive trees.

Oils produced from over-irrigated or water-stressed trees may meet extra-virgin standards; however, oil quality is greatly affected

by tree water stress levels. Fully irrigated or over-irrigated oil olives have lower levels of oil extractability and yield bland oil with less of the fruity, bitter, and pungent flavors that are desired. On the other end of the spectrum, olives from severely water-stressed trees yield oils that are excessively bitter and pungent (Berenguer et al. 2006).

In oil olives, controlled deficit irrigation maintained from May through September did not have significant negative economic effects. Some of the highest-quality oil can be obtained by irrigating as low as 40% of the full ET_c, although at this level, yield will begin to suffer. By balancing oil quality and yield, an optimal range for irrigating oil olives is at 40 to 70% (14 to 29 acre-inches per acre) of the full ET_c. Trees maintained at the upper end of the range (70%, or 29 acre-inches) will have higher production, while trees maintained at the lower end of the range (40%, or 14 acre-inches) will have better oil quality (Grattan et al. 2006).

Summary

In olive trees, water stress impacts tree shoot growth, flowering timing, olive fruit size, and oil quality. Depending on whether the olives are grown for table or oil, irrigation strategies change during drought. Table olive growers must focus on fruit size and yield. RDI regimes can be successfully applied in table olive orchards to maintain revenue while also saving approximately 20% water over a fully irrigated tree. Severe RDI may save 40% of water use over the season, although gross revenue will suffer and orchard production will not be sustainable over the long run. Oil olive growers can focus on production and oil quality. Optimum olive oil yield and high quality oil can be produced when trees are irrigated at a level between 40 and 70% of full ET_c. Even if water restrictions permit irrigation at only 30% of tree ET_c, a high-quality oil may still be obtained in super-high-density olive orchards, although total oil yield will be reduced.

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