University of California Cooperative Extension

First Press

Newsletter of Olive Oil production and Evaluation

Volume 1, Number 4 Summer 2006

Irrigating Oil Olives

Where Quality Meets Quantity

This article is a summary of two articles on research by Paul Vossen, Maria Jose Berenguer, Joseph Connell, Vito Polito and Steve Grattan. The full articles can be found in the Journal of the American Society of Horticultural Science (4-2006) and Agricultural Water Management.

For millennia, no one thought much about irrigating oil olives. One of the things that made them such a great crop in the Mediterranean was their ability to produce under dry-farmed conditions. As for quality? Well, in those days you simply wanted oil, and as much of it as possible, under the conditions that nature handed you.

Modern olive orchards are planted with much tighter spacing in anticipation of regular irrigation. Today's grower faces a much more complex set of choices regarding how much to irrigate oil olives: Is oil quality paramount? Oil yield? Water conservation? Tree growth?

For most growers, the decision will be based on all of the factors combined. Precise irrigation will allow adequate shoot growth (assuring that there is plenty of fruiting wood for next year) without squandering resources, and still produce a good yield of the finest quality oil possible.

Some background basics

It is important to remember that olives fruit on one-year-old wood. The notorious "alternate bearing" tendencies of the olive are caused by this: during years when the tree is supporting a heavy crop of fruit, it lacks the resources to produce a lot of new shoots for next year. This cycle can be ameliorated somewhat by pruning, fertility manipulation and irrigation management.

Keep in mind also that the size of an olive crop is not necessarily directly proportional to the olive yield: a bigger crop does not always mean more oil. The relationship between olive weight and oil yield is complex, and a couple of things are worth remembering. The weight of an olive can be greatly increased by the presence of water; a big olive does not necessarily contain more oil than a small olive. Extractability is the other big variable in this equation. Even though the oil may be lurking inside that olive, it won't necessarily be possible to get it out. High moisture paste is notorious, in fact, for being difficult to work with. The water ties up a lot of the oil in emulsions and so forth, often making the yield disappointingly low.

When talking about irrigation, the concept of ET (evapotranspiration) is important. ET is a measure of the water use of a crop. More simply put, it is the amount of water used by the plant (transpiration) and the amount lost from the soil surface (evaporation) to the atmosphere. Thus, irrigating at 100% ET would completely replace all the water used by the plant ***(Irrigation, cont. on p.2)***

In this issue

California Olive Oil Industry Statistics Update

There has been a significant increase in plantings of olives specifically for oil production since the 2004 UC survey. At that time the survey snapshot put California's acreage at 6,168 ac. In 2005 and 2006 (occurring this summer and committed for this fall) there will have been a documented increase of 3,870 ac. in super-high-density plantings alone. Those plantings are almost exclusively Arbequina, Arbosana, and Koroneiki. Another estimated 500 ac. of standard density orchards also will have been planted, primarily to Frantoio, Leccino, and Pendolino. This means that by fall '06, the total estimated acres of oil olives will be 10,500, an increase of about 70%. In that same period, table olive acreage has declined by about 3,000 acres. Most of the new plantings of oil olives are occurring in Butte, Glenn, San Joaquin, and San Luis Obispo Counties in farms of over 100 ac. in size. One orchard in Glenn Co., scheduled to be planted in August, is 800 acres. Growers are optimistic that with the competitive advantage of mechanical harvest, huge domestic market, and excellent quality that they will be able to compete well against imported oils. An additional 11 new and significantly upgraded mills have also been or are being installed in CA over the last 2 years. —Paul Vossen

(Irrigation, cont. from p.1) and lost by evaporation; 50% ET would mean that you are replacing only half of the water used, and so on. The ET of an acre of a crop is going to be affected by the size and nature of the plants (canopy size and so on) and by atmospheric conditions (day length, temperature, wind and humidity). Detailed information about calculating ET for olives can be found in the *Olive Production Handbook* (ANR Publlications #3353).

When irrigated at less than 25% ET, olives start to show signs of severe drought stress, so this could be considered a "very low" irrigation level. From 25% to 40% ET, olives are stressed, so this could be called a "low" level of irrigation. From 40% to 60% of ET is a "medium" level of irrigation where trees are moderately stressed. 60% to 80% ET would be "high" irrigation where the trees are mildly stressed, and anything above 80% ET is probably "very high" for oil olives.

One final note: in this trial, the aim was to maximize oil quality and production. In a young, non-bearing orchard the objective is different; you are producing tree, not fruit, so the irrigation scheduling should be based on encouraging vegetative growth. Deficit irrigation in a very young orchard will simply slow tree growth and delay the onset of full production.

FIRST PRESS is produced by
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UC irrigation trial

Starting in 2002, researchers from the University of California, Davis and the UC Cooperative Extension collaborated with California Olive Ranch on a two-year study of the effects of different levels of irrigation on olive tree vigor and olive oil quality. The trees were Arbequina I-18, planted in a super-high-density system near Oroville, California.

The trial compared seven different irrigation levels each year ranging from very low to very high. Water was applied with drip irrigation. Pest management, fertilization, weed control and pruning were all conducted according to the standard practices of the ranch.

Fruit was harvested twice each year: late October and mid-late November. The maturity index (MI) of each sample was determined. For a description of the Maturity Index, and instructions on how to calculate it, go to http://cesonoma.ucdavis.edu/hortic/pdf/olive_oil_maturity_index.pdf . Oil was made using the Abencor system, and the extractable oil content calculated for each sample.

The oils underwent sensory evaluation by a trained taste panel using IOOC protocols. This sheet uses an intensity rating of 1–10 for three positive attributes: fruitiness, bitterness and pungency. Tasters also used descriptors to characterize the fruitiness of the oil (woody, nutty, herbaceous, etc), in order to give a more complete picture of the oil.

The trees themselves received horticultural evaluation. Changes in trunk diameter and branch length (shoot growth) were measured monthly. The number of flowers was measured as well, as was fruit set and fruit retention. A year after the research trees were returned to normal cultural practices, a follow-up assessment was made.

The horticultural findings

Not surprisingly, the treesresponded to higher levels of irrigation with greater growth. Shoot growth increased with more water, with greater differences showing between the lower irrigation levels. By the end of the season in both years there was no significant difference in the branch length between the highest three levels of irrigation. Trunk diameter showed similar effects, except that the highest level of applied water showed the largest gain.

Fruit yield increased with more water, as did fruit size. The differences were substantial each year, with the lower irrigation level fruit weighing about half as much as fruit from more heavily irrigated trees. The gap narrowed considerably with the later harvest, possibly due to rain that fell between the harvests.

The percent of extractable oil decreased with applied water, however. Because of the rainfall between the two harvests, the first harvest findings are probably more meaningful; they show a clear decrease in extractability as irrigation levels increase. When looking at the combination of yield rising with more water and oil extractability falling, the optimum irrigation range for oil yield per tree appears to be fairly broad, from the low end of medium to the upper end of high.

The experimental plot was returned to normal irrigation in 2004. That year there appeared to be a large difference in the return bloom on well-watered versus poorly-watered trees. The very low and low level irrigated trees showed many times more flowers than the highest levels of irrigation. The vigorous vegetative growth of the high and very high level irrigated trees during the research years came at the expense of reproductive growth the following year. But since those trees also had grown to be larger and had more new wood, the differences tended to even out between the different treatments. In the final analysis, yields were not affected when under-irrigated trees were returned to the normal irrigation regimen.

The maturity index of the fruit was also influenced by the irrigation; the drier treatments started their maturation process a bit later, but then matured faster than the wetter treatments. By the second harvest, there was a difference of more than one MI point between the wettest and driest ***(cont. on p.4)***

Simple Scheduling:
A Recipe for Drip Irrigation

A cookbook approach to anything can be limiting, implying as it does a lack of understanding of the deeper levels of a subject. But it can also be practical; sometimes you're hungry, darn it, and you just want to make dinner! This article is meant as a quick-start guide to managing drip irrigation for your oil olive trees. For detailed information, see *The Olive Production Manual* (UC ANR Pub.#3353).

Water use is measured in evapotranspiration (ET), that is both water used by the plant and lost by evaporation, given in inches per day. The irrigation rates in this chart are based on the historical midsummer ET for various regions. Since the actual ET will vary because it is affected by the weather, this chart will provide only an estimate of the amount of water needed.

Your water application rate will be determined by the output of the emitters and the number of emitters per tree; you can verify the output by running an emitter over a bucket. Tree size is measured in square feet (ft^2) and is the area of ground covered by the canopy (think of the tree's shadow at high noon). It should be noted that a live green cover crop uses water and makes the effective coverage of an orchard 100% regardless of the size of the trees. Dead, brown cover crops use no water.

With drip irrigation, water should be applied daily or every other day. The idea is to provide just what the tree will use, regardless of soil type or water holding capacity. Roots develop under the emitters so the storage capacity of the soil is irrevelant.

A look at the chart shows that the amount of water applied to a young tree is more than twice that recommended for a mature tree. This is because of the higher water needs of a tree that is growing to fill its space in an orchard; remember that more water will result in more vegetative growth. A tree that is producing fruit for oil should be irrigated to maximize oil quality and yield (see "Irrigating Oil Olives" on page 1). Our chart shows an irrigation range of 45–60% ET for mature trees. The lower end of the range will probably result in the highest quality oil; the higher end of the range in more fruit and greater tree growth. In years when the trees are supporting a heavy crop, more water will be required to encourage adequate shoot growth for the following year. Our chart shows water based on 100% ET for young trees. On very small trees, it's even higher since a decent-sized area must be wetted for optimum root growth.

There are critical periods for a tree's growth; during these times it is important to provide ample water. These critical periods are when a tree is young, as mentioned earlier, and when a tree of any age is in bloom and setting fruit.

The chart shows four climate zones and the water requirement at midsummer for each one. The zones are defined as follows, but the water recommendation from one zone might be totally appropriate for another zone during a cooler or warmer period (ie. Coastal Marine would apply to Coastal Warm in the early spring).

Coastal Marine: Cool days; early spring/late fall inland.
Coastal Cool: Warm days, some fog; spring/fall inland.
Coastal Warm: Hot days, no fog.
Interior Valley: Very hot days, windy.

One final reminder as you work on your irrigation scheduling: keep good records of water amounts and outcomes.

—Paul Vossen & Alexandra K. Devarenne

Approximate Water Use Based on Historical ET in Four Different Climate Zones (Gallons per Tree per Day)

Age / Size of Olive Tree (spacing)	Coastal Marine (ET 0.10 in/day)	Coastal Cool (ET 0.20 in/day)	Coastal Warm (ET 0.25 in/day)	Interior Valley (ET 0.30 in/day)
	*Gals/tree/day**	*Gals/tree/day**	*Gals/tree/day**	*Gals/tree/day**
1 ft^2 newly planted tree	0.5	0.5	0.5	0.5
4 ft^2 young tree	0.5	0.5	0.75	1
10 ft^2 young tree	0.75	1.3	1.6	2
25 ft^2 young tree	1.6	3.5	4	5
50 ft^2 young tree	3.2	6.5	8	10
50 ft^2 mature (Super High Density 13' x 5')	1.5 – 2	3 – 4	4 – 5.3	4.5 – 6
75 ft^2 young tree	5	10	12	15
100 ft^2 young tree	7	13	16	19
100 ft^2 mature tree (16' x 8')	3 – 4	6 – 8	7 – 9.3	9 – 12
150 ft^2 young tree	10	19	24	29
200 ft^2 young tree	13	25	32	38
200 ft^2 mature tree (20' x 12')	6 – 8	11.5 – 15.3	14 – 18.7	17 – 22.7
250 ft^2 young tree	16	32	40	47
300 ft^2 mature tree (20' x 16')	8.5 – 11.3	17 – 22.7	21 – 28	25.5 – 34
1 acre of mature trees with green cover crop	1,215-1,620	2,450-3,270	3,058-4,080	3,666-4,890

** Adjustments made for tree age (crop coefficient 45 – 60% of full ET for mature trees)*

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Upcoming Educational Events

- **Specialty Table Olive Short Course–Nov 14 & 15, 2006 at UC Davis**
  For information, call Bill Krueger, Farm Advisor, 530-865-1107 or www.extension.ucdavis.edu; 800-752-0881

- **Olive Oil Production, Processing and Evaluation (SusAg 118)**
  Santa Rosa Jr. College –Fall semester, 2006. For info www.santarosa.edu

- **Sensory Evaluation of Olive Oil–Mar. 30 & 31, 2007 at UC Davis**
  For info or to register: www.extension.ucdavis.edu or call 800-752-0881

(Irrigation, cont. from p.2) treatments, with the wetter treatments showing greener fruit.

The sensory findings

The different irrigation treatments had a distinct effect on the character of the oil in the first year of the trial. Keeping in mind that Arbequina is typically a fruity oil with some pungency but virtually no bitterness, the different irrigation treatments manipulated the character of this variety in a very definite way.

In the first year, the fruitiness of the oils changed with increasing amounts of water, with the lowest level of irrigation showing the highest fruitiness. But the fruitiness was very woody, strongly herbaceous and green. Combined with the extreme bitterness and pungency, it added up to an unbalanced oil, lacking in complexity. As the amount of water increased, the intensity of the oil decreased, but it was still unbalanced: too bitter, and woody, herbaceous and green, lacking in complexity.

The low to medium levels of irrigation treatments yielded oils with the best balance and most complexity. The bitterness finally fell to below the fruitiness, and the fruit showed some complexity with pleasant notes of artichoke, green apple, grass, nuts and other ripe fruits. With more water, the oils became noticeably less bitter and pungent.

At high to very high irrigation levels, the bitterness and pungency fell to almost imperceptible levels, but the fruitiness also fell. The end result was oils that were extremely bland and almost indistinguishable from each other. They were all characterized as having a very mild ripe olive fruit flavor, balanced, but lacking complexity. It is interesting to note that the perception of ripeness increased with higher irrigation even though maturity indices were lower (indicating that the fruit was greener in color).

In the second year of the trial, the most balanced oils came from the very low to low water treatments. The fruitiness in these oils was similar in intensity, with ripe and green characteristics, but bitterness and pungency declined substantially in the higher water treatments. The medium level irrigation treatments were fairly fruity, but very low in bitterness and pungency. The two highest irrigation levels were mildly fruity with a predominantly ripe character and virtually no bitterness or pungency.

The only laboratory-measured oil characteristics closely tied to irrigation levels both years were polyphenol content and oil stability. Both decreased significantly as the trees were given more water.

And the winner is...

Several general conclusions can be drawn from this study. Except in the case of young trees, where maximum growth is the most important consideration, any irrigation above the medium level is probably just wasting water; we saw no meaningful increase in tree growth when trees were irrigated more heavily.

Important increases in fruit yield can be achieved by giving the trees more water; especially meaningful is the addition of some extra water to severely drought stressed trees. Increases in fruit yield do increase the total amount of oil produced per acre up to the high level of irrigation, but some of that gain is lost when water is applied beyond the high end of the medium range because of the difficulty extracting the oil from the paste.

We also had our suspicions confirmed in that when trees are given a lot of water, it dilutes the flavor of the oil. The best sensory characteristics seem to emerge from the upper end of the low range to the middle of the medium range, depending on the style of oil you're after. Combining extractability and yield, we find an irrigation level of medium to the middle of the high level to be satisfactory. The lines seem to intersect in the lower half of the medium range, producing a balanced, complex oil combined with a good yield. Based on this work we are recommending to apply approximately 45% ET to mature oil olive trees when there is a light crop or when oil quality is paramount and about 60% in years with a heavy crop or to boost fruit yield.

—Paul Vossen, Maria J. Berenguer, Steve Grattan, Joseph Connell, Vito Polito and Alexandra Devarenne