Irrigation of olives in Western Australia

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Dick Taylor

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IRRIGATION OF OLIVES
IN WESTERN AUSTRALIA
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INTRODUCTION

Olives can be grown without irrigation in the south-west of Western Australia. However, to obtain maximum yield irrigation is required. The yields obtained from unirrigated crops may be half those of irrigated crops, with the actual yield decrease being dependent on the rainfall and length of growing season.

Research in Spain showed that 80 per cent of maximum yield was obtained when olives were irrigated with 25 per cent of the water required for maximum yield.

Olives in higher rainfall lower south-west and south coastal areas can be grown with considerably less irrigation than olives grown north and east of Perth. Tables 1 and 2 give the estimated irrigation requirements for olives in different parts of the south-west of the State when using drip and sprinkler irrigation respectively. The figures for young trees in Tables 1 and 2 relate to tree spacing of 8 metres x 5 metres (250 trees/ha).

This Bulletin outlines how to calculate the irrigation requirements of olives. Considerable debate occurs as to the water requirements of olives in Western Australia. There have been no irrigation trials on olives in this State and the crop factors outlined come from overseas experience.

However the experience of olive oil processors in the Eastern States is that excessive irrigation can lead to lower oil extraction percentages. Therefore growers should record the amount of irrigation applied and the yield of oil. Adjustments in irrigation should be made in subsequent years to optimise yield and oil extraction percentages. Other factors such as cultivar, time of harvest and oil processing temperatures also determine oil yields and organoleptic quality. These factors have been widely researched and understood in traditional olive growing countries and similar observation and research is required for Australian conditions.

Research in California with regulated deficit irrigation (RDI) on olives has shown that lower amounts of water than outlined in this Bulletin may be used without yields decreasing. In addition oil quality may improve by reducing water applications. However for RDI to be applied

<table>
<thead>
<tr>
<th>Table 1. Approximate irrigation requirements for olives grown in the south-west of Western Australia when using drip irrigation (m³/ha/year).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Albany</td>
</tr>
<tr>
<td>Mt Barker</td>
</tr>
<tr>
<td>Manjimup</td>
</tr>
<tr>
<td>Margaret River</td>
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<tr>
<td>Wokalup</td>
</tr>
<tr>
<td>Armadale</td>
</tr>
<tr>
<td>Medina</td>
</tr>
<tr>
<td>Wanneroo</td>
</tr>
<tr>
<td>Gingin</td>
</tr>
<tr>
<td>Geraldton</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2. Approximate irrigation requirements for olives grown in the south-west of Western Australia when using sprinkler irrigation (m³/ha/year).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Albany</td>
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<tr>
<td>Mt Barker</td>
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</tr>
<tr>
<td>Gingin</td>
</tr>
<tr>
<td>Geraldton</td>
</tr>
</tbody>
</table>

The data is for under tree sprinkler irrigation. It is assumed that when the trees are young irrigation is applied only to the area immediately below the tree.
successfully, growers need an efficient irrigation system and be determining the trees irrigation requirements by the use of soil moisture sensors or daily evaporation data. In addition, they should be recording data on tree performance. While RDI on olives has not been widely tested on commercial properties growers are encouraged to experiment with this principle.

The data in this Bulletin provides a good starting point for calculating how much water to apply to olives, which can then be monitored and adjusted by using tensiometers and by watching crop growth. Table olives require approximately 20 per cent more water than olives grown for oil. The data presented in this Bulletin are for growing olives for oil.

IRRIGATION SCHEDULING

Irrigation scheduling is the term used to describe the two fundamental questions in irrigation - how much water to apply and how frequently to apply that amount? The two methods commonly used to schedule irrigation are evaporation replacement and soil moisture sensors. It is suggested that you use the evaporation replacement method to initially determine how much water and when to apply it and then use soil moisture sensors, such as tensiometers to monitor and modify your irrigation program.

Evaporation replacement

The amount of irrigation that a plant requires is related to evaporation. The evaporation rate is multiplied by a crop factor which takes into account the crop type and different stages of tree and fruit development.

Evaporation data can either be obtained by measuring the loss rate from an evaporation pan or by using long-term average data such as that provided in Table 3. Your own evaporation pan is more accurate than using average data as it measures actual evaporation and takes into account hotter and milder periods in the month. Farmnote 42/88 describes how to make an evaporation pan. In some districts evaporation figures are given out over the radio.

This Bulletin uses long-term average monthly evaporation data in the examples. If you have an evaporation pan substitute the long-term average with your previous days evaporation. The amount of irrigation to apply is calculated by multiplying the average evaporation (Table 3) by the crop factor for that month (Table 4).

<table>
<thead>
<tr>
<th>Growth stage</th>
<th>Crop factor</th>
<th>Approximate month (south-west of WA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflorescence</td>
<td>0.25-0.3</td>
<td>August - September</td>
</tr>
<tr>
<td>Flowering</td>
<td>0.4-0.5</td>
<td>October - November</td>
</tr>
<tr>
<td>Fruit setting</td>
<td>0.4-0.5</td>
<td>November - December</td>
</tr>
<tr>
<td>Stone hardening</td>
<td>0.5-0.55</td>
<td>January</td>
</tr>
<tr>
<td>Fruit ripening</td>
<td>0.4-0.5</td>
<td>February - March</td>
</tr>
<tr>
<td>After harvest</td>
<td>0.3</td>
<td>April - June</td>
</tr>
</tbody>
</table>

Note: These crop factors do not make allowance for the water usage of cover crops or heavy weed growth. They also assume a good irrigation uniformity and that the irrigation water is not saline.

Table 3. Mean daily Class A pan evaporation (mm/day) for the irrigation season

<table>
<thead>
<tr>
<th></th>
<th>Sept</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albany</td>
<td>2.8</td>
<td>3.4</td>
<td>5.0</td>
<td>6.4</td>
<td>7.1</td>
<td>6.1</td>
<td>4.8</td>
<td>3.1</td>
<td>2.0</td>
</tr>
<tr>
<td>Cranbrook</td>
<td>3.0</td>
<td>3.8</td>
<td>5.7</td>
<td>8.3</td>
<td>8.5</td>
<td>8.2</td>
<td>5.9</td>
<td>3.7</td>
<td>2.1</td>
</tr>
<tr>
<td>Esperance</td>
<td>3.8</td>
<td>4.8</td>
<td>6.4</td>
<td>8.2</td>
<td>8.5</td>
<td>7.5</td>
<td>6.2</td>
<td>4.4</td>
<td>3.0</td>
</tr>
<tr>
<td>Manjimup</td>
<td>2.6</td>
<td>3.2</td>
<td>4.8</td>
<td>6.4</td>
<td>6.8</td>
<td>6.2</td>
<td>4.8</td>
<td>2.9</td>
<td>2.1</td>
</tr>
<tr>
<td>Margaret River</td>
<td>1.8</td>
<td>2.5</td>
<td>4.3</td>
<td>5.5</td>
<td>5.5</td>
<td>5.8</td>
<td>2.2</td>
<td>1.9</td>
<td>1.7</td>
</tr>
<tr>
<td>Medina</td>
<td>3.3</td>
<td>4.8</td>
<td>6.6</td>
<td>8.4</td>
<td>8.8</td>
<td>8.2</td>
<td>6.8</td>
<td>4.0</td>
<td>2.6</td>
</tr>
<tr>
<td>Gingin</td>
<td>3.8</td>
<td>5.6</td>
<td>8.0</td>
<td>10.4</td>
<td>10.6</td>
<td>10.6</td>
<td>8.4</td>
<td>5.0</td>
<td>3.1</td>
</tr>
<tr>
<td>Northam</td>
<td>3.7</td>
<td>5.6</td>
<td>7.9</td>
<td>10.9</td>
<td>11.8</td>
<td>11.0</td>
<td>8.5</td>
<td>5.0</td>
<td>2.9</td>
</tr>
<tr>
<td>Geraldton</td>
<td>4.7</td>
<td>7.0</td>
<td>9.3</td>
<td>11.8</td>
<td>11.6</td>
<td>12.0</td>
<td>10.1</td>
<td>6.9</td>
<td>4.9</td>
</tr>
</tbody>
</table>

For evaporation data from other areas refer to ‘Evaporation data for Western Australia.’ Agriculture Western Australia, DRM Technical Report 65.
HOW MUCH TO IRRIGATE

**Young orchards**

Use the following formula to calculate irrigation requirements when the olive trees shade under 60 per cent of the orchard floor.

\[
\text{Quantity of water in litres/tree} = \text{mm evaporation} \times \text{canopy area} \times \text{crop factor}
\]

For young trees the canopy area of the tree is used to calculate the water requirement. Water use is proportional to the area of the tree’s canopy. This factor makes allowance for the water requirements with changing tree size. The area of a circular tree canopy can be calculated by \( \text{Area} = \pi r^2 \). Where \( \pi = 3.14 \) and \( r \) is the radius of the trees canopy. Use of the equation above assumes that the water is applied to where the tree roots are growing i.e. dippers, or sprinklers which have a hat deflector which restricts the wetted area to beneath the tree.

**Example 1**

Calculate the water requirement of a young olive tree with a canopy radius of 1 metre in January at Gingin.

\[
\text{Canopy area} = \pi r^2
\]

\[
= 3.14 \times 1m \times 1m
\]

\[
= 3.14 \text{ m}^2
\]

Daily evaporation in January = 10.6 mm/day (Table 3)

Crop factor in January = 0.55 (Table 4)

Sprinkler or dripper flow = Four x 2 litre per hour drippers per tree

\[
\text{Quantity of water in litres/tree} = \text{mm evaporation} \times \text{canopy area} \times \text{crop factor}
\]

\[
= 10.6 \text{mm/day} \times 3.14 \text{m}^2 \times 0.55
\]

\[
= 18 \text{ litres/day/tree}
\]

**Mature orchards**

Use the following formula to calculate irrigation requirements when the olive trees shade over 60 per cent of the orchard floor.

\[
\text{Quantity of water in litres/tree} = \text{mm evaporation} \times \text{tree spacing} \times \text{crop factor}
\]

**Example 2**

Calculate the irrigation requirement of a mature olive tree in January at Margaret River.

Tree spacing = 5m x 8m = 40 m\(^2\)

Daily evaporation in January = 5.5 mm/day (Table 3)

Crop factor in January = 0.55 (Table 4)

Sprinkler or dripper flow = One x 60 litre/hour mini sprinkler per tree.

\[
\text{Quantity of water in litres/tree} = 5.5 \text{mm/day} \times 40 \text{m}^2 \times 0.55
\]

\[
= 121 \text{ litres/day/tree}
\]

**WHEN TO START IRRIGATING**

In the south-west of Western Australia rainfall greatly exceeds evaporation over the winter months. Olives will rarely require irrigation over this period. The exception may be on sands north of Perth that have a low water holding capacity, particularly if the trees are watered by drip irrigation.

When to start irrigating is determined by soil type and prevailing weather conditions. In most years this will be in mid to late spring. Heavy spring rainfall and mild conditions will delay the need for irrigation. Olives grown on sandier soils will need irrigating earlier in spring as the amount of water stored in the soil from winter rainfall is less than on loamy soils.
Irrigation can be applied daily to olives as calculated in Examples 1 and 2. However, in many cases, particularly with sprinkler irrigation, it can be applied less frequently. This increases the efficiency of water use as there is less evaporation from the foliage and soil surface. With drip irrigation, particularly on sands with a low water holding capacity, irrigation may need to be applied more frequently than once per day. The aim is to apply sufficient water to fill up the soil in the plants root zone. Applying more water than what the root zone can hold will result in deep drainage which wastes water and leaches fertiliser. Note that when saline irrigation water is used, additional water must be applied to leach salt from the root zone (see section on Water and soil salinity).

The frequency of irrigation depends on the readily available water holding capacity of the soil (RAW) and the depth of soil from which the olive roots extract water. The RAW figures for different soil types are given in Table 5. The effective rooting depth of the olive trees needs to be estimated. The effective rooting depth is the depth where 70 per cent of the tree roots are located and the majority of the water is extracted. The effective rooting depth at maturity may be over 1 metre on deep sands. On clayey soils, that become waterlogged, the effective rooting depth at maturity may only be 0.4 m. A hole should be dug adjacent to a tree with a spade or backhoe to determine the effective rooting depth.

**Table 5. Readily available water (RAW) for various soil types**

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Readily available water (mm/m of soil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>20</td>
</tr>
<tr>
<td>Loamy sand</td>
<td>35</td>
</tr>
<tr>
<td>Sandy loam</td>
<td>50</td>
</tr>
<tr>
<td>Loam</td>
<td>60</td>
</tr>
<tr>
<td>Clay loam</td>
<td>70</td>
</tr>
<tr>
<td>Clay</td>
<td>60</td>
</tr>
</tbody>
</table>

RAW calculated as 50 per cent of total available water holding capacity

**Canopy area and wetted area**

In order to calculate the frequency of irrigation the canopy area and area wetted by the irrigation need to be calculated. Figure 1 shows the canopy and wetted area. To calculate the area of the tree canopy or of a circular sprinkler or drip pattern use Area = \( \pi r^2 \). Where \( \pi = 3.14 \) and \( r \) is the radius of the trees canopy or irrigation wetting pattern. The quantity of water available to the tree roots is related to the area of soil that is wetted and this determines the frequency of irrigation. Drip irrigated trees need to be watered more frequently than trees watered with sprinklers because sprinklers wet a larger soil area.

---

**Figure 1. Diagram showing the relationships between canopy area and the wetted area with different irrigation methods.**

- Dripper or Sprinkler
  - Wetted area less than canopy area
    - use wetted area to calculate irrigation frequency.
  - Effective rooting depth

- Canopy area

- Sprinkler
  - Canopy area less than wetted area
    - use canopy area to calculate irrigation frequency.
If the wetted area is less than the canopy area (which is frequently the case when drip irrigation is used) use the wetted area to calculate the irrigation frequency. If the canopy area is less than the wetted area (which is frequently the case when young trees are watered by sprinklers) then use the canopy area to calculate the irrigation frequency.

**The wetted area is less than the canopy area**

Use the wetted soil volume to calculate the irrigation frequency. This is usually the case with drip irrigation.

**Example 3**

Calculate the irrigation frequency for young olives with a canopy radius of 1 metre in January at Gingin. The soil is a sand and 70 per cent of the roots occur in the top 40 cm of the soil. Table 5 shows the RAW for this soil is 20 mm/m. There are four x 2 litre per hour drippers per tree. Each dripper has a wetting pattern with a 0.3 m radius.

To calculate the canopy area use:

- Canopy area = \( \pi r^2 \)
  - \( r = 1 \) m
  - \( \pi r^2 = 3.14 \times 1 \) m x 1 m = 3.14 m²

To calculate the wetted area use:

- Wetted area = \( \pi r^2 \)
  - \( r = 0.3 \) m
  - \( 3.14 \times 0.3 \) m x 0.3 m = 0.28 m² x 4 drippers
  - 1.1 m²

The wetted area is less than the canopy area, therefore use the wetted area to calculate irrigation frequency.

\[
\text{Volume of water available in root zone} = \text{wetted area} \times \text{RAW} \times \text{effective rooting depth}
\]

- \( 1.1 \) m² x 20 mm/m x 0.4 m
- = 9 litres

i.e. the soil below the wetted area can hold 9 litres of irrigation before deep drainage occurs.

\[
\text{Irrigation frequency (days)} = \frac{\text{volume of water available in root zone (litres)}}{\text{daily water requirement (litres)}}
\]

- \( 9 \) litres /18 litres (from Example 1)
- = 0.5 days

The trees should be watered twice per day with about 9 litres of water in each application.

\[
\text{Hours of irrigation} = \frac{\text{litres per tree required}}{\text{Sprinkler or dripper flow (L/tree/hour)}}
\]

- = 18 litres /tree
- 8 litres/hour
- = 2.2 hours every day split into 2 equal shifts.

**The canopy area is less than the wetted area**

Use the canopy area to calculate the irrigation frequency. This is usually the case with young trees irrigated with sprinklers.

**Example 4**

Calculate the irrigation frequency of mature olives in January at Margaret River. The trees have a canopy radius of 2.5m. The soil is a loamy sand and 70 per cent of the roots occur in the top 80 cm of the soil. Table 5 shows the RAW for this soil is 35 mm/m. Sprinkler irrigation is used and it has a diameter of throw of 6 metres (radius = 3m) and an output of 60 litres per hour.

To calculate the canopy area use:

- Canopy area = \( \pi r^2 \)
  - \( r = 2.5 \) m
  - \( 3.14 \times 2.5 \) m x 2.5 m = 20 m²

To calculate the wetted area use:

- Wetted area = \( \pi r^2 \)
  - \( r = 3 \) m
  - \( 3.14 \times 3 \) m x 3 m = 28.3 m²

The canopy area is less than the wetted area, therefore use the canopy area to calculate irrigation frequency.

\[
\text{Volume of water available in root zone} = \text{canopy area} \times \text{RAW} \times \text{effective rooting depth}
\]

- = 20 m² x 35 mm/m x 0.8 m
- = 560 litres

i.e. the soil can hold 560 litres of irrigation before deep drainage occurs.

\[
\text{Irrigation frequency (days)} = \frac{\text{volume of water available in root zone (litres)}}{\text{daily water requirement (litres)}}
\]

- = 560 litres/121 litres (from Example 2)
- = 4.6 days

The trees should be watered every 4 days with about 484 litres (4 x 121 litres) of water.

\[
\text{Hours of irrigation} = \frac{\text{litres per tree required}}{\text{Sprinkler or dripper flow (L/tree/hour)}}
\]

- = 484 litres /tree
- 60 litres/hour
- = 8 hours every 4 days
TENSIOMETERS

To more accurately predict when to commence irrigation, tensiometers should be installed within the root zone to monitor soil moisture. Start irrigating when the tensiometer reaches the levels shown in Table 6. Farmnotes 24/90, 25/90 and 88/93 provide details on how to install tensiometers and interpret the readings.

Tensiometer readings should be used to fine tune irrigation recommendations based on pan evaporation.

Table 6. Approximate tensiometer readings at which irrigation of olives should start

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Tensiometer reading (centibars or kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sands (Coastal Plain)</td>
<td>10</td>
</tr>
<tr>
<td>Loamy sands</td>
<td>20</td>
</tr>
<tr>
<td>Loams and clays</td>
<td>40</td>
</tr>
</tbody>
</table>

FACTORS AFFECTING IRRIGATION REQUIREMENTS

Method of irrigation

Sprinkler irrigation is less efficient than drip irrigation, as the water is not applied directly to the soil and root zone but into the air and onto the leaves. Evaporation of sprinkler droplets in the air and from vegetation varies widely with weather conditions.

Increase the irrigation time by up to:
- 25 per cent for overhead sprinklers used during the day
- 10 percent for overhead sprinklers used during the night
- 15 per cent for under tree sprinklers used during the day
- 7 per cent for under tree sprinklers used during the night

The uniformity of the irrigation system should be consistent otherwise additional water will be required to ensure that the driest parts of the irrigated area receive sufficient water. Farmnote 35/90 describes how to evaluate the performance of sprinkler and drip irrigation systems.

Method of irrigation on sands

Sands have a low water holding capacity and require smaller, more frequent irrigation than heavier soils. Sprinkler irrigation is better suited on sands because it wets a greater soil volume. If drip irrigation is used on sands then additional drippers or two driplines per tree should be used to ensure a sufficient volume of soil is wet.

Water and soil salinity

If the water salinity exceeds 200 mS/m (1100mg/L) the amount of irrigation applied to olives should be increased by 10 per cent to leach salts from the root zone. Irrigation with water that has salinity over 250mS/m will decrease yields but soil type and method of irrigation used will be factors that determine the extent of this decline. Refer to Farmnote 46/99 ‘Water salinity and crop irrigation’ for details on irrigating with saline water.

Rainfall

If significant rain occurs during the irrigation season then irrigation can be turned off for a short period. As a general rule the first 5 mm of rain during the warmer months is not considered effective due to evaporation losses from the canopy. Recomence irrigation when the tensiometer increases to levels shown in Table 6.

Planting density

Water use is related to leaf area in the orchard. A mature orchard with 250 big trees per hectare will use roughly the same volume of water as a mature orchard with 500 smaller trees per hectare. The trees in a more closely planted area will not grow as big as those on a wider planting due to competition. The water requirements for young trees on a higher density orchard will however be higher.

Cover crops and weeds

In some olive groves, cover crops may be established to stabilise the soil and to provide mulch for the summer period. In young groves using sprinkler irrigation, extra water may be required to establish the cover crop. The cover crops can then be mown or sprayed off in spring, which will reduce summer water use.

If weeds are not controlled and become a problem, irrigation may have to be increased by up to 15% to compensate.

REFERENCES

- Tensiometers - preparation and installation. Agriculture Western Australia Farmnote 25/90.
- Interpreting tensiometer readings. Agriculture Western Australia Farmnote 24/90.
- Tensiometers: a practical guide to problem solving. Agriculture Western Australia Farmnote 88/93.
- Water salinity and crop irrigation. Agriculture Western Australia Farmnote 46/99.
- Evaluating sprinkler and trickle irrigation systems. Agriculture Western Australia Farmnote 35/90.