



## Irrigation scheduling for vegetable crops

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*This Agriculture Note describes how an irrigator would determine irrigation scheduling (timing and quantity of water to be applied) for vegetable crops.*

### Introduction

Irrigation scheduling is the process by which an irrigator determines the timing and quantity of water to be applied to the crop. The challenge is to estimate crop water requirements in the context of growth stages and climate. It is important to develop irrigation scheduling techniques that are suited to local climatic conditions.

In water stress sensitive crops such as vegetables grown for their fresh leaves or fruit, growers should schedule irrigations very carefully to avoid losses from over- or under-watering.

Under-watering for example, can lead to:

- Loss in market value through yield reduction
- Reduction in fruit size and quality.

Whereas over-watering can cause

- Unwanted vegetative growth
- Losses of valuable water to the watertable and run off
- Increased operational costs (labour and pumping)
- Leaching of nutrients
- Downgraded product quality and reduced yield
- Plant disease such as root rot.

### Irrigation scheduling methods

To avoid over or under irrigation, it is important to know how much water is available to the plant, and how efficiently the crop can use it. There are many methods available to measure these factors. They include direct measurements such as plant observation, feel and appearance of the soil, and using soil moisture monitoring devices; or indirect measures which estimate available water from weather data.

The vegetable growers in the SMDB (Southern Murray Darling Basin) are currently using a combination of the following irrigation scheduling methods:

- Plant observation.
- Feel and appearance of the soil.
- Weather based data
- Soil moisture monitoring.

### Plant observation

In the field, growers often estimate when to irrigate by observing the condition of their plants. Visible changes in plant characteristics, such as leaf colour, curling of the leaves and ultimately wilting can be useful guides to crop moisture stress. The crop is irrigated as soon as these symptoms are seen but productivity may be lowered, particularly if moisture depletion is allowed to the point where wilting occurs. The moisture status of plants can also be measured using sap flow sensors (used mainly for research), infra-red guns (used in the cotton industry) and pressurised chambers which measure leaf water potential.

### Feel and appearance of the soil

Visual observation and feel of the soil is probably the most common method growers use to monitor moisture levels in their fields. A soil sample can be obtained by using a soil probe, auger or spade. By squeezing soil into a ball, observing the appearance of the ball and creating a ribbon of soil between the thumb and forefinger, soil moisture can be estimated (Table 1).

Although judging moisture levels of the soil by feel and appearance is not the most accurate method, with experience most growers should be able to estimate fairly well when to irrigate based on this approach. This method is one of the cheapest, but it requires the irrigator to have extensive experience. Reinforcing this approach through the use of soil moisture monitoring tools is highly recommended.

### Weather based data

There are two traditional weather - based scheduling systems used to measure the amount of water lost from a crop. These are:

Evaporation from an open water surface

Historical climate data such as relative humidity, temperature, wind speed and sunshine hours.

Pan evaporation is the simplest and most commonly used method for calculating crop water use. Some growers use a Class A pan. Crop water use is generally less than open pan evaporation, and the difference is known as the crop factor, so that:

$$\text{Crop Water Use (mm)} = \text{Crop Factor} \times \text{Pan Evaporation (E}_{\text{pan}})$$

**Table 1. Soil appearance at different moisture contents (Cornish et al, 1990).**

Available water	Sands and sandy loams	Loams, clay loams and clays	General comment
Above field capacity	On squeezing, free water is expressed from the ball of soil	Soil very sticky and sloppy and when squeezed oozes water.	Soil waterlogged, no air can get to the roots
100 % (field capacity) *	Upon squeezing no free water appears on the soil, but wet outline of ball is left on hand	Soil sticky. No free water appears on the soil when ball is squeezed, but wet outline of ball is left on hand. Possible to roll long thin rods (2.5 in diameter) between fingers.	Plenty of water available to the plant, and enough air.
75 %	Slightly coherent. Will form a weak ball under pressure but breaks easily.	Soil coherent. Soil has a slick feeling and ribbons easily. Will not roll into long thin rods 2.5 diameter.	Adequate water and air and plant grows well
50 %	Appears to be dry. Tends to ball under pressure but seldom holds together.	Soil coherent. Forms ball under pressure. Will just ribbon when pressed between finger and thumb.	Just enough water available to the plant.
25 %	Appears to be dry, will not form a ball under pressure	Somewhat crumbly but will form a ball under pressure. Will not ribbon between finger and thumb.	Past refill point; plant growth has ceased.
0-25% Wilting point	Dry, loose, flows through fingers	Crumbly and powdery. Small lumps break into powder. Will not ball under pressure.	Desperately needing water; plants will die soon.

\* Field capacity is the maximum amount of water the soil will hold against the pull of gravity.

A crop factor relates crop water use at a specific development stage to the amount of evaporation from a US Class A Pan ( $E_{pan}$ ), and is expressed as a decimal value. On the other hand, a crop coefficient relates crop water use at particular development stage to the amount of reference crop evapotranspiration ( $ET_0$ ) as calculated from automatic or manually collected weather data.

**Crop water use (mm) = Crop coefficient X Evapotranspiration (ET)**

It is very important to know the difference between crop factor and crop coefficient, as they can differ by as much as 30%. The two methods are similar and equally valid, but one should be chosen and used consistently. In general, crop factors are used with pan evaporation figures, while crop coefficients are used with evapotranspiration ( $ET_0$ ) figures.

### Soil moisture monitoring

Soil moisture can be measured as a suction or volume of water. In some respects, the soil can be considered as a semi-permeable material like a sponge. If force is exerted on the sponge by squeezing, water can be extracted. This idea is applicable to how much force a plant can exert on the soil to extract the amount of water it needs for growth. Soil moisture suction can be used as a measure of plant stress and for that reason it is a handy tool for growers to use in scheduling their irrigations.

There are a number of soil moisture monitoring devices available on the market. They can be divided into two categories; those that measure soil moisture suction, and those measure soil water content. They differ in terms of simplicity, cost, labour required for installation, time and labour for monitoring and accuracy. The choice of equipment depends on what you want to achieve from monitoring (refer to Charlesworth, 2000).

Tensiometers and resistance blocks are used to measure soil moisture suction. On the other hand, there are a range of instruments that measure soil water content, including neutron probe, EnviroScan<sup>®</sup>, Gopher<sup>®</sup>, Time Domain Reflectometry (TDR), DRW Microlink<sup>®</sup> and Aquaflex.

Soil moisture monitoring is used as a basis for irrigation scheduling as it can provide accurate information about the extraction of available water by the crop. They are particularly useful in difficult soils such as Red Brown Earths, which require careful irrigation management.

Using this approach, a well-trained operator can identify waterlogging, root activity, infiltration as well as fluctuations in the depth of the watertable.

### Making decisions about irrigation

Soil moisture monitoring on a continuous basis accurately shows the relative changes in soil moisture before, during and after an irrigation event.

This information can be further used in making decisions on irrigation management. However, it should not be the only basis for irrigation scheduling and it must be used in conjunction with climate, crop and soil data.

### References

- Charlesworth P. (2000). Soil water monitoring, CSIRO land and water, Land and Water Australia, Canberra.
- Cornish J.P., Murphy J.P. and Fowler C.A. (Eds) (1990). Irrigation for profit: Water force Victoria. Irrigation Association Australia, Numurkah, Victoria.

## Further information

### Manuals and guidelines

Best management practice manuals and irrigation guidelines for vegetable crops\*

- Best Management Guidelines for Irrigation of Processing Tomatoes, Melons, Carrots and Onions.
- Irrigation scheduling for vegetable crops - growers guide.
- Agriculture Note: Estimating vegetable crop water use with moisture accounting method.

\* Available from the authors

### Other information sources

- Allen R.G., Pereira L.S., Raes D. and Smith M. (1998). Crop evapotranspiration: guidelines for computing crop water requirements. FAO Irrigation and Drainage paper No. 56. Rome.

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