Agriculture Notes

Irrigation scheduling for regulated deficit irrigation (RDI)

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Irrigation is generally associated with minimising moisture stress. Under such conditions trees grow quickly and are very vigorous. Until a tree has reached its desired size it should not be stressed for water. Once the tree has grown to its desired size, however, vigorous growth not only increases the need for pruning but can reduce yield. Irrigation can be managed in such a way as to control the growth of shoots. Such management is known as regulated deficit irrigation (RDI) and in experimental plots has maintained and sometimes increased yields of pears and peaches, and reduced irrigation by about 30%.

The RDI technique

With RDI, trees are kept short of water when fruit growth is slow or after harvest but are given ample water during the time of rapid growth of fruit. This reduces the growth of shoots. If RDI is properly managed, there is no reduction in the size of fruit or yield; in fact, both may increase - such results have been achieved. The reason why the above technique works relates to the growth pattern of shoots and fruit. On most deciduous fruit trees, the shoots grow rapidly early in the season, and their growth slows down as the fruit begins to grow rapidly. In contrast, early in the season the fruit grows slowly. Water stress at this time will reduce the growth of shoots without markedly affecting the growth of fruit.

With RDI, the irrigation season can be divided into four periods. The duration of these periods is determined by both weather and the relationship between vegetative growth and the growth of fruit.

Period 1

In this period, the trees are not irrigated, which allows the soil to dry out. With most crops this period follows flowering, however, with peaches there is initial rapid fruit growth following flowering when water stress must be avoided. In the Goulburn Valley trees are not irrigated until evaporation exceeds rainfall by 100 mm. If low rainfall during winter and early spring occurs or in environments dissimilar from the Goulburn Valley (for example, trees growing in lighter or deeper soil types), soil moisture must be measured. Irrigation should commence when the soil has dried out to 100 kPa in a sand or 400 kPa in a clay loam. In the Goulburn Valley this could be as late as mid-November in a wet spring or late October in a dry spring.

Period 2

Once irrigation commences, the trees are watered, but with greatly reduced volumes of water compared to that which would normally be applied. Irrigation replacements of pan evaporation of less than 30% are recommended. Period 2 commences at the initial irrigation and continues until six weeks before harvest for early-maturing fruits (that is, before mid-January), and eight weeks before harvest for later maturing fruits. Soil moisture in the middle of the wetted fibrous root zone should not exceed 100 kPa in sand or 400 kPa in clay loams.

Period 3 (from the end of period 2 until harvest)

In this period, the fruit is growing rapidly and the tree now needs ample water to maintain this growth. Water stress must not occur during this final period of fruit growth. Irrigation replacements of pan evaporation of 80 to 100% are recommended. Soil moisture in the middle of the wetted fibrous root zone should not exceed 40 kPa in sand or 60 kPa in clay loams.

Period 4 (post harvest)

After harvest a similar strategy as during period 2 can be implemented. In early maturing varieties and species (for example, cherries and apricots) there is considerable shoot growth after harvest which should be kept in check to maintain fruitfulness and even cropping within the canopy. Irrigation replacements of pan evaporation of less than 30% are recommended. Soil moisture in the middle of the wetted fibrous root zone should not exceed 100 kPa in sand or 400 kPa in clay loams.

Scheduling RDI from evaporation

In all three periods, evaporation readings, which are readily available in most districts, can be used to schedule irrigation. However, it is strongly recommended that soil moisture monitoring be integrated into an irrigation schedule to avoid over or under stressing trees.

In Table 1, examples of how to use evaporation to schedule RDI irrigations are shown for trickle, microjet and sprinkler irrigations. The table is divided vertically into three sections; each section refers to a different form of irrigation - trickle, microjet and sprinkler.

To show the influence that the spacing between trees has on the calculations for scheduling of irrigation, different spacings between trees are used for each of the three systems of irrigation.As previously mentioned, the irrigation season is divided into three periods, and the calculations needed during each of these periods is set out below the appropriate period. These calculations are divided into various sub-headings shown on the left side of Table 1. The following explains these sub-headings and should be read in conjunction with a perusal of the table.

1. Accumulated evaporation (mm)

In period 1, Table 1 suggests to begin irrigation when accumulated evaporation exceeds rainfall by 100 mm. On many soils, approximately two thirds of the available water will have been used by this time.

2. Weekly evaporation (mm)

In periods 2 and 3, irrigation is scheduled on the previous week's evaporation. These readings are generally available in most horticultural areas, so to use the table you merely have to replace the figures given in the example by those that you have collected in the previous week.

3. Replacement factor

This is the per cent of the evaporation that needs to be replaced. This percentage varies between periods; the trees receive very little water in periods 1 and 2. In the table, the replacement factor is expressed in the decimal form (for example, 0.8 = 80%). The replacement factor in periods 1 and 2 determines the degree of moisture stress imposed on the tree and in period 3 defines the sufficient amount of water to be applied to maintain rapid fruit growth. The replacement factor can also be used to adjust for the efficiency of the irrigation system. For example, the replacement factor is higher under sprinkler than when microjet or trickle irrigation is used, the latter two being more efficient (ie. wasting less water).

4. Evaporation to replace (mm)

Evaporation (in mm) is multiplied by the replacement factor, for example $50 \times 0.8 = 40$ mm or 80% of 50.

5. Area of planting square (m^2)

This equals the distance between rows multiplied by the in-row distance between trees and should be calculated in square metres. Different spacings between trees are given for each form of irrigation.

6. Water required weekly (litres)

As one millimetre of water over one square metre equals one litre, the litres of water that need to be replaced can be obtained by multiplying the area of the planting square in square metres by the required millimetres of evaporated water to be replaced.

7. Recommended interval between irrigations (days)

The interval between irrigations is also important with RDI, and recommended intervals are given. For trickle irrigation, the rationale behind these recommendations relates to the size of the wetted root zone. In period 2, frequent irrigation (that is, daily) wets a small volume of soil regularly. In contrast, using a two-day interval in period 3 enables a much greater volume of water to wet a much larger root zone. This manipulation in wetting the root zone could be responsible for the observed improved growth of fruit in period 3 and higher yields on RDI-managed trees. If, with trickle irrigation, the system has to be run for more than 24 hours every second day to provide the required quantity of water, serious thought should be given to upgrading the system to a higher rate of discharge.

The longer interval between irrigations in period 2, than in period 3, for both microjet and sprinkler irrigations, is necessary to allow sufficient irrigation to wet the soil to a reasonable depth.

In period 2, with microjet and sprinkler irrigations, an interval of seven and 21 days respectively is recommended. If the combined effects of evaporation, spacing of trees and rate of application result in less than two- and eight-hour irrigation times respectively for microjet and sprinkler irrigations, the interval will need to be extended until such figures are reached. For these long intervals, irrigation is based on the accumulated evaporation since the previous irrigation.

8. Water required for irrigation (litres/tree)

For period 1, this quantity has already been calculated at step 6. For periods 2 and 3, the quantity of water required at each irrigation is multiplied by the interval between irrigations in days and divided by 7 (that is, by the number of days in the week). For example, if the weekly irrigation requirement is 36 litres but the interval is only one day, then approximately 5 litres of water is applied daily ($36 \times 1 \div 7$ = approximately 5).

9. Application rate (litres/hour/tree)

If not known, this should be measured.

10. Running time (hours)

This is calculated by dividing the number of litres required per irrigation by the rate of application.

11. Interval between irrigations (days)

This is the same as in 7 but is repeated at the bottom of the table for easy reference.

RDI with flood and furrow irrigations

With surface irrigations, such as flood or furrow, it is difficult to control the amount of water applied per irrigation. Nevertheless, the principles discussed above apply; the initial irrigation can be delayed and the interval between irrigations can be increased in period 2. After 12 years of experimenting with RDI it became obvious that in the past much water was wasted on early irrigation. Our results at Tatura indicate that mature trees would have cropped better with less water.

Table 1.

	Trickle 6 × 1 m planting Periods			**Microjet 3 × 5 m planting Periods**			**Sprinkler 6 × 6 m planting Periods**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
1. 1. Accumulated evaporation (*mm*)	100			100			100		
2. Weekly evaporation (*mm*)		30	50		30	50		30	50
3. Replacement factor	0.1	0.2	0.8	0.1	0.2	0.8	0.3	0.3	1.0
4. Evaporation to replace (*mm*)	100×0.1 = 10	30×0.2 =6	50×0.8 =40	100×.01 =10	30×0.2 =6	50×0.8 =40	100×0.3 =30	30×0.3 =9	50×1.0 =50
5. Area of planting square (m^2)	6	6×1 =6	6	15	3×5 =15	15	36	6×6 =36	36
6. Water required weekly (*litres*)	6×10 =60	6×6 =36	40×6 =240	15×10 =150	15×6 =90	15×40 =600	30×36 =1080	9×36 =324	50×36 =1800
7. Recommended interval between irrigation *(days)*	na*	1	2	na*	7	3	na*	21	5
8. Water required for each irrigaton (*litres/tree*)	60	36×1÷7 =5	240×2÷7 =68	150	90×7÷7 =90	600×3÷7 =260	1080	324×21÷7 =972	1800×5÷7 =1286
9. Application rate *(litres/hr/tree)*	4	4	4	40	40	40	120	120	120
10. Running time *(hours)*	60÷4 =15	5÷4 =1¼	68÷4 =17	150÷40 = 3¾	90÷40 =2¼	260÷40 =6½	1080÷120 =9	972÷120 =8	1236÷120 =10
11. Interval between irrigations *(days)*	na*	1	2	na*	7	3	na*	21	5

*not applicable