Soil Moisture Monitoring
HOW and WHY?

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What does irrigation farming mean? It means applying water to a crop in order to supplement water requirements not met by rain, in order to grow the maximum yield and quality of the desired plant product.

Knowing how much water to apply and when to apply it is a fundamental management decision on which effective water management practices should be based. However very few irrigation farmers are using such technology. About 4% in Australia.

Before we discuss some of the issues about soil moisture monitoring and irrigation scheduling, lets look at some important points when understanding the importance of water for plant production. There has been a considerable amount of research into the general relationships between plant responses and soil moisture conditions. It is important to understand that the various stages of growth, for example vegetative growth, flower- bud initiation, fruit development, etc., are a function of the moisture supplies, (and other factors), and thatthe total growth and yield of a crop will be a combination of the effects of soil moisture conditions (among other factors) at each growth stage.

When considering a watering regime for a crop, it is wise to understand the various growth stages and the water requirements of the crop in order to achieve maximum yield and quality potentials. In perennial crops, the future growth and cropping efficiency of the plant has to be safeguarded at all stages by preventing drought conditions. However, if one particular stage of growth has a more significant influence on yield, for example the flowering stage of a crop where fruit is to be marketed, then water supply conditions to the plant during flowering may need to be managed more carefully than at other stages of growth. Maintaining adequate soil moisture conditions during moisture-sensitive stages of growth will have a significantly beneficial effect on plant growth. Significant reductions in yield will result from restricted water supply during these moisture- sensitive stages because the provision of adequate water at other (not so moisture-sensitive) stages will not compensate for the harm sustained.

Most annual crops exhibit a differential response to moisture supply because they are especially sensitive to water shortage from the time of flower initiation, during flowering and, to a lesser extent, during fruit and seed development. Perennial crops are sensitive to a restricted water supply generally at the same periods and in precisely the same way, but it is doubtful whether the sensitivity during fruit development is more pronounced than it is during vegetative development, and in particular when fruit development and vegetative growth occurs at the same time or when the rate of growth during a particular day length period or temperature period determines the yielding capacity of the crop.

Research has proven that the organs growing most actively during moisture stress periods suffer the greatest check to growth. Consequently, it has also been suggested that the process of cell division (reproduction) appears to be less affected by moisture shortage than that of cell elongation (cell expansion).

The importance of hi2h soil moisture supply at certain growth stases are illustrated below

Development effects

• Vegetative growth of perennial crops is sensitive to soil moisture stress.

• Optimum soil moisture conditions help to maintain cell division and expansion, and transport nutrients to the actively growing sites of the plant.

• Maintain vegetative growth phase for the yield and quality of successive crops in both young and mature perennial plants.

• Example of how the vegetative growth phase is important for high yields can be illustrated in crops such as sugar cane, which benefits from severe moisture stress prior to harvesting; avoidance of moisture stress during the vegetative growth phase considerably reduces the time taken to reach maximum productivity. Mature mango trees may also be irrigated to encourage a particular growth flush so that they can bear flowers and fruit at the desired time.

Internal water relations

• There is a change in the internal water relations of both annual and perennial plants during the transition from vegetative growth to reproductive development. Transpiration requirements are reaching a maximum at a stage where water absorption may be reduced by a depletion of soil moisture reserves as well as reduced root growth. The net result may be a lowering in the water content of the plant, which in certain crops may favour flower-bud initiation. During flower-bud differentiation, when the sexual organs are formed, and during subsequent flowering, most crops, both annual and perennial are particularly moisture-sensitive.

• Floral organs in many annual and perennial plants are extremely sensitive to water stress. Water shortage at this time may result in defective floral organs sterility, reduced numbers of flowers formed and failure of flowers to open. Therefore, during the period from the development of the reproductive organs and until fertilisation has occurred, plants require optimum water supplies and are particularly responsive to irrigations.

Root growth and availability of water

• Studies have demonstrated that during certain growth stages, especially flowering and the formation of fruit, root growth is retarded or ceases completely.

• For annual crops in particular, there appears to be an increased risk of water stress during the development of reproductive organs, when root growth ceases.

• Reduced root growth, especially in annuals, is likely to be a contributory factor causing marked sensitivity to soil moisture conditions at certain stages of growth, and hence explain the beneficial effects of irrigation at such times.

Availability of nutrients

• Soil moisture status and mineral nutrition of plants are interrelated.

• Irrigation or rainfall at a specific growth stage may facilitate nutrient uptake by plant roots by increasing the availability of nutrients or by providing suitably moist conditions for root activity in the nutrient rich topsoil.

• The beneficial effect of rain or irrigation at certain growth stages may be caused primarily by an increase in the availability of nutrients rather than by the increased water supply.

• Evidence has shown that enhanced availability of nutrients is particularly beneficial for annual crops at certain stages of growth and also for perennial crops, notably during the periods of vegetative growth, flower development and fruit setting. The beneficial effect of a plentiful supply of water at certain growth stages is partly the result of the increased or sustained availability of nutrients to the plant, especially when the period for maximum nutrient requirement coincides with the stage of maximum moisture sensitivity.

• Excess soil moisture conditions, above field capacity can result in excess drainage, leaching nutrients below the active root zone of the crop.

The importance of low moisture supply at certain growth stages are illustrated below

Development effects

• A low soil moisture supply in the early stages of growth of an annual crop can influence the earliness of flowering through a reduction in the number of nodes formed before flowering occurs.

• Similarly, flower-bud initiation can be encouraged or hastened in perennial fruit crops by restricted soil moisture supply at the time that flower-bud initiation should occur. Drought may be used to ensure satisfactory flower-bud initiation in citrus and mango trees.

• There are periods during the development of perennial crops when a certain degree of moisture stress may not appear harmful when considered over only one or two seasons. However successive short periods of moisture stress during the vegetative growth phase will have a cumulative effect on growth and therefore cropping potentials.

Drought hardening effects

• Results have proven that a reduced water supply in the early stages of growth encourages the development of a large, deeply penetrating root system, (where soil structure is not limiting), which is considered a desirable buffer against drought.

Alterations in the chemical composition and physical characteristics of plants

• An internal water stress in plants alters the balance of the various physiological processes, and as a result the chemical and physical composition of the plant or its parts can be altered.

• Sometimes a water deficit produces desirable changes in composition. For example, water shortage before harvest improves the sugar content in sugar cane and can be used to increase the concentration of sugars in wine grapes. Holding water back from other crops, such as tomatoes prior to harvest can also increase the sugar concentration and increase the solid contents of the fruit, or in apples, can be used to increase sugar concentration or harden fruit by concentrating the cells, by reducing water content prior to picking.

The time when water shortage begins to influence plant growth will be related to the volume of soil available per plant. Providing adequate soil moisture reserves, while annual plant roots are actively growing into fresh regions of soil, sufficient water can usually be obtained to satisfy transpiration requirements and maintain unchecked growth. When, however roots can no longer extend into a fresh volume of moist soil, the plants become more dependant on and therefore respond more to rainfall and irrigation.

There appears to be two distinct phases of root development for annual plants. Phase 1, when roots are still extending strongly into new soils, and phase 2, when the available soil has been fully occupied by roots. The time at which phase I ends will be related to the activity of the roots and their spatial distribution, the plant spacing and depth of soil for rooting. Research has shown that responses by annual crops to irrigation may have been related to the time when the available soil volume becomes fully occupied by roots and only by chance to a particular stage of growth.

Many perennial crops appear to be more sensitive to soil moisture conditions during the establishment period, while their roots are developing into and colonising the available soil volume, than when their permanent roots have occupied the soil volume. Soil volume differences will often be reflected in the final size reached by the mature perennial plant; a larger shoot system will be carried on a tree in deep soil than on one in shallow soil and a larger root/shoot ratio will be developed where soil moisture supply conditions are least favourable.

Agronomic implications

The sensitivity of the flower development process to water conditions has emerged as a common phenomenon in both annual and perennial plants. Many annual crops have also shown to be moisture-sensitive during flowering, while perennial crops appear to be moisture-sensitive during the period of maximum vegetative growth and probably again immediately after their flowers have been fertilised. Water supply for perennial crops should be adequate to maintain, at all stages of growth and development of the crop, an effective and healthy foliage able to utilise as fully as possible the incoming energy. Thus any stress condition that is required to suppress or restrain growth or to favour crop quality should lie within the range of stress that the plant can tolerate without detrimental effects to its overall health.

The agronomic implications of moisture-sensitive stages of growth are of considerable importance. Irrigation practice needs to be made as efficient as possible in terms of water use, not only because water for irrigation purposes are often in short supply, but because the returns per unit cost of irrigating are reduced by using excessive quantities of water. The aim should be to obtain the maximum possible yield of marketable produce from a given quantity of water supplied to a crop. The practical application of such management strategies can be used to apply water at any sensitive stages of growth, and to postpone irrigating at other stages, until the estimation of

soil moisture deficits from monitoring show that a predetermined limiting deficit (refill point) has been reached for a given crop on a particular soil.

So what does this mean? It means that a greater understanding of the relationship that water has with plant growth needs to be attained. Soil moisture monitoring does not simply mean measuring how wet or dry a soil is. Objective soil moisture monitoring can enhance water management strategies to improve crop yield and quality potentials. “Irrigation scheduling” can be defined as applying the correct amount of water at the correct time to a crop in order to maintain optimum soil moisture conditions to produce the maximum yield and quality of the desired plant product. Objective soil moisture monitoring allows the manager to plan irrigations according to soil water holding capacities, plant water use, prevailing weather conditions and quantified management decisions.

How do you decide when to water and how much to apply

- Historic information
- What the neighbours do
- Look at the crop for signs of water stress
- Set routine
- Dig stick
- Evaporation pan
- Soil moisture monitoring
- “Guesswork”