Irrigation Theory 101

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Simply calculating irrigation need by measuring the changes in soil moisture in one spot and using the following equation, is too simplistic:

$$DS = R_F + I - R_O - D - E - T$$

(*DS* is the change in soil moisture, R_F is rainfall, *I* is irrigation, R_O is runoff, *D* is drainage, *E* is evaporation from the soil, and *T* is transpiration from the plant.

Water moves in, through and out of a soil by means of several mechanisms. Before we can use soil moisture measurements to determine our irrigation need we need to understand a few principles and get acquainted to terminology used by irrigation consultants.

Soil texture and compactness has a big influence on water movement through the soil. Where gravity pulls water down through macro-pores, capillary forces can move water up and sideways through narrow pores when the matrix potential of the soil pulls harder on the water than gravity can pull it down. In first instance when using drip irrigation this creates a very different moisture pattern in fine (onion shape) or coarse structured soils (carrot shape). While this is well known to most people, it is often misunderstood that this same principle can stop water from flowing down a profile from a fine textured soil into a gravel sub-soils. This creates a wet zone above the gravel and often one will find there more roots than anywhere else in the soil profile.

We therefore have to speak not only of the *water holding capacity* of a soil but also must know how well the water is available to the plant and one must know what to measure. We use the term ready available water to describe water that is held in the soil with a force that allows a plant to easily extract that water from the soil. *Readily available water* is water that is held in the soil with suction between 0.1 bar (*field capacity*) and 1.0 bar (*refill point*). Above 1 bar suction water is still available to the plant but it is harder to access. If more than 15 bar suction is needed most plants will not be able to extract any more water from the soil and we speak about the *permanent wilting point*. In this way each soil layer can be described with its own soil moisture curve. Hence, does one measure all soil layers or only the top one?

Not only does the soil moisture curve vary with depth but also horizontally throughout the vineyard there can be huge differences. For instance the Wairau valley in Marlborough is an old braided riverbed and it is generally accepted that the basic soil type can change every 50 m across a vineyard. Can one now measure soil moisture just near the water pump or does one need more measurements around the vineyard?

The irrigation tape just runs under the vines and in very dry climates that is where one can expect the majority of the roots. However, in most places in New Zealand irrigation is only an addition to natural rainfall hence roots will be spread widely. Measurements done in Marlborough have clearly shown that vine-roots take much of their water from the inter-row and it is therefore important to know the soil moisture availability both under the vines as well as under the inter rows.

All these measurements can make determination of vine water stress very complicated. Simpler but accurate methods might become available in the near future:

Marlborough irrigation research

Irrigation research in Marlborough has shown that besides the use of soil moisture some very accurate measurements of plant water stress can be done by means of stem sap flow. The accuracy of stem sap flow has been shown by controlling vine water use in a lysimeter. We now also have managed to show a very strong correlation between the main reason for transpiration, the size of the vine canopy, and stem sap flow. Putting all this information tog ether allows us to create a model that can predict vine water use. By showing that with our canopy measurements we are capable of predicting vine water stress with similar accuracy as we can by using extensive soil moisture measurements we will be capable of developing a model that allows us to do canopy measurements anywhere in the vineyard to get a plant integrated impression of the actual water stress.

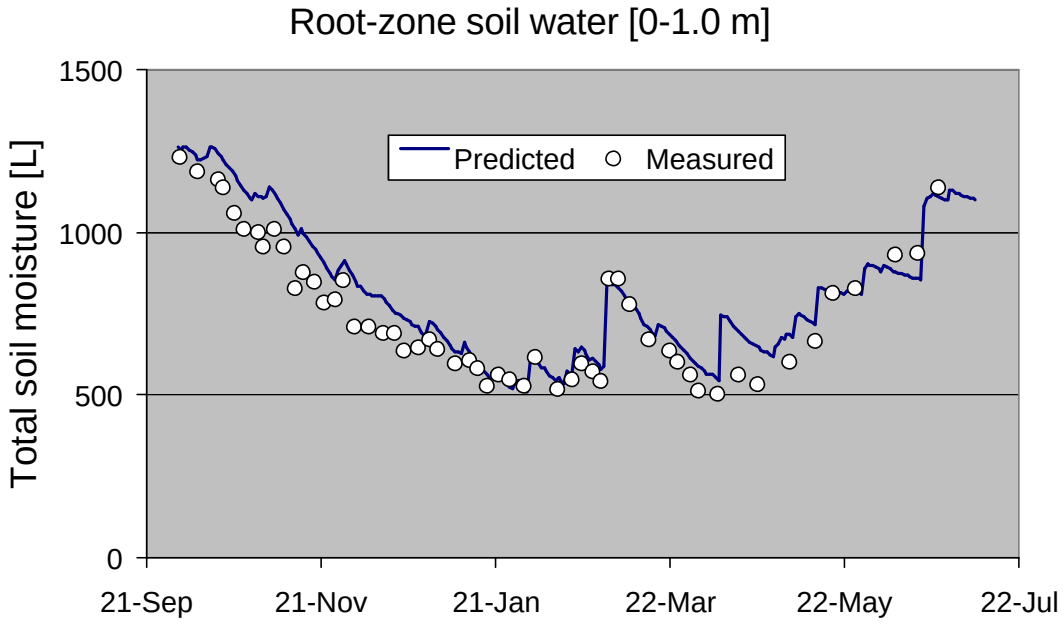

Figure 1: Modelled and measured soil moisture by using meteorological data and canopy measurements.

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