SOIL MOISTURE SENSORS FOR WINE GRAPES

After determining your goals for irrigating wine grapes and designing an appropriate irrigation system, soil moisture monitoring should be considered as an important tool for meeting your goals. Soil moisture monitoring will help you determine the level of water in the soil that causes the appropriate canopy development which in turn helps produce the quality of wine grape that you desire. Soil moisture monitoring will not automatically give you the ideal soil moisture level for growing wine grapes in your vineyard. Your experience in growing a quality product must be correlated with the soil moisture readings. However, after coming to understand how soil moisture affects canopy development, soil moisture monitoring will help you adjust your irrigation schedule to repeatedly produce high quality grapes in the variable weather conditions of each growing season.

In comparing soil moisture sensors, one of the first questions asked is, "Which sensor is most accurate?" Accuracy is an important factor. You want to be sure the sensor you purchase will work in the soil type and moisture ranges of your vineyard. However, an equally important question is how well the sensor fits into your operation. You should also be asking questions like:

- What is required to properly install the sensor?
- What is required to maintenance the sensor?
- Will the sensor interfere with standard cultural practices?
- How often do the sensors need to be read?
- What is required to obtain a routine reading?
- Will extra personnel be needed?
- Can the soil moisture data be processed in a timely fashion?
- Will the irrigator be able to interpret the sensor readings and make appropriate adjustments to the irrigation schedule?
- What initial capital is required?
- What are the total costs over a longer time frame?

In summary, a properly selected sensor will minimize the investment in time and money that is required to reap the benefits of soil moisture monitoring.

In order to answer some of these questions, Washington State University is comparing a variety of sensors under a variety of conditions through a grant to promote Scientific Irrigation Scheduling from the Northwest Energy Efficiency Alliance. The sensors being compared are: Irrometer (tensiometer), Watermark, CPN neutron probe, Troxler Sentry, EnviroScan, Aqua-Tel, Aqua-Flex, Tektronix TDR, Gro-Point, Aqua-Pro, and Trime probe. Most of the soils in Washington vary between a loamy sand, very fine sandy loam, and silt loam. There are some very coarse sands but very few soils high in clay content for sensor testing. Certainly, this effort has not tested all possible combinations of soils, sensors, and crops in Washington let alone the irrigated grape growing regions of the world. However, there has been a significant increase in our knowledge base to facilitate your decision of a soil moisture sensor.

The method a sensor uses to measure soil moisture is important for understanding the sensor's performance characteristics. The tensiometer uses a porous ceramic tip in direct contact with the soil to measure soil tension. The Watermark measures the change in electrical resistance that occurs as soil water moves in and out of the sensor in response to the surrounding soil moisture. The neutron probe counts the number of neutrons that collide with the hydrogen in water. Tensiometers, resistance sensors, and neutron scattering have a fairly long history of use in soil moisture monitoring. Most of the new sensors available on the market today measure the dielectric constant of the soil which is most affected by the change in soil moisture. One way to determine the soil's present dielectric constant is by measuring the change in a radio wave frequency as it passes through the soil. The EnviroScan, Troxler Sentry, Aqua-Pro and Aqua-Tel use this method called Frequency Domain Reflectometry (FDR) or Capacitance. Another, way to determine the current dielectric constant of the soil is to measure the reflectance pattern of a voltage pulse that is applied to a wire guide. The Aqua-Flex, Tektronix unit, Gro-Point and Trime probe use this method called Time Domain Reflectometry (TDR).

The different measurement methods are also configured in a variety of ways that affect installation. The tensiometer and Watermark are small sensors that can be attached to 1-inch insertion tubes. Therefore, a one-inch auger or probe can be used to place the sensors at multiple depths with a soil slurry to insure good contact. The Aqua-Tel, Aqua-Flex, Gro-Point and Tektronix TDR are larger sensors that require soil excavation and careful repacking of soil. Deep installation of these sensors (important for monitoring deficit irrigation of wine grapes in deep soils) will be difficult and a large excavation is required unless you have someone with very long arms available. Also, excavation disturbs the soil and roots at the point of measurement, but this will only be a temporary problem in a perennial crop such as grapes. The Aqua-Flex is a ten foot long tape and requires a ten foot trench; however, a long sensor can help reduce the variability in soil moisture measurement especially when water is delivered from a drip source. Finally, neutron probe, EnviroScan, Troxler Sentry, Aqua-Pro, and Trime measure soil moisture through the walls of an access tube (1.0 to 2.0 inches). Air gaps must be eliminated from all sensors that measure dielectric constant, so in the case of access tubes, the tube must be driven into the soil and augured for the inside. Only, the neutron probe is less sensitive to the problems of poor installation.

Soil moisture sensors also differ by how measurements are made and displayed. Electronic reading units with wire clips that attach to individual sensor wires are a common means of obtaining measurements for the Watermark, Aqua-Tel, Gro-Point and Tektronix units. For the tensiometer, a gauge is attached to every sensor which means a reading is available whenever personnel are in the field and the device has been maintained. The readings from the above units are usually hand recorded and graphed on a periodic basis. Another important approach is the portable sensor/reading unit used with access tubes such as the neutron probe, Troxler Sentry, Aqua-Pro and Trime. This arrangement allows a single sensor to be used at multiple locations on a periodic basis. The readings from these portable units can be hand recorded or logged by the unit and latter downloaded to a personal computer. The EnviroScan and Aqua-Flex sensors are hard wired to a control unit that frequently measures and stores the soil moisture on a

datalogger. This intense data stream is downloaded and graphed on a personal computer. The continuous record of soil moisture will help identify water management problems such as over irrigation that could be missed by periodic measurement. Since deep percolation is not a problem in deficit irrigated grapes, continuous monitoring may not be necessary. The tensiometer, Watermark, Gro-Point and Aqua-Tel can also be data logged. Good software to help you process data logged soil moisture is very important.

The absolute accuracy of sensors varied greatly in the Washington trials and it was difficult to find any two sensors that measured the same value when the manufacturers' recommended calibration was used. Even though, the actual values differed greatly, the relative changes in soil moisture were quite similar. In other words, similar trends were observed when the sensor results were graphed side by side over time. This means that recalibration of the sensors would result in very similar soil moisture values. However, many wine grape producers will find it more practical to calibrate themselves to the sensor results than to correct the sensor calibration. The tensiometer and Watermark sensors did not responded to soil moisture changes in very course sand and a low-tension gauge will be used in this situation on the tensiometer in the future. Also, tensiometers and Watermarks are limited in their ability to measure extremely low soil moisture levels that are created when deficit irrigating wine grapes. Some research suggests that instruments that measure dielectric constant may encounter greater difficulty with repeatable accuracy in clay soil (especially clay that shrinks and swells) but these conditions were not encountered in the Washington trials.

Finally, the cost of the sensors is an important factor. In the case of tensiometers and Watermarks, both the sensor and the reading unit/gauge are relatively inexpensive but a sensor is needed at every measurement location. The EnviroScan, Aqua-Flex, Gro-Point and Aqua-Tel also require a sensor at every measurement location and the sensors are more expensive. Dedicated dataloggers further increase the cost of these sensors. The neutron probe, Troxler Sentry, Tektronix and Trime are expensive units but they can be used at many inexpensive locations via access tubes and home made sensors (Tektronix). The Aqua-Pro is a low cost access tube unit. In addition to the capital cost of these sensors, the cost of installing, maintaining, and reading the sensors must be considered.

The sensor characteristic described in this article should provide some guidelines for choosing the soil moisture monitoring system most appropriate for your vineyard. In an article of this scope, it is difficult to include all the pertinent details. If you are interested in more information and being updated on the future results from the comparisons of soil moisture sensors link to Washington's Scientific Irrigation Scheduling web site at http://sis.prosser.wsu.edu.

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