

Controlling Moisture Levels in Soils and Planting Media

Precision moisture control in the root zone is necessary to prevent disease, conserve water, and to manipulate plant responses such as growth, dormancy, flowering, and fruiting. Some growers rely almost exclusively on fully automated watering schedules and crop models, while others prefer to water manually. You can use your Argus system for either. Whether you require automatic or manually initiated watering, you can take advantage of our system-wide capacity management, multi-zone watering schedules, and automatic zone queuing. You can also use a variety of sensors, event records, alarms, and data recording to control and track all of your irrigation related processes.

Fixed Setpoint, Open Loop, and Closed Loop Strategies

There are three general strategies used for automated irrigation control: **fixed setpoint**, **open loop**, and **closed loop**.

Fixed setpoint control uses operator setpoints such as the day of the week, time of day, and the watering duration to irrigate at predetermined times. No sensors are directly used to produce or alter the scheduling of irrigation events. This 'time clock' watering method has the advantage of being very simple, but the disadvantage of producing a fixed output under all circumstances. With this method, you often need to manually override or adjust the watering parameters to compensate for changing crop and weather conditions.

Open loop strategies often combine some elements of fixed setpoint strategies with a predictive or 'feed forward' component that is based on measurement of one or more of the factors that influence soil moisture levels. For example, you can use accumulated values from a light sensor to regulate watering frequency. Since there is generally a good correlation between accumulated light levels and water demand, you can use this information to create a self-compensating watering strategy that increases the amount of water that is applied in relation to the amount of accumulated light. With good management, we have seen open loop irrigation control strategies that provide excellent dynamic watering control. Compared to sensors that measure moisture levels directly, the indirect sensors that are used for predictive purposes generally tend to be more reliable and stable. They are also more economical, since a single sensor (such as a weather station light sensor) can be used in all schedules. One disadvantage however, is that since there is no automatic mechanism for correction, the predictive calculations must accurately match the actual water demand. To effectively manage this type of system, you need to be regularly inspecting your crops and adjusting the prediction calculations as needed. This is not necessarily a bad thing!

Closed loop watering strategies normally use some sort of feedback sensor to modify or trigger irrigation events. This is usually accomplished with one or more moisture sensors located somewhere in the crop. This may sound like the perfect solution, since closed loop systems are essentially self-adjusting in direct response to the changing conditions in the crop environment. However, there can be a variety of problems associated with sensor reliability and finding representative measuring locations. Since the sensors are usually placed directly in the crop, they are generally subject to higher loss and damage than indirect sensors such as light sensors. It is often necessary to use redundant sensors at several locations to compensate for the problems of getting representative readings. For true feedback control, you often require separate sensors in each watering zone. This can get expensive. Closed loop systems that rely exclusively on feedback control are also more prone to serious errors should the sensor ever malfunction or

become displaced. To work effectively, a number of safeguards must be employed to warn you against these conditions. This includes using event records to keep track of the number of waterings or the total duration of waterings. You can then set up alarms based on this information to warn you of out-of-bounds situations.

With your Argus system, you can use all of these strategies individually, or combine them in a blended approach. You can take advantage of capacity management, multi-zone watering schedules, and automatic zone queuing whether your watering events are triggered manually or automatically. You can also use a variety of sensors, event records, alarms, and data recording to control and track all your irrigation related processes.

Sensor Selection

If you are planning to use open loop control methods, chances are you already have the sensors you need on your Argus system. You can use your weather station light sensor to accumulate light in watering schedules, or you might want to perform more complex calculations involving temperature, humidity, and light. Regardless of your watering methods, moisture sensors can help you to monitor the moisture levels in your crops.

For feedback sensors, you can choose from a variety of options. Most sensors can be interfaced either directly or indirectly to your Argus system, but you should check with us to confirm compatibility. Whether you use them for direct control or not, moisture sensors can provide useful feedback for water management purposes. Since they are normally placed at the end of the watering path (where the roots are), they provide the most conclusive proof that the water has actually reached its target. This can be reassuring, particularly when you are monitoring your crops from a remote location.

We are often asked to recommend sensors for various applications. Depending on the situation, we try to recommend alternatives where other customers have had success. Ultimately, the choice is yours, and we are happy to help you get the most from any sensor that can be interfaced to your system. The following is a brief description of some of the more common sensor types.

Electronic Tensiometers

These are well proven for field and greenhouse use and are available in a variety of sizes. They are not affected by salinity. A tensiometer operates by allowing the soil solution to come into equilibrium with an enclosed reservoir of water through a permeable ceramic cup that is placed in contact with the soil. A pressure sensor measures the pressure inside an enclosed water-filled tube. At saturation, there is no pressure difference between the inside of the tube and the surrounding soil. However, as the soil dries, water leaves the tube by a process known as soil suction, creating a measurable vacuum in the tube. The drier the surrounding soil, the higher the vacuum that is produced. Tensiometers need occasional maintenance and refilling, particularly if the soil medium is allowed to become very dry. They must also be positioned carefully for good soil contact. They generally require individual calibration but can provide stable, long-term readings with very little maintenance. Tensiometers are commonly available with 4-20 ma transducers. These can be easily interfaced to your Argus system.

Argus Moisture Probe

This is our own specialized conductivity probe that we designed for moisture measurement in soils and container media. As with all conductivity-based sensors, it is somewhat affected by dissolved salts, but much less than most conductivity probes due to its design. It is simple to use, relatively inexpensive and durable, but requires recalibration between different soil types and after large changes in salinity levels. Although we think it is best used for monitoring purposes, we've had good results using it for direct control. Since it requires an AC signal to prevent polarization it must be used on Argus AC input channels or with an AC signal converter.

Load Cells (Weight Scales)

These sensors do not actually measure soil water directly, but the weight of the representative sample. This may be a container, a flat, a pallet, a hanging basket, or even part of a bench. Since daily or hourly differences in the weight of a container crop are almost exclusively due to changes in water content, weight-based moisture measurement can be extremely accurate. It is mostly used in container culture, and is particularly useful where the small cell size of multi-unit containers prevents the use of probe-type instruments. Since the signals generated by most load cells are extremely small, additional signal conditioning equipment is often required when interfacing to your control system. There are many types of load cells made for various applications. If you are interested in using this method with your control system, we can recommend some typical configurations. Since load cells are highly sensitive, they are prone to damage from overloading. They are also quick to react, and may produce transient errors when used outdoors due to wind, or birds landing on the scales etc. When using load cells for direct control these sorts of events need to be detuned with integrated time delays.

Gypsum Blocks

These have been around since the 1940's and have often been used in research applications. Though relatively inexpensive, they require AC signal power and they can be affected by soil salinity levels. They are still used regularly in field applications but less so for greenhouse crops. The blocks dissolve slowly over several years, and since they are prepared from gypsum (calcium sulfate), a semi-soluble fertilizer material, they may slightly alter the nutrient status of the plants in the immediate vicinity of the blocks.

Time Domain, Frequency Domain, Neutron Probes, and others

There are many other measurement systems used to determine soil moisture. While some are highly accurate, they may not be the best for commercial application due to their cost, complexity, or the problems interfacing with existing systems. Many of the more sophisticated measurement systems require a lot more than just a probe. They often need their own specialized signal processing equipment and software. While the expense and complexity of these systems has limited their use to primarily research applications, efforts to commercialize them are ongoing, and we may see some of them in wider commercial use in the future.

Infrared Sensors

Infrared sensors do not measure soil moisture at all, but the temperature of the crop, or the temperature of anything they are aimed at. They are useful as an indicator of plant stress, particularly drought, since plant surfaces tend to heat up on sunny days as the wilting point is approached. This may not always mean that watering is required, but something may certainly

be wrong. You might not want to use this type of sensor for closed loop irrigation, but it could be handy for misting cuttings, or for general monitoring and alarm purposes.

Leachate Meters

These are rain gauges or flow meters used to monitor the amount of runoff from a representative sample of the crop. They can be useful for monitoring overdrain, particularly for highly leached crops grown in inert media such as greenhouse vegetables and roses. Though they do not give a direct reading of the retained moisture in the root zone, they can be useful for confirming irrigation events and for managing runoff rates.

Which Method is Best?

This often depends on who you ask and what they are selling. At Argus, our main concern is that you select sensors that will perform reliably and effectively for your applications, whether or not you use them for direct control. In the end, you need to choose the sensors and control strategies that make the most sense for your application and management style.

All irrigation strategies have their particular strengths and weaknesses. No matter which one you use, they need to be managed. With fixed setpoint schedules, you need to check the moisture conditions regularly and adjust your schedules accordingly. With open loop strategies, you need to adjust your predictive calculations against the actual moisture levels in the root zone. This is particularly important as the seasons progress and the crops mature. With closed loop systems you need to monitor your feedback sensors regularly to ensure sure they are accurately placed, working properly, and are still representative of the crop.

As we mentioned earlier, with your Argus system, you can use a blend of any or all of the basic irrigation strategies that suit your needs. One blended approach that many of our customers have used successfully is to use a light accumulation strategy (open loop), combined with fixed-setpoint minimum watering frequencies. This way your crop will always be watered at the minimum frequency regardless of any sensor information. As light accumulation increases, so does the amount and frequency of water that is applied. If you want to use closed loop watering as well, you can use one or more Watering Equations to schedule additional irrigations based on direct feedback from soil sensors.

If you ask our opinion, we tend to favor the open loop approach over closed loop because it is inexpensive and simple, and has proven to very reliable for a broad spectrum of applications. When properly configured, it is accurate enough for almost any cropping system. Although we generally prefer to use feedback sensors for monitoring and alarms rather than tightly coupled to control, many of our customers have had excellent results using a closed loop strategy.

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