

IRRIGATION SCHEDULING TOOLS

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INTRODUCTION

Yield and quality of a potato crop are controlled by the most limiting factor or interaction(s) of limiting factors. Moisture deficit or excess is one of the major yield and quality limiting factors in potato production.

Numerous research studies have shown that yield and quality are significantly reduced when moisture is present in excess or deficit of evapotranspiration (ET). This term, ET, is derived from the combined water loss from two sources, namely: evaporation and transpiration. Evaporation is defined as water loss from the soil and plant surfaces. Transpiration is defined as water loss from plant tissue.

IRRIGATION MANGAGEMENT

Evaluation of irrigation practices in 45 potato fields in southeastern Idaho showed that moisture deficits resulted in significant yield losses when seasonal water application was 3 to 5 inches below seasonal ET (Fig. 1). Over irrigation also resulted in substantial yield loss in the same study when seasonal water application was 3 to 5 inches over seasonal ET (Fig. 1). Tuber quality was also reduced with both over- and under-irrigation.

Managing water is one of the most critical activities in potato production. There are two main aspects of good irrigation management, namely: irrigation scheduling and irrigation uniformity. Irrigation uniformity deals with insuring a relatively even amount of water is applied across a field. Studies show that lack of irrigation uniformity significantly reduces yields, quality, and profits. It is essential that sprinkler systems are set up and maintained to deliver a relatively even amount of water in all areas of the field (for detailed information see Irrigation Uniformity, B.A. King et. al., University of Idaho Bulletin 824.)

Irrigation scheduling involves determining when and how much water to apply. The goal of irrigation scheduling is to get water into the root zone, maintain consistent water content in the root zone, and avoid pushing excessive amounts of water below the root zone. In order to make irrigation decisions, growers need to know how soil moisture content changes with time. Ideally, these moisture readings would consist of the following: 1) accurate and nearly continuous readings, 2) multiple locations in a field, and 3) multiple depths at each location.

ACCURATE AND CONTINUOUS READINGS

Inaccurate moisture readings will lead to improper irrigation decisions. False-high moisture readings will result in deficit irrigation, which dramatically reduces yield and quality. False-low moisture readings will result in too much water being applied, which results in unnecessary losses of: 1) water, 2) power (for irrigation pump), 3) yield, 4) tuber quality, 5) nutrients, and 6) chemicals. The combination of these losses results in reduced grower profits. Erratic moisture readings (sometimes too high and other times too low) will cause a non-steady supply of water to be present, which also results in reduced yield and, especially, tuber quality.

At a minimum, soil moisture needs to be measured within a few hours before irrigation to determine if and how much water should be applied. Taking a reading once or twice a week only gives a snapshot of that point in time and does not show extreme values that may have an impact on irrigation decisions.

Additionally, nearly continuous moisture readings show diurnal fluctuations of soil moisture, which can give a more accurate assessment of daily crop water usage patterns. These patterns can be used to fine tune irrigation timing and amounts. These continuous readings can also give an indication of when plants become so stressed that they shut down and stop taking up water.

MULTIPLE LOCATIONS

Even if irrigation water is applied uniformly across a field, differences in soil properties and crop growth rate result in spatial soil moisture differences. Soil properties that influence moisture content include: texture (sand, silt, and clay content), organic matter content, compaction severity, root zone depth, infiltration rate, slope steepness, and slope orientation (i.e. north vs. south). The growth rate of the potato crop will also influence soil moisture content, i.e. plants that are growing rapidly will use more water than plants that are growing slowly.

Ideally, soil moisture would be continuously monitored in several locations across a field, in order to have a good assessment of spatial differences. Multiple locations should represent major differences in soil properties in each field. The number of locations needed would be based on how much variability exists in each field. One simple example is with soil texture. If the field being evaluated is 15% sand, 47% loamy sand, 33% sandy loam, and 5% other; it would be ideal to have moisture measurements in all three major texture regions. At a minimum, it would be important to measure moisture content at the each end of the spectrum, i.e. measure the sand and the sandy loam – knowing that the loamy sand will be in between these two. Although, soil texture is one of the most important factors influencing soil moisture holding capacity, it would be ideal to account for other factors of moisture variability as well. Irrigation decisions can then be made based on the percent of the field needing more or less irrigation; factoring price and quality incentives with the fact that excess irrigation results in more wasted inputs, but deficit irrigation costs relatively more in yield and quality.

Although multiple locations are ideal, at least some of these locations should be in the same spot from one measurement to the next. This concept allows for moisture “tracking”, which gives an indication of the overall field water use patterns and eliminates much of the other variability encountered due to soil and crop differences.

MULTIPLE DEPTHS

In addition to measuring moisture at several locations, it is also important to determine moisture content at various depths. Ideally, continuous moisture readings at 4, 8, 12, and 18-24 inches would be taken at each location. Significant quantities of a potato plant’s roots are located down to 18 inches. Despite this, many irrigators keep the top few inches wet, but the bottom of the root zone dry. Measuring moisture at multiple depths helps growers maintain a consistent water supply throughout the entire root zone.

In addition to measuring moisture in the root zone, it is important to measure soil moisture at the bottom or just below the bottom of the rooting zone in order to determine leaching losses. Many growers tend to over irrigate, resulting in water, nutrients, and chemicals being washed below the effective root zone. These leaching losses result in reductions in grower profits and environmental quality.

TOOLS

There are many tools available to help growers perform irrigation scheduling. The University of Idaho recently evaluated several of these tools and found that they all work reasonably well within the parameters they are designed to measure. A brief listing of the capabilities and properties of these various tools are described below.

Calculating daily ET losses, also called the “checkbook” method, uses soil and crop properties to determine how much water is needed for the crop in order to avoid moisture stress. Daily ET is calculated based on local climatic data available from several weather stations in Idaho, which are linked to the US Bureau of Reclamation AGRIMET system by satellite. Readings and subsequent calculations are made every 15 minutes. This information is available on the Internet at <http://mac1.pn.usbr.gov/agrimet/> and in several local newspapers. The soil profile is filled with water early in the season and then replenished based on daily ET estimates. This method works well, but it needs to be verified with some type of in-field assessment. One of the main problems with this method is that it is based on local average crop development and does not take into account site-specific variability.

The shovel is the cheapest and easiest tool and should always be used no matter what other more sophisticated devices are used to measure soil moisture. Using a shovel helps to verify what the other tools may be indicating and helps identify root growth patterns and tuber development. Determining soil moisture with a combination of a shovel and the “feel” method is more subject to individual prejudice and varies widely from one person to the next, although experienced growers and agronomists can develop a high

degree of accuracy with practice. Time is the only limiting factor with this tool in regard to multiple depths and locations within a field.

The Aquateer is a portable measuring device that can be used at multiple locations and depths. The readings from this device vary based on soil density (primarily a function of soil type, traffic, and tillage system), but accurate results can be achieved once the operator becomes experienced at calibrating it for each unique situation. Although the ability to take readings at multiple locations and depths is an advantage, the main disadvantage of this and other portable devices is the lack of water use pattern information or soil moisture “tracking” at a single location. Another disadvantage is that readings at various depths are limited by the ability to push the probe into the soil.

Like the Aquateer, the Portable TDR meter allows for multiple readings, although it is limited to a single depth measurement of 12 inches. This device is also similar to the Aquateer in that its readings can vary based on soil density, but accuracy can be achieved with experience. The readings from this device are repeatable, except in low-density potato hills. Again, similar to the Aquateer, it can be difficult to push the Portable TDR probes into the ground in some instances.

The Tensiometer indicates moisture at a single point in the soil. The range of moisture measured by a tensiometer is somewhat limited, but should be adequate for the range typically observed in potato production. The cost is relatively low for each unit, but individual units will have to be purchased, prepared, maintained, and read for each location and each depth. Most agronomists using tensiometers install them at a minimum of two locations per field with two depths per location, although more locations and depths would give a more accurate assessment of moisture status. Tensiometers provide a continuous reading, but most commonly are read manually and, therefore, the information from a tensiometer is only as good as how often they are read.

Watermark sensors in combination with a data logger, such as the Hansen meter, are similar to the tensiometer in that they indicate soil moisture at a single point in the soil over the course of the season. Readings are continuous, but are recorded every 8 hours (if using the Hansen meter for a data logger). A visual graph of these readings can be viewed at the field meter and can be downloaded for a permanent record at various times in the season. The Hansen data logger supports six sensors, which are generally used for three depths at two different locations.

The Enviroscan is a fixed-position measuring device, but its data logger can support up to eight sites with four depths each. This unit provides a nearly continuous record of soil moisture variation, which can not only be used to determine moisture content, but also depth of rooting, leaching losses, and indications of plant stress. The dealer requires that the unit be professionally installed for a fee. This installation insures minimal soil disturbance and, as a result, better representation of true soil water movement properties.

The Aquaflex takes a fixed reading at one location, but it does take the reading over 10 feet of row space, which allows for a better average moisture reading for a given location. The problem with this unit is that it only measures at one depth at one location per unit.

SUMMARY

Irrigation uniformity and scheduling are an integral part of profitable potato production. Over- and under-irrigation, by even an inch of water, may result in reduced yield and tuber quality. It is important to take moisture readings that allow water to be applied approximately equal to evapotranspiration losses. The best system is probably a combination of fixed and portable measurements. The fixed measurements, especially if they are taken on a nearly continuous basis, provide great insight into daily crop water use. Measurements at multiple depths show how deep the water is in the soil profile, how deeply roots are taking up nutrients and water, and if and when plants are becoming so stressed that they stop taking up water. Although fixed measurements give a valuable baseline for moisture “tracking”, multiple locations need to be evaluated to determine the moisture variability across the field. The devices evaluated by the University of Idaho are all effective, but all have their weaknesses and their strengths.

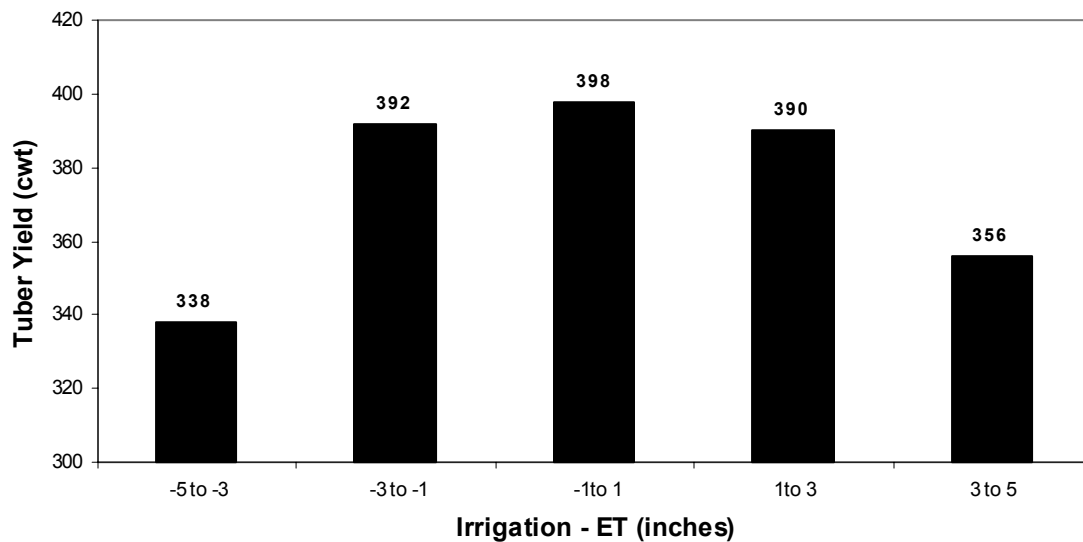


Figure 1. Total potato yield as influenced by the difference between irrigation and seasonal evapotranspiration (ET) on 45 commercial potato fields in southeastern Idaho in 1995. (King, B.A. et. al. Irrigation Uniformity. University of Idaho Bulletin 824.)