Lessons Learned in Automatic Irrigation

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Irrigation costs in much of the nation are second only to labor. If we can increase our capitalization with the expectation of present and future savings of labor and water costs, the long term savings may be worthwhile. Automatic irrigation systems are increasing in number, and the justification is long term economy. An automatic irrigation system has real value for the superintendent to the extent that it is a management tool. Without high management capability it may create its own costly problems. Automatic systems have not always resulted in the savings projected to justify them, and their management capability is the remaining good that can make the system worthwhile or — by its lack — a burden.

We can all recognize the good of economical operation. But automatic irrigation has come to us without our being prepared. We have not known what to ask of it in the way of management capability. We are still experimenting and improving, still discovering new things we want our system to do. We need to develop our criteria for high management capability as soon as possible. The longer we take, the more systems will be installed that are inadequate and soon become obsolete. Here I propose six criteria I should want to use in buying a system.

1. The irrigation design should be adequate.

In the Northeast where a sprinkler system is used to supplement a generally adequate rainfall, second- and third-class design is used, and is tolerable. In the irrigated West where one depends fully upon irrigation, only first-class design should be used in an automatic system. The most sophisticated controller is only as good as the system it controls, and the controller cannot make up for deficiencies in the system. In the West, not only is the single fairway line wholly inadequate but also first-class agricultural sprinkler design is inadequate on turf. With the compaction and traffic it receives, turf has lower infiltration rates than agricultural soils. Application rates are apt to be too high, and the higher they are the more inefficient the operation, the more water is wasted.

Also, agricultural crops send out roots through a large volume of soil holding hundreds to thousands of gallons of water. The large root system compensates in part for inadequacies of application. More water is taken from the wet areas, less from the dry. The turfgrass plant, on the other hand, may explore only a few cubic inches of soil and have only a part of a cubic inch of water available after an irrigation. The only water available is that which enters the soil immediately beneath the plant. There is no adjustment possible between an area that receives too little and one a couple of feet away that receives too much.

Inadequacies of sprinkler irrigation are illustrated by a bowling green irrigation system worked out by Tom Byrne, Farm Advisor in Alameda County, Calif. After much effort to develop the best system possible, 5 per cent of the green was underwatered and 45 per cent received more than twice the needed water. This illustrates the inadequacies and inefficiencies of even the best sprinkler design.

2. *The minimum programmed time should be about two weeks.*

There are two reasons to want this:

(a) In the spring, water applied more often than needed greatly increases weed germination and establishment.

(b) Deep rooted fairway grasses such as bermudagrass will conserve water — will use it more economically only if forced to by using long intervals between irrigations. Water is held with increasing tension by the soil as it dries, and bermudagrass can respond with physiological adaptations which enable it to survive and grow with less water.

For these two reasons we want at least a 14-day program time.

3. *Different stations within the controller must be able to have different automatic programs.*

Shrubs have different requirements from turf; bermudagrass requirements differ from those of bluegrass; those of shade turf from grass in the sun; those of fairways differ from those of the rough. Unless you can irrigate the grass in the shade, for example, every six days, while that in the sun is irrigated every three, you end up irrigating everything according to the needs of the most demanding area of shallow-rooted turf. You should not have to manipulate the controls by hand every few days to get this difference in program.

4. *A single station within the controller should be capable of being programmed differently (and independently) on different days.*

Turf has more roots near the surface, fewer at deeper depths. When the surface layer has dried, soil of the lower root zones may still contain adequate water. However, there are not enough deep roots to take up water fast enough to meet peak needs. Consequently, afternoon wilt develops. A tensiometer-controlled irrigation program at UCLA has given results indicating how we may most economically apply water to use the whole root zone and still avoid mid-day wilt. Their records indicate that the most economical program is one that applies about two shallow irrigations before applying a deep leaching irrigation. The controller should be able to handle this program without need to reset it.

5. *There should be a ratio control so that all stations within a control box can be changed with a single setting and so that each station puts on water in the same proportion to the others as it did before.*

The reason for this is the wish to meet the change in demand with change of the seasons. A box should be reprogrammed about 10 times a year for optimum water economy. If each station were to be reprogrammed individually, some systems I have seen would require 10 to 20 days per year of skilled management time. This discounts much of the labor saving advantages.

Also, suppose you have one station set so that it controls sprinklers in the north shade and another controls heads on a sunny south slope. By trial and error you have adjusted them so that the first puts on about 35 per cent of the second, and both meet the demands of the areas they control. It is unlikely that you could reset these several times a year and still maintain this difference. As a result you would like to be able to set one control and change every station within the box by a proportionate amount.

6. *The controller should be able to apply any single irrigation as a series of repeated short irrigations.*

One difficulty of sprinkler irrigation is that efficiency of application is obtained only at high application rates — rates that are too high. At these rates efficiency of infiltration, of use, is low. Too much water runs off and high spots are left dry. One of the great potentials of automatic irrigation is the possibility of solving this dilemma. By using a high degree of overlap we can increase our efficiency of application but at application rates that are too high. However, the turf mat is able to hold a fraction of an inch of water.

By applying water at a high rate for a short time the water is held in the sponge of the mat until it infiltrates the soil. The application is repeated again and again at spaced intervals until the full application is given. The system operates at a high capacity throughout the interval it is on, but at a single spot, the mean application rate averages out to a suitably low value.

At present all controllers have some of the features I have asked for — none has all. The manufacturer will design a controller with what he considers to be sales features unless you can tell him what you need — what you demand. Automatic irrigation is still young, and controllers will continue to undergo a slow evolution. You can hasten that evolution with a clear statement of your needs and wants.

An example of good use of existing equipment to provide flexible management is provided by the new system at the San Francisco Golf Club, engineered by Don Hogan.

Each station of the controller controls heads of similar elevation and exposure. Each station is set for a short irrigation period (a few minutes) and the times are adjusted (by trial and error) to compensate for differences due to sun, shade, slope, elevation, etc., so each receives a proportion of water appropriate to the area. The entire controller is itself controlled by one station of another controller in the superintendent's office. This two echelon system permits the superintendent easily and quickly to change his program — easily to exercise management flexibility.

A long irrigation is given by allowing a large number of cycles to repeat, a short one by repeating only a few cycles. With the water applied in short cycles, the effective rate of application is reduced, which helps to increase wetting of dry areas and to reduce runoff.

Having a suitable automatic system is not enough. Poor use of it can lead to problems. With poor operation one often sees a tremendous increase in crabgrass and other weeds during the second season of operation.

A new system is not automatic in its programming; the program must be set up by trial and error. The best tool for programming is a soil tube. You must know where the water is going, and nothing beats the soil probe for examining a large number of locations in a short time. Wet and dry soil are easily distinguished, so that you can determine how deep your water is going and whether you are wetting the entire root zone or only part of it.

Once the system is programmed it still requires management to achieve goals of water economy.

The advertised "set it and forget it" exemplifies the abdication of management. The following offers some guidelines for management use of an automatic system after you have it.

1. *Patrol the system regularly.* Operating at night the system is out of sight and often out of mind. Damaged heads, malfunctions, or vandalism may go unnoticed until they show up as dry turf. In a schoolyard a missing head went unreplaced for over a year. A geyser every night caused a permanent wet spot, and the loss of pressure created doughnuts around other heads. But the system was run by a custodian who was uninterested and who responded to the brown turf by increasing the irrigation time. Diddling the controller will not replace a missing head. Patrol for missing or damaged heads, heads not turning, heads cocked at an angle, heads set too low so that they operate under water, or heads blocked by overgrown grass. Check nozzles periodically. An inexpensive set of drills provides a good set of plug gauges for checking nozzle sizes. At longer intervals check pressures at the nozzle with a Pitot gauge. Low pressures may indicate hidden leaks, worn nozzles, corrosion, or dirt blockages.

2. *Start slowly in the spring.* Irrigate as infrequently as you can, but when you irrigate, apply enough to wet through the root zone. This will assist greatly in keeping down crabgrass and other weeds. The cracks that develop as the soil becomes dry will help get the water in with reduced runoff.

3. *For economical water use, change the program according to the season.* Use will depend on the solar energy input. This is affected primarily by the angle of the sun's rays, length of days, and degree of cloudiness. Weekly difference in turf water use tends to be small near the solstices, large near the equinoxes. Economical water use in the irrigated West will require about 10 changes of program a year, each involving at least a 10 percent change in water use. In any location, East or West, close control of water applica-

tion can be achieved by adjusting water application to parallel loss from a Bureau of Plant Industry evaporation pan. This is a pan six feet in diameter, 2 feet in depth, set flush with the ground and having the water surface about four inches below soil level.

4. Avoid daily wetting. Daily sprinkling leads to heavy invasion of crabgrass, Poa annua, dallisgrass, and other weeds. Daily sprinkling keeps the soil at moisture levels where it is most subject to compaction from traffic. Compaction is our biggest turf problem. Daily sprinkling keeps the soil at its lowest infiltration rate so that waste from runoff is maximum. Daily sprinkling stops the cycle of wetting and drying, shrinking and swelling which restores soil texture and aids soil aeration. Daily sprinkling favors disease, buildup of lawn moths, and promotes a soft growth readily injured by stress.

5. Know when to make an exception to Number 4. Sometimes in the middle of summer two or three days of over-irrigation will stimulate the grass, help wet up dry spots, leach salts and improve appearance. Again in late August a few days of heavy irrigation may help relieve summer stressed areas so that they begin to recover. Also, when summer disease has injured roots, a daily sprinkle may keep grass alive until new roots form.

6. Decrease irrigation by increasing intervals. When cutting down on water use after the summer peak, decreasing irrigation frequency is preferable to giving shorter irrigations. More frequent irrigation favors weeds and abuses the soil as discussed above. In addition, remember: a little water does not wet the soil a little bit — a little water wets a little soil and leaves the rest dry.

Several years ago I presented some irrigation design formulas based on plant soil relationships. These are very useful for checking out a system and finding weak points in it. Their usefulness is limited by the fact that often we do not have figures for evapotranspiration and infiltration rates to insert into the formula. However, if we are concerned with the worst month in the worst year in a series of dry years, we can use an ET figure of 2 inches per week and an infiltration rate guessed at 0.1 inch per hour. For a low ET and a high infiltration rate we can use 1 inch per week and 0.5 inch per hour as exploratory values. Even though inaccurate, these values used in the formulas will often point out system weaknesses and indicate the kind of compromises that will need to be made.

(1) $$\frac{\text{Evapotranspiration (in/week)}}{\text{Infiltration rate (in/hour)}} = \text{Hours per week water must be on an area to rewet it.}$$

(2) $$\frac{\text{Irr. operating hours per week}}{\text{Hours to rewet an area}} = \text{Number of sprinkler sections.}$$

(3) $$\frac{\text{Number of acres to be irr.}}{\text{Number of sprinkler sections}} = \text{Number of acres to be irrigated at one time.}$$

Combining equations 1 and 2:

(4) $$\frac{\text{Irr. time (hrs/wk)} \times \text{infiltration rate (in/hr)}}{\text{Evapotranspiration (in/week)}} = \text{Number of sprinkler sections.}$$

Combining 1, 2, and 3.

(5) $$\frac{\text{Total acres} \times \text{ET (in/wk)}}{\text{Irr. time (hrs/wk)} \times \text{infiltration rate (in/hr)}} = \text{Acres to be irrigated at one time.}$$

The flow required to accomplish this:

(6) $$\frac{\text{ET (ins/wk)} \times \text{acres} \times 453}{\text{Irrigation time (hrs/wk)}} = \text{gallons per minute required (gpm)}$$

An approximation of the HP required is given by:

(7) $$\frac{\text{Well dp. (ft)} + \text{av. ht. outlets} + 2 \times \text{op prs. (psi)} \times \text{gpm}}{2000}$$
$$= \text{approx. static h.p. (assuming 50\% efficiency)}$$

(8) Inches of water applied in a month should not be less nor greatly more than total evaporation for the month less rainfall.

Inches applied in a month
$$= \frac{\text{gpm pumped} \times \text{hours run}}{\text{Acres irrigated} \times 453}$$

One Final Tip

Occasionally someone digs through a cluster of control lines. The following summarizes steps to repair the damage:

Hydraulic

1. Join any control line to any valve line. (If system uses pressure to open valves—bleed the line)
2. Turn each line on manually to see which switch now operates which valves.

3a. Relabel and reprogram the controller.
or
3b. Reconnect lines at the controller so each switch controls the desired valve.

Electrical

1. Cut power.
2. Join all ground wires.
3. Join any switch wire to any valve wire of the same wire size.
4. With power on operate switches to see which switch controls which valve.

5a. Relabel and reprogram the controller
or
5b. Reconnect lines at the controller so each switch controls the valve you want it to.