Water Currents

Volume 3, Number 2

Summer 1984

Dear Reader:

In the early days of irrigated agriculture on the Texas High Plains, many of the major financial lending institutions required a "minimum water availability" for operational loans. Ten gallons per minute per acre was generally used as a minimum water availability requirement to qualify a farming operation as fully irrigated and thereby available for loans based on full irrigation.

Irrigation technology improvements, principally the result of research, have reduced this water requirement by about one half. Currently, lending institutions require a water availability of five gallons per minute per acre to qualify a farming operation as fully irrigated. The Federal Crop Insurance Program has further reduced that requirement to only 3.5 gallons per minute per acre for cotton and wheat.

A multitude of improvements have contributed to this reduction in the minimum water requirement. These include improved crop varieties, new designs in water application systems, improved land management practices to use precipitation more effectively, and new chemicals which reduce plant water requirements. The transfer of research technology from the laboratory to the field has helped speed the adoption of these improved technologies and thereby encouraged the reduction in water requirements by financial institutions.

The lower water availability requirement for the total area of the High Plains of Texas does not take into consideration any of the most recent research developments such as the Low Energy Precision Application (LEPA) sprinkler system and the surge time-controlled irrigation system. These and other new developments have the potential to reduce this water requirement even further.

Even though significant advances have been achieved in recent years, area farmers live with the hope that additional improvements can be made which will extend the life of our current water resources and reduce production costs. Only through improved use of water can we farmers continue to provide an abundance of food and fiber for our nation and the world.

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Water Currents reports quarterly on water research conducted by the Texas Water Resources Institute, Wayne R. Jordan, director, and The Texas Agricultural Experiment Station, Neville P. Clarke, director.

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BPG's to Brag About

Just as an increase in energy prices makes motorists more aware of their MPGs (miles per gallon), rising water costs have caused Texas irrigators to look at their BPGs (bushels or bales per gallon).

Today's farmers are caught in a squeeze between declining water supplies and increased pumping costs. They know that irrigation accounts for over 70 percent of all the water used in Texas and are well aware that any reduction in the amount of water needed to produce a crop will reduce production costs.

While interested in increasing yields, the farmers who irrigate the eight million acres in Texas each year are perhaps even more concerned with reducing production costs in order to survive as agricultural producers.

Irrigators also know that irrigation, the greatest consumer of energy in agriculture, is one of the least efficient operations in modern crop production.

Producers who have changed from old irrigation ways to more efficient methods can brag about their improved BPG ratings. Others are painfully aware that they must improve their present ratio of crop yield to applied water if they are to stay in business.

TYPES OF IRRIGATION

Irrigation in Texas falls into three broad categories: surface, sprinkler, and trickle.

Surface, generally called furrow or flood, is the most common method. It involves water delivered to a field by ditch or pipe and allowed to flow by gravity down furrows or to flood an entire field. Seventy-two percent of all irrigated lands in Texas and 95 percent of all irrigated lands worldwide are surface irrigated.

Sprinkler systems greatly increase efficiency over surface systems by evenly distributing water and giving the irrigator greater control over the amount of water applied. Sprinkler systems, introduced in the 1930s and 1940s, now irrigate more than two million acres in Texas. Sprinkler systems generally save on water and labor when compared to furrow systems, but they require a great deal more energy and more capital outlay.

Trickle (or drip) irrigation is an even more efficient method of irrigation because water applied slowly through perforated tubes goes directly into the soil profile. Trickle is an expensive method of irrigation used on relatively few acres in Texas. Trickle irrigation is important in the state, however, because it is used on high value and water intensive crops such as orchards and in water short areas such as the Lower Rio Grande Valley and El Paso vicinity.

INCREASING BPG

Scientists with the Texas Agricultural Experiment Station (TAES) can help farmers "fine tune" their irrigation systems for higher yields with the same amount or less water than they now deliver to their crops. TAES scientists have discovered less wasteful, more efficient methods of irrigation which can help irrigators increase their BPGs - their yields in relation to the amount of water their fields receive in rainfall and irrigation water.

TAES researchers work on improved irrigation methods on the Texas A&M University campus and at research centers in every major irrigation area in the state. They develop new techniques and design new irrigation application systems which help farmers reduce their water losses. Quite often these same techniques can also increase yields.

Research work to improve irrigation efficiency involves scientists in several scientific disciplines and includes many types of crops. Projects to design and evaluate irrigation systems take place in rice fields around Houston, in pecan orchards near El Paso, in peach orchards west of Fort Worth, in sorghum fields north of Amarillo, and in cotton fields near Pecos. TAES research projects also evaluate irrigation application methods and scheduling in citrus orchards in the Lower Rio Grande Valley and in potato fields in the Rolling Plains.

TAES scientists define a crop's efficiency rating (its BPGs) as the ratio of total crop harvested to the total water used. They compare water use efficiency of different irrigation methods as related to energy consumption, economic feasibility, and soil and crop types. Current research conducted by TAES scientists includes evaluation of conventional irrigation methods of furrow, sprinkler, and trickle as well as testing new methods.

Irrigation efficiency, according to researchers, depends upon an irrigator's ability to control (1) the amount of water applied, (2) the timing and rate of application, and (3) the loss of water from the field or root zone. Variables such as climate, soil intake rate, size and slope of the field, type and development stage of crop, and availability of water make the precise control of water application very difficult.

New techniques to give the irrigator control of application amounts, rates, and distribution is the subject of continuing research by scientists with the Texas Agricultural Experiment Station.

The research described in this issue of **Water Currents** exemplifies the variety and scope of an ongoing TAES research commitment to reduce agricultural water demand in Texas. The principles established and some of the systems designed are applicable wherever agricultural producers must supplement rainfall.

SURGE IRRIGATION

Researchers estimate that present furrow irrigation systems in Texas waste about 60 percent of the water applied. Water is lost through evaporation, percolation beyond the root zone, or runoff from the field. Researchers have found, however, that it is possible to apply water by surface irrigation with as much as a 95 percent efficiency.

One of the most promising developments in furrow irrigation is called surge. Newly developed surge equipment includes a set of automated valves which open and close alternately, first watering one area of a field, then another.

By surging the water rather than allowing it to flow continuously, a farmer can advance the water down a furrow before it soaks too deeply into the soil at the top of the furrow. He can also apply more water to the hard-to-water middle of the field without losing tailwater at the end of the furrow.

Farmers in the High Plains who have adopted surge equipment during the two years it has been on the market report a savings of 30 to 40 percent of the amount of water applied in past seasons. Since a set of surge valves and timer cost less than a thousand dollars, the surge equipment can pay for itself in fuel savings alone in one year, farmers report.

TAES researcher Don Reddell is currently looking at the hydrologic reasoning behind the surge concept and is also studying the best management techniques with surge. Reddell, a professor in the Department of Agricultural Engineering at Texas A&M University, believes that after the first surge, water moves down the furrow at a faster rate because of silt layers deposited during water recession. These layers may seal the soil surface and lower the rate of water entry.

Another explanation for the increased rate of advance, states Reddell, is the higher energy level of the stream of water down the furrow which enables it to break new ground. The stream moves faster because it is traveling over already wetted and smoothed ground.

Reddell's research has shown that, when applied properly, surge irrigation can improve the pattern efficiency and overall system efficiency of an existing furrow irrigation system. It can also give a field a more uniform moisture cover.

A farmer is able to irrigate more acres in less time, explains Reddell, because the amount of water is less and the application more uniform. With conventional furrow, an irrigator has to apply enough water to sufficiently water the lower ends of the field. This means he generally over-waters the upper end. With surge he can apply a lesser amount because the water moves more evenly down the furrow.

IRRIGATION BY COMPUTER

Reddell and another TAES agricultural engineer, Joe McFarland, now work on a research project which will bring furrow irrigation - used by the Indians around El Paso more than 500 years ago - into the computer age. Their system depends upon soil moisture sensors in the furrow sending messages to a computer. The computer then programs the surge equipment to apply water at the rate and amount needed by that particular furrow.

Field tests indicate that by computerizing their applications, furrow irrigators can reach the high efficiencies or BPGs now enjoyed by farmers with more modern methods. The researchers predict that their computerized furrow systems could mean a savings of three million acre-feet each year in the High Plains.

CENTER PIVOT STUDY

Researchers stationed at Amarillo and Bushland recently completed a study of the efficiency of high and low pressure center pivot irrigation systems.

The systems they studied were representative of the more than 5,000 center pivot units now in operation in the High Plains.

When operated properly, the researchers say, the center pivot sprinkler system gives the producer a number of advantages offered by no other system. In recent years, though, more and more of these systems have been operated less than optimally. With declining water levels in the Ogallala Aquifer and increased costs of natural gas, researchers have found that the economic feasibility of a center pivot system on the High Plains becomes more questionable every year.

Changes in management practices, according to the TAES researchers, can significantly improve the water efficiency of crop production. One such modification to reduce production costs of center pivot sprinkler systems is to convert the conventional high pressure sprinkler system to low pressure spray heads.

TAES scientists Thomas Marek and Daniel Undersander, working in cooperation with Nolan Clark, a researcher with the U.S. Department of Agriculture (USDA), set up two center pivot frames with high pressure impact sprinkler heads and outfitted two more center pivots with low pressure sprinkler nozzles. They evaluated the systems at the TAES Bushland research center located 8 miles west of Amarillo and at the TAES Etter research station 65 miles north of Amarillo.

Agricultural engineers Marek and Clark and crop scientist Undersander looked at the application and distribution efficiencies of high pressure impact sprinklers compared to low pressure systems. The impact sprinklers spray water a relatively long distance above the crop in an arched pattern; the low pressure systems emit a gentle spray from nozzles dropped beneath the center pivot frame. Because the low pressure spray nozzles discharge the same total flow as the impact sprinklers over a much smaller area, there is greater potential for runoff from the low pressure systems.

Part of the research was to design effective methods of evaluating each system's efficiency. The researchers used plastic containers topped with metal fuel funnels to catch and measure the applied water at various locations beneath the sprinkler systems. They also evaluated the systems in conjunction with variables such as wind, temperature, rainfall, and solar radiation.

They concluded that there was no significant difference between the two types of pressure in application or distribution efficiency if systems are well-designed and well-managed. They did find, however, that an irrigator could typically save around 15 percent in energy costs by converting to a low pressure system.

While comparing efficiencies of high and low pressure systems during the two years of the study, Marek, Undersander, and Clark also evaluated two land treatments under the test sprinkler systems. They compared runoff and water retention of fields prepared with conventional furrows and those with furrow dikes installed. Furrow dikes are mounds of dirt formed across furrows at intervals to hold irrigation water and rainfall.

They also looked at tillage practices such as chiseling and minimum tillage and found that these practices can reduce runoff. They also concluded that furrow dikes can practically eliminate runoff from a field irrigated with a center pivot system and recommend that diking be used in all center pivot farming operations.

NEW CONCEPT DESIGNED

Center pivot or lateral move sprinkler systems in general provide greater control over application rates than do furrow or flood irrigation systems, but they require a great deal more energy.

Most high impact sprinkler systems lose a great deal of water to evaporation before the water ever reaches the ground. Runoff is also a common problem for sprinkler systems operating on low-intake soils.

The problems of high energy demand, evaporation, and runoff have been significantly reduced in a system designed by Bill Lyle, a TAES agricultural engineer working at the research centers in Lubbock and Halfway. Lyle modified an overhead sprinkler frame with drop tubes to apply water just above ground level. The system, which applies water at very low pressure, not only requires less energy than conventional sprinklers, but also reduces evaporation by applying water below the plant canopy.

A leader in new water efficient irrigation technology, Lyle's design is called LEPA, an acronym for Low Energy Precision Application.

Lyle's research has shown that when the system is used on a field cultivated with furrow dikes, the LEPA system can apply water with as high as a 99 percent application efficiency.

Lyle and TAES researcher Jim Bordovsky are currently modifying the LEPA design so that it can be used to apply various agricultural chemicals. They report that LEPA can be used to accurately apply chemicals such as fertilizers, pesticides, anti-transpirants, growth regulators, and soil evaporation suppressants. Precise application of chemicals through the irrigation system, say Lyle and Bordovsky, will mean fewer tractor trips across the field saving energy and time and reducing soil compaction. Their research objective, in fact, is for the LEPA design to eliminate all tractor trips across a field except for planting.

TRICKLE SYSTEMS STUDIED

Trickle irrigation offers the farmer even more control of water application than the LEPA method. Trickle irrigation delivers water to individual plants or groups of plants through tubing. The tubing can lay on the surface of the soil or underground. Trickle systems generally apply water at a flow rate so low the water moves into the soil profile with little or no ponding on the surface and with little loss to evaporation.

Because there is practically no runoff and less evaporation with trickle irrigation, an irrigator can reduce the amount of water he applies to a crop by as much as 50 percent by changing to trickle methods. Instead of flooding an entire orchard, for instance, an irrigator can water only the soil where there are tree roots.

Trickle irrigated acreage in the state has increased to 25,000 acres, and the method has received much attention from TAES researchers in recent years.

Shelby Newman and Jody Worthington, TAES scientists stationed at the Stephenville research center, have studied trickle irrigation methods in orchards for the past 15 years. They have found trickle irrigation to be an efficient and economical method of irrigating orchard crops.

Newman and Worthington have looked at the effects of different rates of trickle irrigation on mature peach trees. By applying trickle irrigation to water trees at high, normal, and low application rates, they found that trees receiving less water than the pan evaporation rate each day produce higher yields and resist diseases better than those trees receiving more water.

Joe McFarland, a TAES scientist in the Department of Agricultural Engineering has worked with Newman and Worthington on a project to determine the most efficient application rates for trickle irrigation of peach orchards.

The researchers planted two mature peach trees in two metal cylinders installed below ground. The cylinders, eight-foot in diameter and five-feet deep, were designed so that they could be weighed.

By weighing the trees and soil in the cylinders each day, the researchers could determine the amount of water lost to evapotranspiration. During the monitoring period, the trees were subjected to water stress to study their ability to tolerate low moisture conditions.

The research with the two weighed trees and field research have shown that peach trees generally depend upon water in the top two feet of soil for growth and production needs. Peach trees use moisture deeper than two feet for survival during periods of moisture stress. The researchers also found that a mature peach tree uses as much as 50 gallons per day during hot, dry periods.

Newman, Worthington, and McFarland also looked at the relationship between the water status in the soil and the water status in the leaves of the trees. This relationship, incorporated into numerical modeling, will be a valuable tool in future orchard water use studies.

EFFICIENT SYSTEMS COMPARED

Researchers at the TAES research center in Halfway have compared three of the most efficient methods of irrigation: subsurface trickle, surface trickle, and LEPA. The team of researchers headed by Jim Bordovsky looked at crop yields and soil moisture stress in vegetable crop production using the three different systems.

When supplied with identical amounts of water, trickle irrigated potato plots yielded a significantly greater amount of large, high-value potatoes than did those irrigated with the LEPA method of irrigation. Trickle irrigation also produced higher yields of jumbo size onions. Total yields (including all sizes and grades) of potatoes and onions as well as total yields for soybeans, the only traditional field crop in the study, were not significantly different.

Systems which apply water below the soil surface showed the least amount of evaporation and also maintained the lowest soil moisture stress. In other words, the applied water was more available to the plant roots in the test plots irrigated with subsurface irrigation.

No matter what method is used, the secret to more efficient irrigation, according to researchers, is to apply water at precisely the time and amount the crop needs it and in a way that all the water remains where the crop can use it - in the soil root zone. Irrigators can reduce the water required to grow a crop or can increase yields without increasing water applications (1) by better control of the amount and timing of applications and (2) by reducing losses from runoff and evaporation.

As TAES researchers continue to design and introduce water efficient application methods, irrigators should find them attractive alternatives to present methods. Irrigators, in fact, will find that an increase in their BPGs equals more dollars in their pockets.

Ripples & Waves

Rapidly rising fuel costs mean irrigators face increasingly serious management decisions in the use of irrigation for crop production. They must learn to irrigate according to the soil moisture level of the field and the consumptive use of the crop.

Farmers can no longer afford to irrigate according to the calendar or the clock. No matter what application system irrigators choose, they must apply the water at the time the crop can make the best use of it.

A concept developed through research efforts of the Texas Agricultural Experiment Station (TAES) and tested at research centers throughout the state can help irrigators determine the most effective times to apply water to their crops. Called the Stress Day Index, the method uses information on a crop's sensitivity to a water deficit during different growth stages. This information is coupled with the actual water deficit to determine the best time to irrigate.

Research has shown that by using the stress day index irrigators can increase their water use efficiency up to 50 percent over conventional irrigation scheduling methods.

"Both timing and amount of water affect water use efficiency," says Ed Hiler, head of the TAMU Department of Agricultural Engineering, "but we have found that timing is the most critical factor. During certain growth stages, severe water deficits can damage the plant so badly it can't recover as far as yield is concerned."

TAES researchers are working with many types of soils and crops to help irrigators in the future know the exact time to apply water. They also design and evaluate sophisticated monitoring equipment to better determine soil moisture and crop moisture demands. In addition, plant scientists study crop varieties to determine water requirements at various stages of growth.

Because Texas irrigators must reduce the amount of water applied to crops in the future, TAES research on irrigation scheduling will become increasingly useful to the irrigators in the state.