CABLEGATION: A REVIEW OF THE PAST DECADE AND PROSPECTS FOR THE NEXT

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Cablegation is an automated surface irrigation application system (Kemper et al., 1987). It was conceived and first tested in 1980 by USDA-Agricultural Research Service scientists at Kimberly, Idaho (Kemper et al., 1981). Over the past ten years, cablegation has been adapted to a wide range of conditions and a variety of commercially-available components have been developed. Over 100 systems have been installed on farmers' fields in 9 western states. The potential labor and water savings have been demonstrated.

After initial widespread interest and rapid growth, the rate of system installation has declined and about 40% of the installations are no longer being used as designed. The objective of this paper is to describe the reasons for the reduced growth and to project the adoption of the technology for the coming decade. Many of the motivations and constraints discussed are common to other automated surface irrigation systems.

BRIEF HISTORY

The first experimental cablegation system was installed in southern Idaho in 1980. The system was featured in several magazines and newspapers, and in 1981, 6 farmers from 5 states approached ARS personnel requesting help to install cablegation systems. Wide press coverage continued and in 1982 and 1983, 22 more systems were installed at farmers' requests with ARS assistance. Two small private companies formed to manufacture components and to design and install systems. Cablegation system computer design software was written and a manual was published.

By 1984, the USDA-Soil Conservation Service in several states was actively promoting, designing and assisting in the installation of cablegation systems. Agricultural Research Service personnel provided training for the SCS engineers and technicians. Many systems were installed in special project areas where cost sharing funds for irrigation improvements were available. Soil Conservation/Natural Resource Districts sponsored several demonstration systems.

The number of installations grew rapidly between 1984 and 1986 (Fig. 1). Eighty systems had been installed by 1986 in nine western states and 20 more were planned for 1987. Most activity was in the states of Washington, Nebraska, and Colorado. The cablegation concept was adapted to local needs and preferences in each area resulting in a diversity of system configurations and components. The ARS conducted an annual Cablegation Workshop at Kimberly, Idaho each January which was attended by SCS personnel, farmer-users, and component manufacturers. An annual "Cablegation Update" was published

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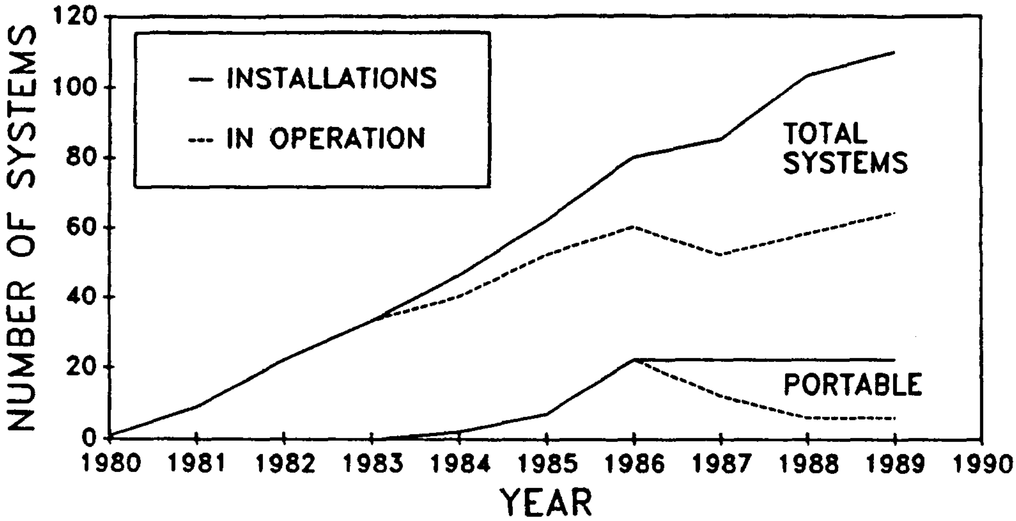

Fig. 1 Total number of cablegation systems and number of portable systems installed and in operation. Portable systems (all located in Nebraska) are removed before harvest and reinstalled each spring after cultivation is completed.

describing new technology and components. By 1987 the technology was well established and all required components were commercially available. Considering the basic development work to be essentially complete, ARS researchers redirected their efforts to other areas and research in cablegation decreased to about 2 scientist-months per year.

In 1987, the SCS was given responsibility to provide technical support for the conservation planning requirements of the 1985 Food Security Act. Consequently, water management activities, including cablegation promotion, were sharply curtailed. Annual cablegation installations decreased to about 10 per year, concentrated primarily in eastern Colorado. By 1990, about 90 permanent and 20 portable cablegation systems had been installed in the U.S. plus 5 systems in southern France. Sixteen systems use buried pipe with large risers to irrigate borders. The remainder are furrow systems with surface pipe. Of the U.S. systems, 64 permanent and only 6 portable systems continue to be operated as cablegation systems. Those 70 systems are located on 45 farms with 14 farmers operating two to five systems.

REASONS FOR REDUCED GROWTH

Several technical, economic, and social factors have contributed to the slowed growth of cablegation usage. Technical constraints include field geometry requirements, system water supply capacity limitations, component failures and the effects of variable infiltration on performance reliability. Economic reasons include low capital availability for farmers, stable water and energy costs, substantial increases in plastic pipe costs, and system installation costs. Social hindrances include the lack of a promoter and farmers' reluctance to change from traditional irrigation methods. Several of these constraints are discussed in detail.

Field Shape and Slope Constraints

The ideal cablegation field is rectangular (equal row lengths and straight along the head end), has a uniform cross-slope at the head end of between 0.004

and 0.008, and is irrigated with at least four irrigation sets (so that labor savings are significant). Probably less than 10% of the surface irrigated fields in the U.S. meet all these requirements. The purpose of much of the research in cablegation has been to adapt the system to non-ideal field conditions. Adjustable outlets along with manual or automatic plug speed adjustment allow variable row lengths and cross slopes to be effectively irrigated. Pliable cablegation plugs can pass through gradual bends and even elbows in pipelines. Precision trenchers allow furrow system cross slopes as small as 0.002. With energy-dissipating furrow outlets, there is no upper cross-slope limit. Probably over 50% of surface-irrigated fields meet these loosened requirements. However, many of these adaptations increase system costs and operational complexity. Practical field shape and cross-slope considerations may limit the adoption of cablegation to no more than 25% of surface-irrigated fields. This limitation is especially constraining to adoption because these fields tend to be the easiest to surface irrigate with traditional methods, while farmers are most interested in alternatives for their more difficult-to-irrigate fields. Also, unless a substantial portion of a farmer's fields can be automated, the overall labor-saving benefits are often reduced.

Water Supply Capacity Constraints

Many farmers can occasionally obtain more than their customary or documented water supply rate. When extra water is available and scheduling is tight or crop water needs are high, they are accustomed to pushing extra water through their irrigation systems. While many surface irrigation systems can accommodate extra water without large efficiency decreases, cablegation systems (like sprinkler and drip systems) have specific capacity limitations. Furrow cablegation systems require free surface flow in the pipeline, and thus flow capacity is limited to about 85% of the full pipe capacity at the installed slope. Exceeding this limitation is a common cause of poor system functioning. Farmers are often reluctant to over-design cablegation systems to accommodate occasional increased supply because of the higher cost of larger pipe.

Component Failure

Component failure is a serious potential problem with all mechanized irrigation systems. A failure can have serious consequences such as flooding and erosion or crop loss or simply cause inconvenience and water wastage. An occasional failure may negate previously accumulated water savings. The real or perceived possibility of failures can eliminate the labor-saving benefits of automated systems because an unreliable system requires frequent checking.

Cablegation is mechanically simple with few moving components, and thus is potentially more reliable than most other automated surface irrigation systems. The only moving parts are the plug which slides through the pipe, the cable which restrains plug movement, and the controller which reels out the cable at a pre-set rate. Potential failures include the plug sticking in the pipe, the cable tangling or breaking, or controller malfunction. Although these failures generally cause little damage (the flow remains distributed across the field), they waste water and reduce reliability and farmer confidence. A reason several portable systems in Nebraska are no longer in use is plug sticking on the rolled male ends of aluminum gated pipe. Controller failures, although often the result of misunderstanding controller operation or inadequate maintenance, still waste water and reduce confidence in the system. Examples include failure to maintain required water levels in waterbrake controllers and exceeding the system capacity, either of which can lead to waterbrake freewheeling and rapid plug movement to the end of the pipe.

Component reliability in an agricultural environment requires conservative (robust and foolproof) and innovative design, ample field testing, and specialized product development. Private manufacturers are often unwilling to devote the resources required to develop reliable specialized components due to unproven demand for automated surface irrigation components and the small market volume early in development. The component reliability required for wide adoption depends on the perceived likelihood of wide adoption.

Infiltration Variability

Infiltration variability is an inherent problem for most surface irrigation systems, but is especially problematic to automated systems. Surface irrigation performance is highly sensitive to infiltration, so temporal and spatial infiltration variability creates the need for frequent monitoring and system adjustment. Frequent monitoring and adjustment reduce the labor-saving benefits of automated systems. Lack of monitoring and adjustment often result in poor performance. Cablegation is similar to other automated surface irrigation systems in this regard. The primary advantage of sprinkler and drip irrigation systems is that they can usually be designed to apply water at less than the infiltration rate, thereby avoiding infiltration influence on performance.

This constraint to adoption of automated surface irrigation systems is the most difficult technical problem to solve. Efforts to predict, manage and reduce variability in infiltration have had limited success. Correcting poor water distribution caused by infiltration variability is often more difficult with automated than with manual systems. For example, with cablegation it is difficult to extend the irrigation time or re-irrigate a limited number of rows on which stream advance was not complete due to high infiltration. On cablegation systems with limited furrow outlet sizes operating near capacity, increasing furrow flow rates sufficiently to match high infiltration rates during certain irrigations is difficult because water pressure on the outlets can't be boosted.

Some types of field feedback control to automatically adjust the application system to field infiltration rates can be easily adapted to cablegation (Trout, 1987; Humphries and Trout, 1990). Such controls reduce the sensitivity to infiltration variability but add complication to an otherwise simple system.

Installation Constraints

Cablegation is more difficult to install than conventional gated pipe systems because of stringent pipe elevation (grade) tolerances. Installation usually requires technical assistance and a significant amount of labor or specialized equipment. The SCS, as presently staffed, does not have sufficient personnel to provide the required assistance beyond the demonstration stage. Private installers with precision trenching equipment could efficiently install cablegation pipe, but their services must be available at the required time and location and the demand for their services must be sufficient to provide the required profits. A commercial cablegation installation company begun in 1982 did not generate sufficient business within its geographical area to be profitable.

Installation constraints are especially limiting for the portable systems used in Nebraska. Most farmers in a given area desire to install their systems within the same 1-to-2 week period between final cultivation and first irrigation. Technical help and commercial installers can have limited impact in such a short time frame.

Complexity of Surface Irrigation

Surface irrigation is complex. A relatively fixed water supply is applied to a wide variety of field shapes, slopes, soils and soil conditions at varying rates and times to infiltrate a difficult-to-quantify amount of water as uniformly as possible without excessive tailwater runoff. Due to the complexity, farmers develop qualitative guidelines that seem to work for a given irrigation technique over their range of conditions. The continuallymoving set of a cablegation system operates differently from fixed-set manual systems and requires developing new guidelines.

Cablegation is not necessarily more difficult to learn to manage than fixed-set manual systems. In fact, several characteristics of cablegation provide management advantages over manual systems. However, exploiting these advantages requires understanding of and familiarity with the system. This requires time and effort. The more complex the cablegation system or difficult the field conditions, the more time required to both de-bug the system and understand the operating procedures. Consequently, the labor-saving potential of cablegation is seldom realized the first year. Also, since cablegation cannot be applied to all surface-irrigated fields, it generally must be used with other systems on a farm, requiring the irrigator to operate more than one type of system.

Farmers who make the original decision to use cablegation systems usually operate them successfully and are pleased with their performance. However, systems inherited by new owners or operated by hired irrigation labor are often unappreciated and mismanaged. Transient labor and hired irrigators who feel threatened by labor-saving systems are especially unwilling to learn a new system for the complex task of irrigating. Automated systems can reduce the need for hired labor if significant portion of a farm's fields can be converted to automated systems. However, automated systems, both surface and sprinkler, although less labor intensive, are often more management intensive. Even large farms seem more willing or able to hire many irrigation laborers than a few higher-qualified water managers.

Lack of Promotion

There are over one million surface-irrigated fields in the U.S. In spite of this large potential market, few manufacturers, retailers, or consultants perceive sufficient profits in innovative surface irrigation systems to promote them. Farmers are accustomed to purchasing materials and equipment, but are seldom willing to pay the true costs of technical assistance. Consequently, retailers must absorb the cost of promotion and technical assistance in profits from equipment sales. It's much easier to cover these costs in equipment-intensive sprinkler and drip irrigation systems than in management-intensive surface irrigation. A dealer who invests in developing the expertise to provide surface irrigation technical assistance generally cannot compete price-wise with the dealer who just retails pipe, fittings, and concrete ditches.

Cablegation systems are composed of pipe and one plug and controller per system. Specialized components to convert a gated pipe system to a cablegation system can cost less than $500 per system. This lack of specialized components is an advantage for innovative farmers, but a disadvantage for potential private sector promoters. Lack of private sector promotion is a primary reason for lack of innovation in surface irrigation. (The only recent exception has been the private development and promotion of surge irrigation valves.) Unless farmers realize the benefits and are willing to pay the costs of technical assistance, this will not change.

Without private sector involvement, promoting and designing improved surface irrigation systems is left to public sector agencies such as Cooperative Extension and the SCS. While most farmers require assistance adapting an automated irrigation system such as cablegation to their field, water supply, and cropping system; both public agencies lack personnel and resources to interact one-on-one with large numbers of farmers in one particular subject area. Both agencies are also subject to mandated responsibilities and priorities which frequently change. A recent example is the SCS responsibility under the 1985 Food Security Act to write large numbers of conservation plans. This effort required most of their resources for 3 years and essentially eliminated their involvement in water management at a time when cablegation was growing rapidly. This was a major reason for reduced growth in cablegation in the last three years. Innovative surface irrigation systems such as cablegation, which require significant amounts of engineering and relatively small amounts of specialized hardware, will likely require continuing promotion and technical assistance from government agencies.

PROSPECTS FOR THE FUTURE

Many automated surface irrigation systems have been developed and promoted in the past without gaining widespread acceptance. The above list of constraints and limitations can lead to the conclusion that the prospects for widespread cablegation adoption are also poor. It is difficult to have promoted automated surface irrigation systems and be optimistic.

However, these constraints do not negate the potential for cablegation to save water and labor compared to conventional surface irrigation systems, and to save energy and investment costs compared to sprinkler systems. Methods have been devised to overcome, or at least reduce the impact of, most of the technical constraints. Cablegation is possibly the most widely adopted form of automated surface irrigation in the U.S. Most of the early systems are still being operated after eight years. Farmers who installed those initial systems foresaw the potential benefits and were motivated to achieve them. However, farmers must see substantial benefits to be willing to make the financial and personal investment required to overcome the constraints and adopt a new irrigation method such as cablegation. The present benefits may not be adequate for many farmers.

The original reason in 1980 for developing cablegation was to provide surface irrigators an alternative to switching to higher energy-consuming sprinkler systems for saving irrigation labor and water. The assumption was that energy, water and labor costs would increase faster than farm commodity prices. However, energy prices have increased little over the past ten years, water supplies are not noticeably more limited or more expensive to most farmers than they were ten years ago and most farmers can still afford to hire irrigation labor. Until the last two years of the decade, commodity prices also remained low, reducing farmer's available capital for irrigation improvements.

Our limited petroleum resource and lack of low-cost alternative energy sources dictates that energy prices will again increase. Water costs will also increase as competition for water in the West and environmental concerns increase. More stringent employment regulations and increasing minimum wages may reduce the availability of low-cost irrigation labor. Irrigated farm profits have increased with increasing commodity prices in the last two years. These economic changes will motivate farmers to increase irrigation efficiency and reduce labor inputs, and discourage increased energy usage.

Legislated water management improvements will also influence farmers to adopt improved irrigation systems. Water quality concerns and groundwater depletion have already resulted in mandated irrigation efficiency improvements in some areas. More regulations are inevitable. Legislated changes are often accompanied by financial incentives (cost sharing) and sometimes include increased technical support.

If the economics and priorities change in favor of improved surface irrigation systems, cablegation is a developed and proven technology which can be applied in many areas. Continuing technological improvements and cost reductions in sensor technology and computer control systems, and any improvements in infiltration management and control, will reduce the primary constraint to efficient automated surface irrigation - infiltration variability. Farmers will learn to operate and manage cablegation as they have gated pipe and center pivot systems in the past. Additional adoption will create demand for components so that these inputs become easier to acquire and of higher quality.

Increased demand will increase the need for design, installation, and operation technical assistance. This must be provided either by the government or the private sector. Continuing federal budget deficits make greatly increased government involvement unlikely. When demand is sufficient, retailers and contractors, by integrating technical design assistance with installation, pipe sales, and specialized component sales, should be able to generate sufficient profits. Training and design materials could be provided by ARS to commercial operators as it has been provided to government action agencies in the past. This type of linkage between government-funded research and private business to get technology into use is being encouraged by both the administration and congress.

SUMMARY

After rapid initial growth, cablegation adoption has slowed in the last three years. Constraints to growth include a number of technical problems and limitations, the lack of promotion, farmer reluctance to learn a new system, and the economic climate. However, the practicability and potential benefits of the system have been proven, and the adoption rate in the next decade will depend primarily on the motivational influence of energy, water, and labor costs. When demand increases, private sector contractors and retailers will be needed to provide the required technical assistance.

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