Improving Applications of Center Pivot Irrigation

Dana Porter, Ph.D., P.E., Professor, Extension Program Leader and Associate Department Head, Department of Biological and Agricultural Engineering and Texas A&M AgriLife Research and Extension Service, Lubbock, Texas
d-porter@tamu.edu

Thomas Marek, M.S., P.E., Regents Fellow and Senior Research Engineer
Texas A&M AgriLife Research, Amarillo/Bushland, Texas
tmarek@ag.tamu.edu

Abstract

Low pressure center pivot irrigation systems, offering potential for high energy efficiency and high water application efficiency, are widely used in much of the Great Plains, especially in the Texas High Plains. Further improvements in adoption and management of these systems are possible, and benefits are more likely to be realized with simplified integration of readily available information (such as soil moisture, evapotranspiration, forecast conditions, etc.) for improved irrigation scheduling. Advancements (patents pending) will provide viable solutions to overcome existing barriers to adoption and limitations of commercially available systems by offering platform independent integration of information to simplify and improve irrigation management. These developments simplify integration of information for irrigation decisions using commercially available sensors and components, greatly improving potential benefits of existing technologies (and return on investment for these technologies) for a relatively low cost.

Keywords: Precision irrigation, LEPA, LESA, irrigation management, center pivot control

Background

Low pressure center pivot irrigation was introduced to the Texas High Plains approximately forty years ago with the development of Low Energy Precision Application (LEPA) irrigation (Lyle and Bordovsky, 1981). LEPA and important adaptations of low pressure sprinkler irrigation, including Low Elevation Spray Application (LESA), Mid-Elevation Spray Application (MESA), and Low Pressure In-Canopy Irrigation (LPIC) and other related systems have become the predominant irrigation application platform, comprising approximately 70% of the irrigated acreage in Texas (Wagner, 2012); over 75% of the irrigated acres in the Texas Northern High Plains (Amosson, et al., 2016); 70% of irrigated acres in Oklahoma (Taghvaeian, 2015); and over 50% of irrigated acres in the many other states, including Nebraska and Kansas (USDA-NASS, 2013).

Many factors have contributed to the popularity of low pressure center pivot irrigation systems. Since energy requirement (and hence energy cost) is directly related to system pressure, low pressure center pivot systems require less energy for operation than higher pressure systems. In arid and semi-arid conditions, especially in highly advective environments, low pressure application systems that apply water at or near the soil surface and/or deliver relatively large water droplet sizes reduce evaporation losses during application compared to high pressure systems. While true LEPA systems' applicability is limited to fields with relatively low slope (less than 1% slope), the low pressure spray irrigation systems (LESA, MESA, LPIC) are widely applicable over a range of topographies, soil types, row spacings, and crop types.

During the last forty years, center pivot associated technologies have expanded and have been adopted for a wider range of conditions and crops, as end-users sought - and equipment manufacturers delivered – solutions to practical challenges in the field. From LEPA drag hoses and bubblers, to a wide range of sprinkler options (applicator height and trajectory options, droplet sizes, and chemigation applications), to corrosion-resistant materials, low pressure center pivot irrigation tools are readily available for diverse agricultural irrigation applications.

Cost-share programs, including USDA-NRCS Environment Quality Incentives Program (EQIP) and low interest loan programs offered through groundwater conservation districts have encouraged adoption of higher efficiency irrigation systems to replace lower efficiency systems. These programs have been expanded to incentivize improved irrigation management, including application of soil moisture sensors and weather-based irrigation scheduling, variable frequency drives, and other improvements (USDA-NRCS, 2018).

Challenges

While there are great technologies and tools commercially and readily available, the potential benefits promised by low pressure center pivot irrigation generally are not fully realized. “Implementation gaps” (Lamm and Porter, 2017) often are linked to knowledge gaps related to the technologies. For instance, end-users tend to under-utilize the variable rate irrigation (speed control) capabilities of commercially available center pivot irrigation controllers, either because they are not familiar with their systems’ capabilities, or they are not able to obtain, implement, or justify time or expense of updating VRI prescriptions. They may not understand the relationships between design flow rate, pressure, and nozzle packages, and their impacts on distribution uniformity. Hence potential water use efficiency gains afforded by precise placement of water and fertigation are missed. Many knowledge and implementation gaps can (or should) be addressed through additional research and improved communication among - and technology transfer by- research/extension programs, USDA-NRCS, equipment manufacturers and dealers.

It is worth noting that *lack of knowledge* does not necessarily equate to *lack of information*. A great body of research and increasingly available and affordable sensors and telemetry systems make data readily available for weather-based (evapotranspiration-based) irrigation scheduling, soil moisture monitoring, plant water status monitoring, soil and plant fertility monitoring. Even technology savvy and progressive end-users can be overwhelmed with the large quantity of information, and lack time and understanding to interpret it and ability to translate it into their irrigation and crop management decisions. Increasingly, irrigation scheduling tools (software) and irrigation system control technologies are integrating field-based data and research-based recommendations into useful, “user-friendly” packages, whereby information can be processed and interpreted for the user, with minimal effort and expertise required of the user.

Integration of Information and Technologies

Major manufacturers and third party companies offer advanced remote center pivot irrigation system monitoring and control (Mowitz, 2013; Kranz, 2011) and/or field data acquisition and interpretation. Manufacturers, other private (commercial) interests, universities, and USDA-Agricultural Research Service have developed a wide range of irrigation management software (decision support systems), smart phone apps, and other useful resources. Their products range in applicability, technical sophistication, level of technical support, and ease of use. Examples of such decision tools include DIEM (Bordovsky, et al, 2016); SmartIrrigation Apps (Migliaccio, et al, 2016); and many others.

There are a great number of useful advanced irrigation technologies and tools available, with more under development. Maximizing their benefits will require addressing several considerations, including applicability to the specific crop production system (soils, climate, crops/rotations, irrigation system capabilities/constraints, management/labor capabilities/constraints); education and technical support; cost effectiveness; and ease of use. Some of these concerns are addressed in a suite of technologies (patents pending) that include improvements over existing technologies:

- precise center pivot system speed control;
- optimization of the number and placement of soil moisture sensors; and
- irrigation system control with predictive water balance capabilities.

The approach used in these developments include:

- wireless sensors/technologies and automated data acquisition and packaging to minimize data entry requirements by end-users;
- integration of data from multiple sources and appropriate models and machine learning to automate interpretation of field-based information to inform irrigation decision making;
- use and incorporation of commercially available “off-the-shelf” components for cost-effectiveness;
- operational platform independence for transferability and ease of “retrofitting” to existing systems in the field; and
- simple user interface for convenient access via personal computer, tablet or smartphone devices.

Despite the many great advances by industry and public sector programs, knowledge gaps remain. Crop models have their shortcomings; new crop genetics requiring differing management continue to evolve; many site-specific, season/climate-specific, and crop-specific considerations are not easily “simplified” or modeled; and communications and internet connectedness can be limited in rural areas. Agricultural systems are increasingly complex, so ongoing research and development are needed to fill gaps in knowledge and technology applicability.

Summary

Communication, education and collaboration will continue to be important in supporting optimal use of available and emerging irrigation tools and technologies. Improved communication between and among the irrigation industry, service providers, technical advisors, educators, researchers, end-users, water planners and policy makers, and other decision makers will help deliver clearer, consistent messages to support better irrigation decision making. Given that end-users are increasingly busy, and rthat highly qualified technical support professionals are invaluable and often hard to recruit, train and retain, new approaches to education, communication and technical support are needed. Information delivery and technical support must adapt to end-users’ preferences (venues, “on-demand” media, concise presentation). Workforce challenges (limited numbers of people interested in irrigation work, exacerbated by limited and declining numbers of academic programs offering relevant irrigation curricula, sometimes attributed to limited external investment in the programs) affect both industry and academic /public sectors. Integration of information and technologies and improvements in technology transfer to support most beneficial use of the information and technologies will be increasingly important as irrigation water resources continue to decline regionally, nationally and globally.

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