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Ogallala Aquifer Program
Center Pivot Irrigation Technology Transfer Effort

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ABSTRACT

The year 2018 will mark the 40th anniversary of research and development with Low Energy Precision Application (LEPA) for use with center pivot sprinkler irrigation systems. Since that time, researchers and extension specialists in the Ogallala region have continued development of multiple types of technologies that are suitable for mobile lateral irrigation platforms. A two-year technology transfer effort with funding from the USDA-ARS Ogallala Aquifer Program (OAP) was initiated in January 2017 to promote adoption of advanced and efficient irrigation technologies and to highlight recommended practices for these mobile irrigation platforms [center pivots (CP) and lateral move systems (LMS)]. This paper will report on pertinent mobile irrigation history and the progress and future plans of the project with a particular focus on the current status of the technology and research and educational needs.

INTRODUCTION

The Kansas and Texas High Plains / Southern Ogallala Aquifer Region are noted for limited and declining groundwater resources (Konikow, 2013) and relatively high rate of adoption of efficient advanced irrigation technologies (Wagner, 2012; Colaizzi, et al., 2009). One of the earliest advanced mobile sprinkler irrigation technologies, Low Energy Precision Application (LEPA), was first researched in the OAP region near Halfway, Texas by William Lyle and James Bordovsky beginning in 1978 (Lyle and Bordovsky, 1981, 1983). Low pressure center pivot irrigation, including (LEPA), Low Elevation Spray Application (LESA), Mid-Elevation Spray Application (MESA), and other variations have become the most widely practiced irrigation methods in the region (Colaizzi, et al., 2009). This is due in large part to the suitability of the technologies to the crop production systems in the region; relevant applied research programs; collaborations among research and extension programs and with industry; effectiveness of cost-share programs, and the willingness of agricultural producers in the region to adopt technologies and BMPs to adapt to limited water conditions (Wagner, 2012). From the early work on development on LEPA that began in 1978 and later Low Elevation Spray Application (LESA) irrigation and Mid-Elevation Spray Application (MESA) to the newer integrated sensor/control systems mounted on CP and LMS systems, OAP affiliated programs have made important contributions to the advancement of irrigation using mobile platforms.

While low pressure center pivot irrigation is widely practiced in the region, applied research continues to refine recommendations, so this technology transfer effort is providing opportunities for end-users to hear up-to-date recommendations to aid in their irrigation decisions. There is much less understanding by "non-practitioner audiences (absentee landlords, ag lenders, crop insurance agents, policy makers) about the most appropriate uses of these technologies, so this effort will help to improve their understanding of the state of the art, considerations for irrigation management, and appreciation for the advances in agricultural irrigation technology, management and efficiency. The technology transfer effort will also provide a good opportunity for the engineers and scientists to collaborate and synthesize "what we know" into more accessible publications and media as well as to provide a venue to brainstorm additional improvements to systems and technologies.

A BIT OF HISTORY OF LOW PRESSURE CENTER PIVOT IRRIGATION

Although by no means do the OAP project participants plan to limit their technology transfer effort to low pressure center pivot irrigation, some historical discussion is warranted to illustrate how the science and conceptualization of LEPA and its prodigies (i.e., LESA and MESA) can lead and has led to improved irrigation management in the OAP region and beyond.

Original development of the LEPA system coincided with a period of relatively high energy costs and concerns about energy availability in the late 1970s, thus low energy usage was a key objective in its development. In Texas where LEPA was originally developed under semi-arid conditions, air and canopy evaporative losses from sprinkler irrigation can be appreciable, reducing crop yields in water-limited operations with low capacity irrigation systems, so reduction or elimination in these losses were assets to the LEPA system. Original design issues were development of an application system adaptable to flowrates from 100-1000 gpm with operating pressures between 5 and 20 psi (Lyle and Bordovsky, 1981). The system was to be adaptable to all soil types, and since there are great differences in water infiltration rates across soil types, runoff was to be controlled by using micro-basin tillage techniques (Lyle and Bordovsky, 1981). Early development of LEPA was on land slopes of less than 1 percent and physical geometry limitations of the micro-basins imposes some limitation on their effectiveness on greater slopes. For example, runoff from LEPA sprinklers was negligible on 1% sloping silt loam soils in eastern Colorado but exceeded 30% when slopes increased to 3% (Buchleiter, 1991). Scientifically, LEPA has always been considered to be a system of technologies with both center pivot hardware and adoption of specific farming practices (Lyle, 1992). Application efficiencies in Texas for LEPA and conventional sprinkler irrigation were measured at 99 and 84%, respectively, when micro-basin tillage was practiced as compared to 88 and 81% when conventional tillage was used (Lyle and Bordovsky, 1983). The worldwide annual benefit of LEPA has been estimated to be $US 1.1 billion with a $US 0.477 billion benefit to consumers in the United States (Lacewell, 1998).

Failure to adopt the underlying LEPA system principles will usually result in unsuccessful application of the technology. Producers' reluctance to adopt some of the guiding principles or land considerations have led to alternate in-canopy or near-canopy application systems such as LESA and MESA, which are spray applications at low and mid elevations, respectively. These systems with a larger wetting pattern reduce the chance of excessive runoff, particularly when used in conjunction with conservation tillage (Lamm et al., 2017). The adoption of LESA and MESA systems as compared to LEPA is more prevalent moving northward in the southern and central Great Plains, particularly on tighter soils, greater land slopes and with greater capacity groundwater wells.

Briefly summarizing the history, the science and conceptualization of low pressure center pivot irrigation technologies led to multiple adaptations of the overall technology that have been adopted on a relatively wide scale. When the implementation knowledge was ignored or discarded much of the potential water and energy saving benefits were not realized.

CENTER PIVOT BRAINSTORMING AND BRAIN STRETCHING RETREAT

In the spring of 2017, an invitation was sent out to a broad range of irrigation engineers, scientists, USDA NRCS specialists, and industry representatives associated with center pivot technologies to participate in a brainstorming retreat sponsored by the OAP CP Technology Transfer Project to be held in Amarillo, Texas on March 28-29. A total of 39 individuals from 16 U.S. states (Alabama, Arizona, California, Colorado, Georgia, Idaho, Kansas, Louisiana, Mississippi, Missouri, Nebraska, Oklahoma, Texas, South Carolina, South Dakota, and Virginia) were able to participate in the retreat. There were several goals of the retreat including networking opportunities for both more experienced and less experienced individuals, electronic distribution of large bodies of CP-related publications from the Central Plains Irrigation Conference and the USDA-ARS Conservation and Production Research Laboratory, discussion of past and current research, identification of research, extension and educational needs, and discussion of industry status and information gaps.

Although it is impossible to fully capture the richness and value of this two day event in this brief report, an attempt to tabulate the key topics, their status and the important knowledge gaps was concluded by these two authors. No attempt to prioritize any of the key topics was intended through this tabulation (Table 1), nor should it be considered inclusive of all topics discussed during this two-day event.

OTHER PLANS FOR THE TECHNOLOGY TRANSFER EFFORT

Technical Sessions at Conferences

The Irrigation Association (IA) technical session for which this paper is a part was developed and coordinated through the USDA-ARS OAP Center Pivot Technology Transfer Effort. Through coordinating of this session, the project brings together engineers, scientists, agency staff, and industry and the general public for networking and further technology transfer about CP technologies. Further technical sessions are being planned and coordinated for regional conferences such as the High Plains Conference in Amarillo, Texas on February 7, 2018 and at the Central Plains Irrigation Conference in Colby, Kansas on February 20-21, 2018. These sessions are geared toward producers, consultants, irrigation professionals and agency staff and they leverage annual educational events and ongoing programs. Additional technical sessions at national professional conferences are being proposed for IA in Long Beach, California in December 2018, the American Society of Agricultural and Biological Engineers (ASABE) in Detroit, Michigan in July 2018 and the Agronomy, Crop Science (ASA-CSSA) meeting in Baltimore, Maryland in November 2018. These meetings are geared more toward scientist to scientist/industry interchanges.

Review or Summary Papers

Participants in the technology transfer effort have agreed to prepare literature reviews or summary papers during the coming year. Topics that have been agreed upon thus far are a summary paper on history and development of LEPA, a conceptual discussion of all in-canopy and near-canopy sprinkler irrigation and a summary paper on irrigation decision support systems. Other possibilities include a state of the art discussion on remote sensing, UAVs and their role in CP management, a review or summary paper on sprinkler chemigation, a summary paper on VRI and a summary paper on future needs for CP. There are opportunities for non-project participants to lead or collaborate on some of these efforts.

Tours and Field Days

Specific CP technology transfer field days are being planned for the summer of 2018 in both Texas and Kansas. Dates and locations have not been finalized as of this time. Additionally portions of other tours and regular university field days will likely encompass some of our presentations. It is anticipated that the center pivot technology industry will be approached for support of these activities. If you are interested in supporting this project, feel free to contact either of the authors who are the project's principal investigators.

Website and Activity Listing

The project can be followed at this link http://www.ksre.k-state.edu/irrigate/cptt/index.html

The project has been very active to date with 1 book chapter, 3 refereed journal articles, 11 national or international conference papers, 14 regional conferences papers, and 51 additional miscellaneous technology transfer activities documented at
http://www.ksre.k-state.edu/irrigate/cptt/TechTranCPTTT.pdf

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Watch for our project logo.

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Table 1. Key topics, comments and information status and key knowledge and/or implementation gaps identified at a center pivot irrigation brainstorming retreat in Amarillo, Texas, March 28-29, 2017. *The order or extent of the listing does not indicate any priority, nor should it be considered inclusive of all ideas discussed during this two day event. This tabular listing is meant only to portray the wide range of topics and some key gaps that were identified.*

Key Topic	Comments and Information Status	Key Knowledge and/or Implementation Gaps
Variable Rate Irrigation (VRI) or Site Specific Irrigation (SSI)	Emerging technology, still uncertainty about extent of future needs and adoption. Three types identified (Sector Control, Speed Control, VRI Zone or Individual Sprinkler Control). Many current (commercially available) CP systems have more capabilities than recognized by system owner. VRI not needed by all and some producers will not recoup costs of implementation.	Hardware development has outpaced development of management information. Although many teams working on dynamic prescriptions, continued work is needed to remove this impediment. Uncertainty about producer expectations. Abandonment can be high in absence of appropriate support to producers from industry, universities, consultants, and/or USDA-NRCS. Continued need for research and education.
Sprinkler Packages	Maturing technology, many different types of packages are provided by industry to meet needs of producers. Selection should consider crop, soil, water source/quality and energy. LEPA, LESA and MESA have specific requirements that need consideration. Greater interest and adoption of in-canopy and near-canopy application when evaporative losses are higher, irrigation capacity is lower and land slope is lower.	Although maturing technology, still many implementation mistakes. "One size fits all" mentality ignores the knowledge we have. Runoff must be controlled first for any realistic success with in-canopy and near-canopy sprinkler application. Educational needs of producers still remain.
Sprinkler Uniformity	Hydraulics can be modeled, but catch can results are still instructive and can point out hardware and implementation problems. Catch can tests are still time and labor intensive. Mismatch of nozzle package and operating pressure is commonplace. Need to remember that crop can integrate some minor uniformity problems.	Uncertainty of continued status of some modeling efforts. CPED is now available from USDA-NRCS in a MS-Excel format. Producers still need to monitor and respond to the basic information of system flowrate and pressure.
Mobile Drip Irrigation	Emerging technology with just a few research studies to date. Can reduce wheel track problems (rutting).	Scope of appropriate applicability of the technology (e.g. soil type, slope, crops) is still unknown. Rodents can be a problem. Forces applied on CP systems may be concern. Maintenance issues, filtration needs and other concerns.
Wheel tracks, rutting and getting stuck.	Primarily anecdotal or industry-held information. Actually may negatively affect irrigation management, such as early end-of season irrigation termination.	Need for generic (non-brand specific) publication or guidance on span selection and wheel/flotation system selection.

Chemigation	Maturing technology, but perhaps not as much recent research efforts by Universities. Uncertainty of audience (i.e., end-users, regulators or chemical industry) may result in inertia	Sprinkler packages and sprinkler spacings. VRI interactions with chemigation. Safety and standards needs; associated educational needs.
Microbursts /Tornadoes and CPs	No known resources identified. Student project or modeling effort??	What direction to park CP? Loaded with water for downforce or not?
Center Pivot Safety	Maturing knowledge base USDA-NRCS has some materials and trains their own staff about approaching CP systems.	Producers and installers still need education. Need for lay-oriented publications. Who has expertise/presentations?
Remote Sensing	Emerging area with large amount of interest Can interface with VRI research needs but standalone research area as well. UAVs are of considerable interest to producers now. Remote sensing could encompass weather, soil, or plant information and combinations of the three types.	Lots of approaches are necessary for research but make selection of approach difficult for producer. Hardware offerings may presently outpace development of management information. Continued need for research and education.
Variable Frequency Drives (VFDs)	Technology is maturing and interest is growing due to more usage of electricity as sole energy source for CPs. Still not economical for many cases. Economic feasibility will depend on field slopes and other changes in pressures, time of operation, and price of energy.	Some evaluations have been done in region but more are needed. More modeling is needed. VRI will further complicate the need for VFDs
Publications and Information Needs	Mature, yet continuing evolving topic area. Fewer attendees at traditional university-led workshops, tours, and field days. Not just agricultural problem with attendance, landscape having similar issues. Grower panels can be useful when remaining sufficiently unbiased and scientifically sound. Younger generation audiences are definitely more open to electronic media. Fewer, but better, regional conferences may be an option for “sounding” the knowledge but may still have attendance issues.	How well are we targeting audiences? Do we adjust to the audience (i.e., professional, producers, regulators, industry, legislators, urban audiences, genders and age). Could public/private partnerships be used to greater advantage? Individual companies may have material that could be packaged better for broader industry-wide educational material. Technology farms or large plots research may be better at information delivery.
University Degree Programs and Certificate Programs	Small and decreasing number of agricultural irrigation programs in USA and attracting fewer US-born students. Importance of agriculture is not always reflected at universities. Community colleges may be able to fill some staffing needs. USDA-NIFA may need to provide irrigation fellowships to help build capacity.	Industry needs well-educated staff that are willing to live in agricultural regions. Universities need well-trained faculty and funding to retain good faculty. Universities need to develop students to find food and fiber solutions for 9.6 billion people by 2050.