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Annual Report for FY21

Sustaining rural communities through new water management technologies

Progress Report

The Ogallala Aquifer Program (OAP) is a research and education consortium seeking solutions to problems arising from declining water availability from the Ogallala Aquifer on the Southern High Plains. The consortium includes Kansas State University, Texas A&M AgriLife Research and Extension Service, Texas Tech University, West Texas A&M University, and the USDA ARS National Program 211 research projects at Bushland and Lubbock, TX. OAP funding is from the USDA ARS at Bushland, and OAP management is led by ARS at Bushland with cooperation of a management team composed of the principle investigators for the funding agreements with the four universities.

University and ARS collaborators in the OAP produced 24 publications in FY21 and in prior years that were not reported previously. These are listed in the publications for this research project. These publications support the seven substantive accomplishments reported here.

Accomplishments

Patented control system delivers precise irrigation applications. Irrigated crop production in the Texas High Plains is of major importance because irrigated crops produce grain yields that are typically two or three times greater than rainfed production. However, water resources are limited in this region. Site-specific variable rate irrigation (VRI) systems are moving sprinklers that can apply variable amounts of water over a field. VRI systems can use plant and soil water sensing feedback for irrigation management to improve crop yield per unit of water applied – the crop water productivity (CWP). ARS scientists at Bushland, Texas, patented an Irrigation Supervisory Control and Data Acquisition (ISSCADA) System that uses a software application, ARSPivot, to build watering maps based on sensor information and then control the VRI sprinkler hardware. Results from a two-year study showed that corn yields and CWP from plots managed with the ISSCADA system were similar to those resulting from irrigation scheduling using an expensive and difficult to use "gold standard" for determining crop water needs. The irrigation control system was adapted to irrigate potatoes with similar outcomes as with corn. In addition, trials in four states demonstrated improved yield and CWP that compared favorably with farmer average outcomes. Using the ARSPivot software and ISSCADA system with any type of center pivot sprinkler can help producers all across the United States to save time and improve yields per unit of water applied.

More water per irrigation is better than frequent smaller irrigation applications. Corn production in much of the southern Great Plains relies on irrigation from the Ogallala Aquifer to supplement inadequate precipitation. Decades of pumping with minimal recharge has resulted in declining water tables and reduced well capacities in much of the region, which forces most farmers to use deficit rather than full irrigation. Prudent irrigation scheduling remains an effective tool for maximizing crop water productivity, particularly under deficit irrigation. Although many studies have addressed the effects of irrigation timing and duration of water deficit on corn growth and yield, few have studied the effects of irrigation depth and frequency. Recent results from a crop modeling study by researchers from USDA ARS in Bushland, Texas, and Texas A&M AgriLife indicated in general that increased irrigation application depth reduced seasonal irrigation requirements for all crops. Therefore, researchers from the same two organizations compared yield and crop water productivity between high frequency, low irrigation volume and low frequency, high irrigation volume management in the field. Results indicated there was reduction in evaporative losses associated with the less frequent, greater application under field conditions. Full crop canopy limited excessive evaporation when frequent low volume applications were made. These results suggest when possible that irrigators should make deeper irrigation applications rather than more frequent ones.

Scheduling subsurface drip irrigation using evapotranspiration data and crop coefficients saves water and energy. Fresh water supply for irrigation is decreasing. One solution to decreasing supply is to increase the productivity of irrigation water use through newer irrigation delivery systems, including subsurface drip irrigation (SDI). There are more than 430,000 acres of SDI on the Texas High Plains. However, best management practices for SDI are still under development. USDA ARS scientists at Bushland, Texas, have developed methods of accurately scheduling sprinkler irrigation of corn, cotton and other crops using crop coefficients and estimates of reference evapotranspiration. However, these methods have not been applied for scheduling SDI. Accurate crop coefficients for SDI were thus needed for efficient irrigation scheduling. The Bushland researchers measured corn water use for two years, comparing it between SDI and sprinkler irrigation. Results showed that crop coefficients for SDI were 10% to 15% smaller than those previously developed for sprinkler irrigation. The use of new crop coefficients for SDI will decrease irrigation applications' using SDI, thus saving water and reducing associated energy costs.

Evidence supports using no-till and contour farming to promote dryland crop production. Precipitation is the only water source for increasingly important dryland crops in the Texas High Plains, and runoff decreases both stored soil water and crop yields. ARS scientists from Bushland, Texas, quantified storm water runoff and precipitation storage in the soil under field conditions using conservation practices of either no-tillage (NT) or contour farming. Increased yields of wheat and sorghum grown in a three-year wheat-sorghum-fallow (WSF) rotation were achieved with NT as compared to stubble-mulch (SM) tillage over a 26-year period. By reducing evaporation during fallow, NT had greater soil water and grain sorghum yield than SM. Greater landscape slope increased fallow runoff, but soil water and dryland crop yields were not significantly affected with contour farming. These results will help farmers and crop consultants improve semiarid dryland cropping practices by decreasing evaporation and soil erosion with NT residues.

Wetting front detectors save irrigation water when used with furrow irrigation. Furrow irrigation is still used on the Southern Great Plains and typically has an irrigation efficiency of less than 60% (only 60% of water applied can be used by the crop) compared with greater than 90% efficiency of other application methods. However, there are some fields and situations in which furrow irrigation is the only practical method. Efforts to improve furrow irrigation efficiency have met with limited success. Scientists in Uzbekistan and USDA ARS in Bushland, Texas, studied devices called wetting front detectors (WFDs) to see if they could help to reduce runoff and deep percolation while increasing the crop productivity per unit of water applied. In all three years of a study with cotton, runoff, deep percolation, and volume of irrigation water applied were less when WFDs were used. Both total seed-lint cotton yield and the yield per unit of water applied were increased with the use of WFD. Adoption of this technology should greatly improve irrigation efficiency where furrow irrigation is being used.

Better tools for irrigation scheduling using time domain reflectometry (TDR) type soil moisture sensors. Irrigation management for efficient use of scarce water resources can be greatly aided by use of accurate soil water sensors. USDA ARS scientists at Bushland, Texas, developed accurate, low-cost TDR soil moisture sensors, in cooperation with a commercial partner who now provides them to agricultural producers, equipment suppliers, and irrigation equipment manufacturers. The scientists have written a guide to the best methods of using these sensors and similar TDR sensors for use in agricultural and environmental management, easing the way towards more widespread use of sensors to save water.

Modern drought tolerant corn varieties use less water because they grow faster. Producers in the semiarid Texas High Plains rely on groundwater from the declining Ogallala Aquifer for irrigation to supplement inadequate precipitation for corn production. The use of daily reference evapotranspiration and crop coefficient (Kc) values are commonly used in irrigation scheduling to maximize crop water productivity. However, questions about the applicability of Kc values previously derived from legacy corn hybrids to modern drought tolerant (DT) hybrids have been raised. Researchers from USDA ARS in Bushland, Texas, and Texas A&M University compared lysimeter-derived Kc values from legacy and modern DT corn hybrids. Although maximum daily Kc values were similar for all hybrids, the average season length of the DT hybrid was 25 days shorter than that of the legacy hybrids. Farmers and crop consultants that use evapotranspiration data to schedule irrigation need to be aware of changes in growth characteristics of modern DT corn hybrids so that they can better match water applications with crop needs and reduce pumping costs and water use.

Publications

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