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Annual Report for FY23

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 NP211 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 principal investigators for the funding agreements with the four universities.

University and ARS collaborators in the OAP produced 30 publications in FY23 and in prior years that were not reported previously. These are listed in the publications for this research project. These publications support the ten substantive accomplishments reported here.

Accomplishments

Crop water use data from direct measurements used to establish daily crop water use estimates for the continental USA. Freshwater available for irrigation is decreasing, especially in regions where water for irrigation is from aquifers with limited recharge like the Ogallala in the Southern High Plains; therefore, there is a need to maximize the efficient use of irrigation water through correct irrigation scheduling. However, accurate daily estimates of crop water use in specific fields over wide areas are lacking though they are needed to decide on irrigation quantities. Scientists from ARS at Bushland, Texas contributed a database of multiple years of directly measured daily crop water use data for calibration of five models that base daily water use estimates on a combination of satellite and local weather data. The Bushland data are the most accurate available and were used in establishment of the OPENET platform that provides daily crop water use estimates at 100-foot resolution over the USA. See Volk et al. (2023a,b) and Evett et al. (2022. The Bushland, Texas Maize for Grain Datasets).

Better crop growth and water use models aid management. If they accurately describe yield and water use, crop growth models can be useful tools for assisting in the management of crops as well as for predicting the likely effects of future climate change. An important aspect that determines the ability of crop growth models to simulate growth and yield is their ability to simulate the rate of water consumption or evapotranspiration (ET) of the crop. An inter-comparison of 41 corn growth, water use, and yield models was done by USDA ARS and university scientists using comprehensive datasets from two locations: Bushland, TX, and Mead, NE. There was significant variation among the models in their simulated ET. Nevertheless, several models performed well at simulating ET, as well as yield. Older, well-used models that have been tested over a wide range of conditions did best. Approaches used in the better models were identified. Those models that predicted ET well will help present-day and future farmers and agricultural researchers, and of course all food consumers. See Kimball et al. (2023)

Conversion to cotton cropping saves water in northern Texas High Plains. Decades of pumping combined with limited recharge has resulted in decreased groundwater levels in the southern Ogallala Aquifer. Alternative cropping systems using less water-intensive crops such as cotton may extend limited groundwater resources in the Texas Panhandle region. Traditionally, cotton was grown predominately in the Texas Southern High Plains (SHP) but recently, cotton acreage has increased in the Texas Northern High Plains (NHP). Researchers from Texas A&M and USDA-ARS Bushland simulated crop water use for watersheds in the SHP and NHP using the Soil and Water Assessment Tool (SWAT) equipped with their recently developed management allowed depletion (MAD) auto-irrigation function. Simulations of cotton production in the NHP resulted in reductions of 18%, 7%, and 44% in annual irrigation, crop water use, and runoff, respectively, to produce a profitable crop. These reductions are likely understated due to the lack of cotton production data for the NHP, which use anecdotally less water than that shown by the simulations. See Li et al. (2023).

Subsurface drip irrigation saves 3 to 5 inches of water compared with sprinklers. Effective irrigation systems that increase crop water productivity by minimizing evaporative losses are paramount for extending the longevity of finite groundwater resources in the semi-arid U.S. Southern High Plains (SHP). Although subsurface drip irrigation (SDI) is becoming more prevalent, sprinkler systems remain the dominant method of irrigation in the SHP. Researchers from USDA-ARS and Texas A&M AgriLife Research compared lysimeter-derived crop water use values for SDI-irrigated and sprinkler-irrigated corn fields near Bushland, TX to characterize sprinkler application losses. Compared with SDI, sprinkler irrigation lost 3 to 5 inches of water per season to evaporation. Sprinkler drop heights used were 1.5 feet and 5 feet. Findings suggested that sprinkler drop height had little effect on losses as they were largely mitigated under full canopy conditions. However, cumulative losses from sprinkler irrigation were considerable during early season conditions when coupled with hot and dry conditions. Knowledge of these findings are useful for both producers and water mangers when considering irrigation management strategies. See Marek et al. (2023).

Mixing grass and legume forage crops improves protein content and quality. In the semi-arid Texas Panhandle region, water for crop production is limited as the main water source is the highly depleted Ogallala Aquifer. Improving crop water productivity along with producing a high-quality forage are paramount to support the beef and cattle industry. While forage sorghum (a grass) can be grown with less water than grain crops, it is deficient in crude protein and other nutrients. Cropping forage sorghum with a legume, such as sunn hemp, could increase crude protein and its relative feed value. However, studies on sunn hemp have not been conducted in a semiarid region, and the optimum seeding ratio of sunn hemp to forage sorghum to ensure production of a nutritive forage with high dry matter content is unknown. Researchers from USDA-ARS, Bushland, Texas, and West Texas A&M University studied intercropping of forage sorghum and sunn hemp and found that the combination could produce a high value of crude protein. However, the planting geometry and seed ratios for the intercropping of sunn hemp and sorghum requires further investigation to produce an optimal forage. See Mosqueda et al. (2023).

Mobile drip irrigation – a new technology to increase production per unit of water used. Limited water resources in the Southern Great Plains area are driving local producers to grow crops that use less water and to find more efficient methods to apply irrigation. With climate change, cotton can now be produced in the Texas High Plains region using limited water. Mobile drip irrigation technology outfits surface dripline onto existing center pivot systems, allowing water to be applied on the ground near the plants with less evaporation loss than sprinkler systems. However, the advantages of mobile drip irrigation (MDI) have not been well documented. In this two-year study, USDA ARS scientists compared MDI with low elevation sprinkler application (LESA). Overall lint yield was greater for MDI cotton as compared with LESA in both years. Lint yield per unit of water applied was greater in the first year, yet not significantly different in the second year, likely due to a late intensive rainfall event. The MDI technology has the potential to improve lint yield per unit of water applied. See O'Shaughnessy & Colaizzi (2023).

Groundwater management can be helped by technology but boils down to policy. As depletion of the Ogallala aquifer affects more farming populations and surrounding communities, it is understandable that one would question the effectiveness of federal and state research efforts aimed at improving irrigation methods and management, finding alternatives to irrigated production, and understanding the aquifer hydrology and connection to climate change. Scientists from Colorado State University, Kansas State University, Texas A&M AgriLife, and USDA ARS reviewed the literature and concluded that groundwater management was fundamentally a governance issue. They recommended shifts in research, extension, and policy priorities towards sustaining communities dependent on the aquifer. See Schipanski et al. (2023).

Adapting crop models for better water management in the High Plains. The High Plains (Ogallala) aquifer is an important source of water for irrigation throughout the U.S. Great Plains. Approximately 32% of groundwater used for irrigation in the U.S. is pumped from the High Plains Aquifer. This irrigation water generates 10% of the crop sales in the United States. In the Texas High Plains and western Kansas, the aquifer is slowly being depleted resulting in reduced well yields. Inability to meet peak water demands of corn and other crops under limited irrigation reduces yield and profitability, especially in years with below normal precipitation. Crop models can provide guidance to growers in selecting appropriate management interventions required to maximize profitability when irrigation water is limited. For example, reducing the area irrigated may increase or decrease net returns, depending on crop yields in the irrigated area and costs of production. Crop models can generate how profitability changes with irrigated area so that growers can make informed decisions. USDA ARS scientist determined the necessary model adaptations required to simulate center pivot irrigation of corn and provide realistic results under the climate and constraints typical of the Texas High Plains. See Schwartz et al. (2022).

Guidelines for dryland crop production developed over 70 years. Insufficient soil water is the major factor responsible for low yields in seasonally dry and semiarid regions, including the Southern High Plains where dryland crop production is an alternative to irrigated production. Dryland farming generally is defined as agriculture without irrigation where lack of available water limits crop or pasture production in a part of the year. Successful water management under dryland farming conditions invariably involves capturing precipitation and storing it as soil water during fallow periods for subsequent use by dryland crops. During the growing season, management interventions are employed that have the potential to improve crop productivity under water stress. Scientists from ARS-USDA (Bushland, Texas) and Texas A&M AgriLife Research addressed current and past research developments highlighting the effectiveness of management interventions that influence components of the soil water balance and crop water use and yield during the growing season of dryland crops. See Unger et al. (2023).

Accurate crop growth, water use, and yield data provided to enable accurate cropping systems models. A wide variety of cropping systems models are being used to predict outcomes from changes in crop type, management, irrigation method and level, and other agronomic changes that could enable sustainable economic crop production on the Southern High Plains. However, these models are only as good as the crop growth, water use and yield data used by model developers to improve, test, and calibrate the models; and there was a distinct lack of accurate data for this region. In response, scientists and engineers from the USDA ARS at Bushland, Texas, published more than 30 years of highly accurate and complete crop growth, water use, and yield data based on the very accurate large weighing lysimeter research program at Bushland. Crop data published were for alfalfa, corn, cotton, sorghum, soybean, sunflower, and winter wheat under a variety of irrigation application methods, levels, and under dryland conditions in some cases. The data were supplemented with soil water content data to 10-foot depth taken throughout the cropping seasons, and quality controlled weather data at 15-minute intervals, 365 days per year, both of which are needed by modelers to improve, test, and calibrate the models. Data are available to all at the USDA ARS National Agricultural Library Ag Data Commons (https://agdatacommons.nal.usda.gov/) for:

- **The Bushland, Texas, Alfalfa Datasets.** See Kiraga et al. (2023).
- **The Bushland, Texas, Cotton Datasets.** See Evett et al. (2022, 2023a,b)
- **The Bushland, Texas, Maize for Grain Datasets (grain corn).** See Evett et al. (2022); Kimball et al. (2023).
- **The Bushland, Texas, Soybean Datasets**. See Evett et al. (2023c)
- **The Bushland, Texas, Sorghum Datasets**. See Evett et al. (2023e)
- **The Bushland, Texas, Sunflower Datasets.** See Evett et al. (2022)
- **The Bushland, Texas, Winter Wheat Datasets.** See Evett et al. (2022)
- **Soil Water Content Data for The Bushland, Texas Large Weighing Lysimeter Experiments.** See Evett et al. (2023d)
- **Standard Quality Controlled Research Weather Data.** See Evett et al. (2022)

Publications

Andrade, M.A., S.A. O'Shaughnessy, and S.R. Evett (2023). Forecasting of canopy temperatures using machine learning algorithms. Journal of the ASABE. 66(2):297-305. https://doi.org/10.13031/ja.15213

Andrade, M.A., Oshaughnessy, S.A., Evett, S.R., Kisekka, I. (2023). A sensor-based decision support system for variable rate irrigation systems. Irrigation Today. 8(2):30-32. https://irrigationtoday.org/features/a-sensor-based-decision-support-system-for-variable-rate-irrigation-systems/

Bhatti, S., D. M. Heeren, S. A. O'Shaughnessy, C. M. U. Neale. J. LaRue, S. Melvin, E. Wilkening, and G. Bai. (2023) Toward automated irrigation management with integrated crop water stress index & spatial soil water balance. Precision Agriculture. https://doi.org/10.1007/s11119-023-10038-4

Colaizzi, P.D., O'Shaughnessy, S.A., Evett, S.R., Marek, G.W., Brauer, D.K., Copeland, K.S., Ruthardt, B.B. (2023). Data quality control for stationary infrared thermometers viewing crops. Applied Engineering in Agriculture. 39(4):427-438. https://doi.org/10.13031/aea.15642

Evett, Steven R.; Marek, Gary W.; Copeland, Karen S.; Howell, Terry A. Sr.; Colaizzi, Paul D.; et al. (2022). Weighing Lysimeter Data for The Bushland, Texas, Cotton Datasets. Ag Data Commons. Dataset. https://doi.org/10.15482/USDA.ADC/25114670.v1

Evett, Steven R.; Marek, Gary W.; Copeland, Karen S.; Howell, Terry A. Sr.; Colaizzi, Paul D.; Brauer, David K.; et al. (2023a). Agronomic Calendars for the Bushland, Texas Cotton Datasets. Ag Data Commons. Dataset. https://doi.org/10.15482/USDA.ADC/1529368

Evett, Steven R.; Marek, Gary W.; Copeland, Karen S.; Howell, Terry A. Sr.; Colaizzi, Paul D.; Brauer, David K.; et al. (2023b). Growth and Yield Data for the Bushland, Texas, Cotton Datasets. Ag Data Commons. Dataset. https://doi.org/10.15482/USDA.ADC/1529408

Evett, Steven R.; Copeland, Karen S.; Ruthardt, Brice B.; Marek, Gary W.; Colaizzi, Paul D.; Howell, Terry A., Sr.; Brauer, David K. (2023c). The Bushland, Texas Soybean Datasets. USDA ARS NAL Ag Data Commons. https://doi.org/10.15482/USDA.ADC/1528779

Evett, Steven R., Marek, Gary W., Copeland, Karen S., Howell, Terry A. Sr., Colaizzi, Paul D.. Brauer, David K., Ruthardt, Brice B. (2023d). Soil Water Content Data for The Bushland, Texas Large Weighing Lysimeter Experiments. USDA ARS NAL Ag Data Commons. https://doi.org/10.15482/USDA.ADC/1526332

Evett, Steven R.; Marek, Gary W.; Copeland, Karen S.; Howell, Terry A. Sr.; Colaizzi, Paul D.; Brauer, David K.; Ruthardt, Brice B. (2023e). Growth and Yield Data for the Bushland, Texas, Sorghum Datasets. USDA ARS NAL Ag Data Commons. https://doi.org/10.15482/USDA.ADC/1529411.

Kimball, Bruce A., Kelly R. Thorp, Kenneth J. Boote, Claudio Stockle, Andrew E. Suyker, Steven R. Evett, et al, (2023). Simulation of evapotranspiration and yield of maize: An Inter-comparison among 41 maize models, Agricultural and Forest Meteorology, Volume 333, 2023, 109396, ISSN 0168-1923, https://doi.org/10.1016/j.agrformet.2023.109396

Kiraga, S.; Peters, R.T.; Molaei, B.; Evett, S.R.; Marek, G. (2023). Reference Evapotranspiration Estimation Using Genetic Algorithm-Optimized Machine Learning Models and Standardized Penman–Monteith Equation in a Highly Advective Environment. Water 2024, 16, 12. https://doi.org/10.3390/w16010012

Li, B., Marek, G.W., Marek, T.H., Porter, D.O., Ale, S., Moorhead, J.E., Brauer, D.K., Srinivasan, R., Chen, Y. 2023. Impacts of ongoing land-use change on watershed hydrology and crop production using an improved SWAT model. Land. 12(3). Article 591. https://doi.org/10.3390/land12030591

Li, B., Tan, L., Zhang, X., Qi, J., Marek, G.W., Li, Y., Dong, X., Zhao, W., Chen, T., Feng, P., Liu, D., Srinivasan, R., Chen, Y. 2023. Modeling streamflow response under changing environment using a modified SWAT model with enhanced representation of CO2 effects. Journal of Hydrology: Regional Studies. 50. Paper No. 101547. https://doi.org/10.1016/j.ejrh.2023.101547.

Liptzin, D., Rieke, E.L., Cappellazzi, S.B., Mac Bean, G., Cope, M., Greub, K.H., Norris, C.E., Tracy, P.W., Aberle, P.W., Ashworth, A.J., Baumhardt, R.L., Dell, C.J., Derner, J.D., Ducey, T.F., Dungan, R.S., Fortuna, A., Franzluebbers, A.J., Kautz, M.A., Kitchen, N.R., Leytem, A.B., Liebig, M.A., Moore Jr, P.A., Osborne, S.L., Owens, P.R., Sainju, U.M., Sherrod, L.A., Watts, D.B. (2023). An evaluation of nitrogen indicators for soil health in long-term agricultural experiments. Soil Science Society of America Journal. 87(4):868-884. https://doi.org/10.1002/saj2.20558

Marek, Gary W.; Evett, Steve; Thorp, Kelly R; DeJonge, Kendall ; Marek, Thomas Henry; Brauer, David. (2023). Characterizing Evaporative Losses from Sprinkler Irrigation using Large Weighing Lysimeters. Journal of the ASABE, 66(2): 353-365. https://doi.org/10.13031/ja.15300

Marek, G.W., S. Evett, T.H. Marek, D.O. Porter, and R.C. Schwartz. (2023). Field evaluation of conventional and downhole TDR soil water sensors for irrigation scheduling in a clay loam soil. Applied Engineering in Agriculture 39(5):495-507. https://doi.org/10.13031/aea.15574

Mosqueda, H.M., Blaser, B.C., O'Shaughnessy, S.A., Rhoades, M.B. (2023). Intercropping forage sorghum with sunnhemp at different seeding rates to improve forage production. Agronomy. 13(12). Article 3048. https://doi.org/10.3390/agronomy13123048

Naher, A., Almas, L., Guerrero, B., Shaheen, S. (2023). Spatiotemporal Economic Analysis of Corn and Wheat Production in the Texas High Plains. Water. 15(20). Article 3553. https://doi.org/10.3390/w15203553

O'Shaughnessy, S.A., Colaizzi, P.D. (2023). Improving water productivity in cotton using mobile drip irrigation technology. Proceedings of the U.S. Committee on Irrigation and Drainage Conference, October 17-20, 2023, Ft. Collins, Colorado.

Quadros, D.G., Kerth, C.R., Miller, R., Tolleson, D.R., Redden, R.R., Xu, W. (2023). Intake, growth performance, carcass traits and meat quality of feedlot lambs fed novel anthocyanin-rich corn cobs. Translational Animal Science. 7(1). Article txac171. https://doi.org/10.1093/tas/txac171

Schipanski, M.E., Sanderson, M.R., Mendez-Barrientos, L.E., Kremen, A., Gowda, P.A., Porter, D.O., Wagner, K., et. al. (2023). Moving from measurement to governance of shared groundwater resources. Nature Water. 1:30-36. https://doi.org/10.1038/s44221-022-00008-x

Schwartz, R.C., Dominguez, A., Pardo, J., Baker, T.J., Klopp, H.W., Parker, D., Bell, J.M., Guerrero, B., Baumhardt, R.L., Colaizzi, P.D. (2022). Adaptation of MOPECO for water management decisions in the Texas High Plains. In: Proceedings for the International Conference for Dessemination of PRIMA Project Results and Interregional Conference of CIGR Section 1, September 5, 2022, in Albacete, Spain.

Thorp, K.R., Boote, K.J., Stockle, C., Suyker, A.E., Evett, S.R., Brauer, D.K., Coyle, G.G., Copeland, K.S., Marek, G.W., Colaizzi, P.D., Acutis, M., Archontoulis, S., Babacar, F., Barcza, Z., Basso, B., Singh, A., Deb, S.K., Slaughter, L.C., Singh, S., Ritchie, G.L., Guo, W., Saini, R. (2023). Simulation of root zone soil water dynamics under cotton-silverleaf nightshade interactions in drip-irrigated cotton. Agricultural Water Management. 288. Article 108479. https://doi.org/10.1016/j.agwat.2023.108479

Unger, P.W., Schwartz, R.C., Baumhardt, R.L., Xue, Q. (2023). Soil water conservation for dryland farming. Advances in Soil Science. 1-28. https://doi.org/10.1201/b22954

Volk, J., Huntington, J., Melton, F., Allen, R., Anderson, M., Fisher, J., Kilic, A., Senay, G., Halverson, G., Knipper, K., Minor, B., Pearson, C., Wang, T., Yang, Y., Evett, S., French, A., Jasoni, R., Kustas, W. (2023a). Development of a Benchmark Eddy Flux Evapotranspiration Dataset for Evaluation of Satellite-Driven Evapotranspiration Models Over the CONUS. Agric. Forest Meteor. 331, 2023, 109307, https://doi.org/10.1016/j.agrformet.2023.109307

Volk, J.M., J.L. Huntington, F. Melton, B. Minor, T. Wang, S. Anapalli, R.G. Anderson, S. Evett, A. French, R. Jasoni, N. Bambach, W.P. Kustas, J. Alfieri, J. Prueger, L. Hipps, L. McKee, S.J. Castro, M.M. Alsina, A.J. McElrone, M. Reba, B. Runkle, M. Saber, C. Sanchez, E. Tajfar, R. Allen, M. Anderson. (2023b). Post-processed data and graphical tools for a CONUS-wide eddy flux evapotranspiration dataset. Data in Brief 48 (2023) 109274, https://doi.org/10.1016/j.dib.2023.109274

Waldrip, H., Schwartz, R.C., He, Z., Todd, R.W., Baumhardt, R.L., Zhang, M., Parker, D.B., Brauer, D.K., Min, B. (2022). Soil water extractable organic matter under long-term dryland cropping systems on the Texas High Plains. Soil Science Society of America Journal. 1-15. https://doi.org/10.1002/saj2.20432.

Zhang, Y., Ge, J., Qi, J., Liu, H., Zhang, X., Marek, G.W., Ding, B., Feng, P., Liu, D., Srinivasan, R., Chen, Y. (2023). Evaluating the effects of single and integrated extreme climate events on hydrology in the Liao River Basin, China using a modified SWAT-BSR model. Journal of Hydrology. 623. Article 129772. https://doi.org/10.1016/j.jhydrol.2023.129772

Zhang, Y., Liu, H., Qi, J., Feng, P., Zhang, X., Li Liu, D., Marek, G.W., Srinivasan, R., & Chen, Y. (2023). Assessing impacts of global climate change on water and food security in the black soil region of Northeast China using an improved SWAT-CO2 model. Science of The Total Environment, 857, 159482. https://doi.org/10.1016/j.scitotenv.2022.159482