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Annual Report for FY24

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 43 publications in FY24 and in prior years that were not reported previously. These are listed in the publications section of this report. These publications support the 10 substantive accomplishments reported here. OAP scientists also engaged heavily in technology transfer (TT) with 69 separate presentations and reports to stakeholders. The **Big Cotton Project** engendered 16 TT activities; the **Spring Cover Crop Research Project** produced 11 TT activities and products; the **Economic Analysis Team** produced four TT presentations and reports; the **Project Evaluating Site-specific Water Management for Sustainable Agriculture** produced six TT activities; the **Project Integrating Livestock into Traditional Wheat-Sorghum-Fallow Rotations** produced 11 TT activities and reports; the **Project on Strategic Tillage** produced 11 TT activities/products; the **Project on Summer Annual Legumes** produced five TT activities, and the **Project on Developing efficient production practices to optimize water use efficiency of industrial hemp** produced six technology transfer activities. Titles, locations, dates, and in some cases links for download from the Internet are provided in later sections of this report.

The 2024 Ogallala Aquifer Program Workshop and research planning meeting (https://ogallala.tamu.edu/wp-content/uploads/sites/48/2024/04/2024-Workshop-Agenda.pdf) was held in Liberal, Kansas, on March 19-21 in coordination with the Ogallala Summit meeting also held there earlier in the week (https://www.irrigationinnovation.org/2024-ogallala-summit).

The OAP coordinated with Cotton, Inc. to hold an important meeting addressing water use strategies for cotton production at Bushland, Texas in June of 2024. Titled, "Cotton Water Summit: Developing Strategies to Thrive in Arid Conditions", the meeting was attended by stakeholders from Kansas, Oklahoma, and Texas, including irrigation districts, growers, university research and extension, and ARS. The full report is available elsewhere on the OAP website (https://ogallala.tamu.edu/wp-content/uploads/sites/48/2024/07/Cotton-Water-Summit-Notes-June2024.pdf).

The OAP participants held a Forage Meeting in December 2024 at Bushland, Texas, to gain perspectives and information from the beef and dairy industries on forage needs, including qualities and kinds; to gain current understanding of Ogallala Aquifer conditions and trends, including the possibility of Q-stable management; and to discuss past research and assess research needs going forward. The meeting addressed new OAP objectives for 2025 that focused on forage and other production systems that have the potential to reduce aquifer withdrawals. Agenda and presentations from that meeting are also available on the OAP website (https://ogallala.tamu.edu/meetings/).

Accomplishments

Economically viable alternatives to alfalfa found to reduce water use in the southern Ogallala Aquifer region. Due to aquifer declines, it is important to develop cropping systems for efficient management of precipitation and

irrigation to optimize profits and crop production in the southern Ogallala Aquifer region. Working in the ARS Ogallala Aquifer Program, Kansas State University researchers found that summer annual grasses would have higher forage yields and productivity than summer annual legumes, but that summer annual legumes would have higher crude protein concentration and greater digestibility. Researchers identified summer annual legume species that can serve as viable alternatives to alfalfa in the region. Under irrigation, forage soybean, cowpea, and lablab all have potential as alternatives to alfalfa due to their forage yield, nutritive value, and economic profit. In dryland environments, lablab and cowpea showed the most promise, and greater potential than dryland alfalfa. They did not recommend growing either forage soybean or sunn hemp in dryland environments across the semi-arid Great Plains due to both establishment challenges and low economic profitability. They also cautioned against growing sunn hemp under irrigation for forage purposes because it had negative net economic returns even under irrigation. The study provided strong evidence that further investigation is warranted into summer annual legume forage, particularly for the species cowpea and lablab. These species could provide more profit, greater yield, more cropping flexibility, and greater yield stability than dryland alfalfa. Further areas of investigation for these two species include 1) tracking the impact of forage nutritive value and forage yield based on growing degree days as opposed to physiological growth stage, and 2) exploring the impact that using early- vs. late-maturing genotypes have on forage yield, nutritive value, water use and profit. These results mean that dryland annual legumes could be grown to meet the high crude protein forage demand of regional animal industries.

Best planting dates and densities found to optimize crop water productivity of industrial hemp. Industrial hemp is a fiber crop that can reduce water use from the Ogallala aquifer. Texas Tech University Researchers working in in an ARS Ogallala Aquifer Program project showed the critical importance of planting dates and seeding densities in influencing the overall crop productivity, including biomass, fiber, and seed production They also determined the relationships between root morphology, soil water depletion, and water use of industrial hemp. Early planting facilitated longer vegetative growth, improved plant height, stem diameter, and biomass and fiber accumulation, and also demonstrated better root development. Later planting date led to early transition to reproductive phase, consequently lowering the final biomass and fiber production and their water productivity (WP). But, due to early flowering initiation, late planting resulted in higher seed yield. Seeding densities affected growth, with higher densities resulting in denser canopies, better light absorption, and eventually higher final production. These results collectively provide farmers with optimal cultivation methods, offering insightful information for increasing crop yield while advancing sustainable agricultural practices in the hemp sector.

AI shown to provide best maps of irrigated area on the Texas High Plains. Underground water conservation districts and state and regional water planning agencies need accurate yearly maps of irrigated areas within their management areas. Texas A&M scientists working in an ARS Ogallala Aquifer Program project developed a mapping tool with 97% accuracy by utilizing artificial intelligence (AI) based on machine learning to process satellite imagery. Comparison with other mapping techniques showed that the AI based method had superior accuracy. The new tool was used to provide high resolution maps from 2014 through 2024, filling an information need of Ogallala aquifer water managers.

Strategic tillage controls weeds while retaining increased crop water productivity in long-term no tillage operations. Adoption of no-tillage (NT) farming has increased crop water productivity and allowed cropping intensification in semi-arid environments like western Kansas and the Texas and Oklahoma Panhandles. But, maintaining continuous NT has become increasingly challenging because of the lack of herbicides that work against herbicide-resistant (HR) weeds. Kansas State University scientist working in an ARS Ogallala Aquifer Program project investigated the effectiveness of occasional or strategic tillage (ST) to manage weeds, redistribute soil acidity and nutrients, and affect soil water storage, and crop yields. They found that properly implemented ST had no negative effect on soil properties or crop yields, and could be a mitigation option to control herbicide resistant weeds and increase profitability of dryland crop yield under otherwise long-term NT production. Proper implementation was found to involve using sweeps while keeping tillage shallow (1-2 inches) to control weeds while not burying crop residues, and to work best when done during a dry period when no rain is forecast for several days. This finding gives farmers a valid option for weed control in otherwise no-till systems with improved crop water productivity.

Cropping systems intensification in the semi-arid Great Plains can be successfully accomplished using annual forages with reduced water use. The traditional dryland (rainfed) cropping system in the Southern High Plains is winter wheat-grain sorghum-fallow rotation, which while typically reliable could be intensified for greater profitability by inclusion of forages in the rotation. Annual forages use less water than either sorghum or corn grain crops. Kansas State University researchers, working in an ARS Ogallala Aquifer Program project, found that double cropping forage sorghum after winter wheat in the traditional rotation improved water utilization and profitability overall. A more intensified double-cropped rotation [winter wheat followed by double-cropped forage sorghum rotating to forage sorghum in the second year followed by fallow (W/FS-FS-FL)] increased overall forage productivity by 46%. Importantly, averaged-across-years, growing forages in place of fallow tended to improve cropping system profitability even when increased cropping

intensity reduced grain yields. Replacing fallow with forage oats increased overall forage yield by 56%. This finding means that farmers may opt to grow forages rather than grain crops with reasonable expectation of improved profitability and reduced water use, extending the life of the Ogallala aquifer.

Grazing or haying is required for positive economic outcomes if cover crops are planted after winter wheat harvest in wheat-sorhgum-fallow no-till rotations. Cover crops planted in dryland wheat-sorghum-fallow rotations can reduce water availability and grain yield. Kansas State University researchers, working in an ARS Ogallala Aquifer Program project, showed that grazing or haying of cover crops can provide forage for livestock, increase crop residue cover and soil aggregate stability, maintain grain crop yields, and increase net returns in wheat-sorghum-fallow no tillage (NT) systems. Combining the two, haying in wet years and grazing in dry years, could be a means to balance forage availability and forage demand across years. If strategic tillage is necessary in a long-term NT system, for example to correct root-limiting compaction or to control herbicide-resistant weeds, then plant available water, crop yields, net returns, and soil properties are generally unaffected compared to strict NT. This finding gives farmers a valid option for use of cover crops to control erosion while improving net returns on investment.

More accurate crop models assess effects of changing weather. If accurate, crop simulation models can be useful in forecasting effects of changing weather on crop production and nitrogen use. However, commonly used crop models need changes to improve accuracy of predictions of soil temperature, water use, crop yield, and nitrogen losses. ARS scientists teamed with Texas A&M University, China Agricultural University, and the University of New South Wales to improve the commonly used SWAT model to more accurately predict CO2 uptake and nitrogen use and loss. Results indicated that fertilizer applications could be reduced by 10-20% under elevated CO2 levels, saving money while reducing nitrogen losses. Future yields for irrigation cotton and sunflower and dryland cotton were predicted to increase with increasing CO2, while yields of irrigated sorghum and dryland soybean were expected to decrease. Water use was expected to decrease except for irrigated cotton. These result provide guide posts for farmers to deal with changing conditions with better probability of success.

Comparison of 33 crop models shows path to more accurate predictions. Crop models are commonly used to predict water use and yield in response to weather and agronomic practices, including irrigation. Predicted soil temperature is related to predictions of germination, decomposition, evaporation, losses of nitrogen, and carbon sequestration, but models may not accurately predict soil temperature. ARS scientists teamed with 30 universities and research institutions to compare soil temperature predictions of 33 crop models in comparison with measured soil temperature at Bushland, Texas, and Mead, Nebraska. Results showed that five of the six best soil temperature predictions resulted from numerical iterative solutions to a mechanistic model of soil temperature and water content changes in several layers of soil. Incorporation of this kind of solution into other models would improve prediction of soil temperature and related processes, and make crop models more useful to farmers, consultants, water managers, and other users.

Water saving policy in Kansas shown to effectively reduce aquifer depletion but not profitability. The State of Kansas has passed legislation promoting the creation of Local Enhanced Management Areas (LEMAs), which provide a voluntary structure for farmers to come together to set and implement tailored water-use restrictions within an area. However, the effectiveness of LEMAs is debated. ARS scientists teamed with Kansas State University and Northwest Kansas Groundwater Management District #4 to examine ten years of satellite and other data to determine water use before and after the implementation of a LEMA. They found that stakeholder-led restrictions led to 28% reduced withdrawals from the aquifer, while corn yields remained nearly the same across the ten years and cash flow was increased by 4.3%. These results show that the LEMA structure is useful in reducing aquifer depletion while improving profitability.

Mobile drip irrigation produces greater watermelon yields with less water than sprinklers. Center pivot irrigation systems using spray application are the predominant irrigation application method in the Southern High Plains, and when low-elevation spray application (LESA) is utilized these systems are recognized as being efficient. However, wetting the soil surface means that some water is lost to evaporation rather than reaching the crop, and alternative water application systems may be more effective. ARS and Texas A&M AgriLife scientists at Bushland, Texas, employed a new irrigation application system called mobile drip irrigation (MDI) to apply water to a watermelon crop while comparing it to LESA. The MDI system uses drip irrigation lines that are connected to the center pivot irrigation system but that drag on the ground and apply water directly to a small area where it enters the soil and replenishes water needed by the crop without wetting the entire soil surface. The MDI system produced 35% greater yields than did LESA, in part because there were more fruits per plant and larger plants. Fruit quality was not affected, and yield per unit of water used was much greater, indicating that MDI would be a profitable system for watermelon production on the High Plains while reducing withdrawals from the declining Ogallala aquifer.

Publications

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Technology Transfer

The Big Cotton Project engendered 16 technology transfer activities, including the following:

Bell, J., T. Marek, C. Bednarz, G. Marek, B. Guerrero, D. Porter, L. Baumhardt, and J. Dever. 2024 National Cotton Council Beltwide Cotton Conference. Cotton Production in "Thermally" Limited Regions of the Southern Great Plains: Texas Research. January 4. 2024. Fort Worth, Texas

Bell, Jourdan. 2024. January 23, 2024: Texas A&M AgriLife Extension. Top of Texas Ag Conference, Pampa, Texas

Bell, Jourdan. 2024. January 25, 2024: Auburn University Cotton Specialists Podcast with Steve Brown

Bell, Jourdan. 2023. February 13. 2024: Texas A&M AgriLife Extension. NE Panhandle Dryland Crops Conference, Perryton, Texas.

Bell, Jourdan. 2024. February 15, 2024: North Plains Groundwater Conservation District: Master Irrigator, Cotton Planting Dates and Water Use

Bell, J., T. Marek, and D. Porter. 2024. March 26, 2024: USDA-ARS Ogallala Aquifer Program Big Cotton Update

Bell, Jourdan. 2024. March 27, 2024: James Hunt, Texas Farm Bureau, Cotton Options for the Northern Texas High Plains (>20,000 Radio Listeners across Texas)

Bell, J., T. Marek, and D. Porter. 2024. April 4, 2024: USDA-ARS Ogallala Aquifer Program Big Cotton Meeting

Bell, Jourdan. 2024. April 12, 2024: Castro County Producers Meeting: Preplant Considerations

Marek, T, G. Marek and D. Porter, 2023. Irrigation and Water Management. Technical session at the 2023 Texas Plant Protection Conference. Audience included research and extension faculty, as well as agricultural industry (agribusiness and crop consultants). December 6, 2023. Bryan, Texas.

Oduniyi, O., D. McCallister, L. Bastos, and K. Jagadish. 2024. The Impact of Heat Stress on Cotton Yield." Oral Presentation at the 2024 Beltwide Cotton Conference, Ft. Worth, Texas, Jan 3-5.

Porter, D. 2023. "OAP Cotton "Big Project" Technology Transfer, 2023, Texas Edition". Presentation for OAP leadership team to provide updates on project technology transfer activities. Dec. 4, 2023, virtual.

Porter, D. 2024. "OAP Cotton "Big Project" Technology Transfer". Presentation at the OAP Annual Meeting, Liberal, Kansas. March 20-21, 2024.

Porter, D. 2024. Technical tour for Texas A&M University Department of Biological and Agricultural Engineering students in the Cotton Engineering program (Mike Buser, Endowed Chair). Lubbock County. April 5, 2024.

Porter, D. 2024. Soil and Water Management for Cotton Production. Webinar for Cotton 101, Cotton Premier Program professional development training for county extension agricultural and natural resources agents. May 22, 2024. Virtual.

Porter, D. 2024. Cotton production hands-on training field day. Cotton 101 , Cotton Premier Program professional development training for county extension agricultural and natural resources agents. Lubbock, Texas. July 23, 2024.

Members of this project team also participated and/or presented at the cotton water issues meeting, hosted by USDA-ARS-CPRL, Bushland and sponsored by Cotton Incorporated (Ed Barnes and Gaylon Morgan). Bushland, Texas. June 27, 2024.

Results have been disseminated through Texas A&M AgriLife Extension programs reaching over 700 regional producers and crop consultants who own or manage over 1 million cotton acres.

The Spring Cover Crop Research Project engendered 11 technology transfer activities:

Dhanda, S., V. Kumar, A. Dille, A. Obour, and J. Holman. 2022. Integrating Fall-Planted Cover Crops for Weed Suppression in the Semi-arid Central Great Plains, Western Society of weed Science.

Holman, J. and A. Obour. 2023. Opportunities and Challenges of Growing Cover Crops in the Semi-arid Great Plains. WSSA Annual Meeting. Arlington, VA.

Holman, J. D., & Obour, A. K. 2023. Integrating Cover Crops and Annual Forages into Traditional Cereal Grain Crop Rotations on the High Plains. [Abstract]. ASA, CSSA, SSSA International Annual Meeting, St. Louis, MO. https://scisoc.confex.com/scisoc/2023am/meetingapp.cgi/Paper/151305

Holman, J., N. Detter, A. Obour, L. Haag, and K. Roozeboom. 2024. Summer annual legumes: yield potential and water use. Kansas Forage and Grasslands meeting. Salina, KS.

Obour. A., J. Holman, L. Simon, and S. Johnson. 2023. Grazing cover crops improved soil health in dryland cropping systems. 2023 Western Kansas Agricultural Research Report. p. 21-28.

Obour, A. and J. Holman. 2022. Cover crops as forages in the western Great Plains. AFGC Conference. Jan 9-12, 2022. Wichita, KS.

Simon, L., A. Obour, J. Holman, M. Schipanksi, M. Lawrence, S. Johnson, K. Roozeboom. 2022. On-farm soil health practices effect wind erosion potential in the semi-arid Central Great Plains. In ASA-CSSA-SSSA Abstracts 2022. ASA, CSSA, and SSSA, Madison, WI.

Simon, L. M., Obour, A. K., Holman, J. D., Johnson, S. K., & Roozeboom, K. L. 2023. Flexible Fallow Replacement with Cover Crops in a Water-Limited High Plains Cropping System [Abstract]. ASA, CSSA, SSSA International Annual Meeting, St. Louis, MO. https://scisoc.confex.com/scisoc/2023am/meetingapp.cgi/Paper/151218

Simon, L., A. Obour, J. Holman, M. Shipanski, S.Johnson, and K. Roozeboom. 2022. Post-wheat summer cover crop effects crop yields and soil properties in a no-till dryland cropping system. Great Plains Soil Fertility Conference.

Simon, L. A. Obour, J. Holman, S. Johnson, and K. Roozeboom. 2024. Dual-purpose cover crop and occasional tillage effects on crop yields and soil properties in a no-tillage wheat-sorghum-fallow rotation. Great Plains Soil Fertility Conference. Lubbock, TX.

Simon, L., A. Obour, and J. Holman. 2022. Post-wheat summer cover crop effects on crop yields in soil properties in a no-till dryland cropping system. AFGC Conference. Jan 9-12, 2022. Wichita, KS.

The Economic Analysis Team produced the following four technology transfer activities:

Guerrero, B. and B. Golden. (2024). "The Rural Economic Effects of Ogallala Aquifer Depletion: A Case Study in West-Central Kansas." Selected Paper at the UCOWR/NIWR Annual Water Resources Conference. St. Louis, MO. September 30-October 2, 2024.

Almas, L. and B. Guerrero. (2024). "Ogallala Water Conservation and Economic Analysis of Sorghum Silage Potential for Dairy Industry in Texas High Plains." Selected Paper at the UCOWR/NIWR Annual Water Resources Conference. St. Louis, MO. September 30-October 2, 2024.

Impact of the Dairy Industry in the Southern High Plains – Presented at South Plains Commissioners Court Conference, Lubbock, TX, October 30, 2024

Islam, T., L. Almas, B. Guerrero, and C. Arnold. (2024). "Grain Sorghum Production Trend Analysis in Texas under Declining Ogallala Aquifer." Selected Poster at the Southern Agricultural Economics Association Annual Meeting. Atlanta, GA. February 3-6, 2024.

The Project on Evaluating Site-specific Water Management for Sustainable Agriculture produced the following six technology transfer activities

Adedeji, O., & Guo, W. (2023). Assessment of field spatial variabilities to delineate site-specific management zones using precision irrigation technology. ASA, CSSA, SSSA International Annual Meeting. ASA-CSSA-SSSA. St. Louis, MO. October 29 - November 1, 2023.

Adedeji, O., & Guo, W. (2023). Applying precision irrigation technology for water conservation in the Southern High Plains of Texas. West Texas Agricultural Chemical Institute Conference (WTACI), Lubbock, TX. September 14, 2023.

Adedeji, O., & Guo, W. (2023). Application of soil properties, topography, and satellite images in precision irrigation in cotton. Ogallala Aquifer Program Workshop. USDA ARS. Canyon, TX. April 4-5, 2023.

Adedeji, O., & Guo, W. (2022). Opportunities and challenges of precision irrigation in research and applications. International Forum for Agricultural Robotics Conference, Fresno, CA. FIRA. October 18-19, 2022.

Adedeji, O., & Guo, W. (2022). Delineation of site-specific irrigation management zone using remote sensing and precision irrigation technology. Davis College Graduate Conference, Texas Tech University, Lubbock, TX. September 29, 2022.

Adedeji, O., & Guo, W. (2024). Assessing precision water management using unmanned aerial systems and satellite remote sensing. Beltwide Cotton Conference, Fort Worth, TX. January 3-5, 2024.

The Project on Integrating Livestock into Traditional Wheat-Sorghum-Fallow Rotations produced the following 11 technology transfer activities:

Holman, J., A. Obour, A. Schlegel, and L. Simon. 2020. Long-term forage rotation yields, soil water use, and profitability. Proceedings of the Great Plains Soil Fertility Conference. Vol. 18, p.158-164.

Holman, J. and A. Obour. 2022. Annual forage rotations with limited water. AFGC Conference. Jan 9-12, 2022. Wichita, KS.

Holman, J. D., & Obour, A. K. 2023. Integrating Cover Crops and Annual Forages into Traditional Cereal Grain Crop Rotations on the High Plains. [Abstract]. ASA, CSSA, SSSA International Annual Meeting, St. Louis, MO. https://scisoc.confex.com/scisoc/2023am/meetingapp.cgi/Paper/151305

Mauler, P., J. Holman, and A. Obour. 2021. Forage productivity, weed density, and soil properties affected by grazing and tillage of annual forages. ASA-CSSA-SSSA International Annual Meeting, Nov. 7-10, 2021. Virtual meeting. In ASA-CSSA-SSSA Abstracts 2021 [CD-ROM]. ASA, CSSA, and SSSA, Madison, WI.

Mauler, P., J. Holman, and A. Obour. 2022. Forage productivity, weed density, and soil properties affected by grazing and tillage of annual forages. AFGC Conference. Jan 9-12, 2022. Wichita, KS.

Obour, A., L. Simon, and J. Holman. 2021. Effects of grazing cover crops on soil properties in no-till rain-fed cropping systems in west central Kansas. ASA-CSSA-SSSA International Annual Meeting, Nov. 7-10, 2021. Virtual meeting. In ASA-CSSA-SSSA Abstracts 2021 [CD-ROM]. ASA, CSSA, and SSSA, Madison, WI.

Obour, A. and J. Holman. 2022. Cover crops as forages in the western Great Plains. AFGC Conference. Jan 9-12, 2022. Wichita, KS.

Obour. A., J. Holman, L. Simon, and S. Johnson. 2023. Grazing cover crops improved soil health in dryland cropping systems. 2023 Western Kansas Agricultural Research Report. p. 21-28.

Simon, L., A. Obour, J. Holman, M. Shipanski, S.Johnson, and K. Roozeboom. 2022. Post-wheat summer cover crop effects crop yields and soil properties in a no-till dryland cropping system. Great Plains Soil Fertility Conference.

Simon, L., A. Obour, and J. Holman. 2022. Post-wheat summer cover crop effects on crop yields in soil properties in a no-till dryland cropping system. AFGC Conference. Jan 9-12, 2022. Wichita, KS.

Simon, L., A. Obour, and J. Holman. 2021. Post-wheat summer cover crop effects crop yields and soil properties in a no-till dryland cropping system. ASA-CSSA-SSSA International Annual Meeting, Nov. 7-10, 2021. Virtual meeting. In ASA-CSSA-SSSA Abstracts 2021 [CD-ROM]. ASA, CSSA, and SSSA, Madison, WI.

The Project on Strategic Tillage produced the following 11 technology transfer activities/products

Lawrence, M. A., Obour, A. K., Holman, J. D., Haag, L. A., Schlegel, A. J., & Roozeboom, K. L. 2023. Influence of Tillage Intensity on Soil Properties and Crop Yields [Abstract]. ASA, CSSA, SSSA International Annual Meeting, St. Louis, MO. https://scisoc.confex.com/scisoc/2023am/meetingapp.cgi/Paper/151944.

Obour, A.K., M. Lawrence, J.D. Holman1, A.J. Schlegel & L.A. Haag. 2023. Effect of strategic tillage on crop yield and soil properties in dryland wheat-sorghum-fallow rotation. OAP Workshop. April 4-5, Canyon, TX.

Holman, J. D., Obour, A. K., Schlegel, A. J., Lawrence, M., & Haag, L. A. (2022) Occasional Tillage for Managing Herbicide Tolerant Weeds (effects on soil water, crop yields and economics). [Abstract]. ASA, CSSA, SSSA International Annual Meeting, Baltimore, MD. https://scisoc.confex.com/scisoc/2022am/meetingapp.cgi/Paper/141940.

Lawrence, M., A. Obour, J. Holman, L. Simon, A. Schlegel, L. Haag, K. Roozeboom. 2022. Effect of strategic tillage on crop

yield and soil properties in a wheat-sorghum-fallow rotation. In ASA-CSSA-SSSA Abstracts 2022. ASA, CSSA, and SSSA, Madison, WI.
Obour, A.K., J.D. Holman, L. Simon, A.J. Schlegel. 2020. Strategic tillage effects on crop yield and soil properties in dryland crop rotations. In Proc. of the Great Plains Soil Fertility Conf., 2020. Vol. 18:106-111.
Obour, A. K., J.D. Holman, and A.J. Schlegel. 2020. Occasional tillage and nitrogen application effects on winter wheat and grain sorghum yield. Kansas Agricultural Experiment Station Research Reports: Vol. 6: Iss. 9. https://doi.org/10.4148/2378-5977.7976.
Obour, A. K.; J.D. Holman, and A. J. Schlegel. 2019. Occasional tillage and nitrogen application effects on winter wheat and grain sorghum yield. Kansas Agricultural Experiment Station Research Reports: Vol. 5: Iss. 4. https://doi.org/10.4148/2378-5977.7755.
Obour, A. K., J. D. Holman, and A. J. Schlegel. 2019. Strategic tillage in dryland no-tillage crop production systems. Kansas Agricultural Experiment Station Research Reports: Vol. 5: Iss. 4. https://doi.org/10.4148/2378-5977.7756.
Obour, A., J. Holman, and A. Schlegel. 2019. Strategic tillage effects on crop yield and soil properties in dryland no-tillage systems. ASA-CSSA-SSSA International Annual Meeting, Nov. 11-14, 2019. San Antonio, TX. In ASA-CSSA-SSSA Abstracts 2019 [CD-ROM]. ASA, CSSA, and SSSA, Madison, WI.
Obour, A., J. Holman, and A. Schlegel. 2019. New research on strategic tillage in dryland no-till systems, Agronomy e-updates. No. 771, October 25, 2019.
Obour, A., J. Holman, and A. Schlegel. 2018. Strategic tillage to improve crop yields and profitability in dryland no-tillage cropping systems. Proceedings of the Great Plains Soil Fertility Conference. Vol. 17, p.188-191.

The Project on Summer Annual Legumes produced five technology transfer activities:

Holman, J. and N. Detter. 2023. Alternative forage options. In-depth wheat diagnostic school. June 2. Belleville, KS.
Holman, J., N. Detter, A. Obour, L. Haag, and K. Roozeboom. 2024. Summer annual legumes: yield potential and water use. Ogallala Aquifer Program. Liberal, KS.
Holman, J., N. Detter, A. Obour, L. Haag, and K. Roozeboom. 2024. Summer annual legumes: yield potential and water use. Great Plains Soil Fertility Conference. Lubbock, TX.
Holman, J., N. Detter, A. Obour, and Perpetual Tamea. 2024. Effect of Seeding Rate on Annual Warm Season Forage Yield and Plant Structure. Great Plains Soil Fertility Conference. Lubbock, TX.
Detter, N., Holman, J. D., Obour, A. K., Haag, L. A., Roozeboom, K. L., Roberts, T., & Tamea, P. 2023. Summer Annual Legumes: Yield Potential and Water Use [Abstract]. ASA, CSSA, SSSA International Annual Meeting, St. Louis, MO. https://scisoc.confex.com/scisoc/2023am/meetingapp.cgi/Paper/149634
Tamea, P., Detter, N., Holman, J. D., Obour, A. K., & Roberts, T. 2023. Effect of Seeding Rate on Annual Warm Season Forage Yield and Plant Structure [Abstract]. ASA, CSSA, SSSA International Annual Meeting, St. Louis, MO. https://scisoc.confex.com/scisoc/2023am/meetingapp.cgi/Paper/149649

The Project on Developing efficient production practices to optimize water use efficiency of industrial hemp produced six technology transfer activities:

Bajwa, P., Saini, R., Singh, S., Makkar, J., Trostle, C. Effect of early and late POST emergence herbicides on weed suppression, crop injury, and biomass yield of industrial hemp. PSS research symposium, Texas Tech University, Lubbock, TX, USA (23 April 2023).
Bajwa, P., Singh, S., Kafle, A., Singh, M., Saini, R., Trostle, C. Impact of planting dates and seeding densities on root growth, soil water depletion, and water productivity of Industrial hemp in west Texas. ASA, CSSA, SSSA conference, St. Louis, Missouri. October 29 – November 1, 2023.
Bajwa, P., Singh, S., Kafle, A., Singh, M., Saini, R., Trostle, C. Impact of planting dates and seeding densities on soil water depletion, and water productivity of Industrial hemp in west Texas. Davis college poster competition, Texas Tech University, Lubbock, TX, USA (28 September 2023)
Bajwa, P., Singh, S., Kafle, A., Singh, M. Effect of planting dates and seeding densities on growth and yield of Industrial hemp in West Texas. PSS research symposium, Texas Tech University, Lubbock, TX, USA (19 April 2023).
Bajwa, P., Singh, S., Kafle, A., Singh, M. Effect of planting dates and seeding densities on growth and yield of Industrial hemp in West Texas. Ogallala Aquifer Program workshop, Texas (4 April 2023).
Bajwa, P., Singh, S, Singh, M. Evaluating different planting dates and seeding densities of Industrial hemp in the west Texas conditions. Davis college poster competition, Texas Tech University, Lubbock, TX, USA (29 September 2022).