Ogallala Aquifer
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A research consortium between USDA-Agricultural Research Service, Kansas State University, Texas AgriLife Research and Extension, Texas Tech University, and West Texas A&M University

Project Plan from FY2014
(Fiscal Years 2015-2016)

1) Project title: **Forage Sorghum as an Alternative Crop for Water Limited Cropping Systems**

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3) Summary: A significant proportion of forages produced in the southern Great Plains are produced under irrigation. Diminishing well capacities coupled with frequent droughts have made it difficult for forage producers to meet demand from the region's beef cattle and dairy industries. While grains can be brought in from other states within U.S. Grain belt, forages have to be produced locally due to their low bulk density and expensive transportation costs. Corn silage has for a long time been a reliable source of silage for cattle feeders and diaries in the southern Great Plains but with diminished well capacities many producers cannot grow corn silage anymore. There is an urgent need to identify alternative drought tolerant high yielding forage crops that can be grown for silage with less water. Forage sorghum especially brown mid rib (BMR) hybrids offer excellent silage options in the place of corn-silage. This project will generate information on forage sorghum production functions, water productivity, effect of limited irrigation on forage quality, and comparison of profitability of forage sorghum versus corn silage and continuous cotton versus cotton-forage sorghum cropping system.

The objectives will be to:1) develop production functions for BMR and non-BMR forage sorghum and update KSU's crop water allocator web-based tool to add forage sorghum as a crop option, 2) evaluate the effect of limited irrigation on forage quality in terms of acid detergent fiber (ADF), and neutral detergent fiber (NDF), and in vitro true digestibility (IVTD) under SW Kansas environmental conditions, 3) evaluate yield, forage quality, and water productivity of BMR and non-BMR forage sorghum under a water limited cotton-forage sorghum cropping system in the Texas Panhandle, and 4) conduct a partial budget economic analysis to determine the marginal economic impact of producing forage sorghum at different water levels on net returns, and also compare profitability of forage sorghum versus corn silage and profitability of continuous cotton versus cotton-forage sorghum cropping systems under limited water. Research will be conducted at the Texas A&M AgriLife Research center in Halfway and at the KSU SWREC in Garden City Kansas. The specific outputs of this work will include the following: 1) forage sorghum yield production functions and an enhanced crop water allocator web based tool that includes forage sorghum as one of the crop options, 2) recommendations on producing forage sorghum as an alternative crop in water limited traditional cropping systems, and 3) two peer reviewed manuscripts. Long term, we expect this project to contribute to extending the productive life of Ogallala Aquifer through reductions in groundwater depletion while maintaining profitability of irrigated agriculture and related industries.

4) **Project narrative**:

a) **Objectives:** This project will address OAP overall objective 1 related to the development of water management strategies and technologies that could reduce water withdrawals by 20% by 2020 compared to 2012 while sustaining economic viability of agriculture in the region. This project will contribute to achieving OAP objective 1 by accomplishing the following specific project objectives:

I. Develop production functions for BMR and non-BMR forage sorghum over a wide range of irrigation water levels and use these functions to update the web-based decision support tool for allocation of limited water resources to crop mixes called Crop Water Allocator to include forage sorghum as one of the crop choices,

II. Evaluate the effect of limited irrigation on forage sorghum quality in terms of acid detergent fiber (ADF), neutral detergent fiber (NDF), and in vitro true digestibility (IVTD)under SW Kansas environmental conditions,

III. Evaluate yield, forage quality, and water productivity of BMR and non-BMR forage sorghum under a water limited cotton-forage sorghum cropping system at Halfway/Lubbock Texas,

IV. Conduct a partial budget economic analysis to determine the marginal economic impact of producing forage sorghum at different water levels on net returns, and also compare profitability of forage sorghum versus corn silage in SW Kansas and profitability of continuous cotton versus cotton-forage sorghum rotation at Halfway/Lubbock TX.

b) **Rationale/Literature Review/ Conceptual framework:** A significant amount of forages produced in the southern Great Plains are produced under irrigation. Diminishing well capacities due to water level declines in the Ogallala coupled with frequent droughts have made it difficult for forage producers to meet demand from beef cattle feeders and dairies. While grains can be brought in from other states within U.S. Grain belt, forages have to be produced locally due to their low bulk density and expensive transportation costs (Guerrero et al., 2013). With increasing number of low capacity wells (less than 400 gpm), a lot of farmers who can no-longer grow corn-silage are looking for alternative drought tolerant high yielding forage crops. McCorkle et al. (2007) reported that forage sorghum silage presents a viable alternative to corn silage for cattle feeders in the southern High Plains with potential water savings of close to 50%. Studies by the Texas Alliance for Water Conservation have also reported that forage sorghum used close to half the amount of water required in producing comparable amounts of corn silage biomass.

Some BMR and non-BMR forage sorghum hybrids were shown to require less irrigation than corn-silage and have comparable yield and feed value to corn silage (Bean and McCollum, 2006). In addition, they have good ethanol conversions compared to grain sorghums increasing their economic value as an alternative crop (Howell et al., 2010). There is an urgent need to develop management strategies for alternative drought tolerant forage crops that use less water and are profitable. Preliminary work by Bordovsky et al. (2014) has shown for example that a cotton-cotton-forage sorghum cropping system resulted in higher gross returns compared to continuous cotton. Sufficient work (Klocke et al. 2012) has been done in the southern Great Plains to determine production functions for grain crops. But there is a knowledge gap regarding forage sorghum production functions covering a wide range of irrigation water levels under sprinkler irrigation which represents the dominant method of irrigation in the region. Earlier irrigation management research on forage sorghum done in the Texas Panhandle by Bean et al. (2011) and others was mainly done using flood irrigation which is less efficient compared to center pivots. Many producers with limited wells are interested in having long term crop mixes that have forages as part of the mix, but currently available decision support tools such as Crop Water Allocator do not have forage sorghum as a crop option because of lack of production functions to characterize forage sorghum yield response to water. This study will generate production functions of BMR and non-BMR forage sorghum with water levels ranging from very limited (6 inches) to full irrigation 18 inches. We shall also quantify the profitability of forage to corn silage as well as in a cotton-forage sorghum cropping system compared to continuous cotton.

c) **How the objective (s) will be met/Research procedures**: The research will be conducted at two locations: 1) Texas AgriLife Halfway/Lubbock and 2) Kansas State University (KSU) Southwest Research-Extension Center (SWREC) in Garden City Kansas.

Materials and methods for study at Garden City Kansas: At Garden City a four span (144 ft span width) lateral move sprinkler irrigation system (model 8000, Valmont Corp., Valley, NE) modified to apply irrigation water in any desired treatment combination up to 6 irrigation levels will be used in this study. Experimental design at Garden City will be a split-plot randomized complete block design replicated four times with irrigation as the main factor, and crop as the sub-plots factor. Crops will include a BMR and a non-BMR forage sorghum hybrids, and corn silage. Irrigation treatments will comprise:

1. Full irrigation treatment with a well capacity of 600 gpm or 0.25 inches/day (T1)
2. A 500 gpm well capacity or 0.20 inches/day irrigation capacity (T2)
3. A 400 gpm well capacity or 0.16 inches/day irrigation capacity (T3)
4. A 300 gpm well capacity or 0.12 plus 2” pre-irrigation two weeks before planting (T4)
5. A 200 gpm well capacity or 0.08 inches/day plus 2” pre-irrigation
6. Dryland treatment (T6)

The full irrigation treatment will be managed as non-water limited treatment in which soil water will be replenished when available soil water drops to 60% in the top 4.0 feet of the soil profile. Soil water measurements will be made weekly at intervals of 1.0 foot up to a depth of 8.0 feet. Each irrigation event will apply a total of 1.0 inch for all treatments scheduled to be irrigated on a given day. T2 will be scheduled to receive a 1” every 5 days while T3 will receive a 1” every 6 days, T4 every 8 days and T5 every 12 days. Schedules maybe modified based on amounts of rainfall received. Treatments T4 and T5 will receive 2” of pre-irrigation two week before planting. Crop evapotranspiration (ETc) will be calculated from a soil water balance. Fertilization and seeding rates will follow cultural practices for the region for forage sorghum and corn silage. The data will be statistically analyzed using Proc Mixed in SAS.

Materials and methods for similar study at Halfway Texas: A cropping systems study of cotton and forage sorghum in rotation versus continuous cotton has been established under an 8 span center pivot with crops irrigated using the LEPA method and will be continued with this project. The crop rotation treatments include: Cotton-Cotton-Forage sorghum, Cotton-Forage sorghum-Cotton, and Forage sorghum-Cotton-Cotton. These treatments will be compared to continuous cotton. Forage sorghum plots will include BMR and non-BMR hybrids. The crop rotation plots will be organized in a randomized complete block design with four blocks. In addition three irrigation levels will be imposed: 3” pre-plant irrigation+0” in season irrigation, 3” pre-plant irrigation+3” in season irrigation, and 3” pre-plant irrigation+6” in season irrigation. Since the water available for irrigation is low, irrigation applications will be targeted to critical growth stages of forage sorghum. Changes in volumetric soil water content due to cultivar, crop sequence, and irrigation levels will be determined using neutron attenuation methods. Water input, yield, and forage quality from treatments will be used to determine water productivity and economic value of forage sorghum in the cropping system.

Economic analysis will be based on the partial budget type analysis. The analysis will seek to determine the marginal economic impact of varying irrigation applications/well capacity on net returns of forage sorghum and corn silage. Partial budget analysis will also be used to determine the marginal economic impact of a cotton-forage sorghum cropping system on net returns. Production functions forage sorghum prices and production costs will be used in the analysis.

Timelines:

October 2014 through March, 2015:

Prepare field sites and acquire materials and supplies.

April to May 2015:

Establish field plots, plant forage sorghum, cotton as need based on site and install neutron access tubes. Read initial soil water.

Hire student summer help

June 2015 through September 2015:

Irrigate plots according to research protocol.

Periodically record crop growth stages

September-December 2015

Harvest samples at physiological maturity for yield and forage quality

Harvest cotton at Texas study site.

Analyze and summarize first year’s field results.

Subcontract programmer to add forage sorghum in Crop Water Allocator

April to May 2016:

Establish field plots, plant forage sorghum and cotton as need based on site and install neutron access tubes. Read initial soil water.

Hire student summer help

June 2016 through September 2016:

Irrigate plots according to research protocol.

Periodically record crop growth stages

September-December 2016

Harvest samples at physiological maturity for yield and forage quality,

Harvest cotton at Texas study site and analyze and summarize second year’s field results.

Refine production function coefficients for forage sorghum in Crop Water Allocator

Add economic analysis to combined data of both years

Complete project with journal publications and make presentations at professional meetings.

d) Expected Outcome: The specific outputs of this work will including the following: 1) forage sorghum yield production functions and an enhanced crop water allocator web based tool that includes forage sorghum as one of the crop options, 2) recommendations on producing forage sorghum as an alternative crop in water limited traditional cropping systems, and 3) two peer reviewed manuscripts. Professional conferences, field days and county extension events will be used for dissemination of findings. Due to diminishing well capacities, many producers are contemplating shifting to limited irrigation with less water use crops such as forage sorghum. In addition, current state sponsored groundwater management policies such as LEMAs in Kansas may compel irrigators to reduce groundwater consumption by up to 20%. If any of these scenarios happen, there may be an accelerated adoption of the findings from this research. Another catalyst for adoption of findings from this work will be the fact that virtual water can be imported into the region in the form of corn grain from other regions and then supplemented with locally grown forages for sustaining cattle feeding and diary operations in the region.

5) Relevant publications:

James P. Bordovsky, Joe T. Mustian, David Winters, Dana Porter, Calvin Trostle, and Dick Auld. 2014. Cotton Response in Non-traditional Crop Rotations at Low Irrigation Levels. Poster, OAP Workshop, Lubbock, March 2014.

Islam, M.A., **A.K. Obour**, M.C. Saha, J.J. Nachtman, and R.E. Baumgartner. 2013. Small grains have forage production potential and nutritive value in Central High Plains of Wyoming. Forage and Grazinglands. doi:10.1094/FG-2013-0121-02-RS.

Kraig Roozeboom, **Johnathon Holman**, Doug Shoup, Dale Blasi. 2008. Nontraditional Forages as Emergency or Supplemental Feedstuffs. Kansas State University, Forage Facts MF-2872.

6) **References**

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Bean, B., J. Becker, J. Robinso, and D.Pietsch. 2011. Texas Panhandle Forage Sorghum Silage Trial. Texas AgriLife. http://amarillo.tamu.edu/files/2010/11/2011-Forage-Sorghum-Silage-Final-Report.pdf

Guerrero B., S. Amosson and T. McCollum. 2013. The Impact of the Beef Industry in the Southern Ogallala Region. AG 001 Texas A&M AgriLife Extension Service.

Howell, T., Steven R. Evett, Karen S. Copeland, Judy A. Tolk. 2010. Forage Sorghum Evapotranspiration and Crop Coefficients. Phoenix Convention Center, 5 - 8, Phoenix, AZ USA.

McCorkle, D. A., Hanselka, D., Bean, B., McCollum, T., Amosson, S., Klose, S., & Walle, M. (2007). The economic benefits of forage sorghum silage as an alternative crop. Texas Cooperative Extension: Texas A&M University System.

Klocke, R. S. Currie, D. J. Tomsicek, J. W. Koehn. 2012. Corn Yield Response to Deficit Irrigation. Transactions of the ASABE 54(3): 931-940

Volesky, J.D., and A.L. Berger. 2010. Forage Production with Limited Irrigation. NEBGUIDE