Title: Potential of cover crops to diversify dryland crop production in the Central Great Plains

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Summary
Cropping system diversification with cover crops (CCs) in dryland crop production in the central Great Plains (CGP) can provide several benefits, including improving soil quality, nutrient cycling, weeds and pest suppression, reduced wind erosion and increase crop productivity. These touted benefits of CCs and the promotion by USDA-NRCS has renewed interest by producers to incorporate CCs in dryland production systems. The few research efforts involving CCs in dryland were done with wheat-fallow cropping systems, with little or no work conducted with a 3-yr rotation system. This proposed project tends to develop production recommendations for CCs in 3-year no-tillage crop rotations of winter wheat-grain sorghum-follow with or without a cover crop. Cover crop forage production potential, water use and potential impacts on winter wheat and grain sorghum yield penalties will be evaluated. In addition, the impact of removing CCs for forage on wind erosion and other soil quality parameters will be addressed.

Project Narrative
Objectives: Declining water levels of the Ogallala Aquifer has resulted in limited groundwater supplies for irrigated crop production in the CGP region. Continual depletion of the saturation thickness of the aquifer will lead to an expansion of dryland crop production acreage across the region. This proposed project will develop and evaluate sustainable dryland crop production strategies which protect soil, water, and air resources while increasing productivity and profitability of dryland crop production systems. The project addresses the OAP sub-objective # 2 “Developing and evaluating water management strategies and technologies for maintaining and/or enhancing the economic viability of the agriculture industry and the vitality of the Southern Ogallala Aquifer Region.” Specific research objectives are to 1) determine the potential of using cover crops as forage in dryland cropping systems, 2) determine the impacts of forage or cover crop production on winter wheat and grain sorghum yields, and 3) determine soil quality and water productivity of dryland cereal-based crop production systems with cover crops harvested for forage or grown for cover.
Rational/Literature Review
Irrigated agriculture in the CGP is heavily dependent on water withdrawals from the Ogallala aquifer. However, with depletion of the saturated thickness of the Ogallala and higher pumping costs, producers may tend to return irrigated acres to dryland production**.** This scenario provides the impetus to develop and evaluate crop production strategies and technologies that will enhance crop yields and profitability of dryland cereal-based crop production systems in the region.
Due to water limitations, winter wheat-fallow has been the traditional dryland cropping system in the Great Plains including the CGP. The use of conventional tillage operations for weed control during the fallow period has resulted in insufficient crop residue return to the soil, depletion of soil organic matter, declining soil fertility, soil erosion and inefficient water storage. Adoption of

reduced tillage and no-till practices have led to increased moisture storage and allowed crop intensification in dryland cropping systems in the CGP. In addition, rising costs of herbicides and development of glyphosate resistance weeds has renewed interest in cropping systems diversification. However, identifying alternative crops that are adapted to dryland environments of the CGP has been a major challenge to producers and researchers.

Growing CCs for cover or forage has potential to diversify and increase profitability of dryland crop production systems. Replacing fallow with a CC can provide several benefits including increased soil organic matter, weed suppression, nutrient cycling, improved soil structure and reduction in water and wind erosion. Incorporating CCs in a winter wheat-fallow system in southwest Kansas has been shown to increase wet aggregate stability, soil organic carbon and reduced runoff and wind erodible soil fraction (Blanco-Canqui et al., 2013).The ability of CCs to reduce wind erosion is particularly important in semi-arid dryland crop production systems because residue levels are very low, predisposing fallow fields to wind erosion from high prevalent winds.

Despite its potential, CC adoption is not widely popular in the CGP because CCs utilize water that otherwise would be available to the subsequent cash crop. Previous studies in the CGP have reported reduction in wheat yields when fallow is replaced with CCs (Nielson and Vigil, 2005; Schlegel and Havlin, 1997). Nielsen and Vigil (2005) reported a significant negative effect of CCs on winter wheat grain yield in years when precipitation amounts were low. Research conducted in southwest Kansas showed that spring/winter forage crops can replace fallow in wheat-fallow systems with minimal yield reduction in years when precipitation is average or above normal (Holman, et al. 2013a; Holman et al. 2013b). The authors also reported that harvesting CCs for forage or grain can help offset decreases in wheat yield and increase profitability of the system compared to wheat-fallow.

Opportunity does exist to grow CCs in dryland cropping systems and harvest them for forage in late fall or during the spring. Such cropping systems can take advantage of any additional moisture received during wet years to provide the needed forage for the regions livestock industry. Winter feeding is the most costly expense for beef cattle producers because of limited forage availability for grazing during the winter. For instance, winter feeding costs $100 to $200 per cow in most parts of the western USA (Merrill et al., 2008).

The few research efforts involving CCs in dryland were done with wheat-fallow cropping systems, little or no work has been conducted with a 3-yr wheat-sorghum-fallow rotation system. This proposed project will develop production recommendations for CCs as fallow replacement crop in dryland cropping systems by conducting field experiments to evaluate forage production potential of CCs, crop water use and potential winter wheat and grain sorghum yield penalties associated with growing CCs in place of chemfallow. In addition, the impact of managing CCs for forage or cover on soil organic carbon, wind erosion and other soil quality parameters will be evaluated.

Research Procedures: Field experiments will be conducted at Kansas State University research and extension centers near Hays and Garden City. Cover crops will be evaluated in 3-year no-tillage crop rotations of winter wheat-grain sorghum-follow with or without a CC. The experimental design will be a split- plot with four replications in randomized complete blocks. Main plots will be crop phase and sub-plots will be CC type. Each block will be split into three 80 ft. wide by 180 ft. long plots to accommodate each phase of the crop rotation, which will be present in each block and every year of the study.

Cover crop planting and Management: Five CC treatments will be established after sorghum harvest by splitting the sorghum stubble block into five 30 ft. wide by 80 ft. long strips. Selected CCs will be spring oat/pea, spring triticale/spring pea, spring oat, spring triticale, and a six species "cocktail" mixture of spring oat, spring triticale, spring pea, buckwheat var. Mancan (*Fagopyrum esculentum* Moench), purple top turnip (*Brassica campestris* L.), and forage radish (*Raphanus sativus* L.). All CCs will be planted on or before March 15 in each year of the study. A chemfallow with no CC will be included as a check, for a total of six treatments. All crops will be fertilized based on KSU soil test recommendations. These CC species were chosen based on seed availability and previous research showing their adaptability to western Kansas growing conditions (Holman et al., 2013a). Half of the CC plots will be harvested for forage and the other half left for cover.

Fresh weight of CC forage samples will be recorded and sub-samples will be dried at 60^{o}C for at least 48 hours in a forced-air oven for dry matter determination. Oven-dried samples will be ground to pass through a 1-mm mesh screen in a Wiley mill and analyzed for forage nutritive value [crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), *in-vitro* dry matter digestibility (IVDMD) and nitrate (NO_3) concentration].

All CCs will be terminated by June 1 and the plots seeded to winter wheat in the fall. Grain yields of winter wheat and grain sorghum on previously fallow and CC plots will be determined by harvesting an area of 5 ft. × 80 ft. from each plot with a plot combine.

Soil Quality Measurements: Soil samples will be collected from 0 to 7.5 cm, 7.5 to 15 cm, 15 to 30 cm, 30 to 60 cm, and 60 to 90 cm soil depths at the beginning of the study (baseline soil data) and at end of the study period to evaluate the impacts of replacing fallow with CCs on soil physical and chemical properties. The soil samples will be analyzed for soil quality parameters including bulk density, texture, dry aggregate size distribution, wind erosion fraction, SOC, N and P dynamics. Briefly, bulk density will be determined by core method (Blake and Hartge, 1986), texture by the hydrometer method (Gee and Bauder, 1986), dry aggregate size distribution and wind-erodible fraction by the rotary sieve method (Chepil, 1962), total N and SOC by dry combustion using Leco C/N analyzer after acid treatment. The NH_4-N and NO_3-N concentrations in samples will be determined on Seal AQ2 discrete analyzer after extracting the soil with 2 M KCl, and soil P by Mehlich-3 extraction method (Mehlich, 1984).

Soil water measurements: Since water availability is the driving variable in crop productivity in the Great Plains, transpiration of soil water by CCs may pose a concern on yield reduction in winter wheat/grain sorghum. This is offset by potential reduction in soil moisture evaporation during the fallow phase by growing a CC. Therefore, soil moisture storage and availability will be determined at the commencement and termination of the CC, wheat, and sorghum phases of the rotation across all treatments including fallow to determine the impact of CCs on moisture availability to the succeeding wheat and sorghum crops. Soil water content will be assessed gravimetrically to 1.8 m in 0.3 m depth increments in all treatments prior to planting and at termination of CCs, and harvesting of winter wheat and grain sorghum. Three soil cores will be taken per plot and combined for a single soil water content measurement. Soil cores will be weighed wet and then placed in an oven at 105 O°C for at least 48 hours and then weighed dry on consecutive days until a constant weight is reached. Data generated will be used to assess water use and storage for each crop rotation system.

Expected outcomes: The study will develop production recommendations for integrating CCs into dryland crop production systems in the Great Plains testing various CC species, CC water use and potential impacts of growing CCs on winter wheat and grain sorghum yields. As an outcome of the proposed project, we anticipate a significant increase in grower knowledge and understanding of CCs as an alternative crop for fallow replacement in dryland cropping systems. The findings of the study will provide producers the tools to effectively select the best adopted spring CC species for western Kansas. Incorporating CCs into wheat-sorghum production systems has the potential to diversify markets; reduce crop pests, increase crop productivity and farm income. As an output, information generated from the study will be published into a CC production guide for producers. Two to three peer-reviewed journal articles and extension publications will be other outputs of the project.

Technology Transfer: Study results will be presented to producers and agricultural professionals through field tours and field days, producer meetings, and scientific meetings. Publication of results in extension bulletins, news releases, publication in referred journals and production of short YouTube videos are other means the results of the project will be disseminated.

Economic Assessment Plan: Economic analysis will be done by comparing input cost and estimated net income generated from each management option based on a partial budget approach. Total input usage will be recorded for each treatment in order to accurately calculate cost differences across treatments. Likewise, total production will be measured for each treatment in order to determine the benefits of each of the alternative cover crop/crop production options**.**

Pertinent Publications:

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