Title: Integrating Livestock into Traditional Wheat-Sorghum-Fallow Rotations

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Research Location: Research locations will be at the Western Kansas Agriculture Research Center (WKARC) near Hays, Kansas, Southwest Research Extension Center near Garden City, KS, and Black Diamond Angus Ranch near Dodge City, KS.

Summary/Abstract:

The useful life of the Ogallala Aquifer for irrigation is limited and it is inevitable that crop production in the region must transition from irrigated to rain-fed production. At the same time, demands on crop and livestock production have increased through population growth and reduced crop and rangeland. In addition, we must strive to reduce inputs and improve our soil health. Dryland cropping systems that meet these objectives are needed in the region. The recent decrease in grain prices has placed economic returns for many producers below the cost of production, while livestock returns are still strong. Integrating livestock with crop production can reduce market variability, and improve the profitability and sustainability of rain-fed production systems. This research project will 1) determine best management practices for integrating winter and summer annual forages into traditional dryland grain-only cropping systems, 2) identify the impact of grazing versus haying annual forages on soil water availability, crop yield and soil health, 3) evaluate reduced tillage to alleviate potential negative effects of soil compaction associated with livestock grazing, and 4) determine livestock reproductive and growth performance differences from grazing annual forages.

Project Narrative:

Objectives:

Alternative management strategies and technologies are needed to increase the productivity and profitability of dryland cropping systems. This project plan addresses objective 2 of the request for proposals "*develop and evaluate management strategies and technologies that would increase the productivity and profitability of dryland cropping systems*."

The research objective of this study is to compare a traditional winter wheat-grain sorghum-fallow rotation to growing forages in place of wheat or grain sorghum. In addition, forage sorghum either hayed, grazed, or a combination of both (i.e. swath + graze) will be evaluated. Minimum tillage during the fallow period of all crop rotations will be compared to no-tillage. This study will identify options and best management practices for integrating livestock into traditional grain only cropping systems, thereby increasing profit and reducing market risk, while identifying those systems that are most sustainable for dryland farming in the Ogallala region.

Rationale/Literature Review/Conceptual Framework:

Most of the southern and central Ogallala Aquifer region no longer has sufficient irrigation capacity to sustain highly-productive grain-only cropping systems (e.g. continuous corn with >180 bu/A/yr). In fact, many producers have already transitioned some irrigated production land to rain-fed. Thus, one of the greatest challenges for crop production is to implement viable rain-fed cropping systems that are highly water use efficient, minimize yield variability, and improve soil health.

There was a trend for segregation of crop and livestock production systems since the 1980s, but recently that trend has been reversing as an increasing number of producers are interested in integrating livestock and crop production. This trend has been largely driven by an interest in grazing cover crops, market diversification, risk aversion, and the recent decrease in crop prices and high livestock prices (CME, 2015; KFMA, 2015). Livestock producers are interested in utilizing annual forages to increase carrying capacity of their current operations, to rest pastures following drought periods and utilize annual forages at a time of the year when native rangeland is not as productive or high in nutritive value. Crop and livestock producers have found they can mutually benefit from livestock producers paying to graze crop fields. Thus, avoiding livestock ownership responsibilities for crop producers. In addition, smaller and beginner farmers frequently operate both cattle and crop production enterprises to reduce the amount of capital and acres required, as compared to a single enterprise. Grazing recycles nutrients, reduces harvest expense, provides high quality forage, extends the grazing season, and may improve soil health. Grazing stockers on wheat pasture is common in some areas but use for developing replacement heifers or for cows has been limited. Anecdotal reports suggest that grazing wheat pasture during breeding may negatively impact fertility. Negative impacts of high protein diets on dairy cattle reproduction are well known (Butler, 1998). This combination of factors has largely kept producers from grazing wheat pasture with replacement females. Pregnancy rates were not reduced in cows (Johnson and Harmoney, 2011) or heifers (Bryant et al., 2011) grazing wheat pasture at breeding, however conception date was earlier for heifers bred in a drylot compared to grazing a wheat and ryegrass pasture (Beck et al., 2005). More data is needed to assess impacts of high protein forages on reproduction in grazing beef females.

Integrating annual forages into the fallow period may increase the productivity of dryland cropping systems while improving soil health and sustainability within the semi-arid Great Plains. Yet limited data is available on how to best integrate annual forages and livestock into traditional cropping systems. Spring annual forages were grown in place of fallow in a wheat-grain sorghum-fallow rotation at Garden City, KS (Holman et al. 2013a, 2013b). Forages grown in place of fallow improved soil health and profit in wet years (Blanco et al. 2013). However, in dry years, growing an annual forage reduced subsequent wheat yields and profitability. The negative impacts on wheat yields may be minimized with flex-fallow. Flex-fallow is the concept of planting an annual forage crop in place of fallow when soil moisture levels are high and the long-range precipitation outlook is favorable, otherwise fallow is used until planting the next crop in the rotation.

Due to the lower yield potential of spring forage compared to summer forage, and the potential for spring forages to decrease subsequent wheat yields; a more consistent crop rotation may be to grow forage sorghum, sorghum x sudangrass, or other similar annual forage in place of grain sorghum. Many of these forages pose prussic acid risk when grazing, so some producers will wait to graze until after a killing frost when prussic acid levels are low. However, forage quality is lower if the crop is fully matured before grazing. Swathing the crop at an earlier maturity and then grazing the swathed forage in addition to any regrowth after a killing frost (swath-graze) may reduce the risk of prussic acid and improve forage quality and yield compared to grazing at the end of the season. Some producers will double-crop forage sorghum (FS) after wheat (WW) in wet years, but in dry years double-crop yields (WW/FS) can be 50% less than planting forage sorghum the year following wheat (WW-FS) (Holman et al., 2015). Forage sorghum grown the year after forage sorghum (FS-FS) yielded comparable to forage sorghum grown the year following wheat (WW-FS), which has a longer fallow period. However in a similar rotation, grain sorghum (GS) yields were 50% less when grown the year following forage sorghum (FS-GS) compared to the year following wheat (WW-GS), due to a shorter fallow period and less soil moisture accumulation (Holman et al., 2016). These results and other studies have found forages require less water than grain crops. Currently, there is greater profit potential to grow forages rather than grain crops, but of course this is not the case in all years. Many warm-season annual forages can easily be grown in place of grain sorghum without restricting herbicide use or planting equipment. Having proven crop rotations with annual forages would add more risk adversity and market options for growers.

Less information is available on the impact of grazing versus haying annual forages. Baumhardt et al. (2004, 2011) compared grazed and non-grazed wheat and grain sorghum stubble with and without tillage. They concluded that with tillage, wheat and grain sorghum could be grazed without negatively affecting crop yields, although soil moisture storage was greater with no-till. Without tillage, cattle grazing over time caused compaction near the soil surface, resulting in reduced sorghum yield. Grazing wheat out resulted in less soil water storage and reduced grain sorghum yield. In their study, tillage was implemented every year, but many producers only till during the fallow year. Grazing forage sorghum may have different effects on soil compaction, water storage, and crop yields than grazing grain sorghum stubble. Forage sorghums produce two to three times the amount of above ground biomass as grain sorghum, and grazing can be managed to leave as much residue as grain sorghum stalks prior to being grazed. Grazing forage sorghums with higher biomass production, more residue retention, and more manure (more grazable forage) may reduce the negative effects of grazing on soil compaction reported by Baumhardt et al (2011). Previous research has not compared haying and grazing of annual forages, or grazing forage sorghums in traditional wheat-sorghum-fallow rotations.

The benefits of no-till in the Great Plains on reduced soil water evaporation and soil health are well documented. However, many producers are struggling to manage herbicide resistant weeds such as three-awn and windmill grass, and are using light tillage during the fallow phase to control these problem weeds. Schlegel et al. (2014) found wheat responds less favorably to no-till than grain sorghum; in support of this finding, most producers till ahead of wheat rather than sorghum. The impact of reduced tillage on forage sorghums is unknown. Weed management issues are only getting worse as weeds such as kochia and palmar amaranth develop herbicide resistance to multiple herbicide modes of action. If grazing forage sorghums does cause some shallow compaction requiring tillage, tillage may also be an important tool for managing weeds, plus grazing weeds may also help provide some weed control. An evaluation of annual forage management (hay, graze, or combination) on precipitation storage, wheat yield, weed population, soil health, and profitability is needed.

Approach and Research Procedures:

We propose two experiments to reach our overall objective of successfully developing integrated grain/forage/livestock systems. The first experiment will evaluate five crop rotations that integrate haying or grazing forages. The control treatment is the commonly practiced rotation of winter wheat-grain sorghum-fallow. Results will identify those integrated grain and forage cropping systems that could be successfully adopted in the region. The second experiment will compare heifer reproductive performance grazing out either winter wheat or triticale compared to developing heifers on range with supplementation.

Experiment 1 (WKARC-Hays and SWREC-Garden City):

1. Year 1: winter wheat (WW); Year 2: grain sorghum (GS); Year 3: fallow
2. Year 1: winter wheat; Year 2: grain sorghum (graze stalks); Year 3: fallow
3. Year 1: winter wheat; Year 2: forage sorghum x sudangrass (FSS) (graze); Year 3: fallow
4. Year 1: winter wheat; Year 2: FSS (hayed); Year 3: fallow
5. Year 1: winter wheat; Year 2: FSS (swath-graze); Year 3: fallow

Experiment 2 (Black Diamond Angus Ranch-Dodge City):

1. Develop heifers on winter wheat or triticale.
2. Develop heifers conventionally (supplement on native rangeland and limited drylot as needed).

Treatments in experiment 1 will compare: 1) growing FSS or GS in rotation with WW, 2) haying, grazing, or swath + grazing FSS, and 3) reduced tillage compared to no-till. The experiment will be a split-split-plot randomized complete block design with four replications. Main plot will be crop phase of wheat, sorghum, and fallow, and all crop phases will be present each year. Subplots will be sorghum treatments listed above and split plots will be tillage. Reduced tillage plots will only be tilled in the fallow year using a minimal disturbance implement such as a sweep plow. Main plot will be 300 feet wide by 100 feet long, subplots will be 60 feet wide by 100 feet long, and split-plots will be 30 feet wide by 100 feet long.

Experiment 2 will compare heifer development and subsequent reproductive performance grazing either wheat or triticale compared to a conventional method supplementation on rangeland. Forage yield and quality of winter forage and rangeland will be measured periodically throughout the development period. Approximately one-hundred heifers will be assigned to each treatment for a total of 200 head and will be replicated across years. Ovulation will be synchronized and heifers will be bred by fixed time artificial insemination (AI). Heifer weight gain, AI pregnancy and season pregnancy rates will be determined.

The FSS variety grown will have good regrowth potential with the brown mid-rib (BMR) trait. Stocking rate and duration will be managed to maintain at least 1ft of standing residue or more than 60% ground cover. Plots that are to be swathed or hayed will be cut when plants are 50% headed. Plants will be swathed 6” high to retain good residue cover.

Grain Yield and Weed Measurements: Grain yields will be determined by harvesting an area 6ft wide by 100ft long area with a small plot combine. Grass and broadleaf plant density will be measured by species in the fallow phase in each plot prior to tillage. Weed counts will be done by placing a 1-m^2 quadrat randomly in two locations of each plot and the number of individual plants inside the quadrat recorded. The average of the two counts will be computed to represent weed density within each plot.

Forage Yield and Nutritive Value: Forage yield from small plots will be determined by harvesting an area 3ft wide by 100ft long area with a small plot forage harvester. Forage yield from large plots will be determined by measuring ten 1/4m^2 quadrat per plot. Total biomass and nutritive value will be measured at swathing or pre and post grazing. Samples will be dried at 40°C for at least 72 hours, and then weighed dry on consecutive days until a constant weight. Samples will be analyzed for nitrate, prussic acid, crude protein, acid detergent fiber, neutral detergent fiber, lignin, ash, and invitro-true digestibility using near infrared reflectance (NIR).

Soil Water Measurements: Soil water availability will be determined gravimetrically to 1.8 m in 0.3 m depth increments in all plots at planting and termination (harvest/end of grazing, etc.). Two soil cores will be taken from each plot and data averaged for a single soil water content measurement. Soil cores will be weighed wet, then placed in an oven at 105°C for at least 48 hours, and then weighed dry on consecutive days until a constant weight. Data generated will be used to assess water use and storage for each tillage and cropping system.

Soil Quality Measurements: Soil samples will be taken from 0 to 5, 5 to 10, 10 to 15, and 15 to 30 cm soil depths at the beginning of the study (baseline soil data) and annually in the fallow phase. These samples will be analyzed for changes in soil quality parameters including bulk density, aggregate size distribution, wind erosion fraction, pH, SOC, N, P and K distribution. Briefly, bulk density will be determined by core method, 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.

Cattle Measures: Body weights and body condition scores will be taken at the start and end of wheat pasture grazing in wheat pasture and conventionally raised heifers. Reproductive tract scores of heifers will be determined 40 to 60 days prior to breeding. Pregnancy to AI will be determined 30 to 40 days after fixed timed AI. Number of females cycling prior to breeding will be determined by progesterone concentrations 0 and 10 days prior to synchronization of estrus. Blood urea nitrogen concentrations will be determined in serum samples collected prior to synchronization and at time of AI.

Schedule:
2016: Implement all crop phases in initial year and collect baseline soil sample data.
2017: Experiment 1: graze treatment 3 in Aug, graze treatments 2, 3 and 5 in Nov. Experiment 2: graze heifers on wheat/triticale or rangeland and breed in April. All studies: collect forage and grain yield, forage nutritive value, soil water, and soil quality data. Write annual progress report.
2018: Repeat experiments and collect forage and grain yield, forage nutritive value, soil water, and soil quality data. Write annual progress report. Disseminate research information at field days and producer meetings.
2019: Repeat experiments and collect forage and grain yield, forage nutritive value, soil water, and soil quality data. Present poster at annual OAP meeting. Disseminate research information at field days and producer meetings. Publish findings in journal and extension publication for first 3 years of data. Secure funding for 3 more years of research for a total of 2 crop rotation cycles (6 years).

Expected Outcomes:

Economic Analysis:

Production costs and potential revenues will be determined for all tillage and cropping systems. An economic analysis will determine the inflection point where annual forage or grain sorghum should be grown based on crop and livestock market prices and cost of inputs. In addition, based on the livestock production system (i.e. cow/calf, stocker, and duration of rangeland grazing season), the best forage management practice will be determined using partial enterprise analysis. Crop insurance premiums and indemnities will also be estimated and included in the profit calculations. Finally, an economic decision support tool will be written for producers to input crop and livestock prices and cost of production to provide break-even sensitivity analysis.

Sustainability:

It is the intent of this study to be part of a long-term study (six years) to evaluate changes in soil health (bulk density, aggregate stability, water infiltration, soil organic matter, etc.) and heifer retention in the cow-herd. However at the end of this study (year 3) we will be able to quantify short-term changes in soil properties, such as changes in soil organic matter, water infiltration, and bulk density. Our goal is to identify best management options for annual forage production systems that improves or at least maintains soil health compared to traditional grain sorghum production. It may be possible that grazing forage sorghum increases soil organic matter compared to traditional cropping systems.

Technology Transfer:

All the information generated from this project will be utilized in different avenues for research and extension purposes (conference papers, field days, training for extension agents, farmers, and agronomists). In addition to the previous, two extension publication will be prepared as a sub-product of this research project ("Integrating Summer Annual Forages: Best Management Practices" and "Developing Heifers on Winter Wheat/Triticale"). Finally, research will be published in peer-reviewed journal articles.

Relevant Publications:

1. Blanco, H., J. Holman, A. Schlegel, and J. Tatarko. 2013. Replacing fallow with cover crops in a semiarid soil: effects on soil properties. Online. Soil Sci. Soc. Am. J.: doi:10.2136/sssaj2013.01.0006
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10. Holman, J., T. Roberts, and S. Maxwell. 2013. Fallow replacement crops (cover crops, annual forages, and grain pea) impact on wheat yield. Kansas State University Agricultural Experiment Station and Cooperative Extension Service Report of Progress. 1088:5-11.
11. Holman, J., A. Schlegel, T. Roberts, and S. Maxwell. 2013. Cover crop, annual forages, and grain pea effects on soil water in wheat-fallow and wheat-sorghum-fallow cropping systems. Kansas State University Agricultural Experiment Station and Cooperative Extension Service Report of Progress. 1088:12-19.
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