Research Question:

Piloting the wheat-perennial cropping system: testing systems change with and without livestock in western South Dakota

Specific Area of Interest:

Production Research

Specifically, this project addresses the following objectives:

- *Development and application of production systems and management which increase yields, improves production efficiency and addresses environmental and biological stress.*
- *Research projects including: alternative crop rotations; conservation tillage practices; nutrient management; and soil fertility.*
- *Investigate how cultural/management practices (fertility) affect end-use quality and marketability.*

Principal Investigator:

Dr. Christopher Graham, Asst. Professor and Extension Agronomist, SDSU

Co-PI:

Dr. Roger Gates, Professor and Extension Rangeland Management Specialist, SDSU

Dr. Laurent Ahiablame, Assistant Professor, SDSU

Introduction and Background:

The Western South Dakota landscape is a mosaic of land uses; a delicate balance dominated by grassland and wheat production. Between 2008 and 2012, over 1 million acres of grassland was converted to wheat in the northern Great Plains (Olimb, 2013). Currently, as much as 5% of the state's grassland is being converted to cropland each year. By 2030, North and South Dakota landowners are expected to convert an additional 3 million grassland acres into cropland.

As this rapid change proceeds, however, we know very little about the impacts to the ecosystem as a whole, nor the sustainability of wheat production on newly converted ground. For example, producers may see very profitable yields in the first year or two after conversion and rapidly diminishing returns after the initial flush of nutrients and carbon has been consumed. In this case, producers will have lost valuable grazing land and find themselves with only marginal farmland in just a few years' time. The idea for this research is not to discourage wheat production on converted grasslands. Rather, we are proposing a pilot project to demonstrate how and when this conversion is appropriate and what practices (eg. tillage, livestock integration, etc) should be adopted to do so in a sustainable manner.

Research Design:

Paired demonstration plots were established in existing, long-term grassland in western South Dakota. Winter wheat was planted alongside grassland, maintained as a control. The wheat was established using one of three different methods: A) full tillage B) no-till with a glyphosate burndown, planted with a no-till drill and C) heavy grazing prior to planting (no herbicide) and planted with a no-till drill. In the second year of this study (not funded by the Wheat Commission) these plots were rotated to sorghum and a new set of plots was established and planted to wheat.

To document the sustainability of each system, we will monitored several different indicators (all compared against the native grassland):

1) Wheat yield - seed yield, biomass, protein, test weight and maturity
2) Carbon status – change in soil organic carbon
3) Water use efficiency – total, yearly water consumption
4) Soil microbial population – change in total population and composition

From these indicators we can analyze grassland conversion responsibly through a systems perspective. Ultimately, this research is intended to serve as the basis for studying the long-term effectiveness of integrating annual crops (e.g. wheat) into a perennial grass system common in much of the western half of the state. Moreover, we hope to demonstrate to producers how animals can be integrated effectively into this system to reduce external inputs while maintaining a diversified income stream. It is common in mainstream agriculture to view annual and perennial systems as separate entities with animals as a detached production unit. We believe that these systems are not mutually exclusive and that they can be integrated in a sustainable manner. This research will serve as the scientific basis for those insights.

Results and Conclusions

Research plots were established in September, 2015. Along with a control (native prairie, Figure 1), winter wheat was planted in plots that were either tilled (Figure 2), no-till (Figure 3) or no-till with a cattle grazing (Figure 4). In the latter, cattle were grazed at high density (mob grazing) for a short duration to clear prairie overgrowth (see pictures).

As the figures show, there is far more residue in the no-till (Figure 3) versus the tilled (Figure 2) and no-till with cattle grazing (Figure 4) plots, which may have a significant effect decreasing winter kill.

After the first year of study, we saw no differences in yield or protein between the moldboard and no-till treatments with roughly 32 bushels yield for each treatment. It is important to note that this area experienced several periods of drought during the growing season, which affected overall yields.

Examining the effects on carbon, Figure 5 shows organic matter content for two years of wheat during the first year after grassland conversion and sorghum, which was two years out of conversion. While differences were subtle, there is a clear trend towards decreasing organic matter in both cultivated treatments. Tillage had a far greater effect on the loss of organic matter, decreasing by over 0.5%. Likewise, active carbon is a measure of the fraction of the organic matter that is most readily available as a carbon source to the microbial population (Figure 6). In the first year of study, no differences were detected. However, in 2017 when dry conditions persisted, active carbon declined significantly in the no-till and tilled plots. Again, the declines were greater in the tilled plots, which may be an indication of a high rate of oxidation of carbon as increased oxygen is introduced into the soil during the tilling process.

Finally, respiration and soil protein gives an indication of microbial activity (Figure 7 and Figure 8). In 2016, we saw dramatic decreases in respiration following cultivation. However, in 2017 there were much smaller differences. This is a difficult variable to analyze and needs more years of study to draw any conclusions with respect to tillage on the microbial population. Soil protein, an indication of the soil's ability to supply nitrogen to the crop, showed a similar trend to previous variables with overall decrease from the grassland and a greater decrease in the tilled plots (Figure 8). This indicates that over time, tilled plots will show a decreased ability to supply nitrogen and crops will be more dependent on applied fertilizers.

Effects to soil structure and potential water storage based on tillage were less evident in this short study. Aggregate stability is a measure of the soil's ability to form cohesive units, which allows for better water infiltration and soil function. While there is some indication that aggregate stability was decreased in the tilled plots (Figure 9), there is not enough data to conclude this with certainty. Additionally, available water holding capacity is a measure of the soil's ability to hold and retain water. In this study, there was virtually no differences observed. It is likely that differences would emerge as this study continues (Figure 10).

Overall, it is clear that cultivation of any sort generally decreases soil carbon and soil physical variables from the native grassland. It is critical that these studies are maintained over longer study periods to fully assess this affect and its implications for larger ecosystem processes. Integrating livestock as an alternative to spraying out grassland was ineffective at controlling both native plant populations and introduced weeds at the time of cultivation. On a preliminary basis, no-till practices had an overall reduced effect on many of the measured variables, but again it is premature to draw any solid conclusions.

Figures

1) 2)

Figure 1. Native prairie

Figure 2. Native prairie after moldboard plow, planted to winter wheat (on left)

3) 4)

Figure 3. Native prairie, sprayed with Roundup and planted (no-till) to winter wheat

Figure 4. Native prairie mob-grazed (no Roundup) and planted (no-till) to winter wheat (on left)

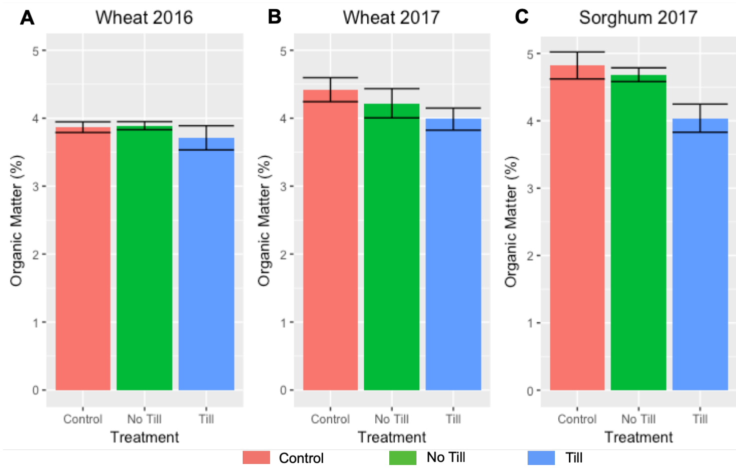

Figure 5. ***Organic matter (%) measures for soils from wheat 2016 (A), wheat 2017 (B), and sorghum 2017 (C). A significant treatment difference was observed only in the sorghum 2017 plots, where till was significantly lower than the other two treatments.***

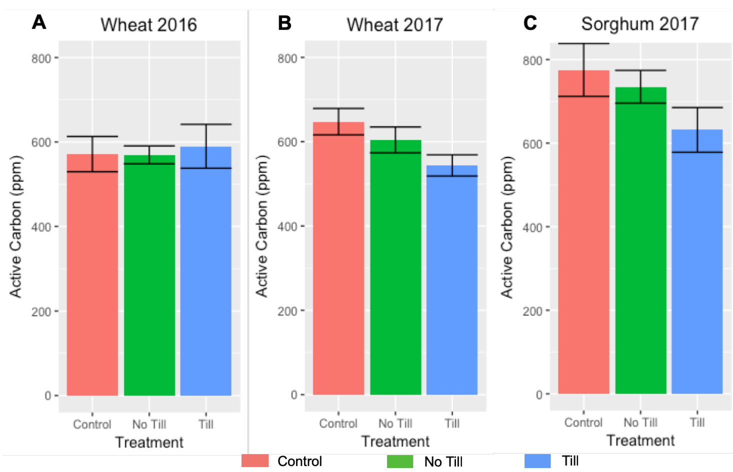

Figure 6. Active carbon (ppm) ***measures for soils from wheat 2016 (A), wheat 2017 (B), and sorghum 2017 (C). A significant treatment difference was observed only in the wheat 2017 plots, where till was significantly lower than the grassland control.***

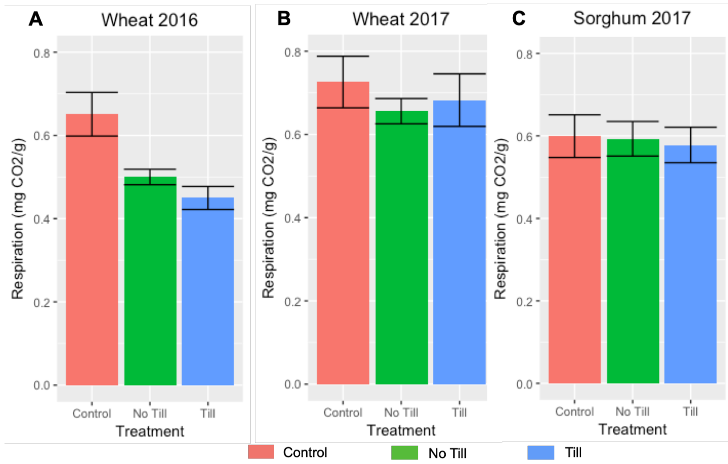

Figure 7. ***Respiration (mg CO_2/g) measures for soils from wheat 2016 (A), wheat 2017 (B), and sorghum 2017 (C). A significant treatment difference was observed only in the wheat 2016 plots, where the grassland control was significantly higher than the other two treatments.***

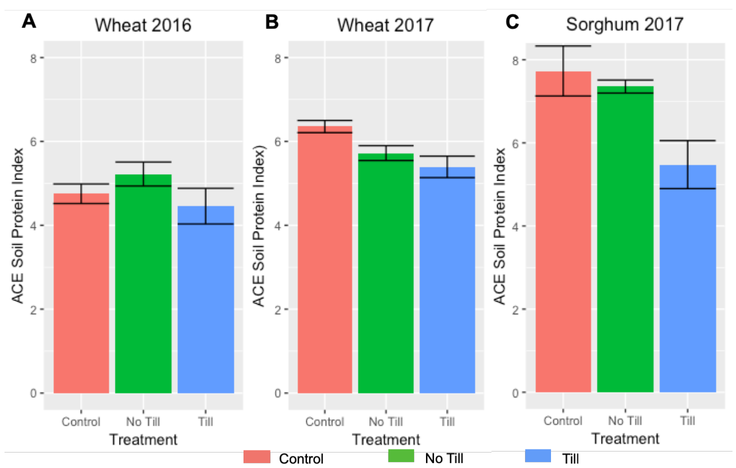

Figure 8. ***ACE soil protein index measures for soils from wheat 2016 (A), wheat 2017 (B), and sorghum 2017 (C). A significant treatment difference was observed in the wheat 2017 and sorghum 2017 plots, where the till was significantly lower than the other two treatments.***

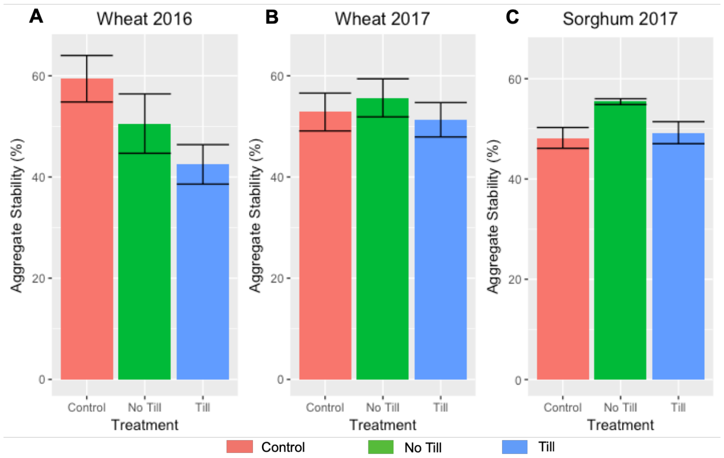

Figure 9. ***Aggregate stability (%) measures for soils from wheat 2016 (A), wheat 2017 (B), and sorghum 2017 (C). A significant treatment difference was observed only in the sorghum 2017 plots, where no till was significantly higher than the other two treatments.***

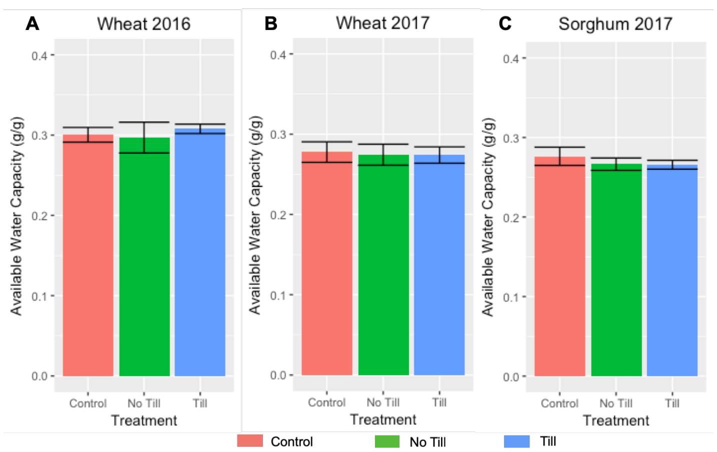

Figure 10. ***Available water capacity (g/g) measures for soils from wheat 2016 (A), wheat 2017 (B), and sorghum 2017 (C). No significant treatment difference was found, in either year or crop.***