# Long-Term Cover Crop Effects on Soil Organic Carbon, Nitrogen Stocks, and Water Stable Aggregates in the Semiarid Central Great Plains

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## Background and Objectives

Growing cover crops (CCs) in semiarid dryland cropping systems in the central Great Plains (CGP) can provide several benefits to soil health.

- Replacing a portion of the conventional fallow period with CCs has the potential to reduce susceptibility of soils to wind and water erosion
- Haying of CCs for forage can provide an economic benefit to offset potential loss in revenue associated with decreased crop yields when CCs are grown ahead of a cash crop in dry years.

The objective of this study was to assess the impact of 11 years of CC management on the soil organic carbon (SOC) stock, nitrogen stocks, and soil structural properties.

## Methods

This study was initiated in 2007 at the Kansas State University Southwest Research-Extension Center near Garden City, Kansas to examine the impact of CC management in semiarid dryland cropping systems. The experimental design was a split-plot randomized complete block with four replications. Main plots were crops in each phase of a no-till winter wheat-grain sorghum-fallow (WSF) crop rotation (Fig. 2) and sub-plots were CC treatments. All crop phases were present every year. Soil samples were collected from the 0-5 cm and 0-15 cm depths in 2012, and 2018 and analyzed for soil health parameters.

Treatments included:

1. Control, Year 1: wheat; Year 2: sorghum; Year 3: fallow (common practice)
2. Year 1: wheat; Year 2: sorghum; Year 3: spring grain pea
3. Year 1: wheat; Year 2: sorghum; Year 3: spring triticale (standing/hayed)
4. Year 1: wheat; Year 2: sorghum; Year 3: oat/triticale/pea (standing/hayed)
5. Year 1: wheat; Year 2: sorghum; Year 3: cocktail* (standing/hayed)

*oat, triticale, pea, buckwheat, turnip, and radish

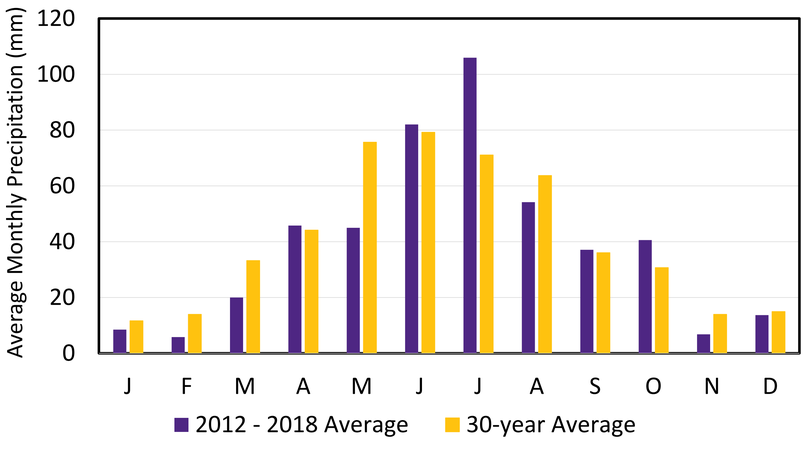


Figure 1. Average monthly precipitation (mm) near Garden City, Kansas from 2012–2018 and the 30–year average (1984–2014)

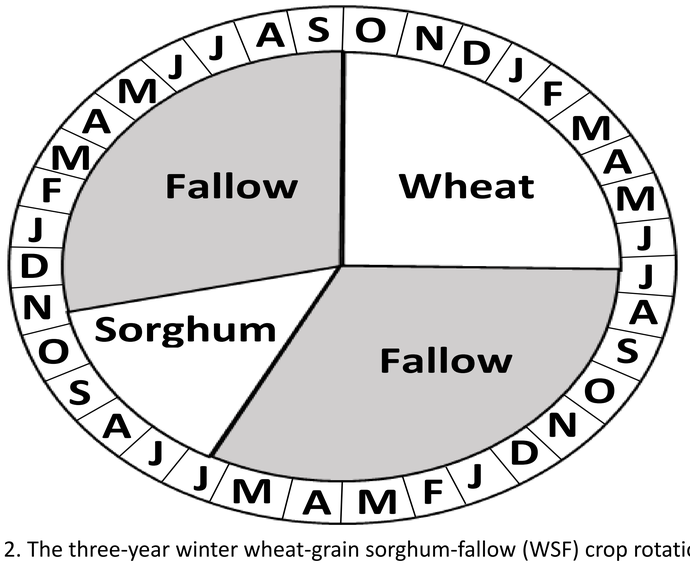


Figure 2. The three-year winter wheat-grain sorghum-fallow (WSF) crop rotation.

## Results

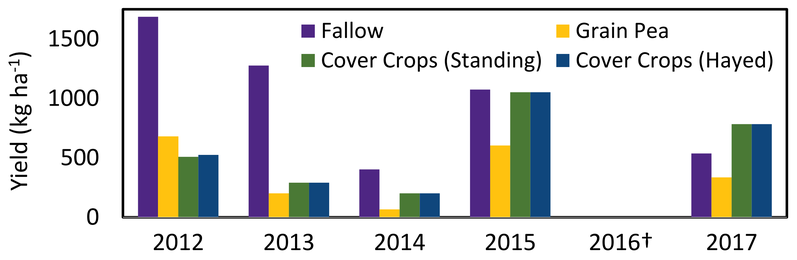


Figure 3. Winter wheat yield in kg ha$^{-1}$ from 2012 to 2017.
†In 2016, a large infestation of jackrabbits and feeding damage resulted in a failed crop and no grain production.

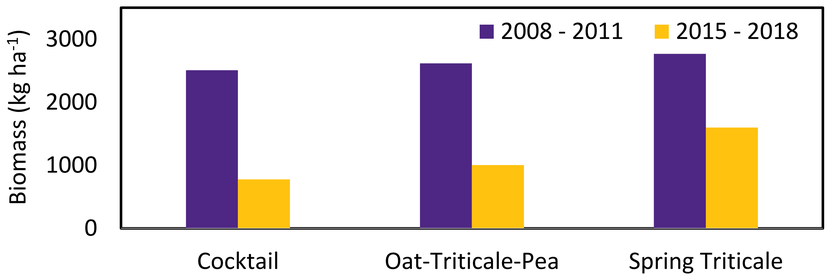


Figure 4. Cover crop biomass production in kg ha$^{-1}$ averaged from 2008 to 2011 and from 2015 to 2018.

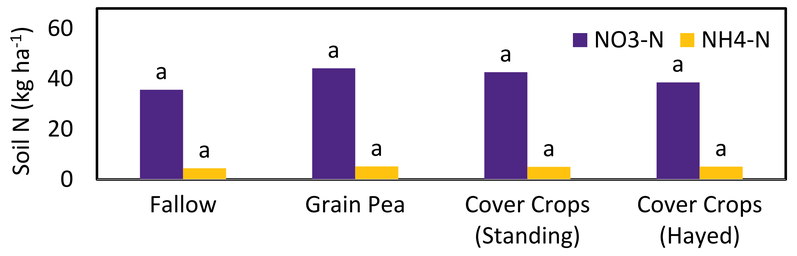


Figure 5. Soil Nitrate ($NO_3$) and Ammonium ($NH_4$) in kg ha$^{-1}$ in the 0 – 15 cm depth.
†Means with the same lowercase letter are not significantly different among treatments.

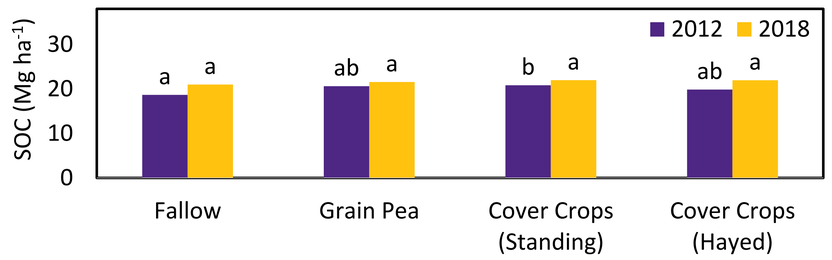


Figure 6. SOC pool in Mg ha$^{-1}$ from the 0 – 15 cm depth in 2018 and 2012.
†Means with the same lowercase letter are not significantly different among treatments within years.

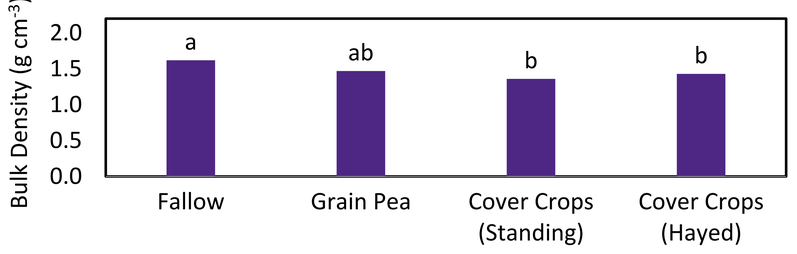


Figure 7. Bulk density in g cm$^{-3}$ in the 0 – 5 cm soil depth.
†Means with the same lowercase letter are not significantly different among treatments.

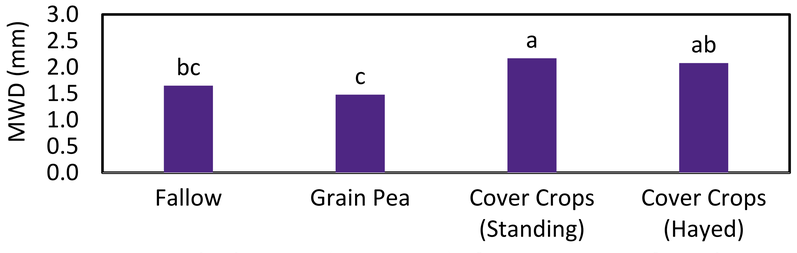


Figure 8. Mean weight diameter (MWD, mm) of wet aggregates from the 0 – 5 cm soil depth.
†Means with the same lowercase letter are not significantly different among treatments.

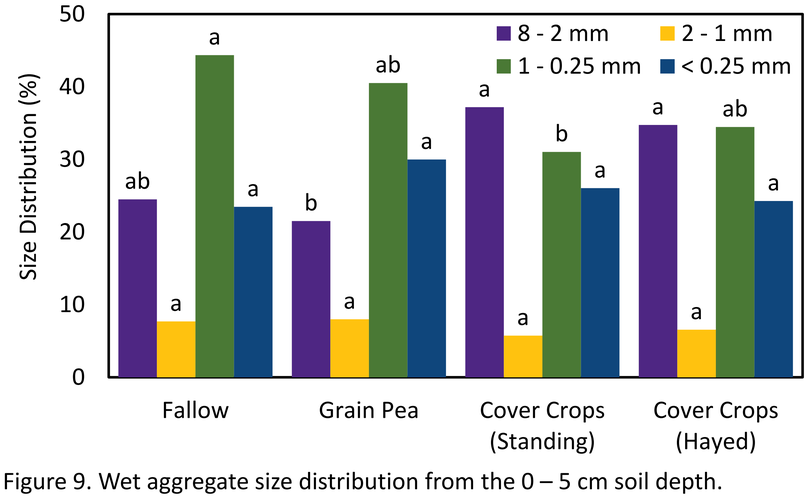


Figure 9. Wet aggregate size distribution from the 0 – 5 cm soil depth.
†Means with the same lowercase letter are not significantly different among treatments within each aggregate-size fraction.

## Discussion

- SOC stocks in 2018 showed no significant differences compared to fallow, but were greater than values determined in 2012 (Fig. 6).
  - This suggests SOC gains made with CCs in semiarid environments could be maintained even with sustained periods of drought (Fig. 1) that reduce total carbon inputs from lower CC biomass (Fig. 4) and wheat yields (Fig. 3) when CCs are grown under very dry conditions.
- Bulk density decreased with CCs compared to fallow (Fig. 7).
- MWD of wet aggregates was not different when CCs were left standing (2.17 mm) or when hayed (2.08 mm), but both were greater than fallow (1.65 mm) or grain pea (1.49 mm) (Fig. 8).
- The proportion of larger (8-2 mm) aggregate size fractions was increased with CCs (36%) compared to grain pea (22%), but was similar to fallow (25%)(Fig. 9).

## Conclusions

- Cover crops can improve soil health compared to chem-fallow.
- Haying of CCs had no effect on soil health indicators compared to CCs left standing.
- No differences in SOC values between treatments in 2018 likely due to drought conditions reducing biomass production relative to pre-2012.
- Grain peas and CCs did not increase soil N compared to fallow. Recommended rates of N were applied to wheat and sorghum which may have also masked any observable differences.
- Relative to fallow, CCs decreased bulk density and improved MWD of wet aggregates.
- Growing a CC increased the proportion of larger (8-2 mm) aggregates size fractions compared to grain pea, but was similar to fallow.