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Dual Use of Cover Crops for Forage Production and Soil Health in Dryland Crop Production

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Dual Use of Cover Crops for Forage Production and Soil Health in Dryland Crop Production

Abstract

Integrating a cover crop (CC) into dryland crop production in the semiarid central Great Plains (CGP) can provide several ecosystem benefits. However, CC adoption is slow and not widely popular in the CGP because CCs utilize water that otherwise would be available for the subsequent cash crop. Grazing or haying CCs can provide economic benefits to offset revenue loss associated with decreased crop yields when CCs are grown ahead of a cash crop. Objectives of the current research were to 1) determine forage production of CC mixtures, and 2) evaluate the impacts of removing CCs for forage on subsequent crop yields and soil health. Cover crop treatments evaluated were a mixture of oat and triticale that were either grazed, hayed or left standing compared to chem-fallow. The study was conducted from 2015 to 2019 in a wheat-sorghum-fallow cropping system with all crop phases present in each block and year of the study. Results showed forage mass varied from year-to-year, ranging from 3145 lb/a in 2015 to 1655 lb/a in 2019, and was highly dependent on growing season precipitation and temperature. Forage crude protein, digestibility, and mineral concentrations were greatest in years when CCs were sampled earlier in maturity. Average CC residue left post-grazing was 79% of forage mass available pre-grazing, and ranged from 60% in 2016 (no regrowth) to 123% in 2019 (more regrowth). Growing CCs ahead of wheat reduced winter wheat yield in 2 out of the 4 years compared to chem-fallow. Across years, winter wheat yield with chem-fallow was 51.9 bu/a compared to an average of 41.8 bu/a for the CC treatments. Cover crop treatments had no effect on grain sorghum yield. Sorghum grain yield ranged from 70.7 bu/a with CC hayed to 77.0 bu/a for the CC grazing treatment. Winter wheat or sorghum yields with haying or grazing a CC were similar to yields when CCs were left standing. Grazing CCs increased bulk density near the soil surface in 1 of the 4 years when bulk density was measured. Compared to fallow, growing a CC increased soil organic carbon (SOC) concentration measured within the top 2- to 6-inch soil depth, but not near the soil surface (0 to 2 inches).

Keywords

cover crops, dryland, forage, grazing, soil organic matter

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Summary

Integrating a cover crop (CC) into dryland crop production in the semiarid central Great Plains (CGP) can provide several ecosystem benefits. However, CC adoption is slow and not widely popular in the CGP because CCs utilize water that otherwise would be available for the subsequent cash crop. Grazing or haying CCs can provide economic benefits to offset revenue loss associated with decreased crop yields when CCs are grown ahead of a cash crop. Objectives of the current research were to 1) determine forage production of CC mixtures, and 2) evaluate the impacts of removing CCs for forage on subsequent crop yields and soil health. Cover crop treatments evaluated were a mixture of oat and triticale that were either grazed, hayed or left standing compared to chem-fallow. The study was conducted from 2015 to 2019 in a wheat-sorghum-fallow cropping system with all crop phases present in each block and year of the study. Results showed forage mass varied from year-to-year, ranging from 3145 lb/a in 2015 to 1655 lb/a in 2019, and was highly dependent on growing season precipitation and temperature. Forage crude protein, digestibility, and mineral concentrations were greatest in years when CCs were sampled earlier in maturity. Average CC residue left post-grazing was 79% of forage mass available pre-grazing, and ranged from 60% in 2016 (no regrowth) to 123% in 2019 (more regrowth). Growing CCs ahead of wheat reduced winter wheat yield in 2 out of the 4 years compared to chem-fallow. Across years, winter wheat yield with chem-fallow was 51.9 bu/a compared to an average of 41.8 bu/a for the CC treatments. Cover crop treatments had no effect on grain sorghum yield. Sorghum grain yield ranged from 70.7 bu/a with CC hayed to 77.0 bu/a for the CC grazing treatment. Winter wheat or sorghum yields with haying or grazing a CC were similar to yields when CCs were left standing. Grazing CCs increased bulk density near the soil surface in 1 of the 4 years when bulk density was measured. Compared to fallow, growing a CC increased soil organic carbon (SOC) concentration measured within the top 2- to 6-inch soil depth, but not near the soil surface (0 to 2 inches).

Introduction

Cropping system diversification with CCs can provide several benefits. These include improving soil quality, nutrient cycling, weed and pest suppression, as well as reduced wind erosion. Cover crop adoption is not widely popular in water-limited environments because CCs utilize water that otherwise would be available to the subsequent

cash crop. Grazing or haying CCs as forage can provide economic benefits and help offset loss in revenue associated with decreases in wheat yields when cover crops are grown in place of fallow. This approach could provide an opportunity for dryland producers to build soil health and produce harvestable forage for the region's livestock.

The few growers that have adopted CCs in dryland systems are using them for soil health improvement and as a supplemental forage resource. Information is limited on best management options for CCs in dryland systems and producers are asking questions on best CC mixtures, and planting times for integrating CCs into cropping systems in dryland environments. Developing climate-specific CC management options for dryland farmers will improve adoption and CC use in the CGP. Our research effort includes investigating a flex-cover cropping option where CCs are grown only in years when there is adequate soil moisture. Flex-fallow is the concept of only planting CC when soil moisture levels are adequate and the precipitation outlook is favorable. Under drought conditions, implementing flex-fallow should help minimize negative impacts in dry years. Research objectives were to 1) determine forage production of CC mixtures, and 2) evaluate the impacts of removing CCs for forage on soil water content, subsequent crop yields, and soil health.

Procedures

This study is a component of a large CC field experiment initiated in spring 2015 at the Kansas State University experiment fields at HB Ranch near Brownell, KS. The overall goal of the CC trials was to develop climate-specific CC management options for integrating CCs into dryland crop production in western Kansas. Field experiments compared summer fallow to grazing or haying CC, and growing CC solely for cover in the fallow phase of a wheat-sorghum-fallow crop rotation system. Study design was a split-plot with four replications in randomized complete blocks. Main plots were three crop phases of wheat-sorghum-fallow, and sub-plots were ten CC treatments of single, two-, three-, and six-species mixtures of oat, triticale, peas, radish, turnips, and buckwheat compared to chemical-fallow. The CCs were planted in the spring of the fallow phase of the rotation. Each phase of the crop rotation was present within each block in each year of the study. In addition, a flex-cover crop treatment was included and planted to CC only when soil moisture levels were adequate and the precipitation outlook was favorable. This treatment remained as fallow when available soil water content at CC planting was < 12 in., and summer and fall precipitation outlook was not favorable. This treatment was implemented only in 2018 when conditions were met (less soil water content and precipitation outlook was unfavorable). The CC treatments were either grazed, hayed, or left as cover. Generally, grazing and haying of CCs occurred at heading. The CCs were all terminated by the third week in June with glyphosate and 2,4-D in 2015. Paraquat and Aim EC were used to terminate CCs in 2016 through 2019.

Prior to grazing, available forage mass from the grazing treatment was sampled by taking two clippings of 3 ft × 2 ft from each plot. Fresh weights of samples were recorded, and oven dried at 50°C for at least 48 hours in a forced-air oven for dry matter (DM) determination. The plots were then mob-grazed using a stocking density that utilized approximately 30 to 40% of the available forage mass at the time of grazing. Residue left post-grazing was determined as described above. Hayed treatments were harvested at

heading to determine forage DM production and nutritive value. Forage harvests were performed during the last week in May 2015, the first week in June 2016 and 2017, and in the third week of June in 2018 and 2019. During each harvest, a 3-ft × 100-ft forage strip was harvested from each plot using a Carter plot forage harvester (Carter Manufacturing Company, Inc.) to a 6-inch stubble height. Whole plots sample weights were recorded, sub-samples were weighed, and oven dried for DM. Oven-dried samples from both grazing and hayed treatments were ground to pass through a 1-mm mesh screen in a Wiley Mill (Thomas Scientific, Swedesboro, NJ). The ground samples were then analyzed for forage nutritive value [crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), *in vitro* dry matter digestibility (IVDMD)], and tissue nutrient concentrations (Ward Laboratories, Inc., Kearney, NE) using Foss 6500 near infrared spectroscopy (NIRS).

Soil samples were taken to determine bulk density and soil water content at winter wheat planting, and were measured at 3 ft in 2015, and at 5 ft in subsequent years of the study (2016 through 2019). Two soil cores were collected from each plot and data averaged for a single soil bulk density or water content measurement. In 2019, soil samples were taken at 0 to 2 inches and 2 to 6 inches after CC termination to determine SOC concentration. Winter wheat and sorghum grain yields were determined by harvesting a 5-ft × 100-ft area from the center of each plot using a small plot combine. Statistical analysis was conducted with the PROC MIXED procedure of SAS (version 9.4, SAS Inst., Cary, NC) to examine forage production, soil bulk density, SOC, and winter wheat and grain sorghum yields as a function of cover crop management options. This report will summarize results of the oat/triticale CC grazing or haying component of this study.

Results

Forage Mass, Nutritive Value and Cover Crop Residue Post-grazing

Results over five growing seasons showed relatively high forage production but available forage mass varied year-to-year. As expected, the forage mass produced varied over the five years because of variations in soil water availability and air temperature in the spring. Across CC treatments, forage mass was greatest in 2015 (3145 lb/a) and least in 2019 (1655 lb/a, Figure 1a). The lower ($P < 0.05$) CC forage mass production in 2019 was due to wetter than normal spring conditions that delayed cover crop planting until late April. Similarly, a cold and dry spring in 2016 resulted in less CC productivity. In years with limited regrowth (2016, 2017, and 2018), CC forage mass at the time of grazing was similar to ungrazed (cover) CC treatment. However, in 2015 when grazing was initiated early, the ungrazed CC treatment had more biomass than was measured pre-grazing. The hay treatment was harvested at a greater height (6 inches) and therefore had relatively lower yields than cover treatments (clipped at 2 inches). In 2015 and 2019 when there was time for regrowth before CC termination, biomass left after grazing was similar to that measured pre-grazing (Figure 1b). Excluding 2019, which had more post-grazed biomass than pre-grazing, residue left post-grazing across the four remaining years (2015 through 2018) averaged 68% of that at pre-grazing. This result suggests careful grazing of CCs can leave an adequate amount of residue to protect the soil to achieve soil health goals while providing a forage resource for livestock.

Forage CP, IVDMD, and mineral concentrations were greater in years when CCs were harvested just at heading (2015, 2017, and 2019) than when CCs were more mature (2016 and 2018) with seed heads (Table 1). In general, grazed CC treatments had more CP, nutrients (Ca, P, K) and IVDMD concentrations than CC hayed treatments. Similarly, the hayed treatment had significantly greater ADF and NDF concentrations compared to the grazed treatments (Table 1). This was expected because grazed treatments were usually sampled 7 to 10 days earlier than the hayed treatments. Delaying harvest resulted in more mature plants, reducing forage digestibility and nutritive value. Nonetheless, in a production setting, grazing of forage would likely begin at a more immature stage of forage growth and the quality would match the needs of stocker cattle.

Soil Bulk Density and Soil Organic Carbon

In general, except in 2015, growing a CC had no effect on soil bulk density measured at 0 to 2 inches at winter wheat planting. Grazing a CC in 2015 resulted in a significant increase in soil bulk density at 0 to 2 inches (Figure 2a). This was because of a significant precipitation event (> 3 inches of rainfall) that occurred during grazing, which prompted removing of cattle from the plots to prevent further soil compaction. No difference in bulk density was observed beyond the top 2 inches over the study period. The SOC concentration measured in 2019 was not different due to treatments at the surface 0- to 2-inch soil depth. However, the CC treatments did increase SOC concentration within 2- to 6-inch depth (Figure 2b) compared to fallow. The SOC concentration with haying or grazing CCs was similar to that of the true cover treatment, suggesting belowground biomass from CC roots contributes to SOC storage. This short-term study showed CCs could be utilized for forage with minimal impacts on SOC.

Winter Wheat and Grain Sorghum Yield

Winter wheat yields after CCs were not significantly affected in 2016 and 2018 (Figure 3a). However, a significant decrease in winter wheat yield was observed in 2017 and 2019 when CCs were grown ahead of wheat (Figure 3a). In 2019, however, the CC hayed treatment had similar wheat yield compared to chem-fallow. Cover crops were terminated in late June in 2018, at that point triticale had matured seeds that resulted in volunteer triticale reducing winter wheat yields in the cover and grazed CC treatments. Averaged across the 5 years, growing a CC ahead of wheat reduced winter wheat yields compared to chem-fallow. Wheat yields averaged 41.8 bu/a with CC treatments and 51.9 bu/a with fallow (Figure 3a), representing a 10 bu/a decrease in wheat yields when a CC was planted ahead of wheat. In general, CC management had no effect on sorghum grain yield in this study. Across years, sorghum grain yield ranged from 70.1 bu/a with the hayed treatment to 77.0 bu/a when a CC was grazed.

Over this 5-year study, haying or grazing a CC had no significant effect on wheat or sorghum yields compared to yields when CC was left as cover (Figures 3a and 3b). This finding suggests CC could be utilized for forage with similar impact on subsequent crop yields compared to when grown as a true CC. This is significant because utilizing CC for forage (grazing or haying) will generate income to offset revenue loss associated with decreased crop yields when CCs are grown ahead of a cash crop. Another benefit is potential savings in herbicide application costs from growing CCs. In this study, three

to four herbicide applications were done to control weeds in chem-fallow treatment compared to two herbicide applications in the CC treatments (termination of CCs and another burndown prior to wheat planting).

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Table 1. Cover crop forage mass and nutritive content¹ at heading, before grain fill over 5 years at the Kansas State University experiment fields at HB Ranch near Brownell, KS

Year	CP	ADF	NDF	IVDMD	Ca ¹	P	K
----- % -----							
2015	19.1 a ²	33.7 c	53.8 c	84.9 a	0.77 a	0.41 a	3.13 a
2016	8.6 d	39.9 a	66.5 a	66.0 b	0.31 c	0.25 d	2.07 c
2017	11.7 b	34.5 bc	62.7 ab	73.0 b	0.46 b	0.29 bc	2.13 bc
2018	9.9 cd	36.4 b	58.1 bc	68.2 b	0.35 c	0.27 cd	2.32 bc
2019	10.3 c	35.8 b	57.1 bc	80.1 a	0.37 c	0.30 b	2.33 b
Cover crop	%						
Grazed	12.9 a	34.2 b	56.2 b	76.6 a	0.51 a	0.31 a	2.43 a
Hayed	11.0 b	37.9 a	63.0 a	72.4 b	0.39 b	0.29 b	2.37 a

CP = crude protein. ADF = acid detergent fiber (higher values reflect lower digestibility). NDF = neutral detergent fiber (higher values reflect lower animal intake). IVDMD = *in vitro* dry matter digestibility (reflects relative energy differences).

¹Only planted when there was adequate moisture. Ca = calcium. P = phosphorus. K = potassium.

²Values within a column followed by the same letter(s) are not significantly different ($P < 0.05$).

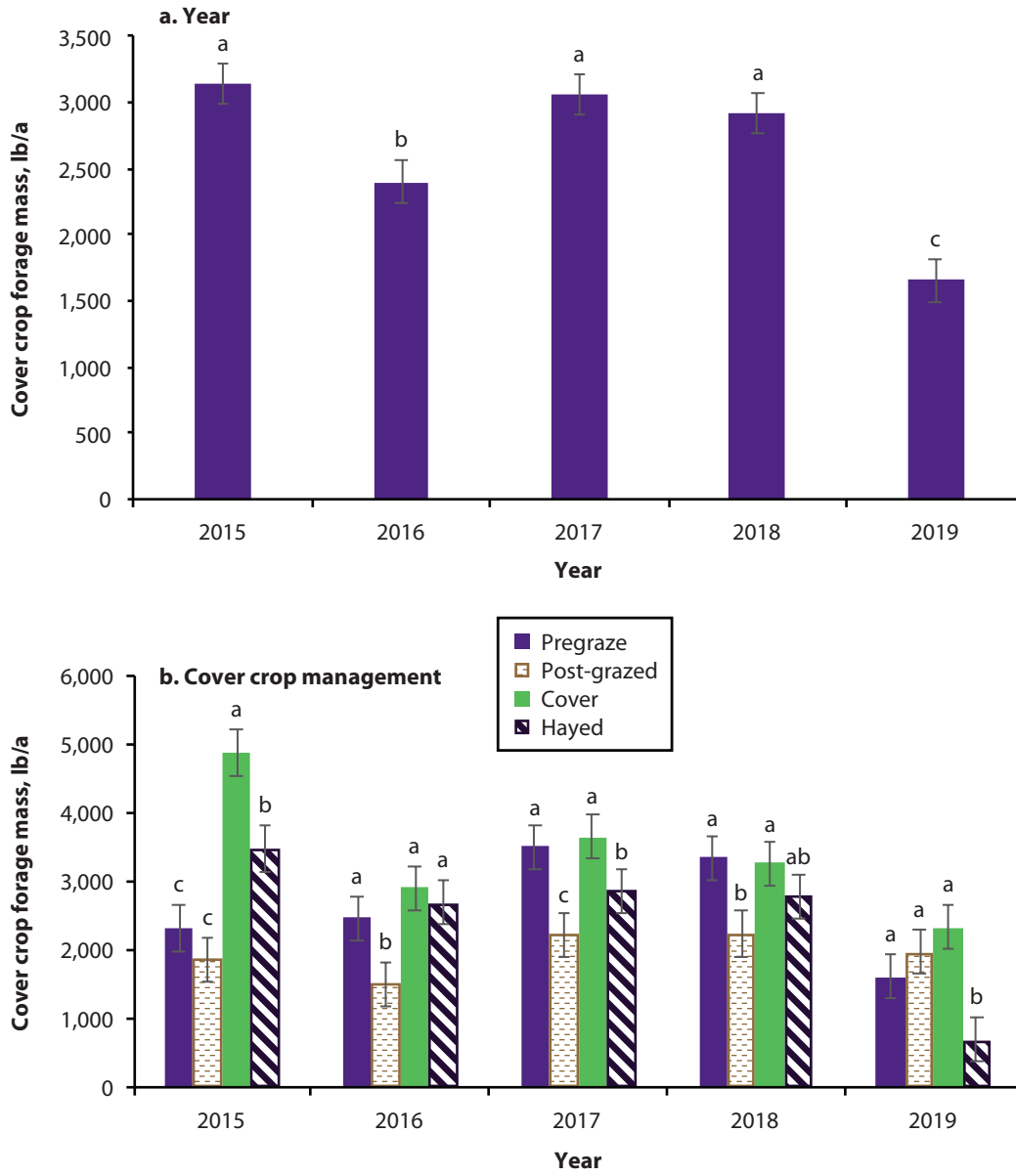


Figure 1. Forage mass as influenced by (a) year and (b) cover crop management at the Kansas State University experiment fields at HB Ranch near Brownell, KS. Bars followed by the same letter(s) are not significantly different ($P < 0.05$).

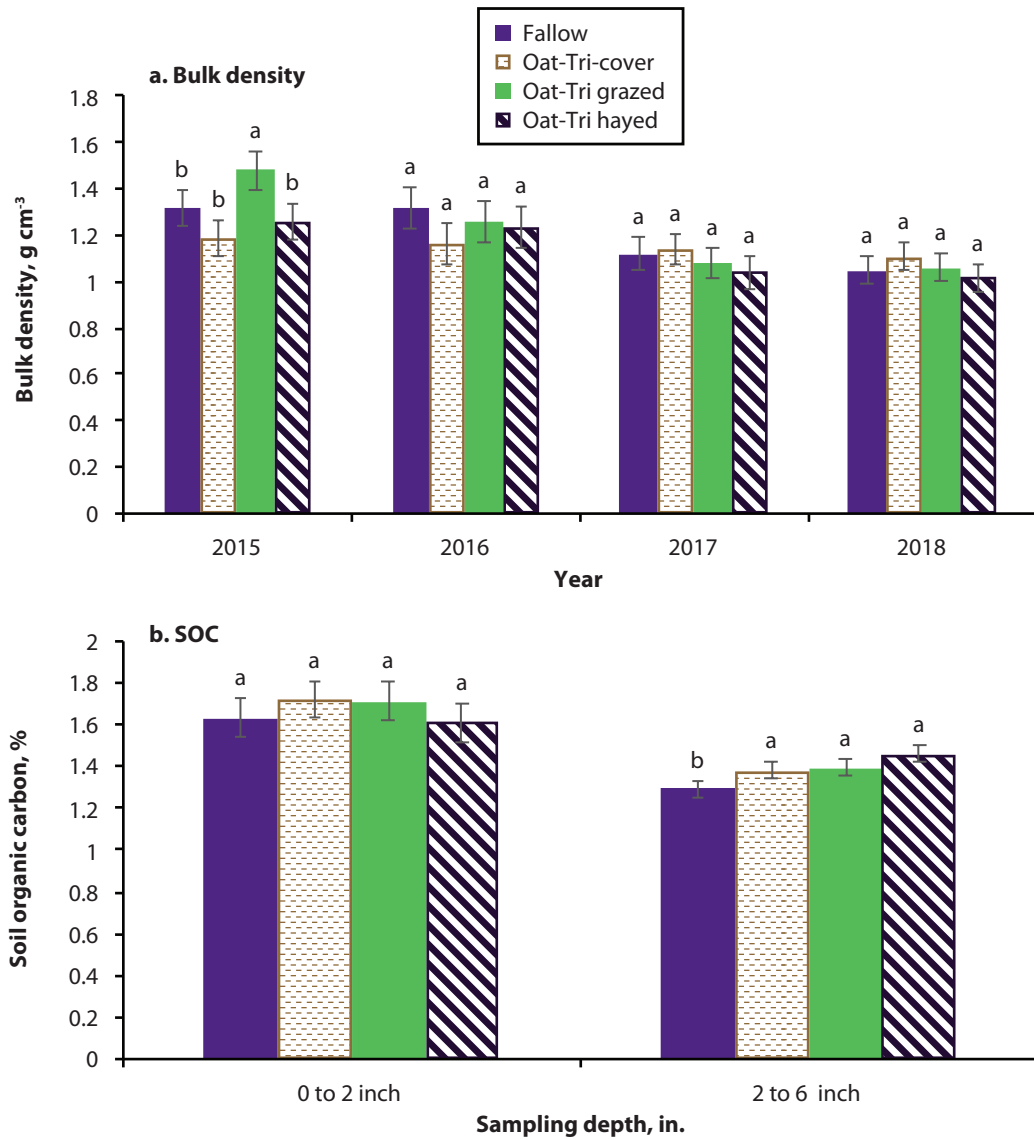


Figure 2. Cover crop management effect on soil bulk density (a) measured from fall 2015 to 2018 and soil organic carbon (b) measured in 2019 at the Kansas State University experiment fields at HB Ranch near Brownell, KS. Bars followed by the same letter(s) are not significantly different ($P < 0.05$).

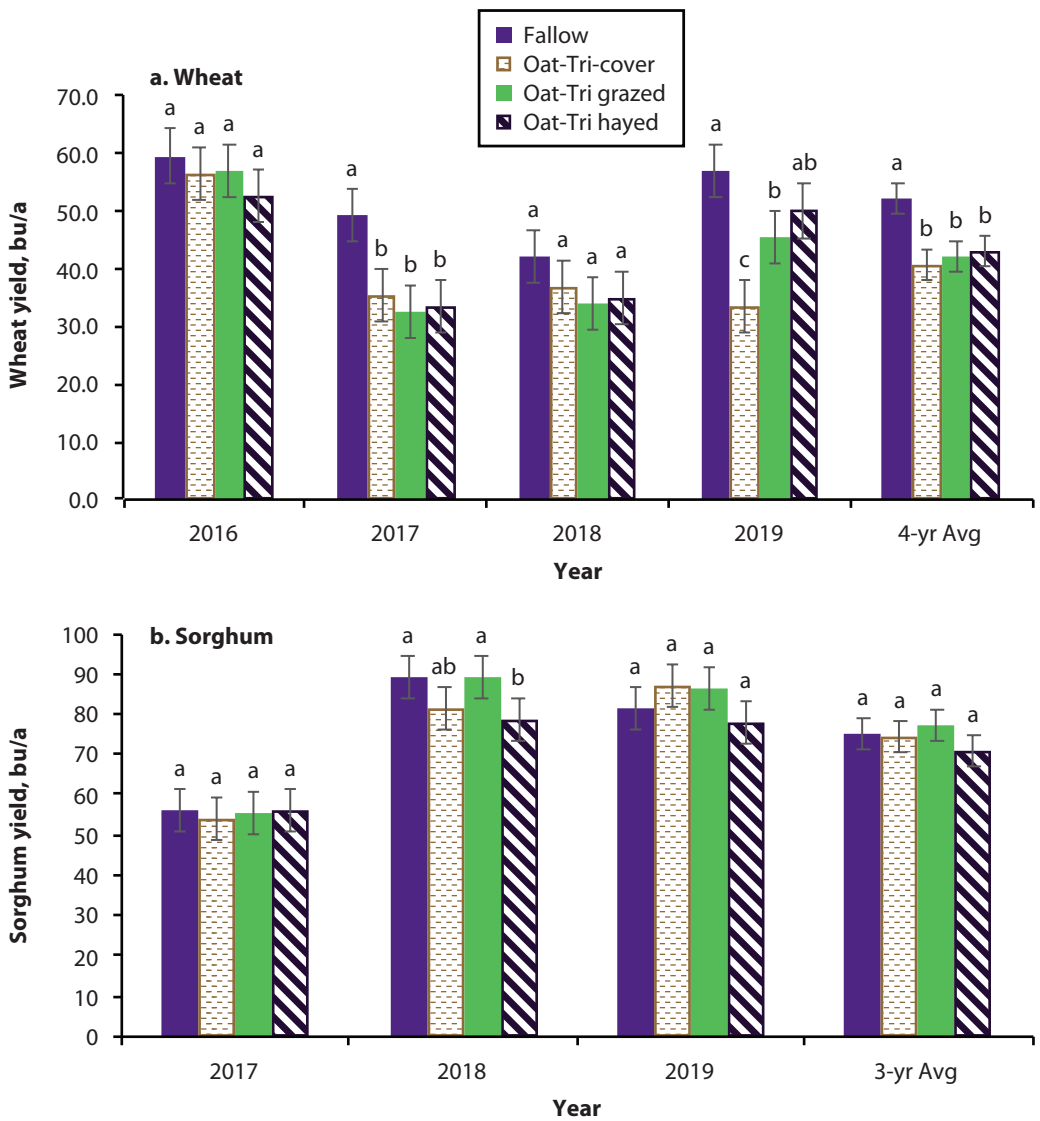


Figure 3. Cover crop management effect on winter wheat grain yield (a) and grain sorghum yield (b) over the study period at the Kansas State University experiment fields at HB Ranch near Brownell, KS. Bars followed by the same letter(s) are not significantly different ($P < 0.05$).