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Impact of Cover Crop Planting Timing and Fallow Management on Biomass Production and Soil Properties in Dryland Cropping Systems

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Summary

Soil health and ecosystem benefits of cover crops (CCs) in semi-arid dryland cropping systems are dependent on CC biomass productivity. The objectives of this study were to evaluate the effects of CC planting time (spring vs. fall) on CC biomass, and fallow management [no-tillage (NT) vs. occasional tillage (OT)] and CC effects on residue cover, and soil aggregate stability in a winter wheat (*Triticum aestivum* L.)-sorghum (*Sorghum bicolor* Moench)-fallow (WSF) rotation. The experiment was conducted at the Kansas State University Hearting Beason (HB) Ranch using a split-plot randomized complete block design with four replications. The main plots were crop phase and sub-plot treatments with triticale (×*Triticosecale* Wittm.), pea (*Pisum sativum* L.) and rapeseed (*Brassica napus var. napus*) mixture planted in the fall**,** oat (*Avena sativa* L.), triticale and pea CC mixture planted in the spring, NT fallow, and OT fallow. Results showed that CC biomass productivity was not significantly different between fall and spring-planted CCs. However, there was a trend for greater biomass production with fall-planted CCs. This suggests flexibility in planting time for maximizing CC biomass productivity in the WSF rotation. Fall-planted CCs had the highest residue cover (89%), followed by spring planting (81%), and NT (78%), while OT had the lowest (67%) due to increased soil disturbance. Soil aggregate stability was greatest under fall and spring-planted CCs, while OT reduced aggregate stability compared to CCs or NT fallow. These findings showed NT with CCs either planted in the fall or spring can maintain soil health by increasing residue cover and soil aggregation in semi-arid dryland cropping systems.

Introduction

In semi-arid environments like the central Great Plains, improving soil health is crucial for sustainable agriculture. Cover crops (CCs) in dryland cropping systems can play a significant role in enhancing soil properties, improving nutrient cycling, and increasing water retention. However, their effectiveness is highly dependent on productivity from CC biomass. The timing of CC establishment influences growth duration, biomass accumulation, and soil health benefits, making it a critical factor for farmers and land managers in these water-limited environments.

Cover crops contribute to soil health improvements by increasing organic matter, enhancing microbial activity, and reducing soil erosion. Early-planted CCs could produce greater biomass due to an extended growing period, leading to improved soil cover and associated soil health benefits. Conversely, delayed planting may limit biomass accumulation due to a shorter growth period and reduced soil moisture availability, which are major concerns in semi-arid regions where precipitation is scarce.

In semi-arid environments, improper timing of CCs can lead to soil moisture depletion, potentially competing with cash crops for water resources. However, when effectively managed, CCs can enhance soil water infiltration, increase water retention, and promote wet aggregate stability, which contributes to improved soil resilience over time. Understanding the relationship between CC timing, management strategies, and soil properties is essential for developing best management practices to improve soil sustainability and productivity in semi-arid environments.

This study investigated the effect of CC planting time (fall or spring) on CC biomass production, fallow management, and CC effects on soil properties in a semi-arid cropping system.

Procedures

This study is a component of a larger CC field experiment that was initiated in spring 2015 at the Kansas State University Hearting Beason (HB) Ranch near Brownell, KS. The overall goal of the CC trials was to develop climate-specific management options for integrating CCs into dryland cropping systems in western Kansas. The current study was established in fall 2023 to investigate the effects of timing of cover crop planting and fallow management on biomass productivity and soil physical properties. The study design was a split-plot randomized complete block with four replications. Crop phase was the main plot and split-plots treatments were triticale (×*Triticosecale* Wittm.), pea (*Pisum sativum* L.) and rapeseed (*Brassica napus var. napus*), oat (*Avena sativa* L.), triticale and pea CC mixture, no-tillage (NT) fallow, and occasional tillage (OT) fallow. The CCs were grown during the fallow phase of a winter wheat (*Triticum aestivum* L.)-sorghum (*Sorghum bicolor* Moench)-fallow (WSF) rotation, planted either in the spring or in fall. Cover crops were managed as standing cover and were compared to NT and OT fallow treatments. The OT treatment was accomplished by tilling to a depth of 3 inches once in July or August during the fallow phase of the rotation prior to winter wheat planting using a sweep plow equipped with 5-ft blades and treaders (Premier Tillage Inc., Quinter, KS, USA). This is a non-inversion, conservation tillage implement commonly used in the semi-arid central Great Plains.

Cover crop biomass was determined by hand-clipping, close to the ground level (~ 1 inch above the soil surface), two areas of 2 × 3 ft per plot. Samples were dried at 122°F in a forced-air oven and weighed to determine dry matter. Intact soil samples were carefully obtained using a flat shovel to determine stability of water-stable aggregates . These samples were air-dried and gently passed through a 19-mm sieve to separate larger aggregates. Subsamples of <8-mm diameter aggregates were then obtained and used to estimate the mean weight diameter (MWD) of water-stable aggregates (WSA) using the wet-sieving method. Residue cover was determined using the line transect method. Statistical analysis was performed using the PROC GLIMMIX procedure in SAS version 9.4, with significance set at $P < 0.10$.

Results and Discussion

Biomass production and residue cover

Biomass of the fall-planted CCs was not significantly different from spring-planted CCs (Figure 1). This suggests that both planting times are viable options for maximizing CC biomass, offering flexibility for when CCs can be planted after sorghum in the WSF rotation.

Fall-planted CCs had the highest residue cover (89%) and it was significantly greater than all other treatments (Figure 2). Although significantly lower than fall-planted CCs, spring-planted CCs (81%) and NT (78%) maintained adequate residue cover compared to the OT (67%). The lower residue cover in OT is likely due to soil disturbance due to tillage, which incorporates some residue into the soil and accelerates residue decomposition.

Aggregate stability

The distribution of water-stable aggregates varied across treatments. Fall and spring-planted CCs had the highest percentage of larger water-stable aggregates (>2-mm diameter), suggesting better soil stability (Table 1). In contrast, OT resulted in the smallest proportion of large aggregates and the highest amount of microaggregates (<0.25-mm diameter). This finding indicates OT could break down soil structure and could predispose dryland soils to erosion. The NT treatment had a similar proportion of small macroaggregates (0.25- to 2-mm diameter) compared to the CC treatments, showing that NT can preserve soil aggregation.

Mean weight diameter of water-stable aggregates was in the order of spring-planted CCs, then fall-planted CCs, then NT fallow, and then OT fallow (Table 1). Overall, these results suggest that CCs and NT help maintain greater soil structure, while OT could reduce soil aggregate stability.

Conclusion

This study highlights the impact of cover crop planting time on biomass production and soil properties in a semi-arid cropping system. Fall planting produced slightly more biomass than spring planting, but the difference was not statistically significant, suggesting flexibility in planting times for biomass production. Planting CCs in the fall resulted in greater residue cover, but soil improvement as indicated by aggregate stability was not different from spring-planted CCs. The OT treatment had the lowest (67%) residue cover and aggregate stability, likely due to soil disturbance, residue incorporation, and residue breakdown. Overall, cover cropping, either planting in the spring or fall, and NT practices maintained the soil health by increasing residue cover and soil aggregation in this dryland WSF cropping system.

Acknowledgments

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Table 1. Effects of cover crop planting time and tillage on water-stable aggregate size distribution and mean weight diameter (MWD)

Treatment	>2mm	2-0.25mm	<0.25mm	MWD
	-------------------------	%	-------------------------	mm
Fall planted	11.9a	35.9ba	52.3b	0.92ba
Spring planted	12.1a	38.9ba	48.9b	0.98a
Occasional tillage fallow	6.8b	31.3b	61.8a	0.65c
No tillage fallow	7.4b	41.9a	50.6b	0.73bc

Means followed by the same letter within a column are not significantly different *(P* < 0.10).

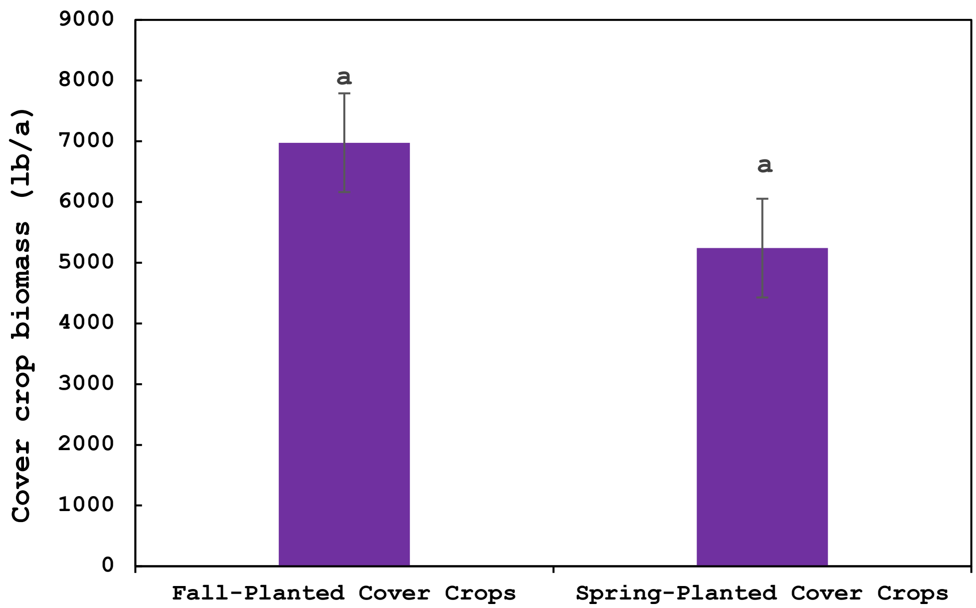

Figure 1. Effects of cover crop planting time on biomass productivity in 2024 at Hays, KS. Means with the same letter are not significantly different (*P* < 0.10).

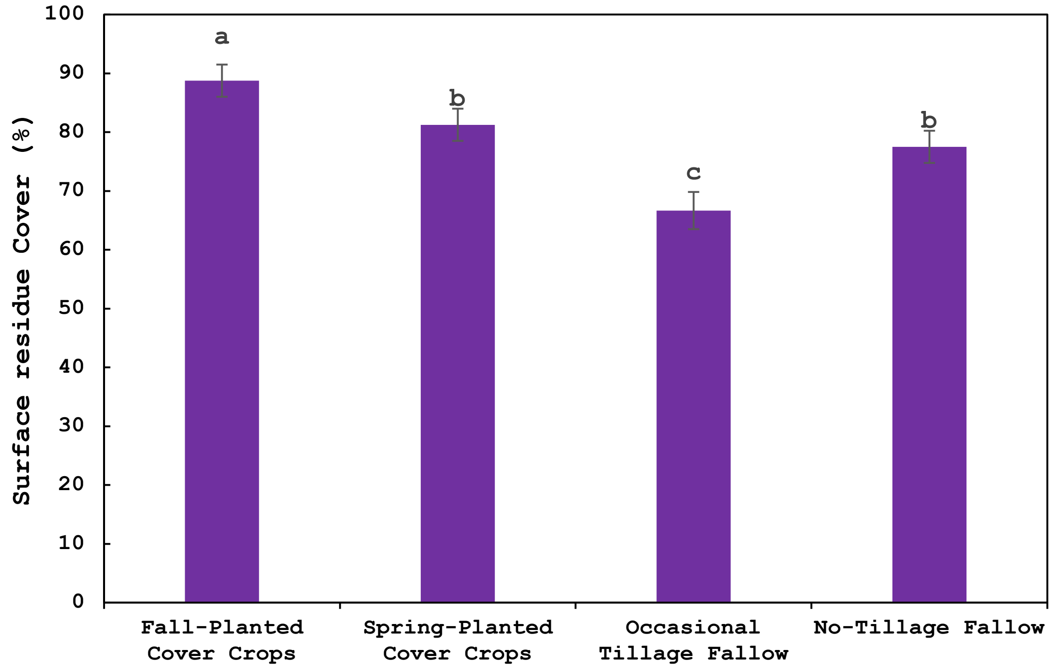

Figure 2. Effects of cover crop planting time and tillage on soil surface residue cover. Means with the same letter are not significantly different ($P < 0.10$).