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Cover Crop Impacts on Soil Water Status

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Cover Crop Impacts on Soil Water Status

Abstract

Water is a primary concern for producers in the Great Plains; as such, research is warranted to quantify how much cover crops affect the amount of soil water available to subsequent cash crops. Cover crop mixes have been marketed as a means to conserve water in no-till cropping systems following winter wheat (*Triticum aestivum* L.) harvest. The objectives of this study are to quantify changes in soil profile water content in the presence of different cover crops and mixtures of increasing species complexity, to quantify their biomass productivity and quality, and to quantify the impact of cover crops on subsequent corn (*Zea mays* L.) yields. We hypothesized the change in soil water brought on by the cover crop treatments would be correlated to the quantity of biomass produced and the species composition, rather than mixture complexity. Soil moisture was measured using a neutron probe to a depth of 9 ft. Results from 2013–14 showed no difference in water use between cover crop mixtures and single species. Cover crops depleted the soil profile by a maximum of 3.5 in. during growth, but fallow was able to gain 0.75 in. of water during the same period. At the time of corn planting, soil moisture under all cover crops had replenished to levels at cover crop emergence, except for the brassicas, which had extracted water from deeper in the profile. Corn yields were reduced following the grass cover crops and the six-species mix. Corn yields were more closely related to the carbon:nitrogen (C:N) ratio of the cover crop residue than to profile soil moisture at corn emergence. The fact that yields were similar for corn after fallow and for corn after brassica cover crops implied that water was not the cause of yield reductions after the other cover crops.

Keywords

cover crops, soil water, fallow, corn

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Summary
Water is a primary concern for producers in the Great Plains; as such, research is warranted to quantify how much cover crops affect the amount of soil water available to subsequent cash crops. Cover crop mixes have been marketed as a means to conserve water in no-till cropping systems following winter wheat (*Triticum aestivum* L.) harvest. The objectives of this study are to quantify changes in soil profile water content in the presence of different cover crops and mixtures of increasing species complexity, to quantify their biomass productivity and quality, and to quantify the impact of cover crops on subsequent corn (*Zea mays* L.) yields. We hypothesized the change in soil water brought on by the cover crop treatments would be correlated to the quantity of biomass produced and the species composition, rather than mixture complexity. Soil moisture was measured using a neutron probe to a depth of 9 ft. Results from 2013–14 showed no difference in water use between cover crop mixtures and single species. Cover crops depleted the soil profile by a maximum of 3.5 in. during growth, but fallow was able to gain 0.75 in. of water during the same period. At the time of corn planting, soil moisture under all cover crops had replenished to levels at cover crop emergence, except for the brassicas, which had extracted water from deeper in the profile. Corn yields were reduced following the grass cover crops and the six-species mix. Corn yields were more closely related to the carbon:nitrogen (C:N) ratio of the cover crop residue than to profile soil moisture at corn emergence. The fact that yields were similar for corn after fallow and for corn after brassica cover crops implied that water was not the cause of yield reductions after the other cover crops.

Introduction
Cover crops have become increasingly popular in no-till systems in recent years as a tool to increase cropping system intensity and diversity. One of the main concerns of Kansas producers is the possibility that cover crops may reduce the amount of soil water stored in the profile for the next grain crop, potentially reducing yields. Some have suggested that complex cover crop mixtures may extract water differently than individual species. To quantify changes in soil profile water content under different cover crops and mixtures, 11 treatments were imposed during the fallow period between winter wheat harvest and corn planting at Manhattan and Belleville, KS. Treatments include both single species and mixtures of increasing complexity as well as a chemical fallow control (Table 1). Results are presented as the average for each type of cover crop as indicated in Table 1 and include results from Manhattan, the only location to have a full rotation to the next corn crop.

Procedures

Cover crops were drilled immediately following wheat harvest in 2013 using a Great Plains no-till drill and were terminated with herbicide in late September at flowering of most species. Seeding rates and ratios were based on recommendations from prominent cover crop seed marketers and publications. Biomass was hand-harvested shortly after termination. Soil water below each treatment was measured using a neutron probe at 1-ft increments to a depth of 9 ft. Neutron probe readings were collected at intervals beginning at cover crop emergence until just before corn planting the following spring. Readings were taken approximately weekly during cover crop growth and monthly up to and throughout corn growth. Readings taken after corn emergence were taken only in the chemical fallow and the brassica species that had extracted the most water during growth.

Results

Figure 1 shows that all cover crop types extracted a similar amount of water to a depth of 3.5 ft by October 16, 2013. The soil profile under the fallow treatment contained more water than all cover crop treatments to a depth of 3.5 ft on that date. The soil contained less water below the brassicas at depths of 5.5 to 7.5 ft compared with the other treatments. By the next spring (Figure 1), differences in soil water at depths of 1.5 ft and less had mostly disappeared, but soil water was greatest in the chemical fallow plots at depths of 2.5 to 4.5 ft. At depths greater than 4.5 ft, the brassica plots still contained the least soil water.

At termination of the cover crops on September 22, the soil profiles held roughly 3 to 3.5 in. less water than at cover crop emergence to a depth of 9 ft (Table 2). The chemical fallow plots held approximately 0.75 in. more water to the same depth, exhibiting a 40% precipitation storage efficiency based on 1.9 in. of precipitation during this period. Complexity of the cover crop mixture did not affect how much water was extracted from the soil profile. Soil water was monitored throughout the winter until just before corn planting in the spring of 2014. By April 15, the plots in fallow contained roughly 1.5 in. more stored soil water to the 9-ft depth than they had the previous August, storing only 23% of the 6.6 in. of precipitation that fell since the previous August (Table 2). Most of the plots with cover crop treatments regained much of the soil profile water lost the previous summer so they contained nearly the same amount of water in the soil profile as they had at cover crop emergence. The exceptions were the plots with brassica cover crops and those with the mix of nine species, both with less water than when the cover crops emerged the previous August (Table 2). This resulted in 2.9 in. less stored soil water in the plots previously in brassicas and 2.1 in. less water stored in plots previously planted with the nine-species mix compared with fallow prior to corn planting.

Corn was planted in the spring of 2014 to assess the influence of the previous cover crop's soil water depletion on corn growth and yield. Neutron probe access tubes were installed in the two corn treatments that had the least (fallow) and most (tillage radish) water extraction the previous season. Soil water was tracked for those treatments from soon after corn emergence until physiological maturity. After corn had emerged in early May, soil water content was essentially equal down to 2.5 ft for the chemical fallow plots and plots that had been planted to tillage radish (Figure 2). At depths from

3 to 9 ft, the chemical fallow plots contained 1.8 in. more soil water. A difference in soil water between the two treatments continued throughout the corn growing season but was reduced to 1.3 in. by mid-August when corn reached maturity (Figure 2). The fact that soil water content increased at depths greater than 4 ft and decreased at shallower depths implies that corn rooting did not extend beyond 4 ft in this environment.

Although several measures of corn performance were influenced by previous cover crop treatment, corn plant density was unaffected. Plant density was relatively high for this environment to maximize water use and increase the likelihood of detecting cover crop treatment differences associated with soil water status. Corn planted in plots following fallow had only three fired leaves in mid-July, and corn planted after the legume and mixture cover crops had four (Table 2). Corn planted after the grass and brassica cover crops showed nearly five fired leaves. Yields after grass cover crops and the mixture of six lagged by 12 to 15 bu/a compared with the highest-yielding plots (Table 2).

The fact that corn yields were similar for both the fallow and the brassica plots implies that soil water was not the primary driver of the yield response to the previous cover crop, because those treatments had the greatest difference in soil water at corn planting. Instead, reductions in corn yield appear to be more closely related to the presence of a grass cover crop, either alone or in mixtures, and the greater C:N ratio of those cover crop residues (Table 2).

Table 1. Cover crop treatments and groupings by cover crop type

Treatment		Cover crop type
1	Chemical fallow	Fallow
2	Sorghum-sudan grass (SS)	Grasses
3	Pearl millet (PM)	
4	Tillage radish (TR)	Brassicas
5	Winfred rape (WR)	
6	Medium red clover (RC)	Legumes
7	Sunn hemp (SH)	
8	Mix of SS/TR/RC	Mix
9	Mix of PM/WR/SH	
10	Mix of SS/PM/TR/WR/RC/SH	Mix
11	Mix of SS/TR/PM/WR/German millet/cowpeas/ hairy vetch/Ethiopian cabbage/Hunter brassica	Mix

Table 2. Change in soil water, corn yield, and number of fired leaves, and carbon:nitrogen (C:N) ratio of the aboveground residue from cover crop treatments

	Change in soil water content, 0- to 9-ft. depth		Corn after cover crops		C:N ratio of cover crop residue
Cover crop type	August 17 to Sept. 22[1]	August 17 to April 15[3]	Fired leaves	Yield	
	--------------- in. ---------------		number	bu/a	X:1
Fallow	0.76 a[2]	1.54 a	3.0 d	83.6 ab	-----
Grasses	-3.18 b	-0.25 b	4.9 a	72.6 c	55.5 a
Brassicas	-3.52 b	-1.38 c	4.6 ab	83.0 ab	27.6 cd
Legumes	-2.97 b	-0.28 b	4.1 bc	84.6 a	25.7 d
Mixes of 3	-3.14 b	-0.05 b	4.2 abc	75.7 ab	36.9 bc
Mix of 6	-2.92 b	0.10 b	4.0 bc	69.7 c	44.4 ab
Mix of 9	-3.19 b	-0.58 bc	4.2 abc	75.4 ab	42.3 b

[1] Period of cover crop growth.
[2] Values within a column followed by different letters are different at $\alpha = 0.05$.
[3] From cover crop emergence to corn planting.

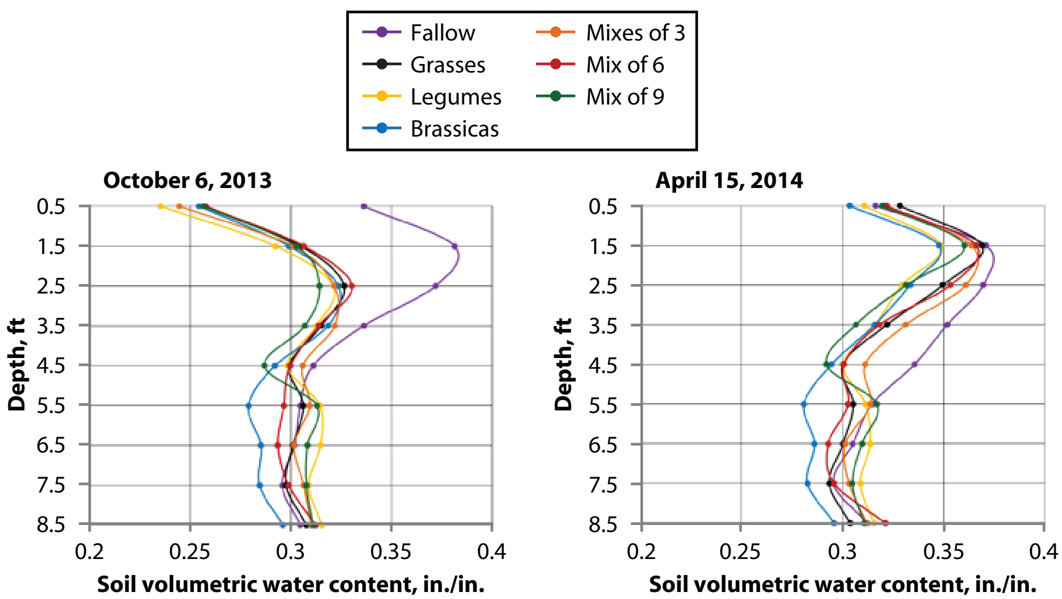

Figure 1. Soil volumetric water content beneath the cover crop treatments and fallow near cover crop termination (left) and before corn planting (right).

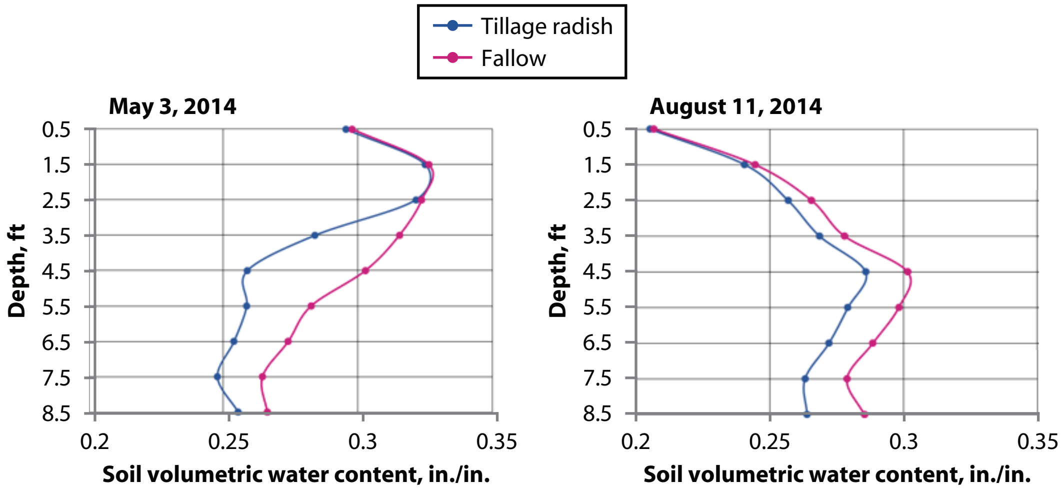

Figure 2. Soil profile volumetric water content under plots previously in chemical fallow or tillage radish the previous year at corn emergence (left) and physiological maturity (right).