Soil Analysis after Growth of Six Winter Cover Crops

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INTRODUCTION

Many long-term studies with winter cover crops have been done showing the effects of crop rotation on soil carbon (Lal et al., 1999, p. 77). These studies have been carried out from 4 to 36 years. Few studies show the effect of cover crops after short periods of time. Hu et al. (1997) in Davis, California, studied short term (< 35 days) effects of cover crops after their incorporation into soil. Seven days after incorporation, soil organic carbon increased from 10 g/kg (before incorporation) to 12 g/kg, but it fell back to 10 g/kg by Days 21 and 35 after incorporation. Apparently, no one has studied the effect of one season's growth of winter cover crops without incorporation into the soil in the semi-arid Great Plains. Thus, the objective of this research was to determine the effect of winter cover crops after one season's growth on soil carbon in Kansas.

MATERIALS AND METHODS

The experiment was carried out at two locations in Kansas: Manhattan (northeastern part of the state), where the soil was a Bismarckgrove-Kimo complex, and Hutchinson (south central part of the state), where the soil was a Funmar-Tarver loam. The six winter cover crops were three legumes [alfalfa (*Medicago sativa* L.), Austrian winter pea (*Pisum sativum* var. *arvense* Poir.; shown in Fig. 1), and red clover (*Trifolium pratense* L.)] and three non-legumes [triticale (X *Triticosecale*; *Triticum* X *Secale*), winter oats (*Avena sativa* L.), and winter wheat (*Triticum aestivum* L.); shown in Fig. 2]. [Freeman (2014) reports the biomass of the cover crops, but gives no soils data.] The cover crops were planted and terminated at times corresponding to how they might be used in a forage sorghum [*Sorghum bicolor* (L.) Moench; shown in Fig. 3] or corn (*Zea mays* L.; shown in Fig. 4) rotation. However, the rotations were simulated, and the corn and sorghum were not planted. The winter cover crops were planted in the fall of 2010 and were chemically terminated with glyphosate in the spring of 2011. The residue was left on the surface of the soil. In Manhattan, the planting times of the cover crops for the corn and sorghum rotations were 6 Oct. 2010 and 16 Nov. 2010, respectively, and the termination dates of the cover crops in the corn and sorghum rotations were 21 April 2011 and 12 May 2011, respectively. In Hutchinson, the planting dates were 6 Oct. 2010 and 19 Nov. 2010 for the corn and sorghum rotations, respectively, and the termination dates were 21 April 2011 and 15 May 2011 for the corn and sorghum rotations, respectively. In the fall, the soil in Manhattan and Hutchinson was sampled on 9 Nov. 2010 and 29 Oct. 2010, respectively. In the spring, the soil in the corn rotation was sampled in Manhattan and Hutchinson on 17 May 2011 and 20 May 2011, respectively. In the spring, the soil in the sorghum rotation was sampled in Manhattan and Hutchinson on 13 June 2011 and 3 June 2011, respectively. Precipitation between October 2010 and May 2011 was 362 mm and 217 mm in Manhattan and Hutchinson, respectively. These amounts were 108 mm and 206 mm below normal for Manhattan and Hutchinson, respectively. The experiment was a randomized complete block experiment with four blocks. In each block, each cover crop covered an area of 6 m by 12 m. In each cover-crop plot, 2 soil samples were taken, so a total of 8 samples for each measurement were taken every sampling time.

Figure 1. Austrian winter pea cover crop

Figure 2. Winter wheat cover crop

Figure 3. Forage sorghum crop (in foreground) in Manhattan, Kansas.

Figure 4. Corn crop in Manhattan, Kansas.

The soil was sampled from the 0 to 30 cm depth, and the samples were analyzed at the Kansas State University Soil Testing Laboratory for pH, organic matter, nitrogen, and carbon. The pH was determined using a 1:1 ratio of soil to water. Organic matter was determined using the Walkley-Black method. Nitrogen and carbon were determined using a combustion technique (Leco Corp., St. Joseph, MI).

RESULTS

Analyses of soil growing the leguminous cover crops were similar to those growing the non-leguminous cover crops. Therefore, analyses from all the soils from the six cover crops were averaged together at each location. The results are shown in Table 1 for Manhattan and Table 2 for Hutchinson.

Table 1. Properties of a silt-loam soil at Manhattan, KS in the 0 to 0.3 m depth in the fall of 2010 before planting of six cover crops and after termination of the cover crops in the spring of 2011 to coincide with a sorghum or a corn rotation. Mean and standard error are shown (n = 48).

Soil property	Fall, 2010	Spring, 2011 Sorghum rotation	Spring, 2011 Corn rotation
pH	5.6±0.03	5.4±0.02	5.7±0.03
Organic matter, %	1.1±0.04	0.8±0.05	0.7±0.03
Nitrogen, %	0.06±0.002	0.04±0.002	0.09±0.002
Carbon, %	0.43±0.02	0.50±0.01	0.48±0.02

Table 2. Properties of a loam soil at Hutchinson, KS in the 0 to 0.3 m depth in the fall of 2010 before planting of six cover crops and after termination of the cover crops in the spring of 2011 to coincide with a sorghum or a corn rotation. Mean and standard error are shown (n=48).

Soil property	Fall, 2010	Spring, 2011 Sorghum rotation	Spring, 2011 Corn rotation
pH	5.6±0.03	5.5±0.03	5.8±0.05
Organic matter, %	1.8±0.03	2.0±0.03	1.5±0.03
Nitrogen, %	0.13±0.001	0.11±0.001	0.13±0.001
Carbon, %	1.17±0.02	1.21±0.01	1.11±0.02

The pH's of the two soils were similar, but the organic matter, nitrogen, and carbon were higher in the soil at Hutchinson than in the soil at Manhattan. At both Manhattan and Hutchinson, the organic matter and nitrogen before planting the cover crops and after their termination tended to be similar. However, at Manhattan, carbon increased in the soil after planting the cover crops. The average value and standard error before planting was 0.43±0.02% C; for the cover crops terminated at sorghum planting time, the average value was 0.50±0.01% C, and for the cover crops terminated at corn planting time it was 0.48±0.02% C. Carbon also increased in the soil at Hutchinson in the sorghum rotation (1.17±0.02% C before planting the cover crops; 1.21±0.01% C after termination). At both Manhattan and Hutchinson, carbon was higher in the sorghum rotation than the corn rotation because the cover crops remained in the soil about three weeks longer in the spring in the sorghum rotation.

CONCLUSION

The results showed that winter crops increased carbon in the soil at Manhattan, which was low in carbon, after one seasons' growth in both the sorghum and corn rotations, and they increased the carbon in the soil at Hutchinson in the sorghum rotation. The increase in soil carbon at Manhattan was 0.07% for the sorghum rotation and 0.05% for the corn rotation; at Hutchinson the increase was 0.04% in the sorghum rotation. The United Nations Paris climate accord, signed in December 2015, included a commitment to increase soil carbon by 0.4 per cent each year. Thus, the increase we observed in the soil carbon after one season's growth of winter cover crops would satisfy about 0.1 to 0.2 of this commitment.

REFERENCES

Freeman, O.W. 2014. Winter cover crops in corn and forage sorghum rotations in the Great Plains. Ph.D. Thesis, Kansas State University, Manhattan. 145 pages.

Hu, S., N.J. Grunwald, A.H.C. van Bruggen, G.R. Gamble, L.E. Drinkwater, C. Shennan, and M.W. Demment. 1997. Short-term effects of cover crop incorporation on soil carbon pools and nitrogen availability. Soil Sci. Soc. Am. J. 61:901-911.

Lal, R., J.M. Kimble, R.F. Follett, and C.V. Cole. 1999. The Potential of U.S. Cropland to Sequester Carbon and Mitigate the Greenhouse Effect. Lewis Publishers, Boca Raton, 128 pp.

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