Influence of Cover Crop on Soil Hydraulic and Physical Properties after Growth Termination

Zoey Ward. Mentor: Dr. Samuel Haruna

School of Agriculture, College of Basic and Applied Sciences, Middle Tennessee State University, Murfreesboro, TN 37132.

Introduction

The projected increase in human population will require more food grown on the set amount of farmland the world has (Connor and Minguez, 2012). In order to sustain the growing population, along with the decrease in arable land, there must be an increase in crop. Although crop yield has been shown to increase the through intensive farming practices and the overuse of resources, the effect of these actions is unsustainable (Yadav et al, 2008). Varying land management strategies influence the quality of soil through altering physical, chemical, and biological processes (Bhardwaj et al, 2011). For example, some cover crops (CC) fix nitrogen and increase yields (Blanco-Canqui and Presley, 2012) while others can take up nitrogen and reduce yields (Behnke and Villamil, 2019). Further, CCs can reduce bulk density (BD), increase saturated hydraulic conductivity (K_{sat}) (Cercioglu et al., 2019), and help buffer against extreme heat change under laboratory conditions (Haruna and Anderson, 2022)

Objectives

This research was designed to answer the following questions:

- Does CCs affect soil hydraulic properties (BD, K_{sat}, water retention) 8 weeks after termination?
- How does CC influence soil thermal conductivity, heat capacity, and thermal diffusivity after their termination?

Materials and Methods

- The experiment consisted of 2 management practices – CC vs NC – laid out in a randomized complete block design.
- The CC used consisted of hairy vetch (*Vicia villosa* Roth), crimson clover (*Trifolium incarnatum* L.) winter wheat (*Triticum aestivum* L.), winter peas (*Lathyrus hirsutus* L.), oats (*Avena sativa*), triticale (*Triticale hexaploide* Lart.), barley (*Hordeum vulgare* L.), and flax (*Linum ustatissimum* L.).
- Soil samples were collected at 3 depths: 0-6, 6-12, and 12-18cm during June and July 2022.
- Bulk density was determined using the core method.
- Soil thermal properties were determined by a KD2 (Decagon Devices, Pullman, WA) heat-pulse sensor.

Results and Discussion

- Cover crop residues left on the soil surface is probably responsible for higher soil organic carbon (SOC) at 0-6 and 6-12 cm depths (Fig. 1).
- The treatment*depth interaction suggests that the roots of CCs below 6 cm depths may be responsible for lowering BD 3 months after termination (Fig. 2b).
- Saturated hydraulic conductivity followed the same pattern as BD, suggesting that CC roots below 6 cm depth can increase subsurface water recharge after CC termination (Fig. 3b).
- For both sample periods, λ and C_V reduced between saturation and field capacity due to a reduction in water content (Table 1).
- In June and July, λ is higher under NC than CC management due to BD and soil water content (Table 1).
- In June, NC had a slightly higher C_V at saturation and field capacity due to higher water content at higher soil water pressures (Table 1; Fig. 4a).
- Surprisingly, NC management had a higher water content from saturation to -5 kPa in June (Fig. 4a).

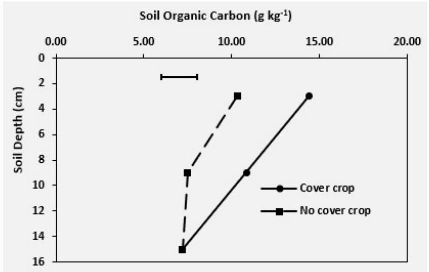

Figure 1: Management effects on soil organic carbon with depth

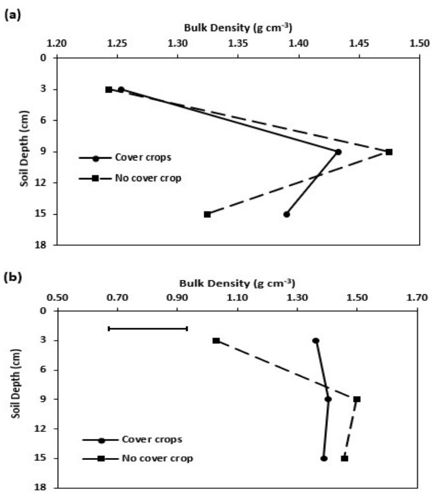

Figure 2: Management effects on bulk density with depth during (a) June, and (b) July

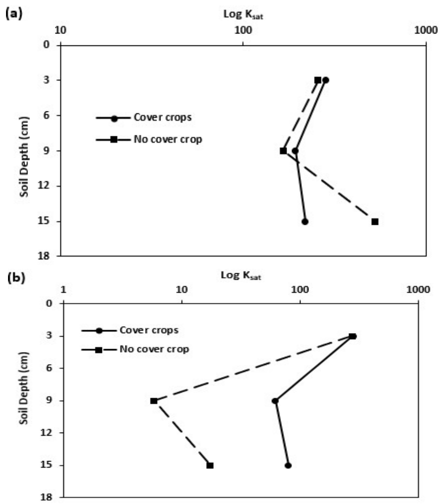

Figure 3: Management effects on saturated hydraulic conductivity (K_{sat}) with depth during (a) June, and (b) July

Table 1. Comparison of Thermal Properties in Relation to Depth, Management, and Pressure

	0 kPa			-33 kPa			-100 kPa		
Treatment	λ (W m⁻¹K⁻¹)	C_V (MJ m⁻³K⁻¹)	D (mm² s⁻¹)	λ (W m⁻¹K⁻¹)	C_V (MJ m⁻³K⁻¹)	D (mm² s⁻¹)	λ (W m⁻¹K⁻¹)	C_V (MJ m⁻³K⁻¹)	D (mm² s⁻¹)
June									
CC	1.679	3.045	0.547	1.618	2.693	0.600	1.649	2.937	0.564
NC	1.743	3.165	0.554	1.691	2.829	0.599	1.689	2.855	0.593
Depth (cm)									
3	1.626	2.999	0.542	1.588	2.701	0.587	1.573b	2.704	0.586
9	1.786	3.083	0.571	1.762	2.830	0.625	1.749a	3.024	0.580
15	1.721	3.234	0.537	1.614	2.752	0.588	1.684ab	2.960	0.569
ANOVA *P > F*									
Treatment	0.394	0.195	0.823	0.294	0.201	0.971	0.434	0.524	0.171
Depth	0.243	0.131	0.620	0.113	0.577	0.299	0.039	0.130	0.797
Tmt*depth	0.296	0.247	0.140	0.837	0.696	0.356	0.163	0.871	0.160
July									
CC	1.712	3.044	0.561	1.586	2.806	0.574	1.690	2.952	0.575
NC	1.739	3.134	0.556	1.686	3.061	0.558	1.662	2.946	0.566
Depth (cm)									
3	1.641	3.074	0.533	1.539	2.883	0.539	1.666b	3.071	0.546b
9	1.864	3.097	0.603	1.794	3.163	0.576	1.850a	2.940	0.632a
15	1.672	3.096	0.541	1.575	2.755	0.584	1.512b	2.834	0.534b
ANOVA *P > F*									
Treatment	0.753	0.333	0.867	0.328	0.379	0.715	0.745	0.963	0.753
Depth	0.111	0.972	0.119	0.117	0.495	0.657	0.028	0.405	0.039
Tmt*depth	0.209	0.468	0.425	0.208	0.843	0.679	0.755	0.166	0.147

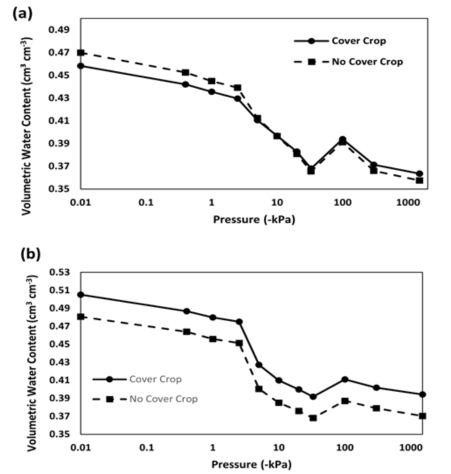

Figure 4. Management Influence on Water Retention during (a) June, and (b) July

Conclusions

- Because of root penetration and the addition of SOC, plots under CC management had a reduced BD.
- Although in June, NC management led to an increase in water content, by July water content was lower than that of CC management at higher soil water pressures.
- Thus, the implementation of CCs can improve water retention, reducing the need for irrigation.
- In general, the lack of significant differences in soil properties between both management practices was probably due to natural soil consolidation in soil particles as a result of several rainfall events after CC termination.
- Therefore, the effects of CCs on soil hydraulic and thermal properties reduces over time after growth termination.

Acknowledgement

This study was supported by the Southern Region Sustainable Agriculture Research and Education (SSARE) James Harrison Hill, SR. Young Scholar Enhancement Grant Program (YES) (LS20-335). Appreciation is also extended to Mr. Will Hutchinson for the permission to conduct this study on his farm.

Literature Cited

Behnke, G. D., & Villamil, M. B. (2019). Cover crop rotations affect greenhouse gas emissions and crop production in Illinois, USA. *Field Crops Research*, *241*. https://doi.org/10.1016/j.fcr.2019.107580

Bhardwaj, A. K., Jasrotia, P., Hamilton, S. K., & Robertson, G. P. (2011). Ecological management of intensively cropped agro-ecosystems improves soil quality with sustained productivity. *Agriculture, Ecosystems & Environment*, *140*(3-4), 419–429. https://doi.org/10.1016/j.agee.2011.01.005

Blanco-Canqui, H., Claassen, M. M., & Presley, D. R. (2012). Summer cover crops fix nitrogen, increase crop yield, and improve soil–crop relationships. *Agronomy Journal*, *104*(1), 137–147. https://doi.org/10.2134/agronj2011.0240

Cercioglu, M., Anderson, S.H., Udawatta, R.P., & Alagele, S. (2019). Effects of cover crop management on soil hydraulic properties. ***Geoderma***, 343, 247-253. https://doi.org/10.1016/j.geoderma.2019.02.027.

Connor, D. J., & Mínguez, M. I. (2012). Evolution not revolution of farming systems will best feed and Green the World. *Global Food Security*, *1*(2), 106–113. https://doi.org/10.1016/j.gfs.2012.10.004

Haruna, S.I., & Anderson, S.H. (2022). Influence of no-till cover crop management on soil thermal properties. ***Soil Research***, 60:580-589. kwwsv=22gr1ruj243143:42VU544<:1

Yadav, R. L., Yadav, D. V., & Duttamajumder, S. K. (2008). Rhizospheric environment and crop productivity: A review. *Indian Journal of Agronomy*, *53*(1), 1–17.