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AGRONOMY, HORTICULTURE & PLANT SCIENCE DEPARTMENT

X-Ray Scanning Confirms Soil Health Benefits from Conservation Practices

Anthony Bly | SDSU Extension Soils Field Specialist **David Karki** | SDSU Extension Agronomy Field Specialist
Navdeep Singh | Postdoctoral Research Associate, Washington State University **Sandeep Kumar** | Assistant Professor, South Dakota State University

Situation

Soil health includes many soil attributes that improve the soils ability to take in water (water infiltration) and exchange air. Soil pores (porosity) enable greater water infiltration, air exchange and internal root exploration for water and nutrients. Native Grass prairies have been shown to have superior soil health characteristics that include improved pore structure, high water infiltration and soil organic carbon levels. In general, soil is made up of 50% solids (clay, silt and sand minerals) of which about 4-5% is organic matter and 50% voids (Hillel, 1998). Healthy plant growth is supported by half of the voids containing water and air stored in the other half (Fig. 1). Soil pores have long been measured by a laborious process of wetting the soil at different pressures and measuring the change in water content to estimate groups of differing pore sizes. Only soil physicists could really understand the process and results. However, currently soils can be scanned with x-rays and computerized tomography (CT), that can reveal the soil pores and their connectivity through stunning images that are easily understandable.

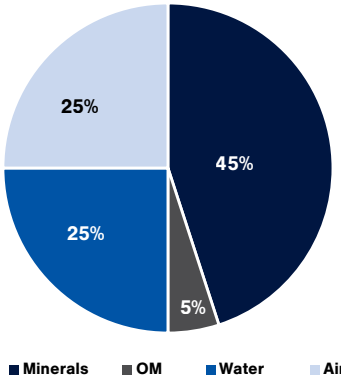

Figure 1. Generalized schematic composition of a soil (by volume)

What was done?

SDSU researchers (Singh et al., 2021) extracted soil core samples (0–4-inch, depth) in special plexiglass cylinders from 3 management systems (Table 1) from producer fields located in McCook County, South Dakota. These samples were then scanned at the University of Missouri Veterinary Health Center at Columbia, MO (Photo 1). Three dimensional images were produced from CT scanning image analysis to show the arrangement of soil pores in 3 management systems. Interconnectedness among soil pores, space-filling characteristics, unconnected pores were also derived from CT-scanned data, among others. Potential hydro-physical soil properties such as porosity, bulk density, water retention properties of soil, internal water movement and soil carbon were determined with conventional physical processes and compared with the CT images.

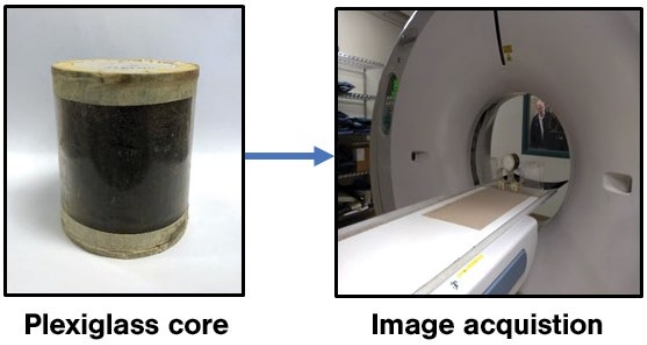

Photo 1. Plexiglass soil core and the X-ray computed tomography (CT) scanner at the UMC.

What the authors found out?

CT images clearly show greater porosity and increased connectivity in soil cores from the native grass (NG) and soil health system (SH) samples as compared with the traditional corn/soybean conventional tillage system (CS) (Photos 2-4). Traditional soil porosity measurements

Table 1. Soil parameters under different farming practices evaluated for soil health conditions.

Practice	Porosity	Bulk Density	Internal water movement	Soil Organic Carbon
	%	lbs./ft3	inches/hr	%
SH - No-till, diversified crop rotation with cover crops, livestock integration	57	73.7	4.7	3.34
CS - Conventional tillage, corn/soybean, no cover crops, no grazing	49	94.3	0.8	2.94
NG - Native Grass (well managed pasture)	67	61.8	8.2	4.18

confirmed what can be seen from the images and the differences in soil voids are depicted in the traditional pie charts (Figs. 2-4). Soil water movement analysis also revealed improved internal water movement within the soil cores with the NG and SH systems when compared to CS. Soil carbon was also greatly improved with SH practices as compared with the NG and CS systems (Table 1). It is very clear that farming systems (SH) that use no-till, diverse crop rotations and livestock integration can attain soil porosity and internal water movement similar to the native grass (NG) levels. This work strongly confirms the importance for adopting soil health practices in South Dakota. More water stored in the soil will greatly mitigate dry periods, improve water quality and reduce soil losses from erosion.

Photos 2-4. Soil pore spaces (green color) shown by X-ray scanning under 3 management systems and associated management system photo.

References

Hillel, D., 1998. Environmental soil physics. Elsevier, Academic press, San Diego, pp 10.

Singh, N., Kumar, S., Udawatta, R.P., Anderson, S.H., De Jonge, L.W., Katuwal, S., 2021. Grasslands conversion to croplands impacted soil pore parameters measured using x-ray computed tomography. Soil Science Society of America Journal, 1-12.

Acknowledgments

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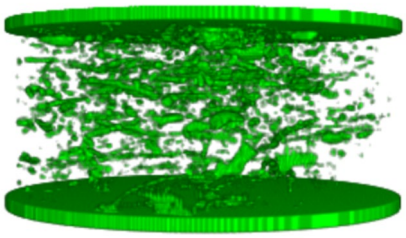
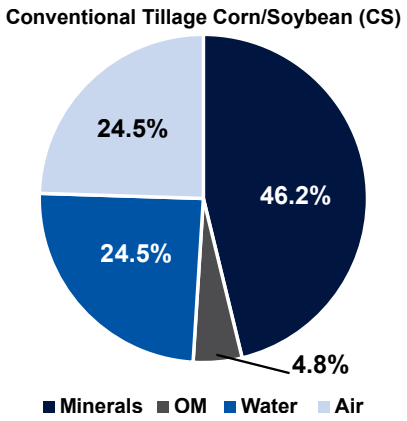
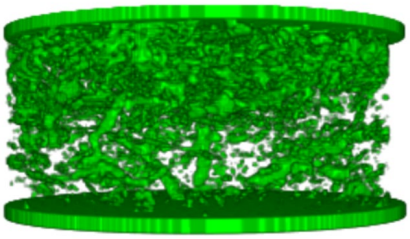
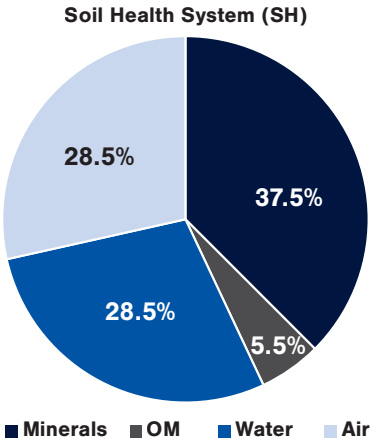
Figures 2. CS – Conventional Tillage (corn/soybean, no cover crop, no grazing)



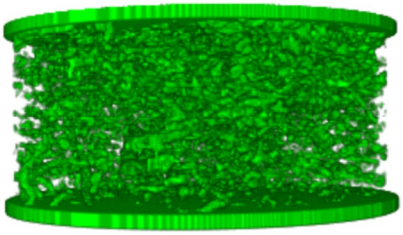


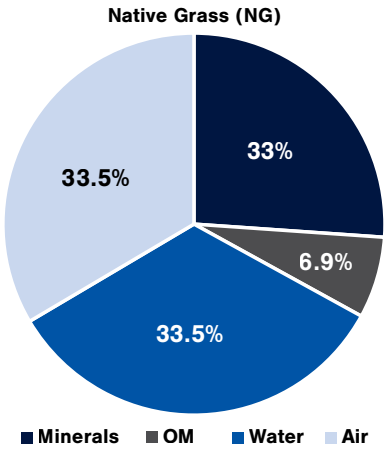
Figures 3. SH – Soil Health system (no-till, diverse rotation, cover crops, livestock grazing)





Figures 4. NG – Native grass pasture (well managed)





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