



# Soil properties and crop–livestock integration

By Matthew Ernst

| November 5, 2021



*Stocker steers grazing cereal rye and turnip forage mixture on vacant cropland following corn harvest in the winter. Photo by Jordan L. Cox-O'Neill.*

Integrated crop–livestock systems (ICLS) bring cattle and cropland together, often incorporating other practices like cover crops, no–tillage, and diversified crop rotations. New research looks at the soil health and water quality of short– and long–term ICLS, including cover crops and livestock grazing in the Northern Great Plains.

---

For more than 30 years, Kurt Stiefvater has winter–grazed his commercial cow herd on corn and soybean stubble at his farm in Salem, SD. In the past decade, Stiefvater started planting cover crops into the fields. “I was really after the winter grazing from my cover crops,” he says.

He is realizing benefits beyond winter grazing, according research recently published in the *Soil Science Society of America Journal* (<https://doi.org/10.1002/saj2.20214>). An analysis of soil samples taken in 2019 from three eastern South Dakota farms, including Stiefvater’s, found that long–term integration of livestock and cover crops increases soil organic carbon, lowers soil bulk density, and improves other hydro–physical soil properties. Those soil property improvements were not observed in corn–soybean fields where an integrated crop–livestock system was used in the short term (less than four years).

That lines up with what Stiefvater observes in his fields, especially since adding cover crops to his winter grazing mix. “The cover crops with the winter grazing—it all just

seems to complement each other all around, and then you start to see the soil impacts over time," he says.

## **The Experiment**

The main objective of the study was to compare the soil hydrological properties from long-term integrated crop–livestock system (ICLS) sites with a short-term ICLS site. Three eastern South Dakota farmers provided long-term ICLS sites where livestock have been integrated with row crops for 30 or more years. The short-term site was at a South Dakota State University (SDSU) research farm where cattle were integrated for less than four years. Row crops at all sites were under no-till management, except at one on-farm site where fertilizer was incorporated with a field cultivator in the control—the fields without livestock and cover crops.

From the long-term sites, researchers sampled soils that included corn–soybean rotations with cattle grazing and cover crops, corn–soybean fields with no cover crops (the control), and native grass pastures. Similar sampling was conducted at the short-term site where the corn–soybean fields added oats as a third rotation crop.

The SDSU researchers found that soil hydrological properties (e.g., water retention, porosity, and water infiltration rate) were higher under long-term ICLS fields compared with the control corn–soybean fields at the same sites. At the short-term site, the researchers found no statistically significant differences in soil properties between the ICLS fields and the fields without livestock use.

"There was clearly an impact on soil properties at each long-term site, showing it takes time for livestock integration to affect these soil properties," says SDSU research assistant Jashanjeet Dhaliwal, who authored the study with Sandeep Kumar, her Ph.D. adviser. "But our results indicate that the livestock and cover crops are not having much impact on the soil properties in the short-term period," she says.

## Soil Organic Carbon and Total Nitrogen

Kurt Stiefvater already knew combining cover crops with livestock was helping enhance soil health. “I’ve seen organic matter increase where I’ve been using cover crops with the grazing in the past 8 or 10 years,” he says.

The SDSU analysis backs him up. The researchers found Stiefvater’s farm had 22% higher soil organic carbon (SOC) in the fields integrating livestock and cover crops than in the corn–soybean fields that were not managed with ICLS. The ICLS fields sampled at the other two farm sites had 20 and 26% more SOC than the control fields.

There were no differences in SOC at the short-term ICLS site. “Changes in soil properties such as SOC and [total nitrogen] induced by grazing management are less likely to occur in a short time period,” wrote Dhaliwal and Kumar, citing a 2010 study in central North Dakota with similar conclusions.

## Soil Bulk Density and Penetration Resistance

Long-term ICLS also improved soil bulk density and water retention, according to the study. The long-term ICLS fields had lower bulk density—18 to 37% lower, depending on the farm site—than the corn–soybean control. The grass pastures at each site had the lowest bulk density.

Soil penetration resistance was also significantly lower in the ICLS fields than in the control fields at the long-term sites. The short-term site showed no differences



*Jashanjeet Dhaliwal takes intact soil core samples to analyze soil physical and hydrological properties. Photo by Navdeep Singh.*

between the treatments for soil bulk density and soil penetration resistance.

Sandeep Kumar says these positive measures show winter grazing can benefit soil health. “Many producers don’t like to use cattle because there is the perception that grazing creates compaction,” he says. “But when we have multispecies cover crops with good, deep root systems and then introduce grazing—but not overgrazing—the roots are still there, helping improve soil properties. And the cattle hooves and the manure are helping, too.”

The no-till residues and cover crops on the cropland also reduce soil compaction risks from grazing. “We see negligible compaction happening when there is a good layer of crop residue between the hooves and the ground, along with good management and proper stocking rates,” Kumar says, adding that crop residue also minimizes adverse impacts from rain droplets.

### **Soil Water Retention**

The long-term ICLS sites all showed significantly improved soil water retention compared with the controls at each site. The native pastures had the best soil water retention of the three treatments. The short-term system showed no differences in soil water retention between the ICLS and control.

At Kurt Stiefvater’s farm, soil water retention curves showed significantly higher soil water content for all eight different soil water pressures (from  $-0.01$  to  $-30$  kPa) evaluated in the study. The two other long-term ICLS sites showed higher soil water retention up to  $-0.4$  and  $-5$  kPa. “In general, long-term ICLS retained more water at all (measures) than the control, but short-term ICLS was not different from the control in its water retention characteristics,” Kumar and Dhaliwal report.

Stiefvater says that matches with his observations. “I definitely notice more crop resiliency in the drier years, which I think is from both using no-till and cover cropping,” he says. “I think that’s from better soil health, better water retention overall.”



*A cover crop mix of 23 different species at a ranch in North Dakota. Photo by Jerry Doan.*

### **Soil Pore Size and Infiltration Rate**

Soil macroporosity was two, six, and nine times higher on the ICLS ground than on the control at the three long-term sites. Total porosity was significantly increased compared with the control. Again, the short-term system showed no differences between the ICLS, cover crop, and control treatments.

The long-term systems also show greater water infiltration rates. That is likely because of the larger proportion of macropores. “The extensive and deeper root systems of most of the cover crops included in this study under ICLS may have created biopores after root decay,” Dhaliwal says. “That might increase water infiltration into soil.”

### **Other ICLS Benefits**

One related soil health benefit emerging from other research in the study, according to Sandeep Kumar, is increased microbial populations, including beneficial microbes not found in traditional corn-soybean systems.

“If you do it right—if you put enough residue there using no-till and if you graze at the right times—we see benefits in soil pores and hence the hydrological properties. And also the microbial populations are really good,” Kumar says.

The researchers reiterate that the improvements related to livestock take time. “There is a long-term impact of cover crop and livestock management practices upon soil physical and hydrological properties,” Dhaliwal says.

Kurt Stiefvater says that is what he sees in his fields, along with other producers that have integrated cattle with row crops and cover crops. “The biggest thing is that impacting the soil doesn’t happen overnight,” he says.

But the gradual changes in soil health are paying off on Stiefvater’s 1,800 acres of row crops and the additional 500 acres of pasture for his 140-cow herd. “I’ve lowered my dry fertilizer rates and reduced pesticide costs since we started using both cover crops with the winter grazing,” he says. “When I started to really use cover crops, I started understanding soil better.”

### **Dig deeper**

Read the original research article, “Hydro-physical Soil Properties as Influenced by Short- and Long-Term Integrated Crop-Livestock Agroecosystems,” in the *Soil Science Society of America Journal* (<https://doi.org/10.1002/saj2.20214>).

[More soil & water management](#)

[Back to issue](#)

[Back to home](#)

---

*Text © . The authors. CC BY-NC-ND 4.0. Except where otherwise noted, images are subject to copyright. Any reuse without express permission from the copyright owner is*

*prohibited.*