Comparison of steady-state, water-infiltration rates among farming systems, final report

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Abstract

During Iowa's spring 2008 floods, PFI members who had grass-based livestock systems and long crop rotations reported that their soils held the rainwater. This experiment tested those claims. The main objective of the study was to quantify the ecological resiliency of different farming systems by measuring the rate of water infiltration and soil quality indicators (reported separately) on neighboring farms with different farming systems. After three years of data collection, there was not a conclusive answer as to whether a specific farming system caused improved water infiltration rates across multiple locations, as the results varied by location.

Cooperators

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Project Timeline

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Web Link

http://tinyurl.com/waterinfiltration

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Kayla Koether recording steady-state, water-infiltration-rate data using a Cornell sprinkle infiltrometer.

Background

Iowa's spring 2008 floods were particularly devastating. Having annual crops covering more than 70% of Iowa farmland was speculated to have exacerbated the flooding (Achenbach, 2008). Farmers who kept soil under wraps—through grass-based livestock systems or long-term rotations, for example—reported that they largely kept their black gold in place—and out of their neighbors' fields and water sources. As Ryan Herman, a grass-fed beef farmer in the corner of Northeast Iowa, reported: "I have seen what a grass-based system can do in such an extreme situation," like the recent floods. "We gained a lot of soil from the fields up river. The grass on our farm held the soil where we are."

Another "grass farmer," Steve Reinart, near Glidden, stated, "I keep the water here, where it can be used. I've had three different 4-inch rain events and I've lost no soil. Most of our current agriculture works to move water off the land fast. We have extensive tiling systems below our fields, we've straightened streams, we've taken out wetlands and we've decreased our farming rotation to two crops. This moves water off the farm too fast."

Initial data from research conducted at the Neal Smith Wildlife Refuge shows that agricultural landscapes need to be redesigned and include at least 10% to 20% continuous living cover. This amount of *cover avoided a 7 T/A loss of soil during the spring floods as compared to systems with no cover. (Personal Communication, Matthew Helmers, 2009).*

Finally, research conducted by Bharati et al. (1995) found that soils growing either switchgrass or cool season grasses held five to seven times more water in one hour than did soils that were either row cropped or grazed continuously. However, the researchers did not measure the water infiltration rate of soils under a managed grazing system in which cows are rotated among paddocks.

Our hypothesis was that different farming systems would have different steady state infiltration rates. Specifically, those farming systems with rotational grazing systems would have significantly greater infiltration rates than continuously grazed pastures or row crop fields.

Method

Data were collected on farms of PFI members and on farms of one or two of their neighbors who used differing farming practices. These groups of farms are referred to as "pods." Pods are located near Fairfield, Giard, Glidden, McGregor, New Albin, and Paullina, Iowa. The farmers in each pod selected sampling locations using their County Soil Series book. The sampling locations were on the same soil type and position on the landscape but had different farming practices for at least the past 5 years, with several locations having more than 10+ years of the consistent farming practice. Each location was geolocated so that multiple years of data could be collected in the same spots. The majority of pods have a silty loam or silty clay loam texture. Soil was hand textured by Jessica Veenstra, Soil Science, Iowa State University.

*Farming system treatments measured within each farm pod are reported in **Table 1**. Treatments are described as:*

- *Conventional Crop (CC): Annual crops in a 2-year (or less) crop rotation (i.e. corn on corn or corn-soybean)*
- *Rotational Graze (RG): Pasture grazed with livestock with a rest period of more than 21 days*
- *Continuous Graze (CG): Pasture grazed with livestock with a rest period of less than 21 days*

In this experiment, a Cornell Sprinkle Infiltrometer (Cornell, N.D.) was used to measure the steady state infiltration rate. Steady state infiltration is the measured water infiltrating into the soil once the soil is saturated. Data were collected on the same day on the neighboring farms within a farm pod, for three consecutive years (2009, 2010 and 2011). The Glidden pod was not established until 2010, so only two years of data were collected there. At the Giard and New Albin pods, the row crop treatment was added in 2010, so only two years of data were used for those pods. For all six farm pods, data were collected in the summer months during the height of the growing season.

Data Analysis

Data were analyzed using a fit model one-way analysis of variance (ANOVA) to determine treatment effects at each location. Steady state infiltration rates were log-transformed for analyses. All reported means are the least-squares means. Comparisons of means were analyzed using the Student's t-test. All data analyses were performed using the JMP9 software (SAS Institute Inc., Cary, NC).

Results and Discussion

The mean steady state infiltration rate for all three years and across all pods was 3.90 in/hr in the rotationally grazed pastures, 3.43 in/hr in the row crop fields, and 3.13 in/hr in the continuously grazed pastures. These differences were not significant when all pods were analyzed together.

*There were, however, significant treatment differences within some of the individual pods (see **Table 1**). At the Giard pod, the row crop had significantly higher*

Table 1

Infiltration Rates

Farm pod location	Mean infiltration rate for pod (in/hr)		Mean infiltration rates of individual farming treatments at each pod (in/hr): Rotationally grazed pasture		Continuously grazed pasture		Row crop	
Giard*	5.21	A	3.45	b	-		5.92	a
Paullina	5.20	A	7.30	a	3.37	b	5.27	ab
New Albin*	3.41	B	1.98		4.21		3.80	
Fairfield	3.10	B	3.32		3.04		2.97	
Glidden*	2.99	B	5.07	a	1.01	b	1.56	b
McGregor	1.98	B	2.50		-		1.42	

Table 1. *Capital letters indicate differences between rows within a column, lower-case letters indicate differences within a row. All differences calculated using the student's t-test, with an alpha-level of 0.05. *Only two years of data were analyzed for these pods.*

Table 2

Infiltration Rates	Mean infiltration rates for individual farming treatments in each year at the Fairfield pod only (in/hr)					
	2009		2010		2011	
Rotationally grazed pasture	4.11	A	2.76	A	6.68	A
Row crop	5.84	A	2.03	A	2.26	B
Continuously grazed pasture	1.44	A	2.05	A	2.25	B

Table 2. *Different letters indicate significant differences within a column. All differences calculated using the student's t-test, with an alpha-level of 0.05*

infiltration rates (5.92 in/hr) than the rotationally grazed pastures (3.45 in/hr). At this pod, there were two sub-treatments within the rotationally grazed pasture, management-intensive grazing (MiG) and mob grazing. In a separate analysis, it was determined that the infiltration rate of the row crop was significantly higher than both the mob grazed pasture (3.70 in/hr) and the MiG pasture (3.19 in/hr).

At the Paullina pod, the rotationally grazed pasture had significantly higher infiltration rates (7.30 in/hr) than the continuously grazed pasture (3.37 in/hr), though neither pasture treatment was significantly different from the row crop treatment (5.27 in/hr).

At the Glidden pod, the rotationally grazed pasture had significantly higher infiltration rates (5.07 in/hr) than both the continuously grazed pasture (1.01 in/hr) and the row crop field (1.56 in/hr), which were not significantly different from each other.

At the Fairfield pod (see ***Table 2****), there were no significant differences between farming treatments when all years were analyzed together, but when the years were analyzed separately, in 2011 the rotationally grazed pasture had significantly higher infiltration rates (6.68 in/hr) than both the row crop (2.26 in/hr) and the continuously grazed pasture (2.25 in/hr). The differences were not significant in other years, but the order of treatments was different each year.*

None of the other pods showed significant differences between treatments because of high variability.

The lack of consistent trends across locations makes it impossible to definitively understand the effect of management on infiltration rates. However, it is worth noting that the rotationally grazed pasture treatment had the highest infiltration rate of all treatments at four out of the six locations, but this difference was not significant at two locations due to the high variability of water infiltration rates. The two locations where infiltration rates were not highest in the rotational grazing treatment were both in northeast Iowa, whether by chance or not. At one of these locations (Giard), the row crop had the highest infiltration rates, but at the other (New Albin), the continuously grazed treatment had the highest infiltration rate.

Many factors could lead to the high variability in steady state water infiltration rates within the same farming treatments at different locations. Despite having selected locations with the same management for five years or more, past history of each crop field or pasture can have lasting effects on soil properties such as infiltrability, regardless of recent management. Also, every farmer manages their farm a little (or a lot) differently, so despite efforts to group management practices based on best information, there still may be differences that are affecting infiltration rates differently. Lastly, inherent soil properties, slope, and other local conditions can cause differing reactions to similar management practices.

Conclusions

This study has not resulted in a conclusive answer as to which farming practices result in the highest steady state water infiltration rates. However at four of the six locations the rotational grazed treatment had a higher steady state infiltration rate than compared to the continuously grazed or row crop treatments. If these farms continue to be managed similarly in future years, the study should be repeated in five to ten years to see if long-term management can affect water infiltration into the soil.

References

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