Comparison of Steady State Water Infiltration Rates Among Farming Systems

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. Data from this experiment suggest that systems with a longer crop rotation and rotational grazing increase the steady state infiltration rate. However, additional data collection and analysis is needed to confirm this trend at additional sites in Iowa.

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Project Timeline

2009-2011 (Year 1 Report)

Web Link

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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," comments Reinart.

Floods of 2008. Photo by Joseph L. Murphy, Photographer/ Writer, Iowa Farm Bureau Federation

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 a longer rotation (3+ years) of crops or rotational grazing systems would have significantly greater infiltration rates.

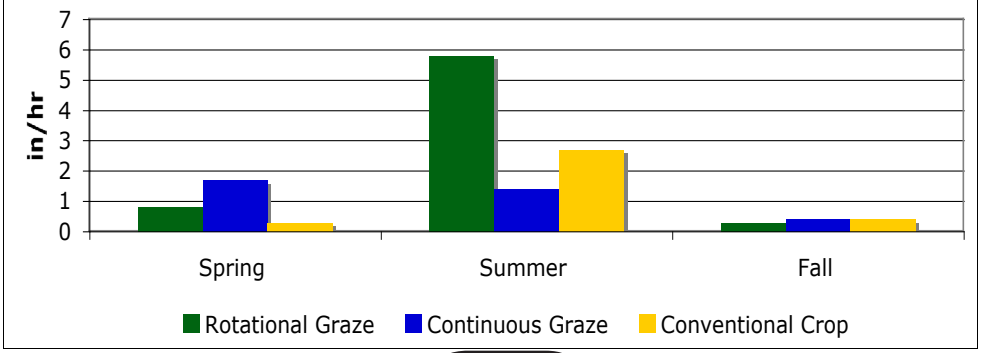
Methods and Materials

Data were collected on farms of PFI members and on farms of one or two of their neighbors who used different farming practices. These groups of farms are referred to as "pods." Pods are located near Fairfield, South English, Maxwell, Harlan, Paullina, Sutherland, Holstein, New Albin, Giard and McGregor, Iowa. The farmers in each pod selected sampling locations using their County Soil Series book. The sampling locations are the same soil type and position on the landscape but different farming practices for at least the past five years, with several locations having more than 10+ years of the same farming practice. We have geolocated each location so that multiple years of data can be collected. The majority of pods have a silty loam or silty clay loam texture, except sites near Maxwell, which were sandy soils. 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 less than a 2 year crop rotation (i.e. corn on corn or corn-soybean)*
- ***Corn Longer Rotation (CLR):*** *Annual crops in a rotation that is longer than two years (i.e. organic row-crop or corn + hay)*
- ***Hayground (H):*** *Land that is hayed but not grazed and is not tilled*

Table 1



- ***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*
- ***Prairie (P):*** *Diverse plant mix with no tillage*

In this experiment, we used a Cornel Sprinkle Infiltrometer to measure the steady state infiltration rate. Steady state infiltration is the measured water infiltrating into the soil once the soil is saturated. Data was collected on the same day on the neighboring farms within a farm pod. For the 10 farm pods, data were collected in the summer months during the height of the growing season. At Fairfield, two other dates, in the spring and fall, were also collected.

Data Analysis

Two reports are provided from this data set: Fairfield Pod and 10 Farm Pod. Data from the three dates at the Fairfield location were analyzed and reported and data from the 10 summer dates, including the summer date from the Fairfield pod, are analyzed and reported.

For the Fairfield Pod report, data were analyzed using a mixed model,

Table 2

	Spring	Summer	Fall
	in/hr		
Rotational Graze (RG)	0.8 AB	5.8 A	0.3 B
Continuous Graze (CG)	1.7 AB	1.4 AB	0.4 B
Conventional Crop (CC)	0.3 B	2.7 AB	0.4 B

Treatments with different letters are statistically different (p>0.05).

and using a Tukey test to determine differences between individual means. For the 10 Farm Pod report, 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. All data analyses were performed using JMP8.

Table 3

Farm Pod Location		Infiltration Rates of Individual Farming Treatments at Each Farm Pod (in/hr)					
Farm Pod Infiltration Rate (in/hr)		Conventional Crop	Corn Longer Rotation	Hayground	Rotational Graze	Continuous Graze	Prairie
Paullina	6.8 a	8.2**	-	-	7.9	4.7	-
Sutherland	4.2 ab	8.1	3.2	2.7	-	-	-
Giard	3.8 abc	-	4.4	-	3.2	-	-
New Albin	3.6 abc	-	-	-	1.5	7.2	-
S. English	3.4 bc	2.0**	-	5.5	-	-	-
Fairfield	2.9 bc	2.7	-	-	5.8	1.4	-
Maxwell	2.5 bc	3.2	-	1.8	2.5	-	-
Harlan	2.0 c	0.7 b	6.0 a	-	1.2 b	-	-
Holstein	2.0 c	-	-	-	1.1	2.1	3.3
McGregor	1.8 c	2.2	-	-	1.5	-	-

*Treatments with different letters are statistically different.
**Treatments are first year transition to organic. They are not considered Corn Longer Rotation because of the rotation length.

Results

Fairfield Pod Analysis: *Steady state infiltration rates were different depending on the sampling date and farming system. Overall the summer sampling date had greater rainfall infiltration rates. In the Summer, RG had the greatest infiltration rate (5.8 in/hr) and was different from all treatments sampled in the Fall: RG (0.3 in/hr), CC (0.4 in/hr), CG (0.4 in/hr) and CC in spring (0.3 in/hr). In the summer CC (2.7 in/hr); CG in both the Spring (1.7 in/hr) and Summer (1.4 in/hr) and RG in the Spring (0.8 in/hr) were similar to the other treatments.*

10 Farm Pod Analysis: *Steady state infiltration rates were different among farm pods but no geographic trends were observed (Table 1). Because location was highly significant ($p<0.05$) and to better know the effect the individual farming systems had on steady state infiltration rate, treatments at each farm pod were compared. Within the 10 pods, only at Harlan ($p=0.0051$) were the steady state infiltration rates significantly different among the farming system treatments. The Corn Longer Rotation treatment (6.0 in/hr) had significantly greater infiltration than the Conventional Corn (1.2 in/hr) or the Rotational Graze (0.7 in/hr) treatments. Other locations did not show significant differences between treatments.*

Conclusions

Our hypotheses from both studies were supported by these results but only during the summer data collection period in Fairfield and at Harlan in the 10 Farm Pod study. From the Fairfield study we can conclude that date of measurement had a significant effect on the infiltration rate and how different farming systems respond. In the summer, the rotational grazing treatment was able to infiltrate twice as much water as the conventional crop and almost four times as much water than the continuous graze system at that time.

In the 10 Farm Pod study we can conclude that location had a significant effect on how different farming systems steady state infiltration rates respond. At Harlan the longer rotation farming system infiltrated five times more water than both the rotational graze and the conventional crop rotation systems.

Data will be collected and analyzed for two more years on a subset of these locations.

References

Achenbach, Joel. (2008) Iowa flooding could be an act of man, experts say. Washington Post June 19, 2008: A01.

Bharati, L. K. Lee, R Schultz. (1995) Riparian zone soil-water infiltration under crops, pasture and established buffers. Unpublished.