MSB February 2023 Progress Report on Nutrient Loss in Runoff - Do Cover Crops Make It Better or Worse?

Ray Weil

Environmental Science and Technology Department

University of Maryland

Figure 1 A Cornell Sprinkler Infiltrometer being lowered down to begin simulated rain inside a 24.1 mm I.D. metal ring installed 7.5 cm into the soil.

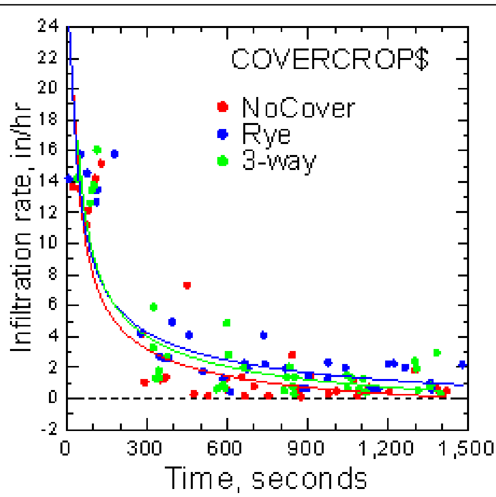

Figure 2. Infiltration rates for three cover crop treatments during a 25-minute simulated rain event that applied approximately 15 cm of deionized water "rain."

Since the last update in August 2022 the project has made good progress. We have been utilizing the Cornell sprinkler infiltrometer to generate simulated rainfall and runoff. With this winter being abnormally dry, few events have generated natural runoff. So this simulated rain method has been very useful to evaluate the impact of 3 years of enhanced cover crop management on the potential for soils to absorb heavy rainfall and lose nutrients in runoff.

The Cornell sprinkler infiltrometer is a mini rainfall simulator that produces a controlled rain of specified drop size and drip-rate. It generates runoff within a confined area and channels it through an outflow hose where the runoff can be measured and collected. Figure 1 shows the sprinkler infiltrometer in use, with the sprinkler being lowered onto the metal ring which has been installed into the soil at a specified depth.

The normal use of this instrument is to measure infiltration rate in soils by measuring the volume of runoff collected at set time intervals during a 1-hour simulated rain event. We modified this protocol so that we could collect samples for analysis. Instead of sampling at even time intervals, we sampled at even runoff volume intervals. After each 1 L of runoff, we recorded the time and collected the sample in a clean bottle. For each plot's rainfall simulation, we collected five 1 L bottles of runoff water. To be able to measure any soil nitrogen or phosphorus lost in the runoff, we used highly purified distilled/deionized water for the "rain."

The time and volume data allow the calculation of several important soil hydrologic parameters (Figure 2). As can be seen in Figure 2, the initial infiltration rate is very high but declines quickly as the soil becomes saturated and within less than half an hour reaches a steady state that reflects the saturated hydraulic conductivity of the soil. Despite infiltration being one of the most spatially variable soil properties, our simulated rainfalls were consistent enough that we were able to detect significant differences among cover crop treatments and between crop residue types.

The data allowed us to calculate these parameters:

- time from start of the rain to first runoff
- infiltration rate
- saturated hydraulic conductivity
- runoff rate
- soil sorptivity
- sediment loss or erosion rate

During December and January, we conducted simulated rain on 18 plots in a clayey field at the Central Maryland Research and Education Center Beltsville facility. This is the same field where we have been collecting natural runoff when it occurs. Very little natural runoff has been generated this winter because rainfall is far below normal. The site received only 1.5 in of rain in January, less than half the normal.

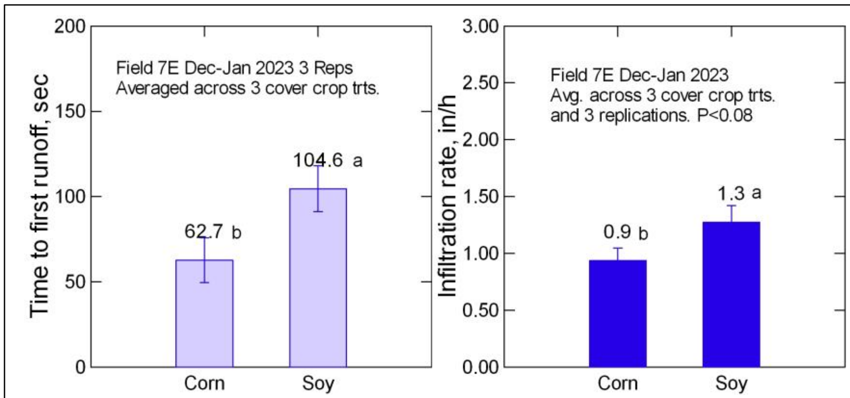

Figure 3. Time to first runoff and infiltration rate in December-January were significantly higher in soybean crop residue than in corn crop residue

Once the runoff water is collected from a rain fall event, the sample is chilled, brought to the lab and a known volume is vacuum filtered through a 0.45-micron filter membrane to remove any suspended particles. The filtrate is frozen for later analysis of dissolved nitrogen and phosphorus. The filter membrane itself is dried and weighed before and after the filtering process to determine the mass of suspended sediment. The sediment collected on the filter membrane will later be digested and its associated nitrogen and phosphorus determined.

The chemical analysis has yet to be done, but the hydraulic parameters and total mass of sediment have been measured. Figure 3 shows that the type of crop residue (corn or soybean) had a significant influence on two important hydrologic parameters. The plots are in a corn-soybean rotation so the crop residue type indicated in the graph is the residue from the fall 2022 harvest. It can be seen that it took longer for runoff to begin in soybean residue-covered plots than in corn residue plots. Similarly, under soybean residue, the infiltration rate was almost 50% higher than under corn residue. This is new and important information.

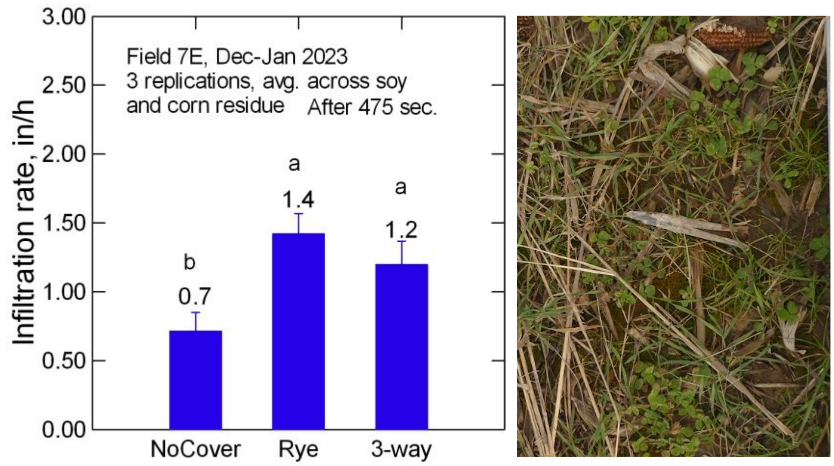

Figure 4. The steady state infiltration rate was significantly higher with cover crops than with no cover crops, regardless of the type of crop residue (corn or soybean) present. Even though both cover crops were very small at the time of infiltration measurement (covering only ~15% of the ground area, photo at right), three years of cover cropping increased the infiltration rate compared to the no-cover crop control.

Due to later than ideal establishment in fall, cover crop growth before winter dormancy this year was considerably less than in previous years. This is typical of many places in Maryland where conditions for early planting of cover crops were not favorable in Fall of 2022. Even though the cover crops this year were quite small, covering only 15 to 20% of the ground, the impact of 3 years of enhanced cover crop management was measurable in the soil hydraulic parameters. Figure 4 shows the impact of 3 years of cover crop management treatments on the rainfall infiltration rate in inches per hour. Both the rye and the 3-way cover crop had similar infiltration rates of 1.2 to 1.4 inches per hour, and these were significantly higher than the 0.7 inch per hour infiltration rate for the no-cover plots. This is important and new information that illustrates some of the long-term benefits of well managed cover cropping. Higher infiltration rates should translate into considerably less runoff during large rainfall events. This means that watersheds in which cropland has been cover cropped for a number of years should contribute less to flooding and water pollution and should infiltrate more water and store it for later use by cash crops. It could be argued that this increased water storage is likely to compensate for the increased water use by the cover crop transpiration. There's very little information on this phenomenon in the literature for long-term no-till soils as are common in Maryland.

Total sediment loss was very low from these plots well armored with both crop residue and cover crop growth. The only exception was one date in December when we ran the rainfall simulations 2 days after a very cold week and found that the soil was still frozen at a depth of about 3 cm. This resulted in significant sediment loss, slower infiltration, and greater runoff. But the relationship with cover crops still applied.

During the remaining months of this grant, and hopefully, during the follow-up grant, we will be able to analyze both inorganic and organic forms of the dissolved nitrogen and phosphorus associated with the runoff from these plots and assess the long-term impact of enhanced cover cropping on nutrient loss potential.