Soil Infiltrometer Experiment 2019

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Abstract

With increasing concerns regarding climate change and its impacts on natural resources comes the need for examining our uses of water and the effects of those uses. Irrigation is the leading use of freshwater supply worldwide and the second in the United States. Moving forward, improvements of traditional agricultural practices are necessary to ensure long term sustainability and water quality protection. The purpose of this study is to analyze different farming methods to maximize water conservation and determine the level of adverse effects of irrigation. Using the Cornell Soil Infiltrometer on various agricultural plots at the Hudson Valley Farm Hub located near Kingston, New York, on-site tests are conducted to determine equilibrium infiltration capacity of soils as well as the turbidity of runoff. These values are used to find the amount of water needed to saturate the top, root-bearing land and quantitatively compare the difference in erosion rates for tilled versus non-tilled plots of land. Runoff from tilled land is found to have approximately 17.5 times the amount of turbidity of runoff from non-tilled land, meaning that the rate of erosion for these plots is 17.5 times greater. Grain size analysis is conducted for different soil samples collected from different plots using a sieve shaker to find the relative composition of sand, silt, and clay particles. All plots tested, including tilled and non-tilled for corn, broccoli, and beans contain clay-loam soil. The average equilibrium infiltration capacity for land is 59.5 cubic centimeter per minute which indicates that maximum rate of irrigation should be in that range. The findings of this study, if implemented on a large scale, would have long-term beneficial impacts on water quality and conservation.

Introduction

The Hudson Valley Farm Hub is an agricultural center for various farming practices and research. Located in Hurley, NY (near Kingston), it expands over 1,255 acres of farmland and borders Stony Creek, a tributary of the Esopus Creek (Figure 1). The purpose of soil infiltrometer research is to determine the amount of water that a body of soil can absorb before runoff begins. This information can be used to better farming practices by pinpointing the amount of water required for crops and can improve water quality by limiting the turbidity of runoff into surface water bodies.

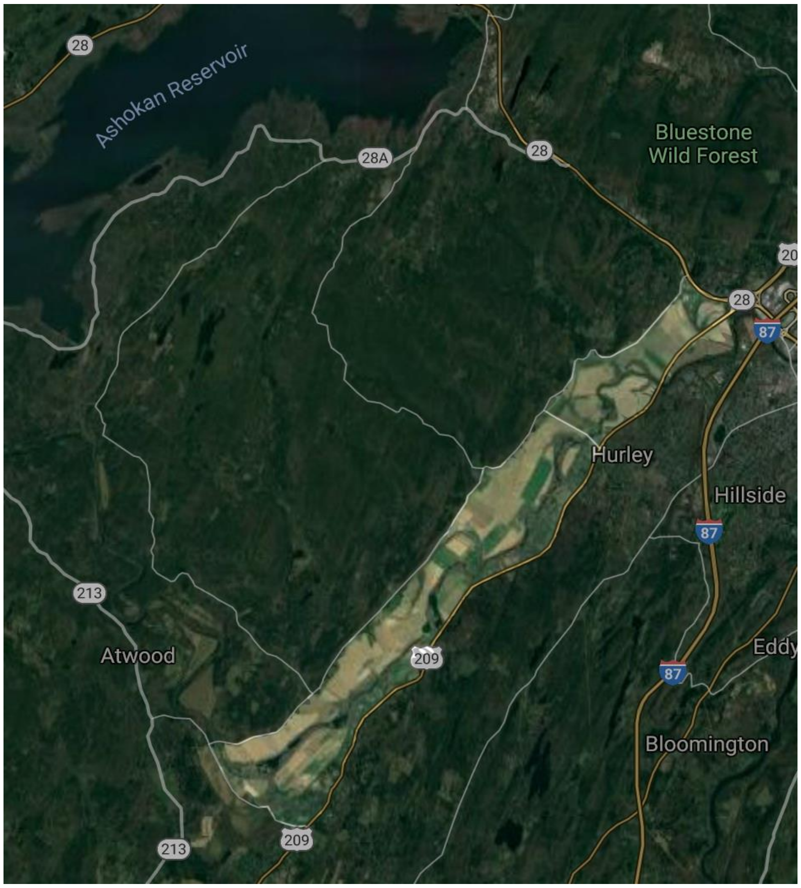


Figure 1: Map of the study area (from Google map)

Methods

Four soil infiltrometers designed at Cornell University were used for this research. Each was operated on site for results specific to a particular geological area and soil body. The infiltrometer is comprised essentially of a cylindrical plastic body with small holes at the bottom for water to escape, mimicking rainfall (Figure 2). When in use, the only airflow to the inside of the structure is a narrow tube which can be adjusted to emulate atmospheric pressure and rate of rainfall. This plastic structure, then filled with water, rests on top of a round metal base inserted halfway into the soil itself. The metal base contains a hole that is situated just above the soil and a stopper with a tube is inserted to collect the runoff water that is then collected into a bucket to measure turbidity for each trial.

Figure 2: Infiltrometer setup in the field

Every three minutes, the water level in the infiltrometer is recorded to maintain that there is a constant rate of water flow into the ground below. The time taken until runoff as well as the total volume of runoff is recorded. Each of the two infiltrometers have independent rates of rainfall with one simulating heavy rainfall and the other simulating lighter rainfall. The trials were conducted at numerous agricultural sites at the Hudson Valley Farm Hub including green beans, broccoli, and corn. Each infiltrometer was run at each site for both tilled and untilled plots of land as well as moderately tilled corn to compare the results of different farming methods. Soil was taken from each site so that grain size analysis testing could be run. Calculations were performed after all experimentation to determine soil sorptivity, infiltration rate, and comparisons were made regarding the various soil beds which experiments took place on.

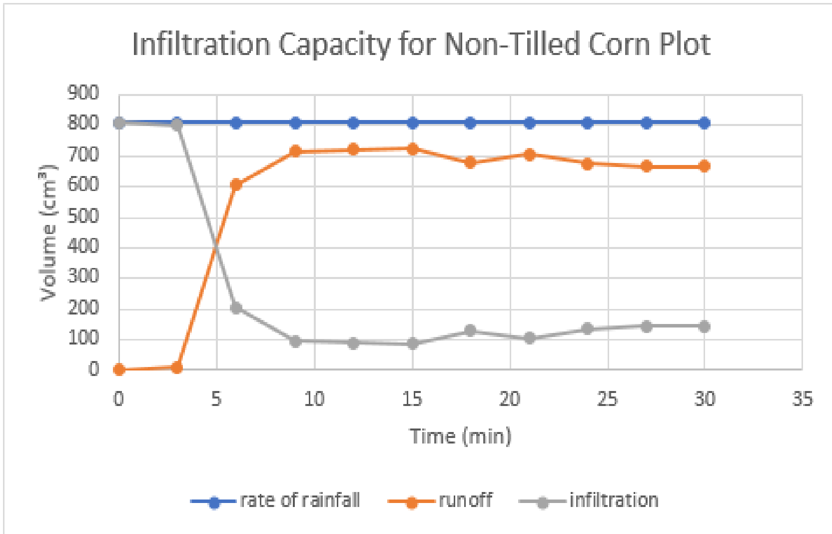
Results

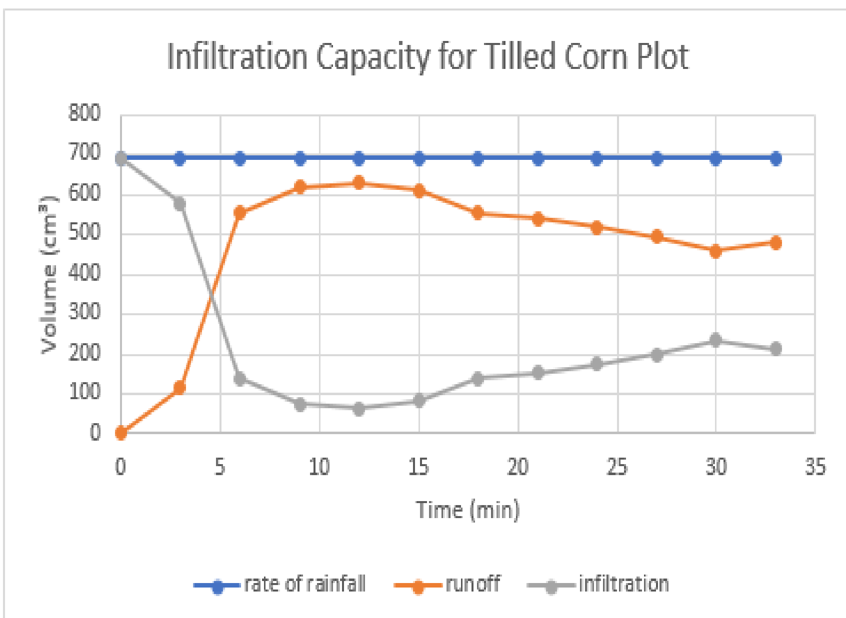
The tables below show the values for Grain Size, Equilibrium Infiltration Capacity (EIC in cm^3/min) and Sorptivity (S in 2.5 cm^3/min) for each plot. NT means Not Tilled, T means Tilled, MT means Moderately Tilled and soil classifications.

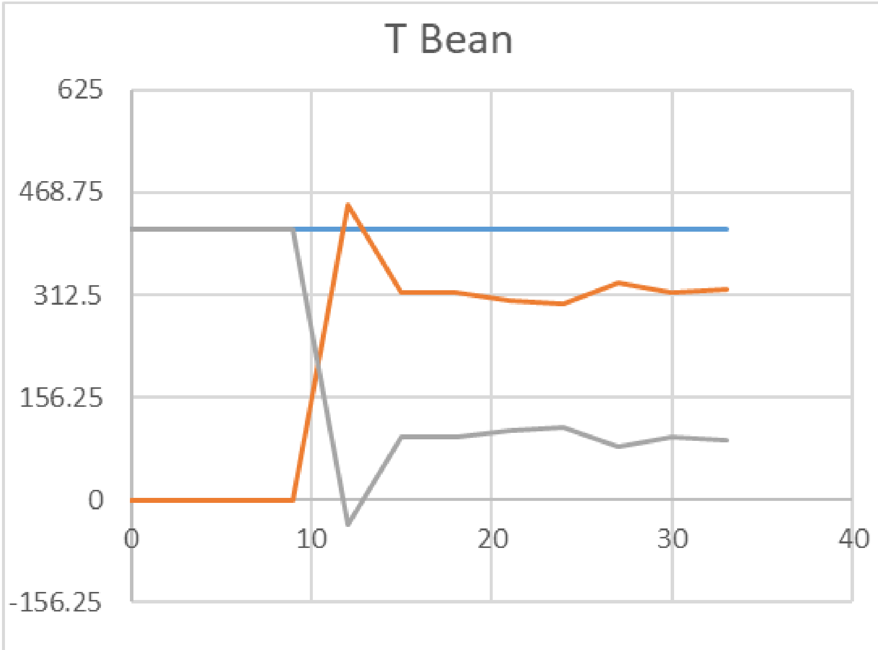
Sieve Size	**NT Bean**	**T Bean**	**NT Corn**	**MT Corn**	**T Corn**	**NT Broccoli**	**T Broccoli**
<0.0787	0.0	0.1	0	0.4	0.8	0	0
<0.028	0.1	0.2	0.3	0.4	0.3	0.5	0.3
<0.0197	0.2	0.6	0.4	0.9	0.6	0.2	0.1
<0.0139	8.9	1.3	2.3	7.2	3.5	5.2	0.1
<0.0098	11.0	17.6	11.9	19.5	19.5	7.6	2.6
<0.0049	79.8	80.5	85.1	71.2	75.3	86.5	96.9
EIC raw	97.8	81.4	29.5	55.5	104.6	125.0	144.9
EIC (smoothed)	65.8	32.5	44.2	55.5	61.7	125.0	101.1
S	2.5	1.3	1.4	1.7	1.2	2.2	1.0

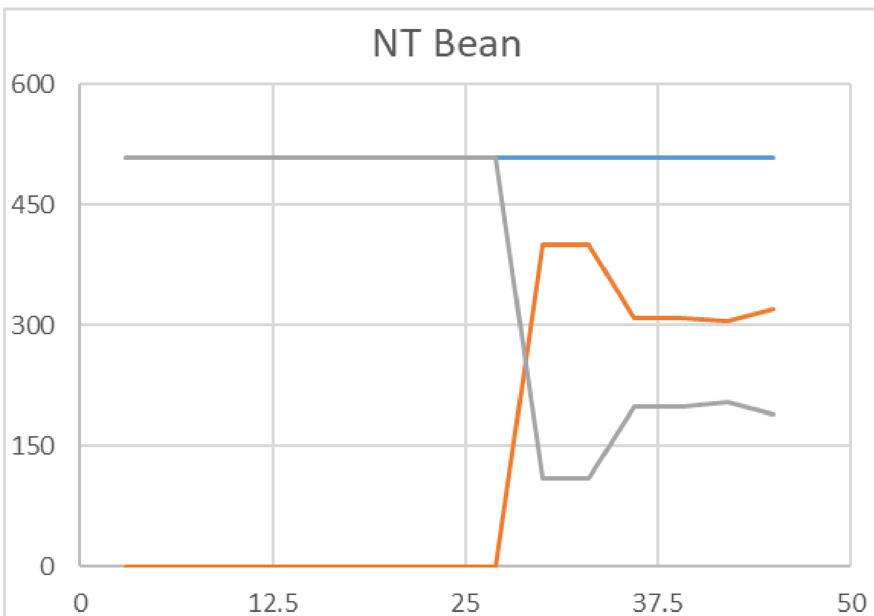
Size (mm)	**Classification**
<0.0039	Clay
0.0039-0.0625	Silt
0.0625-2.00	Sand

Below are few selected graphs plotting the soil infiltrometer data:
(volume of water dispersed by instrument- runoff volume = infiltration volume)






T Bean
625
468.75
312.5
156.25
0
-156.25
0
10
20
30
40


NT Bean
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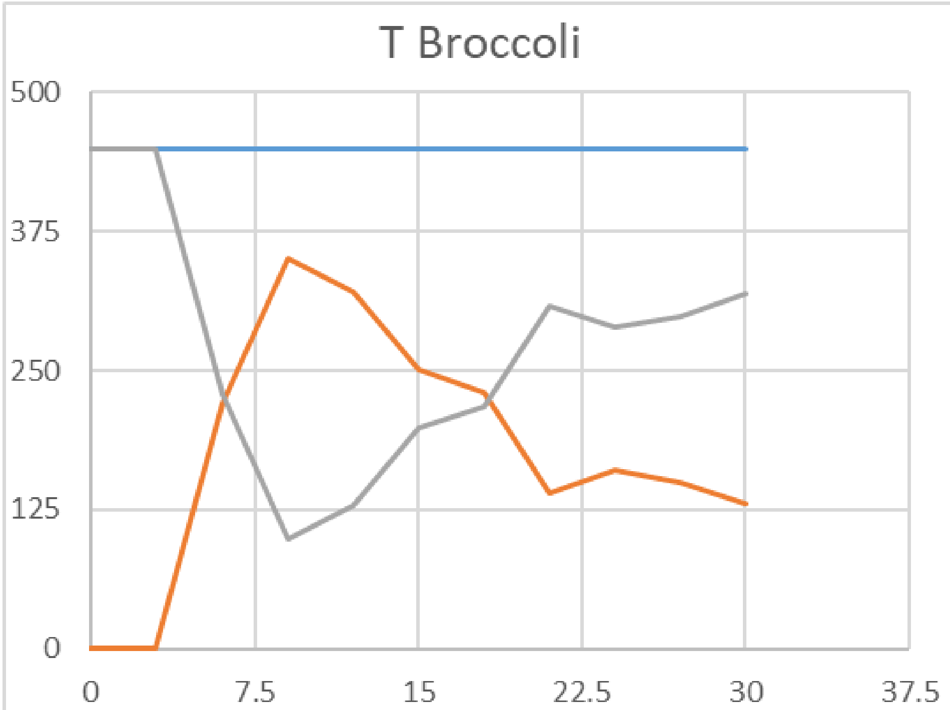
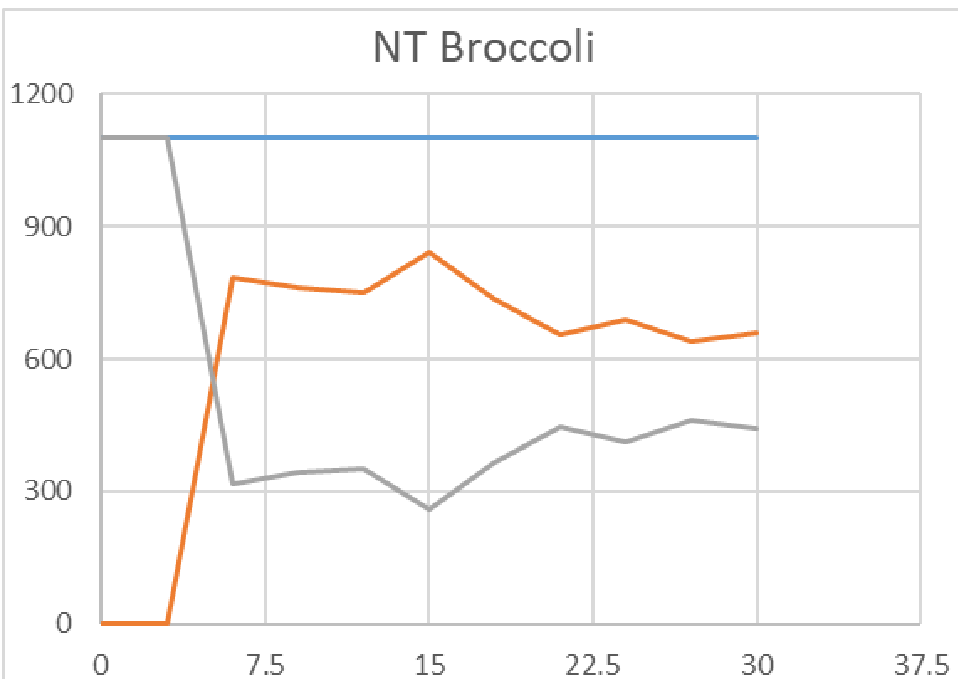
450
300
150
0
0
12.5
25
37.5
50


T Broccoli
500
375
250
125
0
0
7.5
15
22.5
30
37.5


NT Broccoli
1200
900
600
300
0
0
7.5
15
22.5
30
37.5

Effect of Tilling

With all data compiled without taking out any skewed numbers, highest infiltration capacity is found with the broccoli plot which has the highest percentage silt and lowest sand. There seems to be little other effect on the infiltration capacity other than this.

The highest percentage of smallest grain size is found in the broccoli plots, where there is also the highest value for Equilibrium Infiltration Capacity and lowest for Sorptivity, meaning it can intake the largest constant quantity of water but has low ability through capillarity. Increased percentages of silt in soil composition leads to higher value in Equilibrium Infiltration Capacity.

Overall Equilibrium Infiltration Capacity is increased with tilled plots vs non-tilled and sorptivity is greater for non-tilled plots. Turbidity is the greatest factor of change here with the tilled value approximately 17.5 times higher on average than the non-tilled plots of land (see table below).

	Tilled	Non-Tilled
EIC (cm^3/min)	65.1	55.0
S (cm3/min)	1.2	2.0
Turbidity (NTU)	211.7	12.1

Discussion

The most significant finding of this study is the effect of tilling on the turbidity. Turbidity is an important factor of water quality as increased suspended sediment in natural water bodies can detrimentally affect wildlife in the waters as well as prevent drinking water use by humans. Increased turbidity of runoff also directly correlates to the erosion of the land. As soil matter is lost, it must be continuously replaced, especially on farmland, leading to ever increasing turbidity of waters.

Equilibrium infiltration capacity for the tilled plots is 65.1 cm3/min and 55.0 cm^3/min for non-tilled plots. The average equilibrium infiltration capacity for the Farm Hub land is 59.5 cm^3/min (which is equivalent to 1.32 mm/min of rainfall).

Conclusions

Although it is apparent that erosion will be higher on tilled versus non-tilled soil, the actual magnitude of erosion is rarely known. The value of 17.5 times for degree of erosional effect is significant and non-tilling plots are no doubt proven to be environmentally friendly. However, more testing is needed to quantify an accurate rate of erosion. The equilibrium infiltration capacity is higher in the overturned tilled plots due to more porous character in comparison to non-tilled beds. Utilizing this EIC data an ideal irrigation rate can be determined and employed to minimize water use, especially in regions of water scarcity.

References

- Cornell University Sprinkle Infiltrometer Handbook.
- Fetter, C. W., 2004, Applied Hydrogeology, Prentice Hall, 2004.
- Chowdhury, S. H. and Watson, A., 2006, Role of soil macropores in solute transport, GSA Abstracts with Programs, Vol.38, no.7.