Can Tillage and Amendments Turn My Soil Into A Stormwater Sponge?

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Background

- Can tillage provide a benefit to remediate compaction for construction sites?
- Will tillage benefits be maintained for months/years, or will repeated tillage be required?
- Can soil amendments help increase and/or sustain short-term tillage benefits?

Simulated Construction Sites

Fives sites were evaluated, four cut and one fill.

- Compacted exposed soils prior to tillage treatment
- Seeded and fertilized following NC DOT recommendations

Site	Texture	Tillage (cm)	Amendments	Sub-treatment
Sandhills	Sand	0, 15, 30	compost (5 cm), lime (0, 1.5, 3[1] Mg ha^{-1})	--
Mountain	Sandy clay loam	0, 15, 30	compost (5 cm), xPAM[2] (0.32 Mg ha^{-1})	traffic (90 kPa)
Piedmont 1	Sandy clay	0, 15, 30	lime (0, 1.25, 2.5[1] Mg ha^{-1})	traffic (177 kPa)
Piedmont 2	Sandy clay	0, 30	compost (5 cm)	traffic (177 kPa)
Piedmont 3	Clay loam (fill)	0, 30	compost (5 cm), xPAM[2] (0.672 Mg ha^{-1}), gypsum (11.2 Mg ha^{-1})	--

[1]30 cm tillage depth only

[2]Granular cross-linked polyacrylamide

Field Set Up

Ex. Piedmont 3 -- fill material

Measurements

Soil Compaction - Bulk Density

Treatment	Bulk density[2]						
	Months after establishment						
Sandhills	1	6	23	27			
	g cm^{-3}						
Compacted	1.89a[a]	1.76a[a]	1.89a[a]	1.81a[a]			
Shallow till	1.12b[c]	1.45b[b]	1.76b[a]	1.63b[a]			
Deep till	1.11b[c]	1.37b[b]	1.74b[a]	1.68b[a]			
	Months after establishment						
Mountain	2	3	23	30			
Compacted	1.52a[a]	1.38a[a]	1.44a[a]	1.22a[b]			
Shallow till	0.92b[b]	1.15b[a]	1.21b[a]	1.22a[a]			
Deep till	0.84b[b]	1.05b[ab]	1.16b[a]	1.20a[a]			
	Months after establishment						
Piedmont 1	1	5	29	32			
Compacted	1.48a[a]	1.49a[a]	1.44a[a]	1.52a[a]			
Shallow till	1.11b[b]	1.35b[a]	1.28b[a]	1.28b[a]			
Deep till	1.12b[b]	1.25b[a]	1.28b[a]	1.23b[a]			
	Months after establishment						
Piedmont 2	7	13	19	26			
Compacted	1.48a[a]	1.34a[ab]	1.48a[a]	1.29a[b]			
Deep till	1.02b[b]	1.21b[a]	1.28b[a]	1.09b[b]			
Deep till + compost	0.66c[a]	0.66c[a]	0.76c[a]	0.78c[a]			
	Months after establishment						
Piedmont 3	1	3	6	8	12	19	24
Compacted	1.55a	1.92a	1.70a	1.58a	1.64a	1.52a	1.45a
Deep till	1.29b	1.38b	1.43b	1.32b	1.43b	1.37b	1.28b
Deep till + compost	1.00c	0.67c	1.15c	1.05c	1.31b	1.16c	1.18c
Deep till + xPAM[1]	1.25b	1.31b	1.35b	1.29b	1.24b	1.30b	1.29b
Deep till + gypsum	1.28b	1.30b	1.37b	1.30b	1.32b	1.34b	1.29b

Infiltration Rate

Treatment	Infiltration rate[3]				
	Months after establishment				
Sandhills	1	6	18	23	27
			cm h^{-1}		
Compacted	0.3b	2.9b	12.4b	7.1b	11.0b
Shallow till	36.1a	33.8a	31.2a	24.2a	34.0a
Deep till	23.1a	38.5a	34.3a	26.7a	33.9a
	Months after establishment				
Mountain	2	3	23	30	
Compacted	0.5b[b]	0.6b[b]	7.2b[a]	8.2b[a]	
Shallow till	38.4a[a]	23.8a[b]	19.2a[b]	23.7a[b]	
Deep till	43.0a[a]	25.6a[b]	19.5a[b]	24.0a[b]	
	Months after establishment				
Piedmont 1	5	16	28	32	
Compacted	3.9b	1.5b	3.0b	6.7b	
Shallow till	20.3a	21.6a	11.5a	22.1a	
Deep till	21.8a	20.6a	17.1a	23.0a	
	Months after establishment				
Piedmont 2[1]	7	13	19	26	
Compacted / NT	0.6c	2.1b	6.8b	2.8b	
Compacted / T	1.1c	4.9b	10.7b	6.0b	
Deep till / NT	26.2ab	12.5b	29.8a	29.4a	
Deep till / T	13.3b	4.3b	12.4b	10.8b	
Deep till + compost / NT	36.6a	31.1ab	31.2a	30.7a	
Deep till + compost / T	29.9ab	31.8a	26.1ab	24.3ab	
	Months after establishment				
Piedmont 3	3	8	12	19	24
Compacted	0.8b[c]	7.5a[ab]	3.1c[b]	4.1c[abc]	8.6c[a]
Deep till	14.2a[a]	9.4a[a]	14.5b[a]	17.3a[a]	24.9b[a]
Deep till + compost	5.5ab[c]	11.6a[bc]	30.9a[ab]	21.4a[b]	39.5a[a]
Deep till + xPAM[2]	6.7ab[b]	10.8a[b]	31.1a[a]	19.4a[ab]	30.4ab[a]
Deep till + gypsum	6.5ab[b]	7.4a[b]	26.6ab[a]	24.0a[a]	31.1ab[a]

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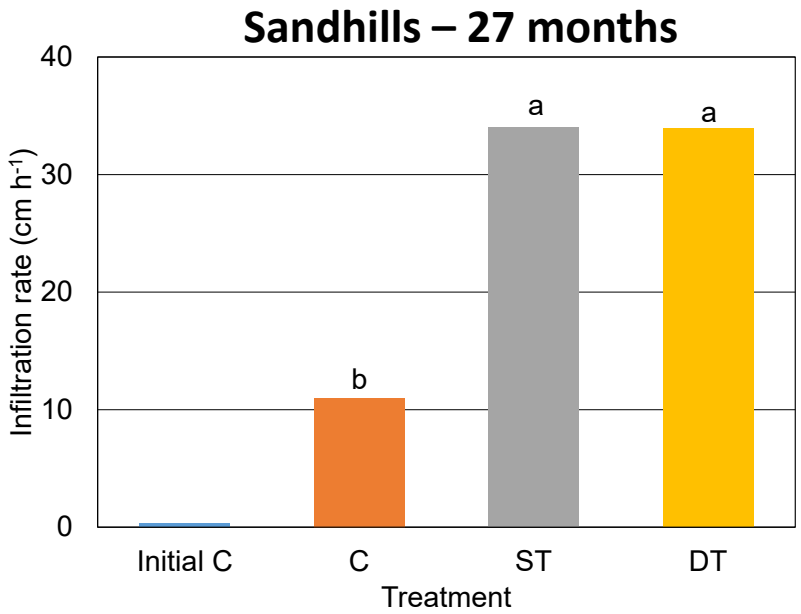
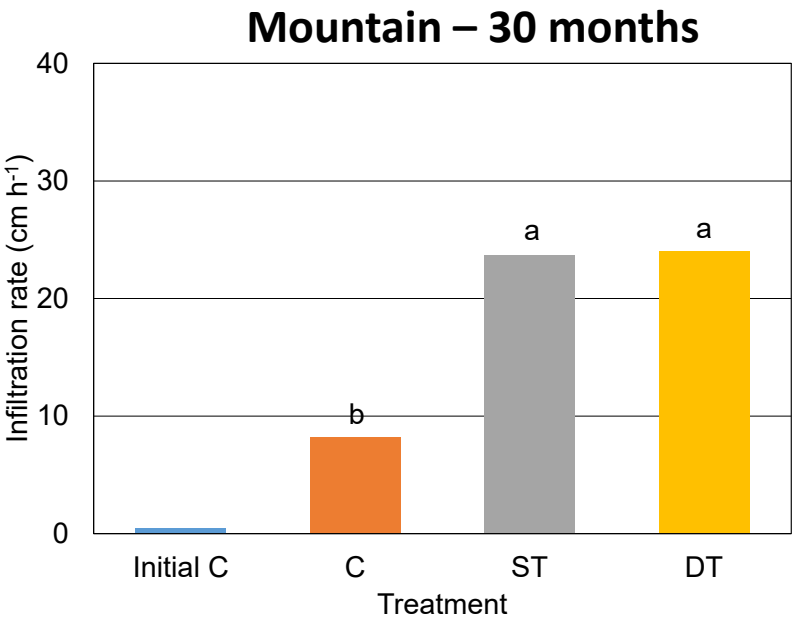
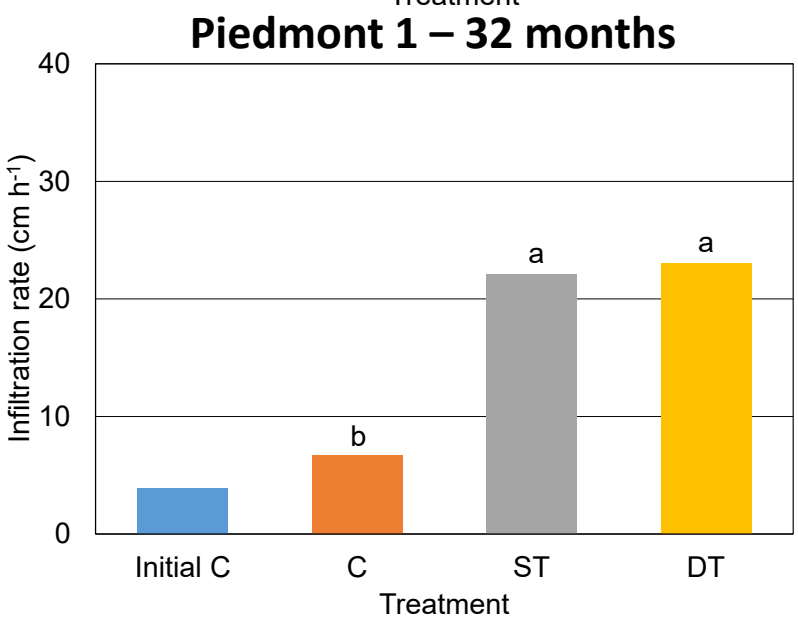
Infiltration Rate







- Tillage depth had no relative effect.
- Compost (Sandhills, Mountain) had no effect relative to tillage alone.
- Traffic (Mountain, Piedmont 1) had no effect.
- With tillage, infiltration was 3X greater than control for ≥24 months.
- No major temporal effect, except drop in infiltration rate in first 3 months in Mountains.

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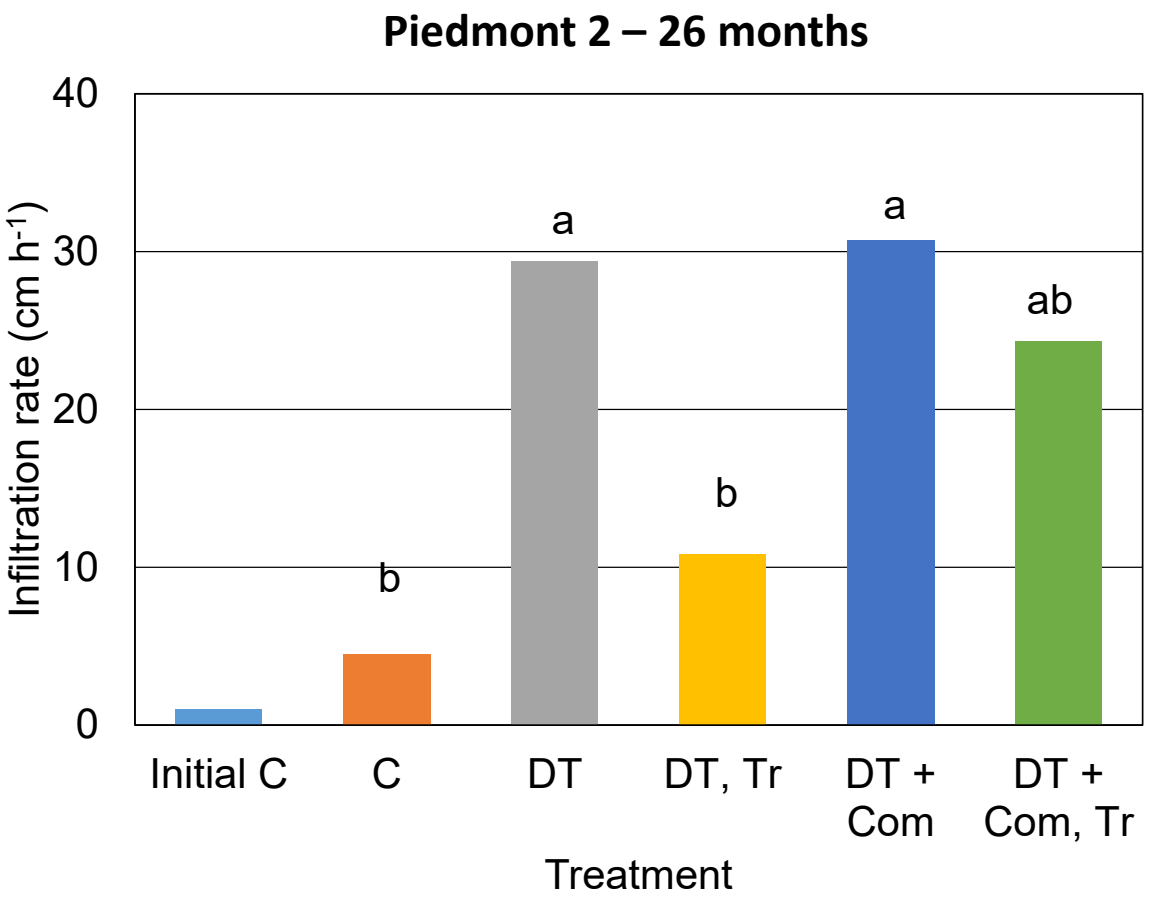
Infiltration Rate



- Traffic reduced the infiltration rate of the tilled soil, but compost mostly mitigated the effect.
- Untrafficked DT with/without compost and trafficked with compost were similar and 3X rates observed for control.
- No major temporal trend.

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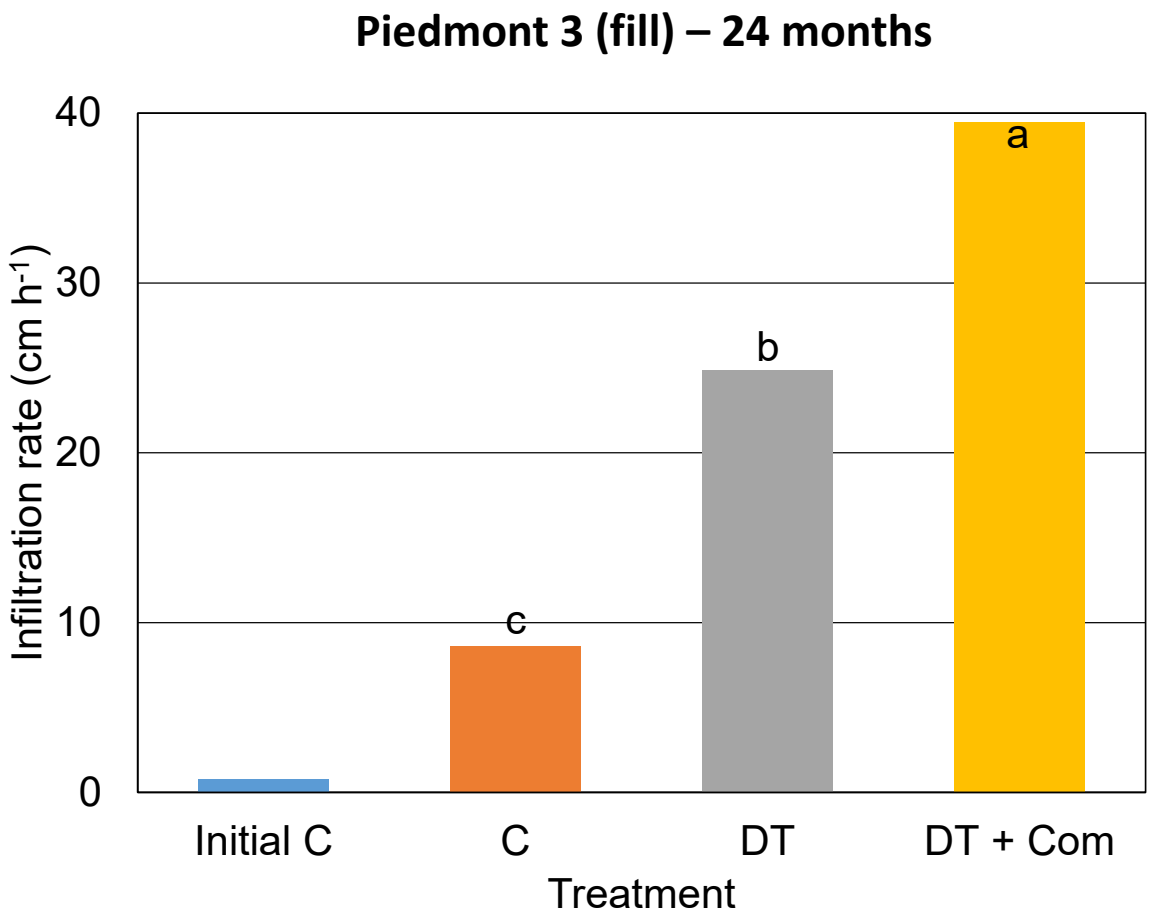
Infiltration Rate



- DT + Compost had greatest infiltration rate; gypsum ad xPAM fell in between DT and DT + Compost and were not statistically different than either.
- All treatments including tillage had infiltration rates ≥3X control at 24 months.

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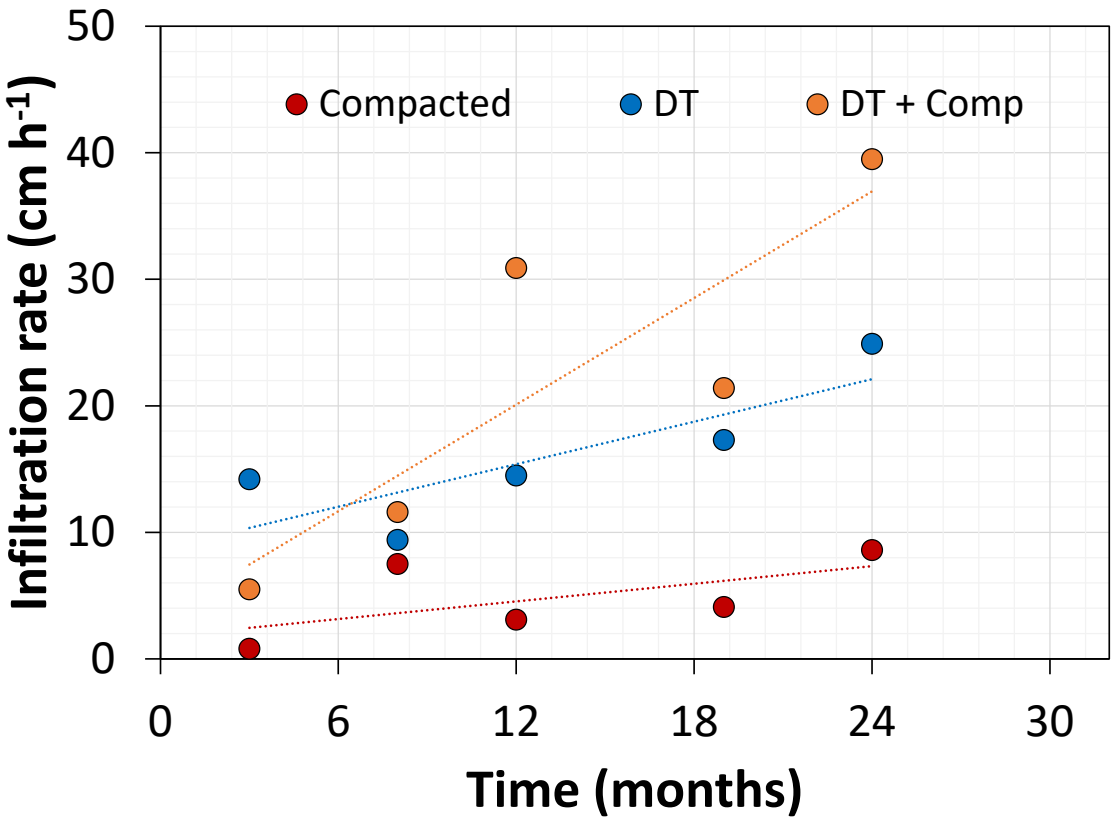
Infiltration Rate

Piedmont 3 (fill)



- Infiltration rates trended upward over time; compost + tillage was greater than tillage alone on two of five dates.
- Overall, data were 'noisy' in time, probably due to lack of any soil structure and heterogeneity of fill material.

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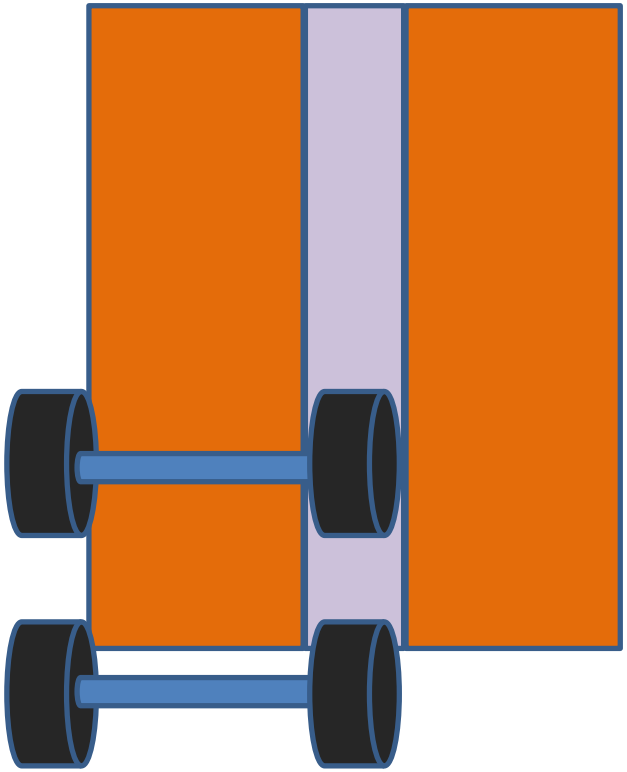
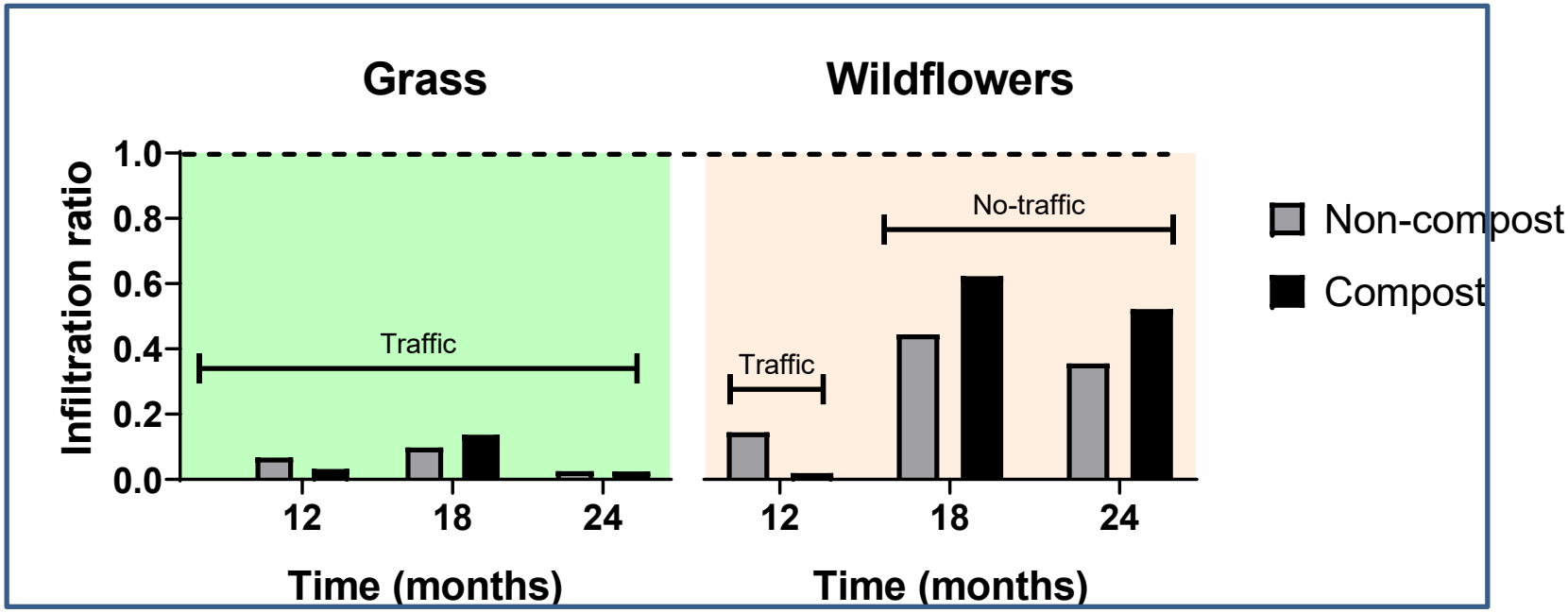
Traffic Experiment

Grass : 4 mowing per year
Wildflowers : 1 mowing per year



Infiltration ratio: Piedmont Site



- Time was significant (wildflower plots rebounded).
- Compost effect not significant (wildflowers/grass).

Synthesis of Five Sites

- Bulk density tended to increase post-tillage, most obviously in the coarsest textured soils (Sandhills and Mountain sites), but remained below pre-tillage levels for >24 months at all sites.
- Compost addition had an effect on bulk density at 2 of 4 sites, but not the sites with the most overall settling and coarsest textures (Sandhills and Mountain sites).
- Tillage depth (where tested) did not affect bulk density or infiltration rates, but did alter the depth at which high soil strength occurred.
- Tillage greatly increased (≥3X) infiltration at all five sites, and the effect was maintained for >24 months.
- Amendments (compost, gypsum, xPAM) generally had little impact on infiltration relative to tillage alone, except one site where compost helped reduce the effects of traffic.
- Mower traffic will compact soil within track, less with fewer mowings (e.g. wildflowers)

Roadside Demonstration Sites at I-40 and I-85

- Slope with moderate grass stand prior to treatment
- 3 treatments (control, tilled, tilled + compost) x 4 reps
- *Control was "retrofit" with existing grass stand and no intentional compaction.*
- NCDOT seed mix; fertilizer according to NCDA (for tilled treatments)
- Tillage to approx. 8 in. depth
- High-grade compost, 2 in. depth
- Runoff directed onto plots from road shoulder
- Water quantity monitored from storm runoff

I-40

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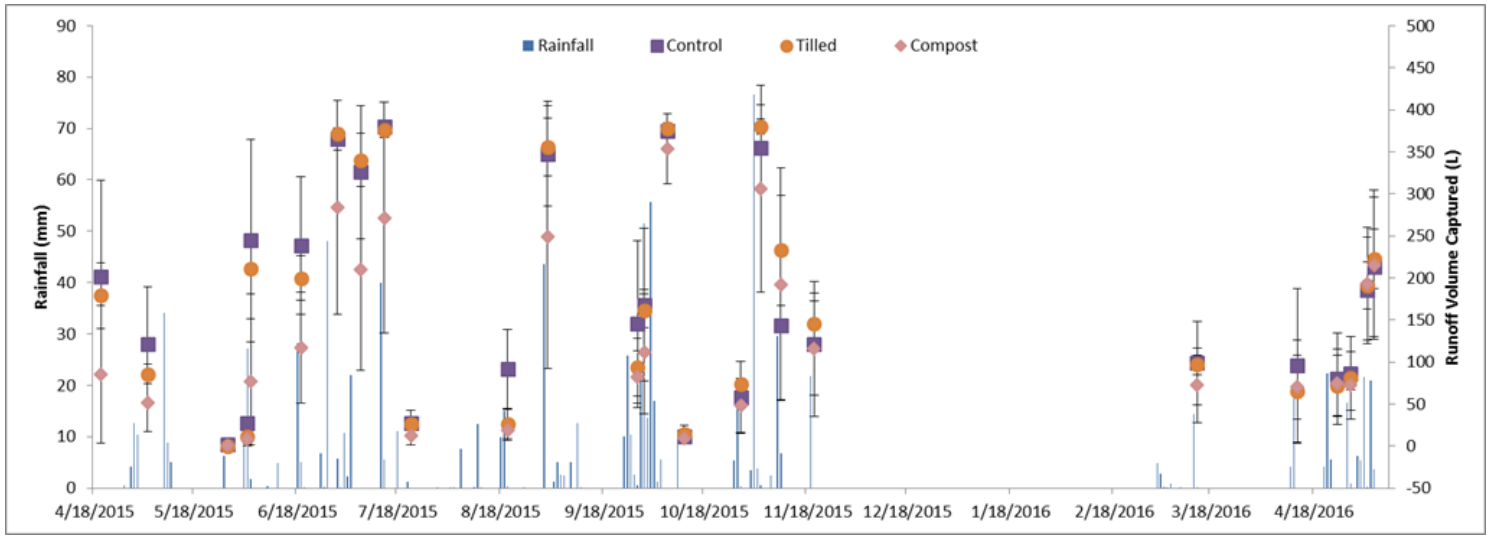
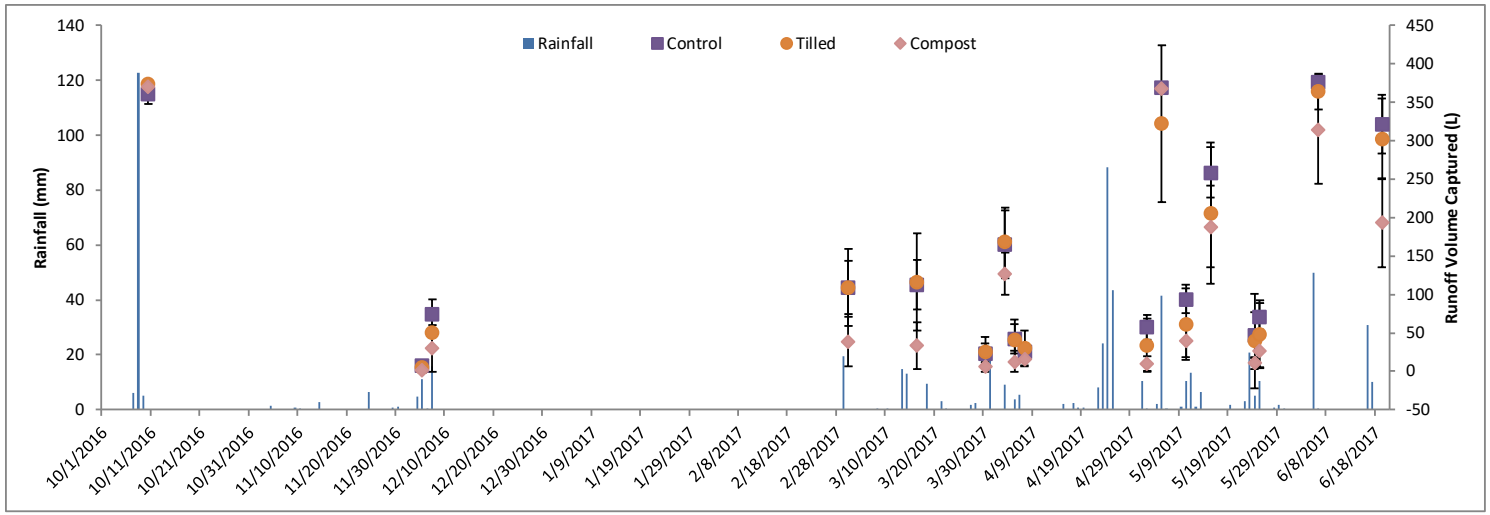
Runoff Collection





- Runoff collected from 21 events over 14 months at I-40 and 13 events over 9 months at I-85 (sites were closed Dec-Feb).

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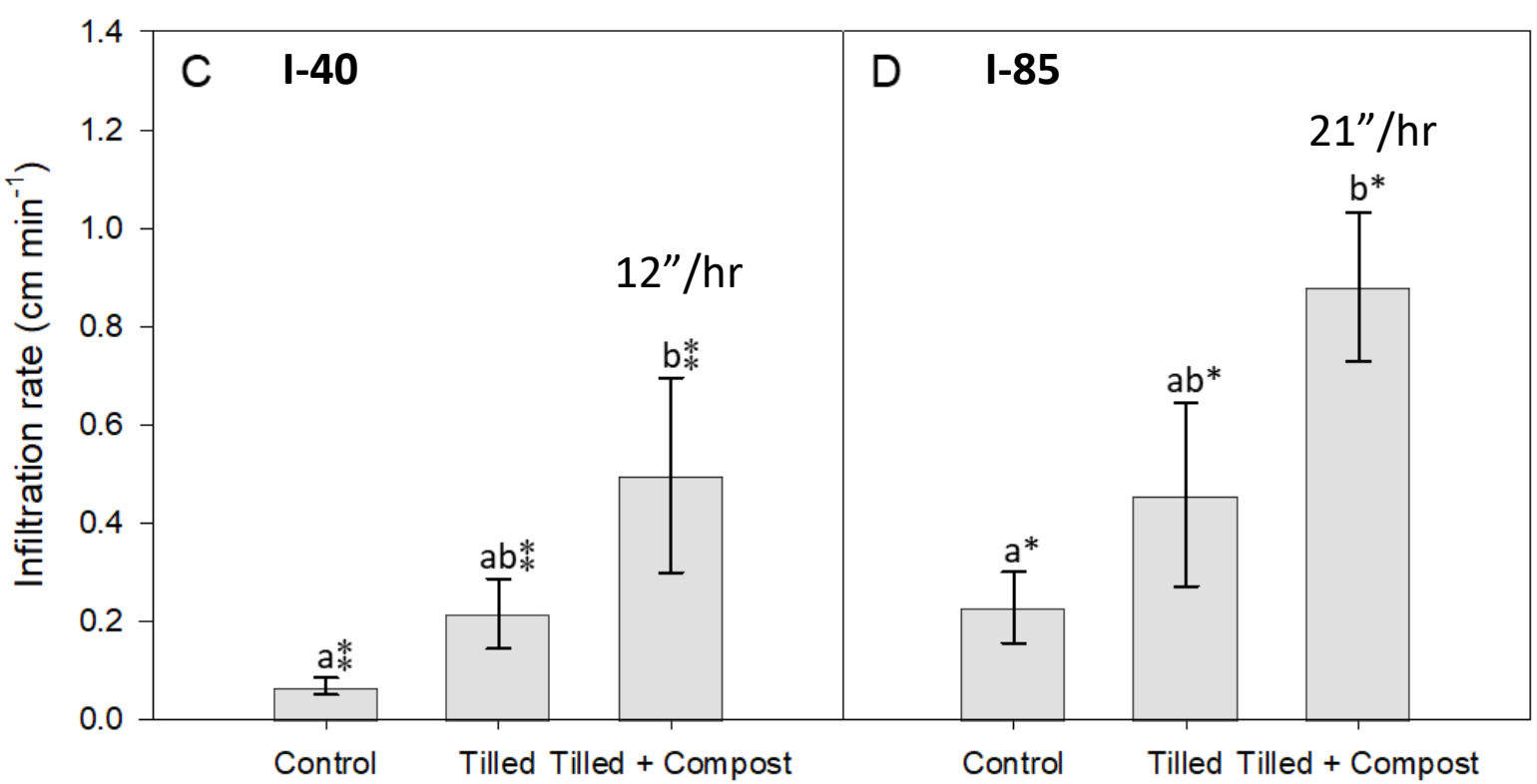
Infiltration Rates



- Both sites had high final infiltration rates as measured by infiltrometers.
- Tilled + compost had less runoff than control for all but one month across both sites.
- Tilled performance compared to control was less consistent.

More Roadside Plots

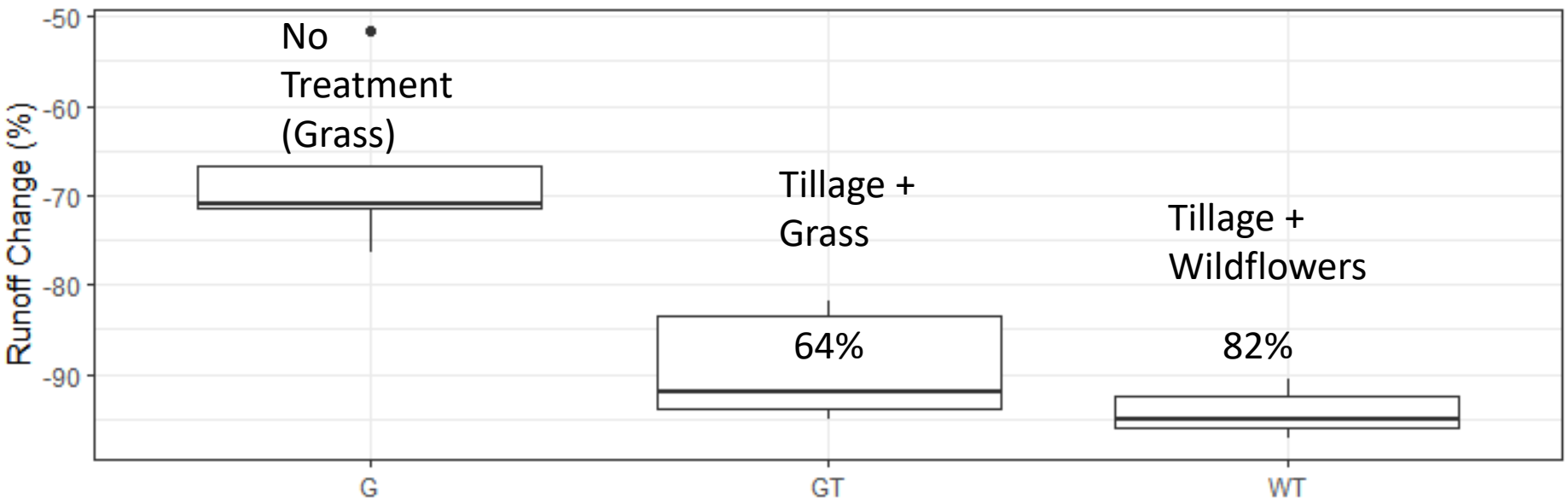
Installing Plots

Study design

- Before/after testing
- Grass, Tillage + Grass, Tillage + Wildflowers
- No compost

9 Months Results

- All plots had lower runoff than pre-treatment due to weather
- Tillage reduced runoff further by 64-82%

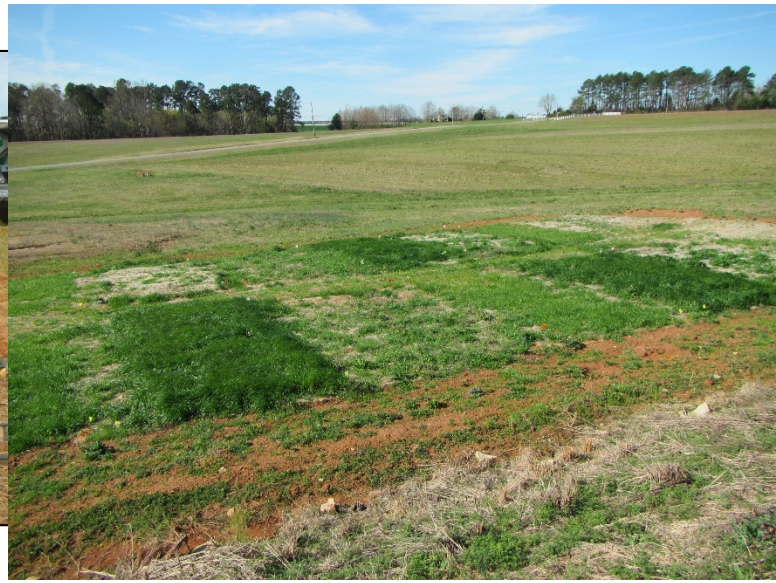


Conclusions

- In compacted soils, tillage plus a vigorous vegetation stand improved infiltration 3X.
- This appears to be maintained over time.
- Compost was not consistently beneficial at the 2” rate tested, but add resistance to compaction.
- Mowing traffic may reduce infiltration in the wheel tracks. Management implications.

Next Questions…

- Optimal compost rate for infiltration improvement.
- Compost source/type.
- Wildflower selection for fast establishment, maximum pollinator/aesthetic/infiltration benefits.



Questions/Comments?

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