Overview of current biosolids studies and summary results of past projects

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Outline

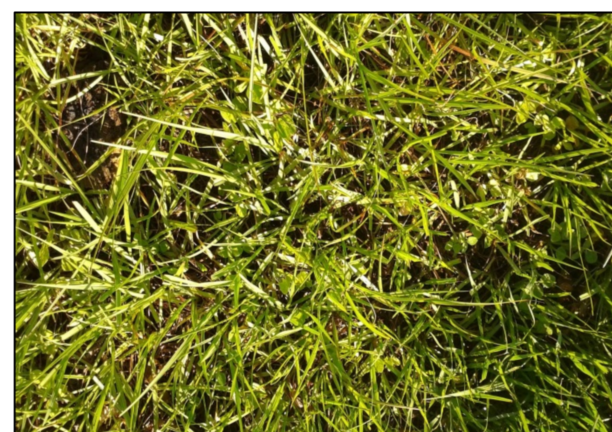
Overview of current biosolids studies and summary result of past projects:

1. Biosolids field study at Ona
2. Land application of aluminum water treatment residual to bahiagrass
3. Rainfall simulation

Agronomic and Environmental Impacts of Biosolids Application to Bahiagrass Pastures in Florida

Maria L. Silveira, George O'Connor, and Joao Vendramini

Funding source: FCA Beef Enhancement Funds (2016 to current)



Agronomic and Environmental Impacts of Biosolids Application to Bahiagrass Pastures in Florida

1. To establish a **<u>long-term, instrumented field trial</u>** designed to evaluate the agronomic benefits and potential environmental impacts of biosolids application to pastures
2. To evaluate the effects of co-application of biosolids and biochar (C-rich material that can act as a strong sorbent) on soil chemical (C, N, and P dynamics), physical (water holding capacity, aggregate stability), and biological properties (microbial diversity)
3. To monitor N and P losses via leaching and gas emissions

Soil type: Smyrna (sandy, siliceous, hyperthermic Aeric Alaquods)

Treatments

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❖ 3 biosolids (Class AA and Class B) + commercial fertilizer (N and P)
❖ Surface applied at a rate of 160 lb plant available N/A
❖ Treatments alone or in combination with biochar (1% basis)

Why biochar?

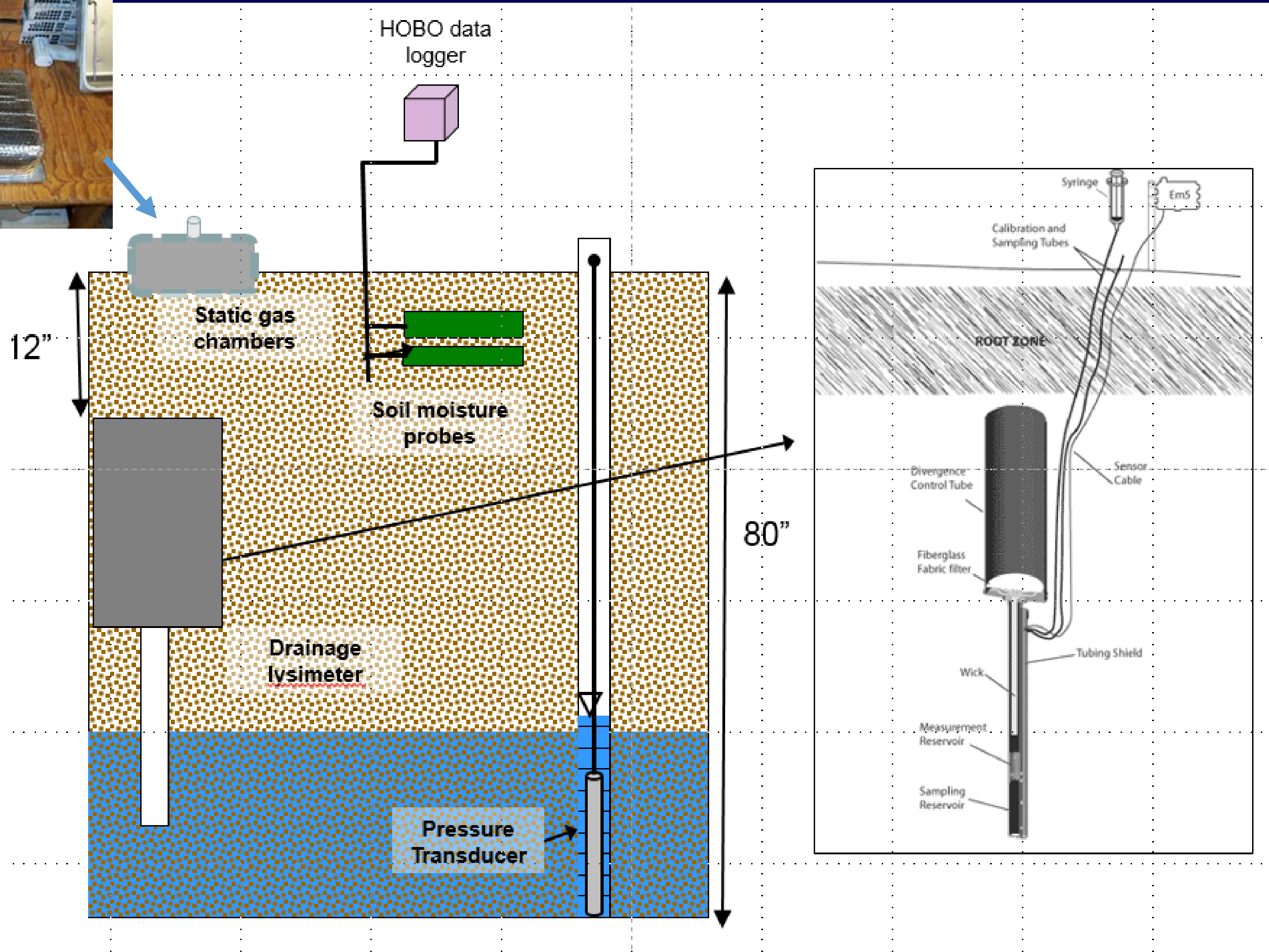
- Strong sorbent that can control excess N and P in soil and water
- Non-hazardous residuals
- Low cost
- Improve soil chemical, physical, and biological properties

drain gauge lysimeters

Gas chambers

Initial soil characterization

Monitoring Instruments



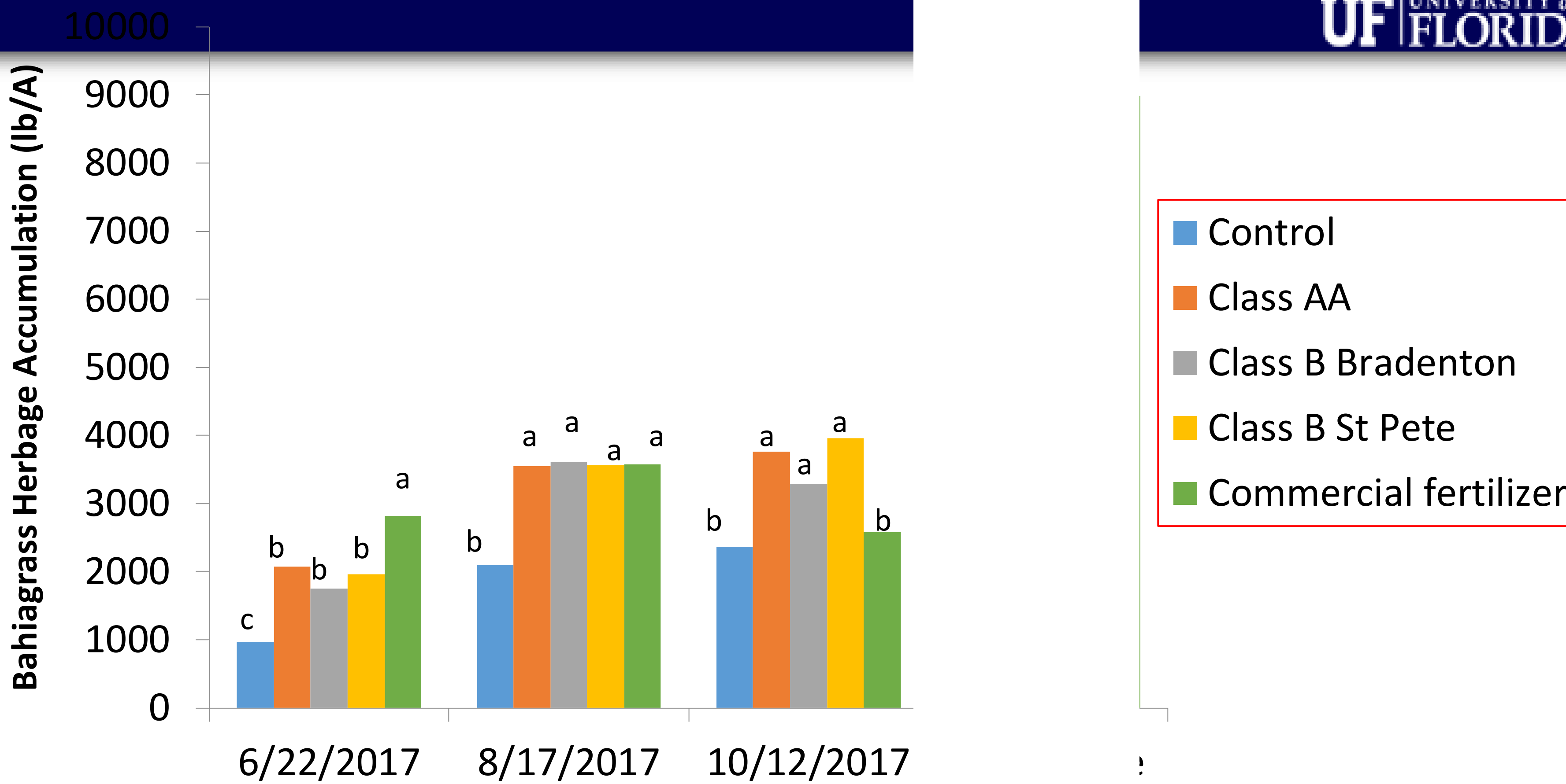
Drain gauge lysimeters

Greenhouse gas collection

Biosolids and biochar application

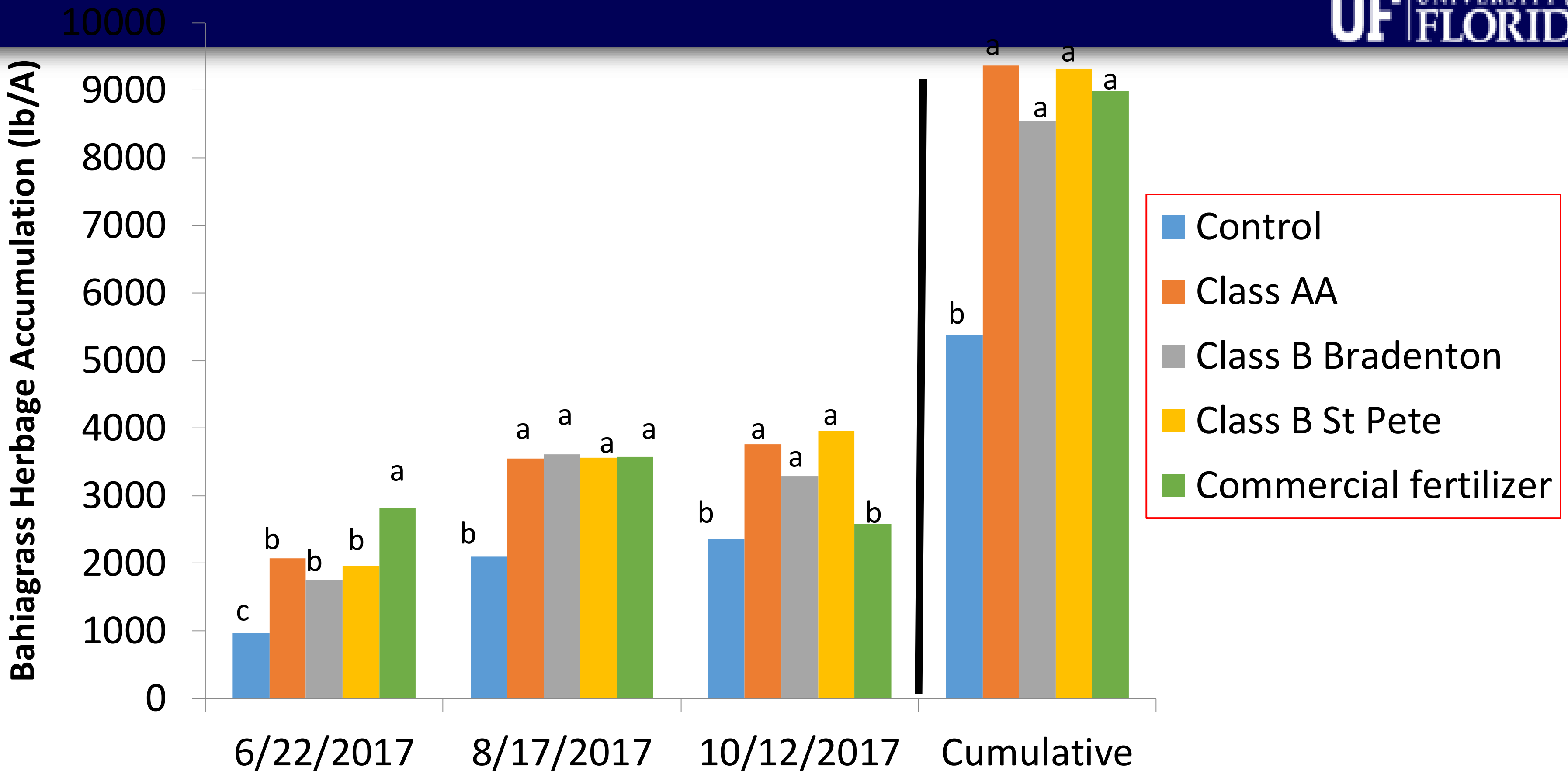
Biosolids and biochar application

Bahiagrass Herbage Accumulation (2017)



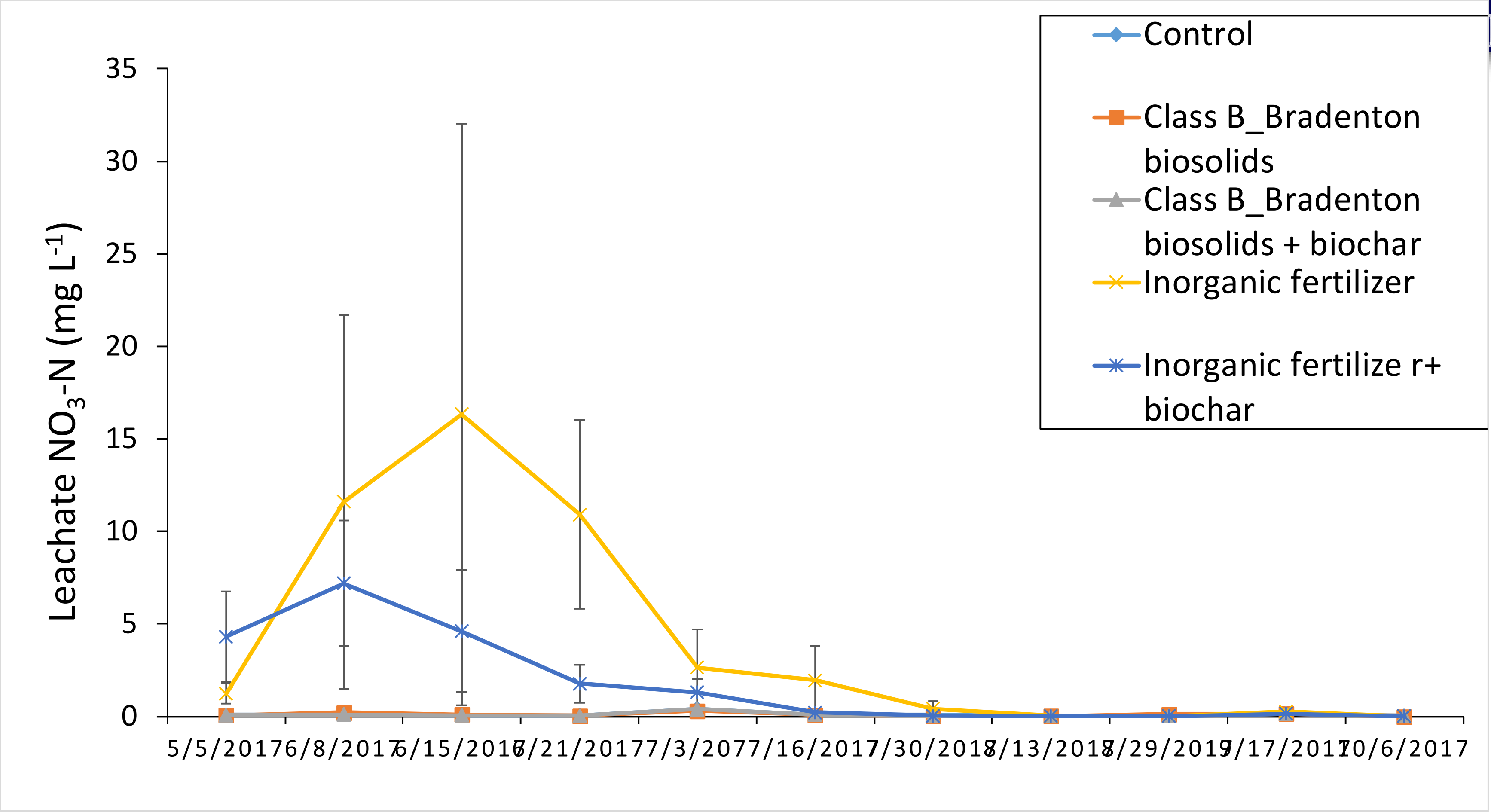
Source: Silveira et al. (unpublished data)

Bahiagrass Herbage Accumulation (2017)



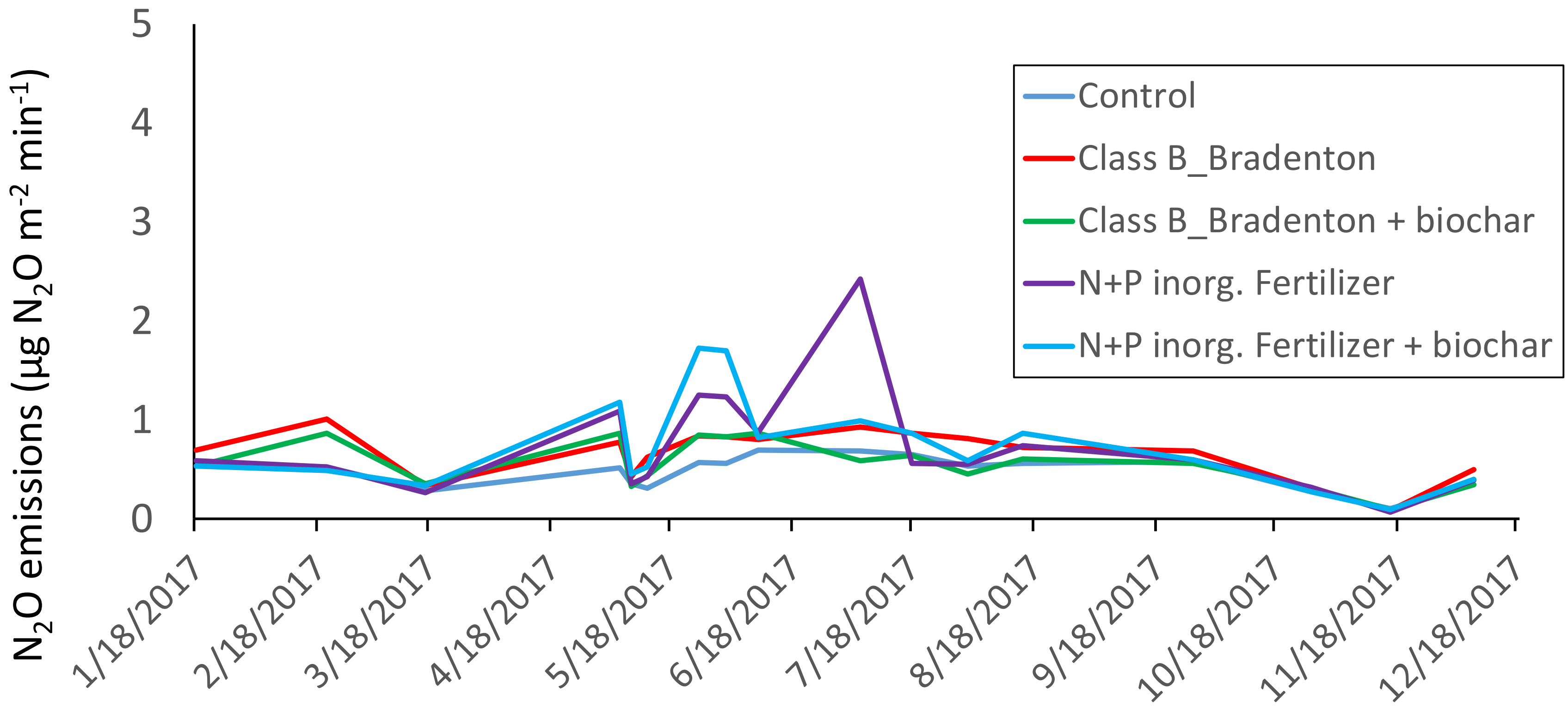
Source: Silveira et al. (unpublished data)

Leachate N



Source: Silveira et al. (unpublished data)

Nitrous Oxide (N_2O) Emissions



Source: Silveira et al. (unpublished data)

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Summary

- Data (2017 and 2018) suggested no significant effect of N source (Class AA, Class B biosolids, and commercial inorganic fertilizer) on bahiagrass herbage accumulation and nutritive value
- Biosolids (either alone or in combination with biochar) had no significant impact on leachate N and P concentrations. Large N and P pulses following commercial fertilizer application were observed in 2017 and 2018.
- No agronomic/environmental benefits of biochar were observed

Assessing Potential Phytotoxicity of Water Treatment Residual Use in Bahiagrass Pastures

Maria L. Silveira, Don Graetz, Lynn Sollenberger, Joao Vendramini

Funding source: FDCAS (2006-2007); IFAS (2007-2009)

Agronomy, Soils & Environmental Quality

Land Application of Aluminum Water Treatment Residual to Bahiagrass Pastures: Soil and Forage Responses

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ABSTRACT

Phosphorus transport is an environmental concern, particularly in coarse-textured soils with minimal P-sorbing capability. This 2-yr study evaluated the impact of an Al water treatment residual (Al-WTR) application on soil P responses, leachate P concentrations, and bahiagrass (*Paspalum notatum* Flüggé) yield and nutritive value. Treatments were a factorial combination of three Al-WTR levels (0, 35, and 70 Mg ha^{-1}) and two methods of application (surface vs. incorporated), replicated four times in a randomized complete block design. Forage was harvested at 28-d intervals from May to November 2007 and 2008 and analyzed for neutral detergent fiber and tissue mineral concentrations. Soil samples were collected in August 2006, before the Al-WTR application, and in November 2007 and 2008. Shallow groundwater P was monitored using a piezometer installed at the 60-cm depth. Soil water-extractable P and leachate P concentrations decreased as Al-WTR application level increased. Mehlich-1 Al and soil P storage capacity values increased linearly as Al-WTR application level increased. Soil disturbance due to incorporation of Al-WTR resulted in horizontal P transport in the soil. Incorporation of Al-WTR caused a yield suppression in Year 1 (~11% compared with surface application), but no negative effect was observed in Year 2. Neutral detergent fiber and crude protein were not affected by Al-WTR application level or method. Data indicate that Al-WTR reduced P mobility in a Spodosol with no impact on forage responses except for a light reduction in yield in the first year if Al-WTR was incorporated.

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Rationale

- Water treatment residuals (WTR), the byproduct of the drinking water purification process, contain amorphous Fe or Al oxides or $CaCO_3$ as well as sediments and humic substances . Extensive research demonstrated WTRs represent a relatively inexpensive alternative to reduce P mobility in P-impacted soils (Makris et al., 2004)

- There is concern in the agricultural sector of using an amendment containing Al and the potential effects that may have on crop growth and production (Al toxicity or P deficiency)

- Because of its chemical makeup and high concentration of Al, Al-WTR may compete with plants for available P

- The **objectives** of this 2-yr field study were to: (i) examine the impacts of Al-WTR application level (0, 35, and 70 Mg ha^{-1}) and method of application (surface vs. incorporated) on soil P concentration, P sorption capacity, and leachate P concentrations in a Florida Spodosol; and (ii) evaluate bahiagrass yield, nutritive value, and tissue P, Al, Ca, and Mg concentration responses to Al-WTR application

Experimental Setup

- Initial soil P concentrations were low (Mehlich-1 P = 2.1 mg kg–1). Additional P was surface applied in April 2007 as triple superphosphate (TSP) with a hand- held fertilizer spreader to all plots at 224 kg P ha–1. Applying TSP at high levels allowed evaluation of the movement of P throughout the soil profile. It also helped to simulate circumstances when P would be applied at high levels to the soil surface, such as in the repeated application of manures or biosolids at N-based agronomic rates. Mehlich-1 soil P level (A horizon) after P fertilizer application was 32 mg kg–1.
- Shallow groundwater P was monitored using piezometer installed in the center of each plot at 60-cm depth just above the spodic horizon.
- Bahiagrass was harvested at 28-d intervals from May to November in 2007 and 2008 (for a total of five harvests per year).

Bahiagrass herbage accumulation as affected by Al-WTR application method and year

Method of WTR application	Bahiagrass Herbage Accumulation ($Mg\ ha^{-1}$)	
	2007	**2008**
Surface applied	10.6 a	11.5 a
Incorporated	9.4 b	11.6 a

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Bahiagrass tissue P concentration as affected by Al-WTR application level

Table 6. Bahiagrass tissue P concentration as affected by Al water treatment residual (Al-WTR) application level.

Al-WTR level	Tissue P†
$Mg\ ha^{-1}$	$g\ kg^{-1}$
0	5.4
35	3.2
70	2.6
SE	0.3
Polynomial contrast	linear***

*** Significant at $P \leq 0.0001$.

† Data represent the average across Al-WTR application method and year.

Soil water-extractable P (WEP) and P storage capacity (SPSC) in the A_1 (0–8 cm), A_2 (8–15 cm), E (15–30 cm), and Bh (30–60 cm) horizons as affected by the Al water treatment residual (Al-WTR) application level at the end of the 2-yr study.

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Al-WTR application level	___________ WEP ____________				___________ SPSC ____________			
Mg ha^{-1}	A_1	A_2	E	Bh	A_1	A_2	E	Bh
	__________________________ mg kg-1___________________________							
0	18	17	4.5	1.7	-32	-12	0.5	16
35	7.3	7.3	1.8	2.5	-4	-0.04	9	25
70	2.8	4.6	1.4	1.0	33	10	22	47
SE	0.9	0.7	0.4	0.6	9	8	11	20
Polynomial contrast	L**	L*	L*	ns	L**	L**	ns	ns

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Leachate P

Al-WTR application level	Leachate P concentration	
	Surface	Incorporated
Mg ha^{-1}	______________ mg L^{-1} ______________	
0	1.0b†	3.4a
35	0.4b	1.4a
70	0.2a	0.5a
SE	0.4	0.4
Polynomial contrast	L*	L**

*Significant at P ≤ 0.05; ns, not significant

** Significant at P≤ 0.01

†Means followed by the same letter within row are not significantly different (P > 0.05)

L = linear

Summary

- Al-WTR reduced soil WEP and Melich-1 P, and the SPSC, particularly in the surface horizon (<15-cm depth). A linear increase in Mehlich-1 Al concentrations in the surface horizons was observed as Al-WTR application increased.
- Leachate P concentrations decreased with application of Al-WTR. Soil disturbance due to incorporation of Al-WTR resulted in horizontal P transport in the soil.
- Forage yield was affected by Al-WTR only during the first year after application when the amendment was incorporated into the soil. This result was due to disturbance of the bahiagrass stand by disking for the amendment incorporation and not to the effects of the Al-WTR.
- Tissue NDF and CP concentrations were not affected by Al-WTR application for the duration of the study. Tissue analysis did not show enhanced accumulation of Al, and accumulation of Ca and Mg was not restricted. This suggests that the application of Al-WTR has no impact on cation accumulation by the plant roots. Tissue P declined with added Al-WTR, but concentrations did not drop below the critical level

Rainfall Simulation

Runoff and Leachate N and P losses from Bahiagrass Pastures Fertilized with Various Biosolids Sources

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[1]UF/IFAS Range Cattle REC, Ona, FL. [2]UF/IFAS Soil & Water Sciences Dept., Gainesville, FL. [3]St Johns River Water Management District, Palatka, FL.

Funding source: St. Johns River Water Management District

Rationale

The St. Johns River (SJR) basin in Florida has recently experienced a dramatic increase in biosolids-P application loads (29 tons of biosolids-P in 2000 vs. 1,508 tons in 2015). Concurrently, P levels in runoff have also increased significantly, particularly in the upper basin where the majority of biosolids are applied mainly to bahiagrass pastures and citrus. Although it nearly impossible to determine whether the increases in runoff P are solely due to biosolids application, historical data suggested that soil test P in the basin is gradually increasing

Objectives: 1. Identify and thoroughly characterize the main biosolids materials routinely applied in the SJR basin, 2. determine N and P losses via leaching and surface runoff associated with selected biosolids materials, and 3. evaluate the relationship between biosolids properties (e.g. water extractable P, PSR) and nutrient levels in runoff and leachate to predict potential risks of nutrient transport

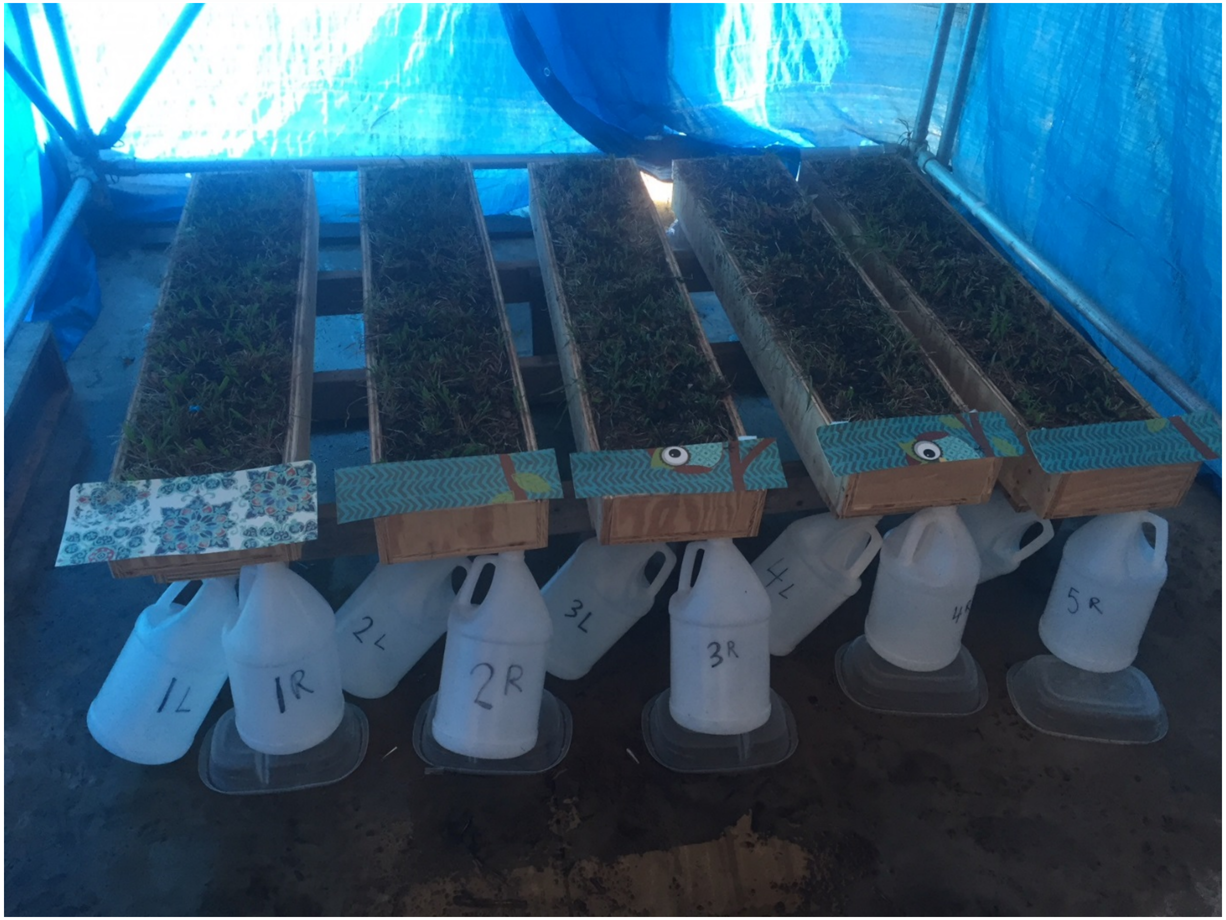
Biosolids chemical characterization

Biosolids	pH	Solids	Total N	Total P	WEP	NH_4-N	NO_3-N	As	Cd	Cr	Pb	Hg	Mo	Ni	Se	Zn
		g kg^{-1}						mg kg^{-1}								
Broward	7.6	170	72	23	0.6	17	3	6.6	1.3	28.9	22.4	0.6	9.4	18.7	5.4	885
Miami-Dade	8.1	230	84	28	0.9	24	3	6.4	6.7	62.7	44.8	0.9	23.1	43.7	11.1	1266
Tampa	7.6	190	61	18	1.7	14	3	4.8	3.9	26.6	43.8	0.6	16.2	26.3	42.4	1163
Orlando	5.9	170	76	34	15	11	3	6.6	0.8	15.6	10.4	0.5	8.6	9.4	9.9	496
GreenEdge	6.5	920	66	19	1.6	6	2	3.6	1.3	22.3	29.1	0.5	45.1	31.7	4.9	891
Bradenton	6.8	150	48	33	1.9	11	7	4.8	1.3	22[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
St. Pete	7.8	160	76	34	4.7	3	9	2.7	0.8	17.0	27.7	0.7	13.9	13.4	6.6	770

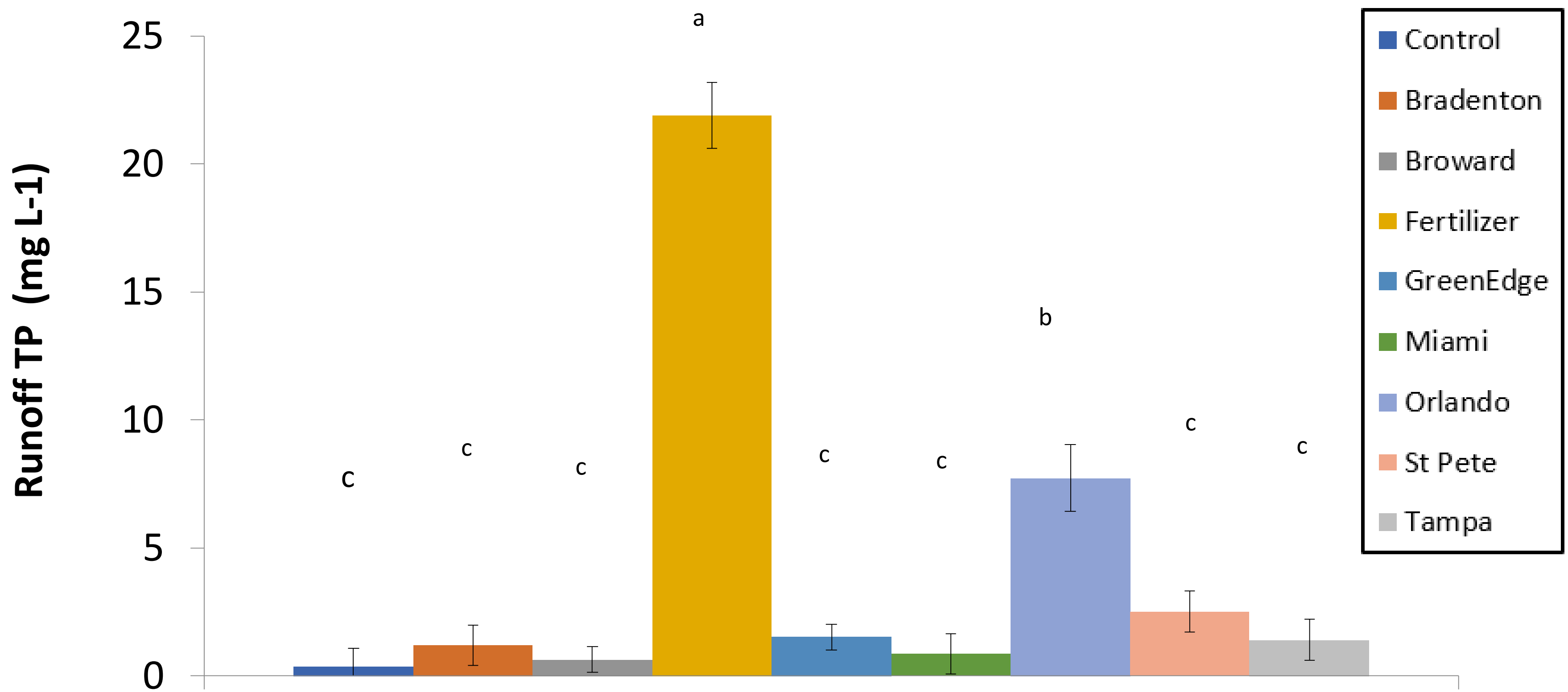
N:P ratio of 1.5 to 3.4

% WEP: ~3 to 44% total P

N and P losses in surface runoff and leaching were evaluated using a modified packed box protocol from the U.S. National Phosphorus Research Project (National Phosphorus Research, 2005). The modified design of the runoff boxes allowed simultaneously recovery of leachate and runoff samples


1L
1R
2L
2R
3L
3R
4L
5R

Flow-weighted runoff total P concentration



Source: Silveira et al. (unpublished data)

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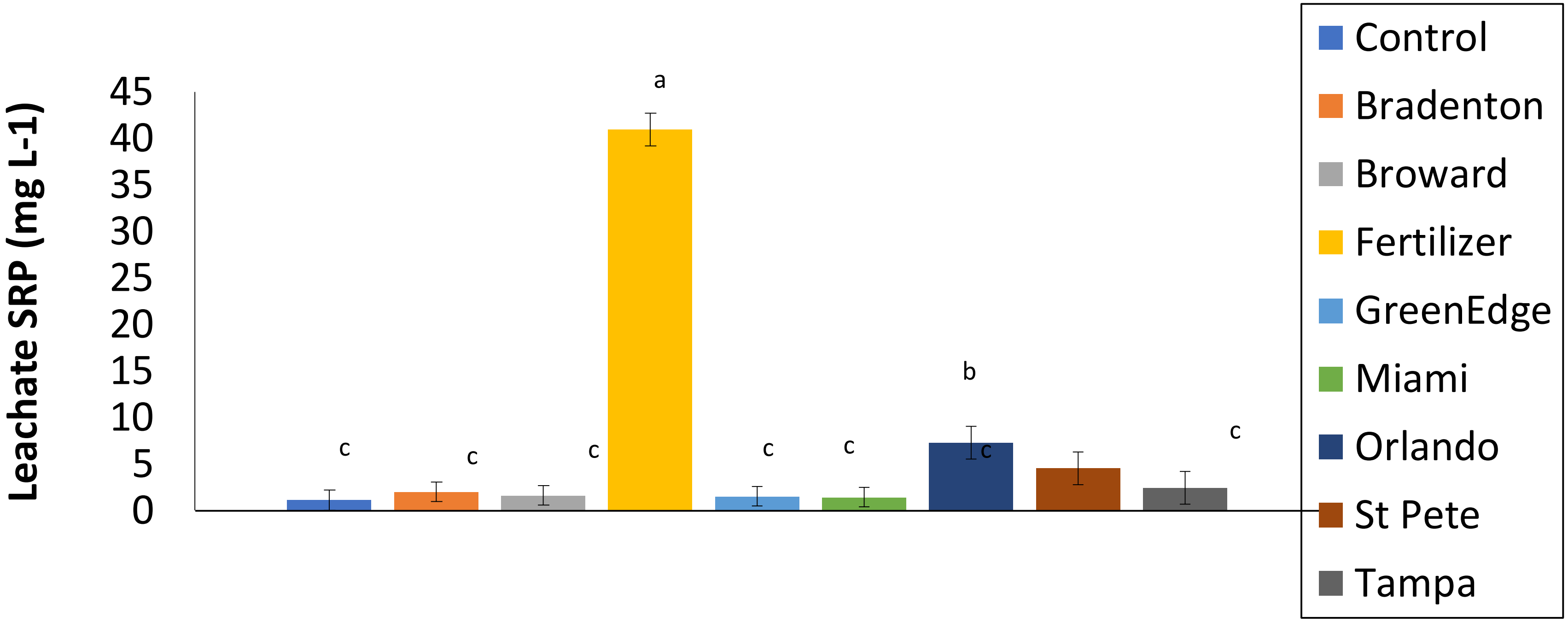
Flow-weighted leachate soluble reactive P concentrations



Source: Silveira et al. (unpublished data)

Cumulative P mass loss in runoff and leachate

	Runoff			Leachate		Total P loss	
	Total P	TDP	SRP	TDP	SRP	P mass in runoff + leachate	Percentage of added P
Treatment	___________________________ mg				___________________________		%
Control	13.4	10.9	9.8	7.2	6.6	20.6	_
Bradenton	25.4	21.1	15.4	30.0	24.8	55.4	2.4
Broward	11.1	10.8	5.8	14.7	12.5	25.8	1.1
Fertilizer	531.4	499.8	441.2	330.2	303.5	861.6	37.9
GreenEdge	29.3	24.6	22.7	24.6	17.5	53.9	2.4
Miami	15.4	10.5	10.4	18.1	17.2	33.6	1.5
Orlando	156.7	145.1	139.1	52.8	50.8	209.5	9.2
St Pete	77.7	60.9	52.9	26.4	25.6	104.1	4.6
Tampa	23.4	21.5	18.8	19.6	14.5	42.9	1.9
SE	12.4	18.7		18.3	17.9		

Source: Silveira et al. (unpublished data)

THANK YOU!

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