AGRONOMIC AND ENVIRONMENTAL IMPACTS OF LAND APPLICATION OF BIOSOLIDS TO BAHIAGRASS PASTURES IN FLORIDA

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1. PROJECT OVERVIEW

Biosolids have clear agronomic benefits, but concerns over nutrient accumulation in soils and subsequent impacts on water quality can limit land application in Florida. The ***objectives*** of this proposal are *(1) to establish a long-term, instrumented, research and demonstration field trial designed to evaluate the agronomic benefits of biosolids and biochar application on bahiagrass production and nutritive value, (2) to monitor the potential effect of biosolids application on water quality, and (3) to evaluate greenhouse gas (carbon dioxide, nitrous oxide, and methane) emissions and the potential impacts of biosolids and biochar application on soil chemical, physical and biological properties.* Our ***principal hypothesis*** is that most biosolids applied to pastures convey significant agronomic benefits and that they behave as "slow release" nutrient sources with minimal negative environmental impact. *This proposal addresses the **FCA Priorities # 9 "Land Application of Biosolids on Pastures"** and **# 1 "Fertilization (Alternative Fertilizer Sources)**.*

2. PROJECT ACTIVITIES (JANUARY – AUGUST 2017)

Experimental Setup

A field trial was established in 2016 to evaluate the agronomic and environmental impacts of various biosolids sources applied to bahiagrass (*Paspalum notatum* Flugge) pastures at the Range Cattle REC in Ona (Fig. 1). In 2017, one Class A biosolids, two Class B biosolids materials, and one wood biochar were selected and thoroughly characterized in the laboratory using routine analysis (Table 1). Biosolids materials were surface applied to the experimental area and compared to nutrition provided with mineral fertilizers. Land application of the residuals occurred during Spring 2017 (April 25-26). Biosolids sources were applied either alone or in combination with biochar to supply an estimated rate of 160 lb plant available N/A/yr, which correspond to UF/IFAS high N option for established bahiagrass and the most common application rate used by commercial cow-calf operations in Florida. The availability of the N in the biosolids was estimated using Florida -DEP factor of 1.5. Nitrogen mineralization from the various biosolids treatments (biosolids alone and co-applied with biochar) were evaluated in the field following the litter bag procedure described by Castillo et al. (2010). Field-incubated bags containing biosolids or biosolids+biochar-treated samples were collected at various intervals and analyzed for total N and inorganic N. Biochar was also applied in April, 2017 at 20 Mg ha^{-1} rate, which corresponds to an application rate of ~ 1% (wt. basis). Control treatments included plots receiving inorganic commercial fertilizer (ammonium nitrate + triple superphosphate alone and in combinations with biochar) and pastures receiving no biosolids, fertilizer, or biochar. Forage, soil, water quality, soil moisture, ground water levels, and gas emissions will be monitored during the 2017 growing season.

<u>Forage Responses</u>

Forage were harvested at 6-week interval from June to November. During each harvest, two 1- x 6-m forage strips were harvested from each plot to a 7.5-cm stubble height using a forage harvester. The remaining herbage was mowed with a flail harvester at the same stubble height. Samples were weighed fresh and sub-samples weighed and oven dried at 60^{o}C for 48 hr for DMY determination. Dried samples were ground to pass a 1-mm mesh and analyzed for total N, P, and trace elements concentrations.

<u>Soil and Environmental Responses</u>

Soil samples (0-12”) were taken in February 2017. Analyses included soil pH, Mehlich-3 extractable P, K, Ca, Mg, Fe, and Al and total C, N, P, and trace element concentrations. Extractable NO_3-N and NH_4-N will also be determined. For each soil depth, the P saturation ratio [PSR = Mehlich-3-P / (Mehlich-3-Al + Mehlich-3-Fe)] was calculated. The PSR relate to soil P retention capacity.

Leachate N and P were monitored in the treatments receiving the class B Bradenton biosolids and commercial fertilizer (total of 24 plots: 1 biosolids material + 1 commercial fertilizer, with or without biochar + 2 control * 4 replicates = 24). Groundwater level, soil moisture content, and weather data were continuously monitored in the experimental site. Leachate samples were collected at 2- or 4-wk intervals and analyzed for total and inorganic P, total N, NO_3-N and NH_4-N concentrations.

Greenhouse gas fluxes were measured (same treatment as the water quality monitoring) using the static chamber technique. Gas samples were collected at 14-d intervals and analyzed for carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) concentrations.

In addition to the field study, a number of laboratory studies (including a leaching and a static incubation experiments) were conducted from January to August, 2017. Data collection relative to these efforts are still underway.

3. RESULTS SUMMARY

Bahiagrass Responses

Addition of fertilizer (either as commercial N and P or biosolids) increased bahiagrass herbage accumulation by an average of 100% (Table 2). Greater bahiagrass herbage accumulation was generally associated with the treatments receiving commercial N and P fertilizer (Table 2). Class A and Class B St Pete biosolids plus biochar resulted in cumulative bahiagrass yields similar to commercial fertilizer.

Addition of biochar with commercial fertilizer increased bahiagrass yield by an average of 17%. Similarly, biochar also had generally positive impacts on bahiagrass yields for the treatments receiving biosolids. Currently, data are still being collected for the 2017 growing season. One more harvest event is expected to occur in October 2017 to confirm whether treatment differences will remain similar as the growing season progressed.

Water Quality and Greenhouse Gas Responses

Leachate P and N concentrations generally remained relatively constant throughout the growing season (data not shown). The only exception were the treatments receiving commercial inorganic fertilizer that resulted in greater N and P leaching compared with biosolids treatments (Table 3). Similarly, greater nitrous oxide and carbon dioxide emissions were also generally associated with the treatments receiving commercial fertilizer (Fig. 2). These results indicated that N and P losses associated with treatments receiving biosolids can be lower than commercial fertilizer. In addition, based on the water quality data collected from May to Aug., 2017, no potential benefit of biochar in reducing N and P losses has been observed.

4. SUMMARY AND CONCLUSIONS

Results suggested significant differences in bahiagrass responses to different biosolids sources. Because nutrients (mainly N) present in biosolids are slowly released, we expect that cumulative annual bahiagrass production for the treatments receiving biosolids will be comparable to commercial inorganic fertilizer. Based on the data from the 2 harvest events, it appears that co-application of biosolids with biochar promotes bahiagrass production. Application of biosolids (either alone or in combination with biochar) had no significant impact on water quality and greenhouse gas emissions. However, when bahiagrass received commercial inorganic fertilizer, large pulses of N and P were observed immediately after fertilizer application. Because temperature and soil moisture affect microbial processes controlling N and P dynamics, it is crucial to continue monitoring N and P losses throughout the entire growing season. We hope that funds will continue to be available through the Florida Cattlemen's Beef Enhancement program to support our current efforts that address research priorities # 9 "Land Application of Biosolids on Pastures" and # 1 "Fertilization (Alternative Fertilizer Sources).

ACKNOLEDGEMENTS

We thank H&H liquid disposal for their assistance obtaining and hauling the biosolids materials to the study site. We also want to extend our appreciation to the FCA for providing the funds to support this project.

5. PERCENTAGE COMPLETION OF PROJECT DELIVERABLES: 100%

Table 1. Characteristics of biosolids and biochar land applied in 2017.

Property[1]	Class AA Pellets biosolids	Class B - Bradenton biosolids	Class B St-Pete biosolids	Biochar
Moisture	8.4	85	84	14.1
T-N (%)	6.6	4.8	7.5	0.34
T-P_2O_5 (%)	4.3	7.5	5.9	0.21
T-K_2O (%)	0.17	0.42	0.63	0.76
NH_4^+-N	0.6	1.1	2.7	0.2
NO_3^--N	0.2	0.7	0.9	0.2
S (%)	2.1	1.0	1.1	0.03
B (%)	0.01	0.007	0.006	0.002
Zn (%)	0.09	0.1	0.06	0.002
Mn (%)	0.01	0.007	0.006	0.05
Fe (%)	1.1	4.4	0.3	0.1
Cu (%)	0.03	0.01	0.06	0.001
Ca (%)	2.5	2.7	2.7	1.0
Mg (%)	0.5	0.6	0.9	0.3
Na (%)	0.3	0.3	0.1	0.07
Al (%)	0.5	0.3	0.3	0.05
Cd(ppm)	1.6	0.6	0.8	0.001
Cr(ppm)	62.1	63.3	23.4	2.5
Pb(ppm)	29.7	14.5	11.8	0.8
Co(ppm)	1.2	3. 8	2.5	0.4
Ni(ppm)	45.3	23.8	13.5	0.2

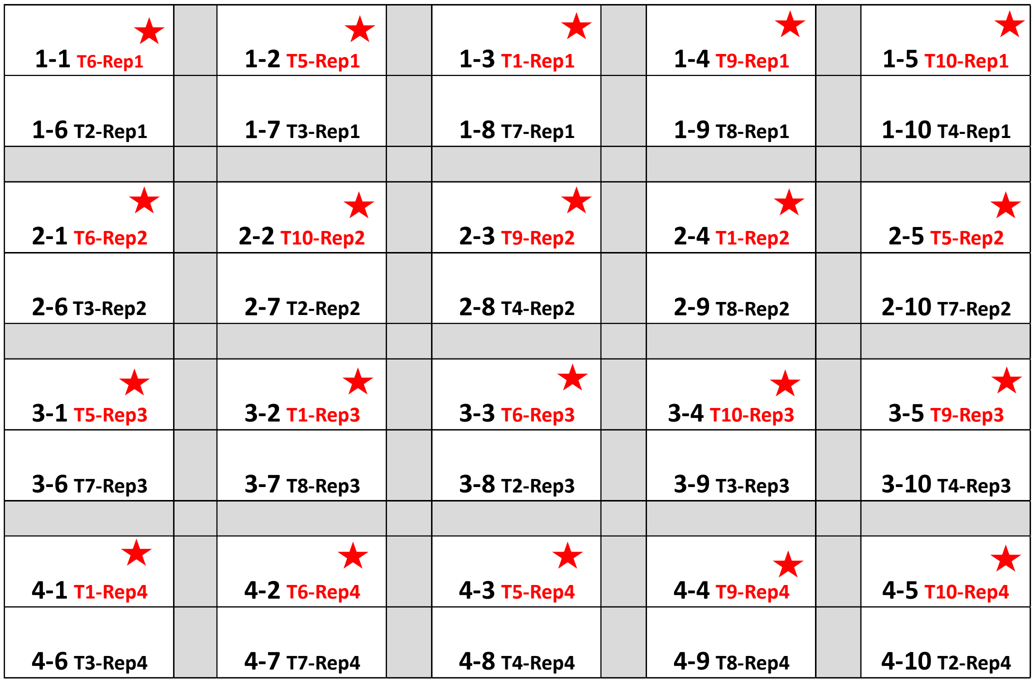
[1]Valuess are expressed in dry basis

Table 2. Bahiagrass herbage accumulation as affected by fertilizer and biochar application

Treatment	Harvest 1 (06/22/2017)	Harvest 2 (08/17/2017)	Sum
	Bahiagrass Herbage Accumulation (lb/acre)		
Control	864 f	2080 d	2944 d
Control + biochar	1073 ef	2114 d	3187 d
Class A pellets	2189 bcd	3154 c	5343 bc
Class A pellets + biochar	1967 cd	3937 ab	5904 abc
Class B Bradenton biosolids	1714 cd	3605 abc	5319 bc
Class B Bradenton biosolids + biochar	1797 cd	3627 abc	5424 bc
Class B St Pete biosolids	1616 de	3250 bc	4865 c
Class B St Pete biosolids + biochar	2305 abc	3884 ab	6189 ab
Commercial fertilizer	2763 ab	3128 c	5891 abc
Commercial fertilizer + biochar	2883 a	4025 a	6908 a
P value	<0.0001	<0.0001	<0.0001

Table. 3 Phosphorus and nitrogen leaching before and after fertilizer/biosolids application.

Treatment			3/14/2017 (Before fertilization)						5/5/2017 (After fertilization)					
Plot ID	N sources	Biochar	Ortho-P	TKN	NH4-N	NOx-N	Organic N	Total P	Ortho-P	TKN	NH4-N	NOx-N	Organic N	Total P
			µg/L	________________ mg/L ________________					µg/L	________________ mg/L ________________				
1-3	Control	no	1.55	0.37	0.16	0.04	0.21	0.37	3.06	0.54	0.27	0.06	0.27	0.54
2-4	Control	no	1.65	0.29	0.12	0.06	0.16	0.29	3.39	0.94	0.21	0.06	0.72	0.94
3-2	Control	no	1.11	0.92	0.09	0.01	0.83	0.92	**NO**	**NO**	NO	NO	NO	**NO**
4-1	Control	no	1.57	0.37	0.16	0.08	0.21	0.37	2.28	0.58	0.22	0.10	0.36	0.58
1-2	Class B_Bradenton	no	2.68	0.38	0.16	0.04	0.22	0.38	4.42	0.79	0.24	0.05	0.56	0.79
2-5	Class B_Bradenton	no	2.04	0.46	0.14	0.04	0.31	0.46	4.02	0.99	0.24	0.02	0.75	0.99
3-1	Class B_Bradenton	no	1.25	0.84	0.12	0.02	0.72	0.84	1.65	0.94	0.23	0.01	0.72	0.94
4-3	Class B_Bradenton	no	1.43	1.33	0.30	0.12	1.02	1.33	1.41	0.82	0.20	0.16	0.62	0.82
1-4	N+P inorg. Fertilizer	no	1.66	0.31	0.14	2.06	0.17	0.31	210.45	0.48	0.26	1.36	0.22	0.48
2-3	N+P inorg. Fertilizer	no	1.78	0.16	0.12	5.53	0.04	0.16	66.88	0.65	0.29	2.30	0.36	0.65
3-5	N+P inorg. Fertilizer	no	2.71	1.05	0.17	0.13	0.87	1.05	10.45	1.07	0.20	0.08	0.87	1.07
4-4	N+P inorg. Fertilizer	no	1.94	2.27	0.21	6.23	2.06	2.27	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
1-1	Class B_Bradenton	yes	1.94	0.49	0.16	0.11	0.32	0.49	**NO**	**NO**	**NO**	**NO**	**NO**	**NO**
2-1	Class B_Bradenton	yes	2.33	0.66	0.12	0.03	0.54	0.66	5.31	0.61	0.26	0.03	0.34	0.61
3-3	Class B_Bradenton	yes	1.32	1.42	0.18	0.04	1.24	1.42	1.13	1.07	0.29	0.08	0.79	1.07
4-2	Class B_Bradenton	yes	1.72	0.70	0.19	0.12	0.51	0.70	2.06	0.74	0.20	0.11	0.54	0.74
1-5	N+P inorg. Fertilizer	yes	2.07	0.52	0.13	2.53	0.39	0.52	96.49	0.75	0.41	1.02	0.34	0.75
2-2	N+P inorg. Fertilizer	yes	2.13	0.45	0.11	7.76	0.34	0.45	8.18	0.20	0.32	5.11	**NO**	0.20
3-4	N+P inorg. Fertilizer	yes	1.06	0.62	0.24	0.16	0.38	0.62	6.11	0.85	0.17	0.22	0.67	0.85
4-5	N+P inorg. Fertilizer	yes	2.10	0.39	0.17	0.09	0.23	0.39	2.75	0.61	0.58	10.94	0.03	0.61



Treatment ID	Biosolids/Fertilizer	Biochar
1	Control	no
2	Control	yes
3	Class A pellets	no
4	Class A pellets	yes
5	Class B_Bradenton	no
6	Class B_Bradenton	yes
7	Class B_St Pete	no
8	Class B_St Pete	yes
9	N+P inorg. Fertilizer	no
10	N+P inorg. Fertilizer	yes

Fig. 1. Schematic representation of experimental layout

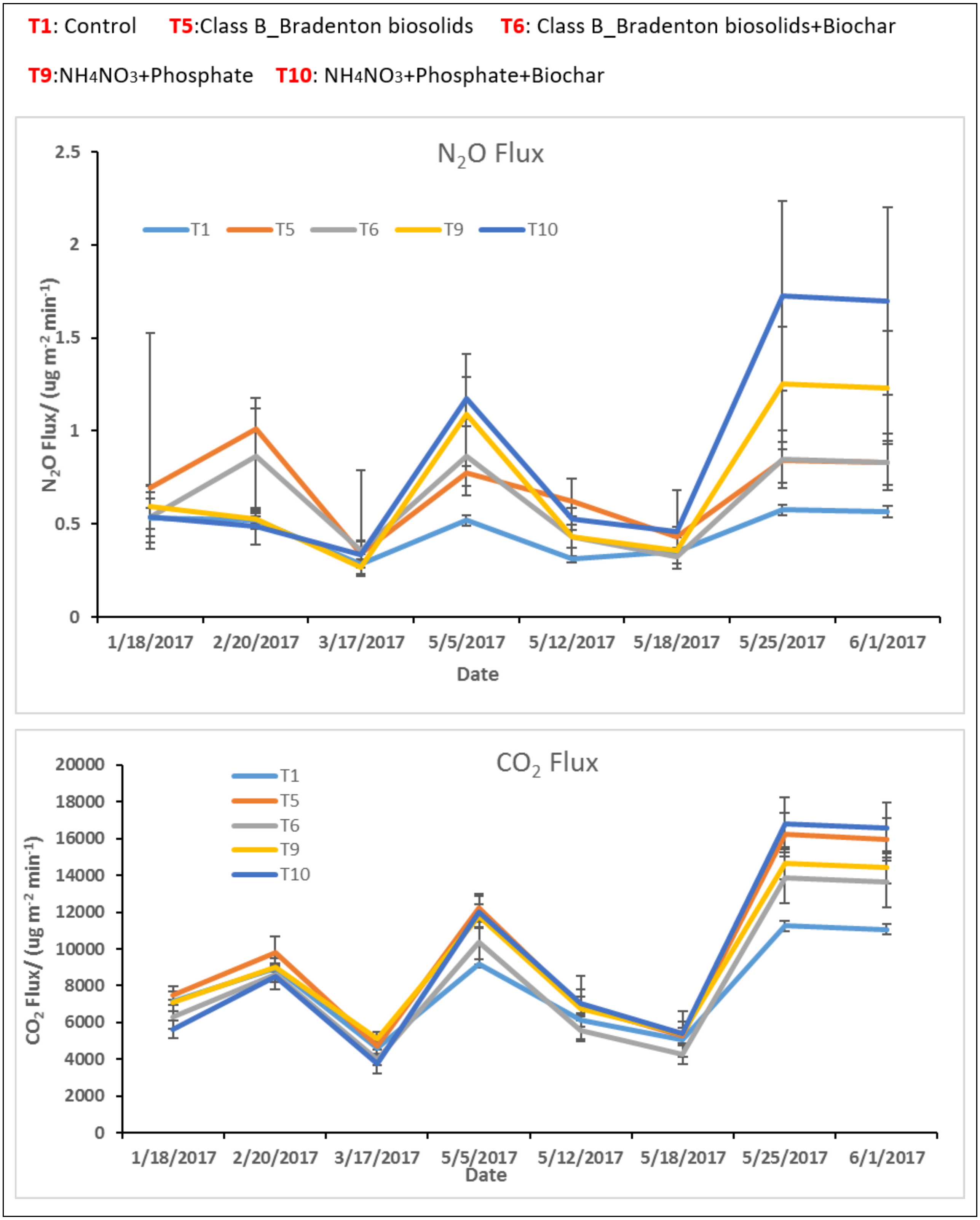


Fig. 2. Nitrous oxide (N_2O) and carbon dioxide (CO_2) fluxes from bahiagrass pastures under different fertilization strategies.

BUDGET FOR FLORIDA CATTLE ENHANCEMENT FUND- BUDGET JUSTIFICATION					
PROJECT TITLE: Agronomic and environmental impacts of land application of biosolids to bahiagrass pastures in Florida (# P0037802)					
DETAILED LINE ITEM DESCRIPTION	QTY	% Complete	TOTAL	EXPLANATION/JUSTIFICATION OF DELIVERABLE	COMPLETION DATE
Water and gas sampling and analysis	N/A	100%	$ 16,931.33	lab consumables (reagents, filter paper, plastic containers, instrument parts), syringes, soil moisture sensors, tubes, vacuum pump	9/1/2017
Forage harvest and soil sampling	N/A	100%	$ 6,921.93	field supplies. Items include (but not limited to): paper bags, soil core liners, batteries	9/1/2017
Fertilizer materials	N/A	100%	$ 4,103.75	purchase of commercial fertilizer and biochar for the field study	9/1/2017
Laboratory analyses	Various	100%	$ 18,226.83	soil, plant tissue, biosolids, and biochar characterization, shipment of samples for analysis	9/1/2017
Equipment	1	100%	$ 5,932.14	soil water release curve characterization	9/1/2017
Final Research Project Report	1			project report detailing research, which may include, findings, future needs, results, conclusions, issues, risks, assessments and all other pertinent information.	9/1/2017
Indirect Cost	N/A		$ 6,160.35		N/A
GRAND TOTAL: (equal to percentage of completion)			**$ 58,276.33**		