Final Technical Report

FCEB Project #18

FINAL REPORT - FLORIDA CATTLE ENHANCEMENT GRANT

Project Title: Evaluating the agronomic performance of bahiagrass under different biosolids and inorganic fertilizer phosphorus fertilization regimens

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Project Overview - Biosolids have clear agronomic benefits, but concerns over nutrient accumulation and subsequent impacts on water quality resulted in more stringent state regulations that will limit the rates of biosolids that can be recycled in pastures. Although new biosolids regulation will not solve water quality problems, it will result in other unintended consequences. From an agronomic standpoint, it will be necessary to supplement pasture fertilization with inorganic fertilizers, which typically cost more and have greater environmental risk than biosolids. Currently there is no scientific study demonstrating that biosolids negatively impacts water quality. Our previous work (Silveira et al., 2019, Lu et al., 2019, 2020a, 2021, 2023) demonstrated that prudent nutrient management is possible on biosolids-amended Spodosols with high water tables. The main objectives of this study are to 1. evaluate bahiagrass production and nutritive value as affected by biosolids and inorganic fertilizer fertilization regimens, 2. examine N and P losses and the relative crop availability of biosolids-P compared with inorganic P fertilizer, 3. investigate the long-term impacts of biosolids application on soil health, and 4. maintain an existing long-term, instrumented, research and demonstration site designed to evaluate the benefits and risks associated with land application of biosolids to pastures. Greenhouse and field studies will be conducted to address these objectives. An established, long-term, instrumented research field trial will be utilized to evaluate the impacts of reduced biosolids P application rates imposed by new FL DEP biosolids rule on bahiagrass and soil responses. A companion greenhouse study will quantify biosolids relative phytoavailability compared with inorganic fertilizer P. This project addresses Florida

Cattlemen's Association research priority "Fertilization - Biosolids and soil amendments use and processing".

Final Report- All deliverables associated with this project are progressing as planned. No major limitations have occurred during the reported. One PhD student is currently working on this project. Treatments (biosolids and commercial fertilizer) were land applied in 2023 and 2024. Forage, water, and soil responses have been monitored during the 2023-2024 growing season. Results will continue to be disseminated through peer-reviewed publications, extension articles, and presentations.

Objective 1. Evaluate bahiagrass production and nutritive value as affected by biosolids and inorganic fertilizer fertilization regimens

A field experimental area was established at the UF/IFAS Range Cattle REC in 2016 on a bahiagrass pasture. **The site represents the only established field trial in Florida addressing issues related to biosolids application.** The experimental area consisted of ~ 20 acres that was fenced and instrumented with water quality monitoring equipment (i.e., drain gauge lysimeters, pore water samplers, pressure transducers) and soil moisture sensors.

Treatments included biosolids and inorganic fertilizer (ammonium nitrate plus triple super phosphate) applied at 40, 80, 160, and 360 lb P_2O_5 A^{-1} yr^{-1}. Treatment selection was based P recommendations imposed by new DEP biosolids regulations (P rates of 40 to 80 lb P_2O_5 A^{-1} yr^{-1} for grazed and hayed bahiagrass, respectively). Based on site characteristics, up to 160 lb P_2O_5 A^{-1} yr^{-1} could potentially be land applied. The highest rate (360 P_2O_5 A^{-1} yr^{-1}) is based on IFAS bahiagrass N requirement but it exceeds FL DEP recommendations.

Bahiagrass was harvested at 45-day intervals from June to November (2023) and in June 2024 to determine herbage accumulation and nutritive value. At each harvest event, a 3 x 12 ft forage strip was harvested with a forage harvester and the remaining biomass was mowed to the same stubble height. Forage samples were analyzed for crude protein, total P concentrations, and in vitro digestible organic matter (IVDOM).

In addition to the field trial, a greenhouse study was conducted to evaluate biosolids relative the P phytoavailability as compared with inorganic fertilizer. Treatments were a factorial combination of two soils , three P sources [Class AA and Class B biosolids, and triple superphosphate (46% P2O5)], and four application levels: 45 (low), 90 (medium), 180 (high), and 360 lb P_2O_5/A(very high). Associated N levels (applied as ammonium nitrate, 34% N) will be 68 (low), 135 (medium), 270 (high), and 540 kg total N ha-1 yr-1 (very high) Treatments were replicated three times for a total of 72 pots (2 soils × 3 P sources × 4 P application levels * 3 replicates). Phosphorus application rates were based on agronomic recommendations and P limits mandated by the new biosolids regulation.

Objective 2. Evaluate N and P losses via leaching and surface runoff from typical Florida Spodosols amended with biosolids or commercial inorganic fertilizer. Leachate was monitored in 21 plots (2x3 factorial experiment design + control) using drain gauge lysimeters (Drain Gauge G3). Groundwater level, soil moisture content, and weather data were also continuously monitored during the 2021 growing season. Leachate samples were analyzed for total and inorganic P, total N, NO3-N and NH4-N concentrations. The frequency of leachate collection was two weeks or after extreme rainfall events (> 10 mm). In addition to the field study, we also conducted 2 rainfall simulation studies to evaluate N and P losses from contrasting soils receiving biosolids and inorganic fertilizer. Treatments consisted of 2 soils (Low or High soil P storage capacity) x 2 P sources (triple superphosphate+ ammonium nitrate and Class AA biosolids), applied at 0, 40, 80, and 160 lb P_2O_5/A.

Objective 3. Investigate the long-term impacts of biosolids application on soil chemical, physical, and biological properties

Soil core samples were randomly collected from each plot at the -6 and 6-12 inches in November 2023 and analyzed using the comprehensive assessment of soil health (CASH) framework. Analyses include pH, organic matter, extractable nutrients, active carbon, total carbon, total nitrogen, soil respiration, and autoclave-citrate extractable protein.

Results

Field trial - In 2023, biosolids and inorganic fertilizer increased bahiagrass annual herbage accumulation by 2- to 5-fold relative to control treatments; however, herbage mass recorded during the 2023 growing season was significantly less than previous years. Lack of potassium (K) application along with repeated biomass removal are likely the reason for the poor bahiagrass performance. Treatments were land applied again in April 2024. This time K fertilizer was also applied to all treatments with the goal of correcting soil K deficiency.

Data recorded in 2024 demonstrated that bahiagrass herbage accumulation increased linearly with increased biosolids or inorganic fertilizer application (Table 1). However, at the highest P rate evaluated in this study, inorganic fertilizer resulted in greater bahiagrass herbage accumulation than biosolids. This result is likely due to the low solubility of biosolids-P as compared to readily soluble inorganic P fertilizer. As the 2024 growing season progresses, we expected that no differences in bahiagrass yields will be observed between biosolids and inorganic fertilizer. Our data (2022-2024) demonstrated that reduced biosolids rates imposed by new FL DEP detrimentally impacted bahiagrass production and nutritive value.

Table 1. Bahiagrass herbage mass recorded in June 2024 as affected by P source and P application rate.

	P source	
P level	Biosolids	Inorganic Fertilizer
lb P_2O_5 A^{-1}	___ Bahiagrass herbage mass (lb A^{-1})__	
0	567a	567a
45	1206a	728b
90	756a	985a
180	1182a	750b
360	1021b	2717a
SE	144	
Orthogonal contrast	Linear (P = 0.08)	Linear (P = <0.0001)

Soil health responses - Although the benefits of land application of biosolids on soil health are evident in many agricultural soils, particularly in those with low levels of organic matter, our soil test results demonstrated no benefits of biosolids application on soil health indicators. Lack of response is likely due to the moist and warm conditions that favor biosolids decomposition and soil characteristics (coarse texture) that offer limited protection against mineralization.

Water quality - Water quality data from field trial supports our initial hypothesis that reduced biosolids load did not positively affect P and N leaching. No treatment effects were observed on leachate P (Table 2), however, modest increase in leachate nitrate mass were observed in treatments receiving inorganic fertilizer. No differences in leachate P and N between biosolids and control treatments were observed. These data are consistent with previous studies conducted under laboratory and field conditions that reported negligible P leaching in response to biosolids application (Elliott et al., 2002; Esteller et al., 2009; Lu and O'Connor, 2001; Lu et al., 2020; Silveira et al., 2019).

In addition to the field trial, two rainfall simulation studies were conducted during the reporting period. Results showed that N and P losses were significantly greater in treatments receiving inorganic fertilizer vs. biosolids. These data are consistent with previously published work and confirm the environmental benefits of replacing inorganic fertilizer with biosolids.

Table 2. Cumulative annual P, NO_3-N, and NH_4-N mass leached as affected by P source and year. Means represent the average across replicates and sampling events.

		P	NO_3-N	NH_4-N
		------- lb A^{-1} $year^{-1}$-------		
P source	Control	0.4	0.2b±	2.1
	Biosolids	0.4	0.2b	2.3
	Inorganic	0.6	0.5a	7.5
	SE	0.03	0.08	1.20
	P-value	0.100	0.021	0.229
Year	2020	0.5	0.4	2.5b
	2021	0.6	0.4	4.3b
	2022	0.5	0.2	6.7a
	2023	0.5	0.3	4.8b
	SE	0.03	0.08	1.20
	P-value	0.010	0.515	<0.001

±Different letters within columns indicate significant difference (Tukey test, $P \leq 0.05$).

Conclusion

Regardless of P (and N) sources and rates evaluated in the current study, negligible amounts of P (and N) are susceptible to leaching. No differences in N or P leaching were observed between biosolids and control treatments. Although inorganic fertilizer resulted in greater NO_3-N mass leached than the other treatments, the proportion of N leached was small. The lack of biosolids application rate effect on leachate P and N indicates that reduction in biosolids imposed by the new regulation will likely have no positive impact on water quality. Data demonstrated that biosolids can be an environmentally sound fertilizer source to perennial grass pastures. Biosolids can also provide a steady source of P that is expected to provide agronomic benefits such as greater forage productivity and nutritive value relative to unamended soils.

ACKNOLEDGEMENTS - We thank the Florida Cattle Beef Board for providing the funds to support this project.

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Invoice Date:	08/12/2024
Invoice Period:	03/01/2024 - 07/31/2024
Principal Investigator:	Silveira,Maria Lucia
Award Begin Date:	10/30/2023
Award End Date:	07/31/2024
UF FEIN:	59-6002052

Sponsor Award ID:	18
Award Title:	Evaluating the agronomic performance of bahiagrass under different biosolids and inorganic fertilizer phosphorus fertilization regimens
Award Amount:	$48,263.00

Invoice #	I000130446
UF Award #	AWD15787
Primary Project #	P0324555
Primary Department:	60780000
Current Invoice Amount:	$26,416.98

Description	Current	Cumulative
Personnel - Salary	$10,691.16	$19,370.83
Personnel - Fringe Benefits	$1,256.96	$2,281.14
Tuition	$4,336.50	$10,841.25
Materials and Supplies	$6,552.90	$6,552.90
Other Expenses	$0.00	$3,194.37
Domestic Travel	$749.07	$749.07
Direct Cost	$23,586.59	$43,092.00
Facilities and Administrative Costs	$2,830.34	$5,171.00
Total	$26,416.93	$48,263.00

For billing questions, please call 352.392.1235
Brown,Katrina Adel brownk3@ufl.edu
Please reference the UF Award Number and Invoice Number in all correspondence

By signing this report, I certify to the best of my knowledge and belief that the report is true, complete, and accurate, and the expenditures, disbursements and cash receipts are for the purposes and objectives set forth in the terms and conditions of the federal award. I am aware that any false, fictitious, or fraudulent information, or the omission of any material fact, may subject me to criminal, civil, or administrative penalties for fraud, false statements, false claims or otherwise. (U.S Code Title 18, Section 1001 and Title 31, Sections 3729-3730 and 3801-3812).

Katrina Brown

Certifying Official

Payment History	
Cumulative Invoices:	$48,263.00
Payments Received:	$21,846.07
Outstanding Balance:	$26,416.93
Note: Outstanding balance includes current invoice amount	

FOR UF USE ONLY Additional Projects: N

Project ID	Deptid	Department Name	Current	Cumulative

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Invoice Period:	05/01/2024 - 07/31/2024
Principal Investigator:	Silveira,Maria Lucia
Award Begin Date:	10/30/2023
Award End Date:	07/31/2024
UF FEIN:	59-6002052

P0324555	60780000	AG-RCREC-ONA	$26,416.93	$48,263.00