Greenhouse Gas Fluxes From Perennial Grass Bioenergy Feedstock Production

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ABSTRACT

Multiple sites in the southeastern Coastal Plain are being used for trials of two bioenergy grasses - elephant grass (also called Napier grass)(*Pennisetum purpureum* (L.) Schum.) and energy cane (*Saccharum officinarum* L.) to obtain data for greenhouse gas Life Cycle Analysis (LCA) of the crop production enterprise. Two sites are located in Tift County, GA (Tifton loamy sand soil), one site in Peach County, GA (Orangeburg loamy fine sand soil), and one site in Randolph County, GA (Greenville sandy clay loam soil) on lands that were previously weed fallow. The grasses were established in a randomized complete block design in 2006 (Ponder Farm site) and in 2011. Depending on the site, treatments for the grasses include different winter covers (Clover, lupine, or no winter cover), different fertilizer N rates (0, 75, 150, and 300 kg N /ha), and different irrigation rates. To provide specific data for the LCA, weekly or bi-weekly samplings of greenhouse gas fluxes (CH_4, N_2O, and CO_2) using vented chambers were started in 2011 and 2012. Data for August, 2011 through February, 2013 showed that there were no treatment differences but there were significant differences between sites for CO_2 flux from the soil. CH_4 (negative) and N_2O (positive) fluxes were low from both sites but there were significant differences among the sites and among the N treatments. Future research will provide data for LCA of these two bioenergy crops and provide data on the potential production of these crops under varying conditions in the southeastern Coastal Plain.

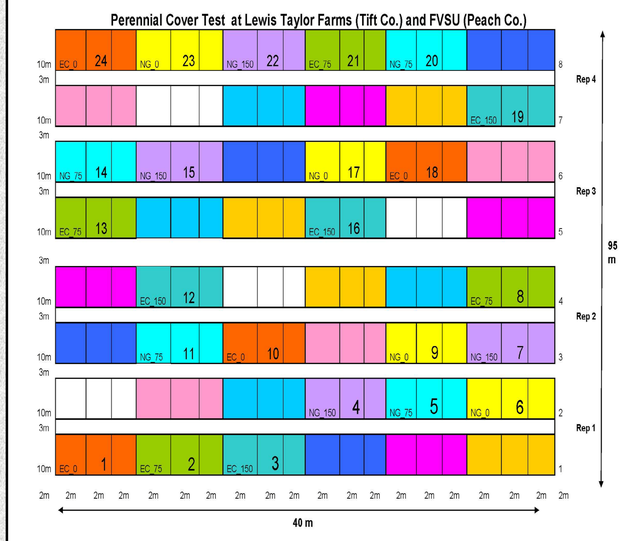
RATIONALE

USDA estimates that up to 50% of biofuel feedstocks to meet Renewable Fuel Standards will be grown in the southern states. A proportion of these feedstocks will come from dedicated biofuel crops, especially perennial crops grown on marginal farmland. We identified area of marginal, under-used farm land in three Physiographic sub Provinces of the Gulf-Atlantic Coastal Plain - Tifton Upland, Dougherty Plain, and Ft. Valley Plateau. These areas are similar in climate but represent three different soil series that will probably be used by farmers for feedstock production. The study is part of a larger study on effects of management practices on productivity and soil quality designed to look at the effects of winter legume cover crops, fertilizer rates, irrigation rates and crop species at multiple sites. This poster presents results from the first full year of greenhouse gas flux measurements study for three bioenergy cropping system experiments.

MATERIALS AND METHODS

Plot Studies

Greenhouse gas fluxes are being measured on three different bioenergy grass experiments. Weekly sampling for greenhouse gas fluxes was started in August, 2011 on one experiment. Fluxes were measured on one-half of the treatments - two grasses x 3 fertilizer rates, all with a clover cover crop (see diagram labeled Perennial cover test at Lewis Taylor Farms and FVSU). Bi-weekly sampling of a second set of experiments began in March, 2012. One experiment was at the University of Georgia Ponder Farm and is a comparison of inorganic fertilizer versus poultry litter as a nutrient source for elephant grass. The grass was planted in 2006 and production data has been published (Knoll et al., 2013). A different experiment was established at the USDA –ARS Farm in Shellman, GA to look at different rates of inorganic fertilizer (N and K rates) and different rates of irrigation in elephant grass production (see figures at right).

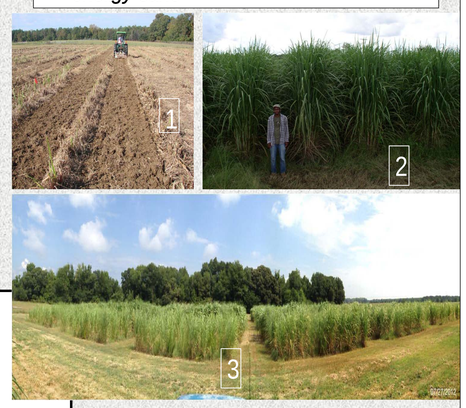


Greenhouse Gas Fluxes

Greenhouse gas fluxes from the soils next to grass clumps are measured using a modified version of the USDA GRACEnet chamber based flux protocol (Trace Gas Protocol Development Committee, 2003; Parkin and Kaspar, 2006). We use 30.5 cm diameter by 15 cm high chambers made from PVC pipe. The chambers fit tightly on bases made from PVC pipe fittings placed in the ground 7.5 cm deep and approximately 1 cm above the soil surface. Outside air samples (25mL) are taken at 0 minutes and gas samples are taken from the vented chambers at 10, 20, and 30 minutes following placement of the cover. Gas samples are stored in evacuated 21 mL vials sealed with a gray butyl rubber stopper and an aluminum crimp-top. Gas samples are analyzed using a Shimadzu 2410 Green house gas analyzer equipped with an methanizer for carbon dioxide conversion and an AOC 5000 static headspace sampler. Nitrous oxide and methane are quantified using the electron capture detector and the flame ionization conductivity detector, respectively. At the time flux measurements are made, we also measure air temperature, soil temperature, and soil water content. Flux rates are calculated using the method of Hutchinson and Mosier (1981).

Pictures below: 1) Vented chamber and base; 2) placing base in the ground; 3) placing chamber on base; 4) sampling from center port of chamber; 5) sample being stored in evacuated vial; 6) vials in headspace analyzer on gas chromatograph.

Pictures below - 1. Planting cover crops. 2. First year elephant grass. 3. First year energy cane



RESULTS AND DISCUSSION

Site means for Ft. Valley and Tifton, all data pooled

Data for Analysis of Fluxes (microL m^{-2} min^{-1})	N_2O	CH_4	CO_2
Number of Observations Read	2592	2592	2592
Number of Observations Used	1275	1111	2299

Site=Ft. Valley

Variable	N	Mean	Std Dev	Minimum	Maximum
FluxN2O	604	0.06	0.31	-1.75	3.03
FluxCH4	617	-0.73	2.24	-28.76	0.85
FluxCO2	1165	2373	2136	0.2	16963

Site=Tifton

Variable	N	Mean	Std Dev	Minimum	Maximum
FluxN2O	671	0.15	0.35	-0.89	4.16
FluxCH4	494	-0.54	1.04	-8.11	2.55
FluxCO2	1134	2214	2283	-1449	23038

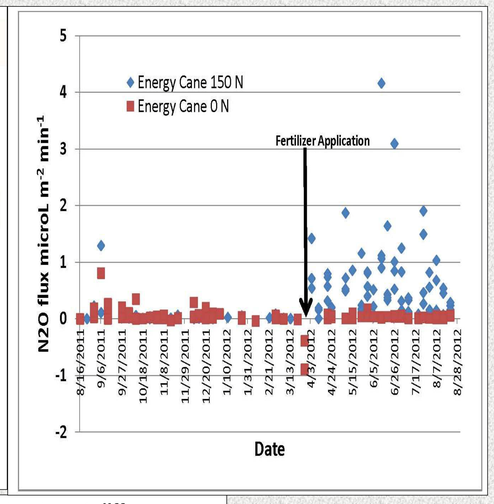
The GLM Procedure
Duncan's Multiple Range Test for FluxN2O
Site=Tifton

Alpha	0.05
Error Degrees of Freedom	665
Error Mean Square	0.112609
Harmonic Mean of Cell Sizes	111.1248

Number of Means	2	3	4	5	6
Critical Range	.0884	.0931	.0962	.0985	.1003

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	Treat
A	0.39682	121	EC_150
B	0.13777	105	NG_075
B			
B	0.13054	116	EC_075
B			
B	0.12801	116	NG_150
B			
B	0.04174	96	EC_0
B			
B	0.04144	117	NG_0



Possible treatment differences

Ponder Farm Elephant Grass Mean Soil Flux Rates (micro L m^{-2} min^{-1})

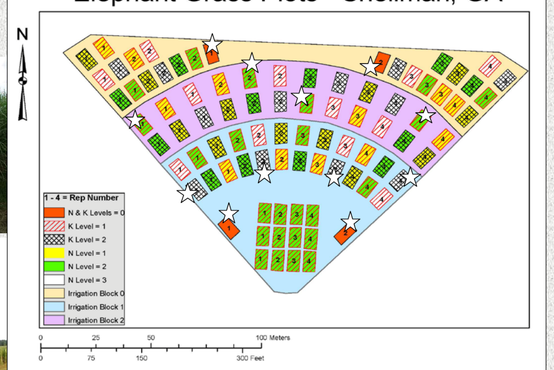
	Fertilizer			Litter			Zero		
	N	Mean	Std Dev	N	Mean	Std Dev	N	Mean	Std Dev
Flux N_2O	33	0.43	1.23	39	0.22	0.62	27	0.03	0.19
Flux CH_4	24	-0.22	0.70	27	-0.65	1.33	36	-0.43	0.80
Flux CO_2	82	2923	2007	81	4154	2828	79	3477	1928

First Year Rates From Elephant Grass Studies

Shellman Farm Elephant Grass Mean Soil Flux Rates (micro L m^{-2} min^{-1})

	N 0 K 0 Irr 0			N 0 K 0 Irr 2			N 2 K 1 Irr 1			N 3 K 2 Irr 2		
	N	Mean	Std Dev	N	Mean	Std Dev	N	Mean	Std Dev	N	Mean	Std Dev
Flux N_2O	15	0.03	0.05	24	0.10	0.21	42	0.11	0.41	48	0.15	0.264
Flux CH_4	20	-0.27	0.62	26	-0.41	1.07	47	-0.36	1.16	36	-0.44	1.15
Flux CO_2	49	3076	2134	46	3615	2413	98	3605	2618	93	3875	2648

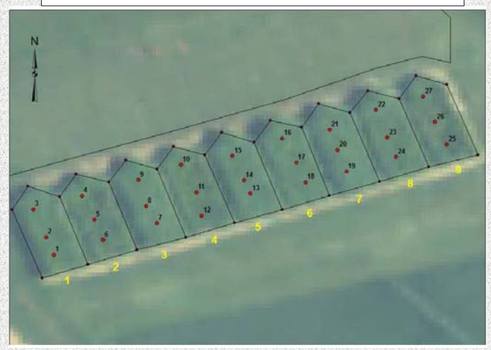
Elephant Grass Plots - Shellman, GA



☆ GHG flux plots. Nitrogen 3 and Potassium 2 treatment of irrigation block 1 (300 lb N/acre and 80 lb K /acre). Nitrogen 2 and Potassium 1 treatment of irrigation block 2 (150 lb N/acre and 40 lb K /acre). Zero N and Zero K of both irrigated and non-irrigated (still need bases on irrigated Zero N, Zero K). All receive same P per acre.

Treatment	GHG
Treatment 1: Energy Cane and Clover + 0 N	EC_0
Treatment 2: Energy Cane and Clover + 75 kg N/ha	EC_75
Treatment 3: Energy Cane and Clover + 150 kg N/ha	EC_150
Treatment 4: Energy Cane and Blue Lupin	
Treatment 5: Energy Cane and Vetch	
Treatment 6: Energy Cane and Rye	
Treatment 7: Napier grass and Clover + 0 N	NG_0
Treatment 8: Napier grass and Clover + 75 kg N/ha	NG_75
Treatment 9: Napier grass and Clover + 150 kg N/ha	NG_150
Treatment 10: Napier grass and Blue Lupin	
Treatment 11: Napier grass and Vetch	
Treatment 12: Napier grass and Rye	

Elephant Grass Plots – Ponder Farm



SUMMARY

Although these are preliminary results, the magnitude of nitrous oxide flux represented by the Energy Cane 150 N rate is less than 4 kg N_2O-N ha^{-1} yr^{-1} if the weekly values are used to estimate an annual rate. No conclusions are possible in these early stages of the research, but there are possible treatment and site effects that may become clearer with the next three years of data. Weekly sampling may allow direct estimates of GHG flux rates but at a minimum should provide a robust data set for modeling the fluxes. If bioenergy grass production proceeds in the Gulf-Atlantic Coastal Plain these studies will contribute both to new understanding and to ongoing Life Cycle Analysis of the dedicated bioenergy crops.

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