GREENHOUSE GAS FLUXES AND ROOT PRODUCTIVITY IN A SWITCHGRASS AND LOBLOLLY PINE INTERCROPPING SYSTEM FOR BIOENERGY PRODUCTION

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This study is part of a larger collaborative effort to determine the overall environmental sustainability of intercropping pine (*Pinus taeda* L.) and switchgrass (*Panicum virgatum* L.), both of which are promising feedstock for bioenergy production in the Lower Coastal Plain in North Carolina. We measured soil CO_2 efflux (R_S) every six weeks from January 2012 to March 2013 in four-year-old monoculture and intercropped stands of loblolly pine and switchgrass (Fig. 1). R_S is primarily the result of root respiration (R_A) and microbial decomposition of organic matter (R_H) releasing CO_2 as a by-product and is an important and large part of the global carbon (C) cycle. Accurate estimates of the two components of total soil respiration (R_S) are required as they are functionally different processes and vary greatly spatially and temporally with species composition, temperature, moisture, productivity, and management activities. We quantified R_A and R_H components of R_S by using a root exclusion core technique based on root carbohydrate depletion, which eliminates R_A within the cores over time. We determined the relationship between R_S, R_A and R_H measurements and roots collected from the cores. We took fresh soil cores in July 2012 to compare root productivity of loblolly pine and switchgrass in monoculture versus the co-culture. Additionally, CH_4 and N_2O fluxes were monitored quarterly using vented static chambers. Pure switchgrass had significantly higher R_S rates (July, August, September), root biomass and root length in the top 0-35 cm relative to switchgrass in the co-culture, while loblolly pine with and without switchgrass had no significant changes in R_S and roots (Table 1). Correlations between R_A and roots showed significantly positive correlation of R_A to grass root biomass ($r = 0.37$, $p \leq 0.001$), fine ($r = 0.26$, $p \leq 0.05$) and medium root surface area ($r = 0.20$, $p \leq 0.1$). The estimated portions of R_S attributed to R_A in the intercrop stand were 31% and 22% in the summer and fall, respectively. No significant treatment differences were observed in either CH_4 or N_2O flux. Our study indicates a decrease in switchgrass root productivity in the intercropped stand versus the monoculture stand which could account for differences in the observed R_S.

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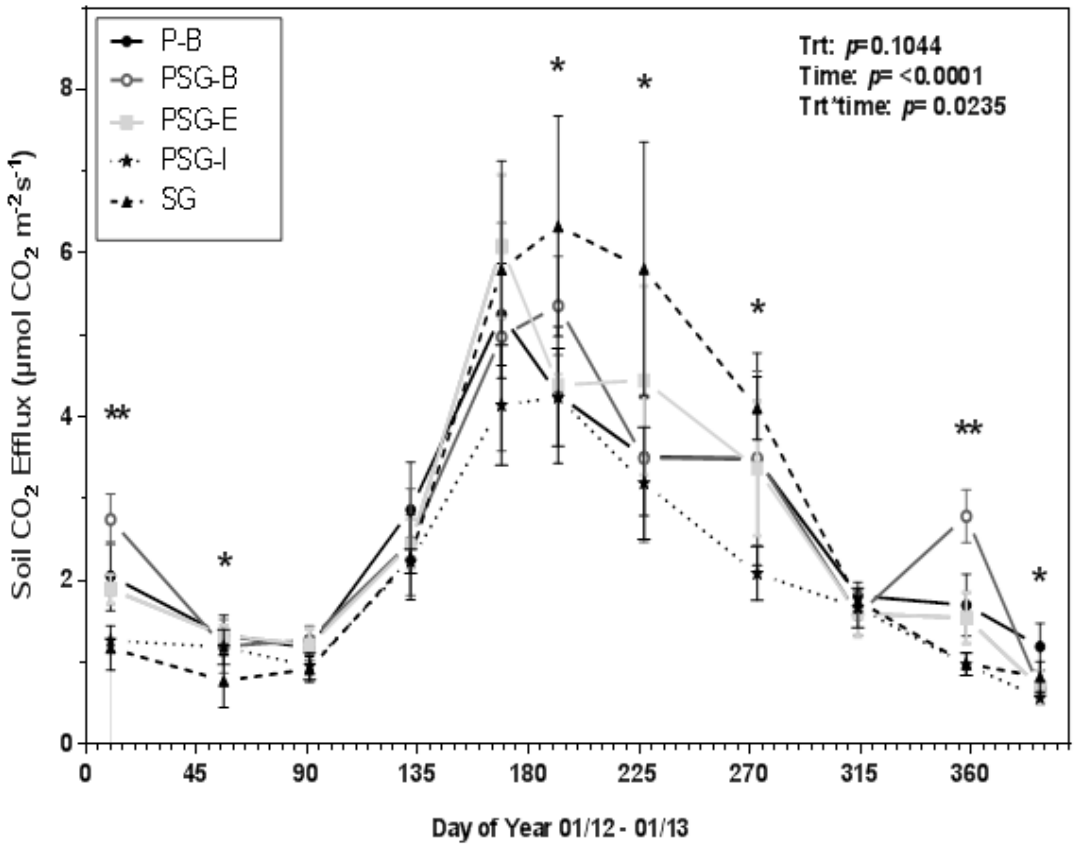

	Jan10	Feb25	Mar30	May10	Jun16	Jul10	Aug14	Sep15	Oct26	Dec09	Jan19
P-B	b	a	a	a	a	b	ab	ab	a	b	a
PSG-B	a	ab	a	a	a	ab	ab	ab	a	a	b
PSG-E	b	a	a	a	a	b	ab	ab	a	bc	b
PSG-I	c	ab	a	a	a	b	b	b	a	c	b
SG	c	b	a	a	a	a	a	a	a	c	ab

Figure 1--Mean soil CO_2 efflux rates (μmol m^{-2} s^{-1}) measured approximately every 6 weeks between January 10, 2012 to January 20, 2013 in a 4-year-old switchgrass and loblolly pine agroforestry system on the lower coastal plain of North Carolina. Error bars represent ±1 standard error from the mean. Stars indicate sampling dates with significant differences between treatments as determined using repeated measures analysis (α = 0.10). The accompanying matrix represents mean separation using Tukey-Kramer HSD where different letters within each treatment date indicate significant differences. Terms with a single asterisks (*) are significant at α = 0.1 level and double asterisks (**) at α = 0.05. P represents traditional pine treatments, SG represents flat planted switchgrass, and PSG represents pine intercropped with switchgrass. Additional treatment designations indicate the microtopographical position of the sample location where B represents the bedded row, I represents the interbed space, and E represents the edge where an aboveground transition from switchgrass to pine can be observed.

Table 1--Switchgrass and loblolly pine root biomass, average root length, and average root surface area in intercrop versus pure stands in 0 to 35 cm soil depth measured in July on the lower coastal plain of North Carolina. Means are followed by ±1 standard errors.

Measurement	Type[a]	Pine roots[b]	Switchgrass roots[b]	Total
Biomass ($g\ m^{-3}$)	P-B	3262[a] ± 501.1	NA	3262 ± 501.1
	PSG-B	3835[a] ± 628.7	182.8[b] ± 51.36	4018 ± 680.06
	PSG-E	1666[b] ± 197.0	1247[b] ± 424.4	2913 ± 621.4
	PSG-I	325.9[c] ± 56.28	1481[b] ± 418.7	1807 ± 475.0
	SG	411.0[c] ± 178.2	5359[a] ± 1842	5770 ± 2020
Length ($cm\ dm^{-3}$)	P-B	2335[a] ± 532	NA	2335 ± 532
	PSG-B	1045[b] ± 170.7	1150[c] ± 330.1	2195 ± 500.8
	PSG-E	844.1[bc] ± 60.38	2941[bc] ± 565.7	3785 ± 626.1
	PSG-I	312.0[cd] ± 56.65	4503[ab] ± 1163	4815 ± 1220
	SG	158.4[d] ± 76.94	7665[a] ± 640.9	7823 ± 717.9
Surface area ($cm^2\ dm^{-3}$)	P-B	35.76[a] ± 7.287	NA	35.76 ± 7.287
	PSG-B	19.50[ab] ± 3.457	10.47[c] ± 2.787	29.97 ± 6.244
	PSG-E	16.03[bc] ± 1.712	31.50[bc] ± 6.147	47.53 ± 7.859
	PSG-I	6.188[cd] ± 1.239	42.02[b] ± 9.801	48.21 ± 11.04
	SG	2.900[d] ± 1.270	90.41[a] ± 4.807	93.31 ± 6.077

[a]P-B = pine bed; PSG-B = pine + switchgrass bed, PSG-E = pine + switchgrass edge, PSG-I = pine + switchgrass interbed; SG = switchgrass.
[b]Numbers in the same column followed by different letters are significantly different at $\alpha = 0.05$.