HIGH BIOMASS SORGHUM PRODUCTION ACROSS TILLAGE SYSTEMS AND NITROGEN RATES

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ABSTRACT

Bioenergy production has traditionally focused on perennial crops; however, these crops require an establishment period before they can be utilized. High biomass sorghum (Sorghum bicolor L. Moench) grown as an annual crop can be used during this establishment period, but typical yields and nutrient removal across different tillage systems and nitrogen (N) rates are not well established in the Southeast. In 2010, an experiment was initiated across conventional and conservation tillage systems on a Compass loamy sand to determine total dry matter (TDM) production and selected nutrient uptake across six different N rates (0, 34, 67, 101, 134, 168 kg ha^{-1}). The split-split plot arrangement of six N rates as main plots and tillage systems as subplots also included a photoperiod sensitive (ES 5200) and a non-photoperiod sensitive cultivar (SS1515) as sub-subplots with four replications. Total dry matter yields averaged 16.3 Mg ha^{-1} (2010) and 15.4 Mg ha^{-1} (2011) across N rates, tillage systems, and cultivars. No TDM response to N was observed either growing season, but an interaction between cultivar and N rate indicated that ES 5200 did respond to the lowest N rate (34 kg ha^{-1}). Nitrogen uptake was highest in 2010 (148.8 kg ha^{-1}) compared to 2011 (99.3 kg ha^{-1}), but was not consistent across tillage systems. Phosphorus uptake for the top three N rates increased 21% compared to no N, but this was only observed for ES 5200. Potassium uptake was 22% greater in 2010 (162.2 kg ha^{-1}) compared to 2011 (132.8 kg ha^{-1}), but was inconsistent across tillage systems and sorghum cultivars. These are only preliminary results, but we have observed increased root knot nematode (Meloidogyne incognita) numbers under the ES 5200 cultivar, which could influence subsequent TDM production and nutrient uptake.

OBJECTIVE

Determine forage sorghum biomass yield response and nutrient uptake across different nitrogen rates within a conventional and conservation tillage system.

MATERIAL AND METHODS

- The experimental site was established in an area where tillage systems have been in place for > 20 yr.
- Main plots consisted of six N rates, subplots were tillage systems (conventional with no cover crop or non-inversion (NI) with a rye cover crop), and sub-subplots were sorghum cultivar [photoperiod sensitive (ES 5200) and sweet (SS1515)] with four replications.
- Total dry biomass production was determined by hand harvesting all aboveground biomass from two 1.5 m sections from each plot and weighing in the field.
- Three randomly selected stalks from the hand harvest samples were ground in the field with a chipper/shredder and weighed, dried at 55 °C for 72 h, and weighed again to correct for moisture content.
- Dried samples were ground to pass a 2-mm sieve and analyzed for total C and N by dry combustion with a LECO C/N analyzer.
- A microwave digestion procedure coupled with ICAP analyses was used to determine Ca, K, and P concentrations in the plant material.
- The product of dry biomass and nutrient concentrations provided nutrient uptake values for selected nutrients.

RESULTS AND DISCUSSION

Table 1. ANOVA (P ≤ 0.10) table for selected main effects and two-way interactions observed for the 2010 and 2011 growing seasons.

	df		Dry	N	Uptake			
Effect	Num	Den	Matter	Conc.	N	P	K	Ca
			Prob > F					
Year (Y)	1	6	0.1531	<0.0001	<0.0001	0.0534	0.0018	0.0042
N rate (N)	5	30	0.1467	<0.0001	<0.0001	0.3965	0.3940	0.3520
Cultivar (C)	1	72	0.0226	0.0758	0.0028	<0.0001	0.0001	0.0042
Y * N	5	30	0.2538	0.0004	0.0016	0.9629	0.4337	0.6709
Y * Tillage	1	36	0.0898	0.0001	<0.0001	0.5530	0.7960	0.0185
Y * C	1	72	0.0078	0.0715	0.5095	0.3904	0.1397	0.7308
N * C	5	72	0.0741	0.7882	0.7481	0.0351	0.3664	0.9279
Tillage * C	1	72	0.1124	0.2127	0.8678	0.0005	0.0612	0.4703

- Cultivar affected each variable examined (Table 1) and the photo-period sensitive cultivar (ES 5200) always produced higher values compared to the sweet sorghum (SS1515), ranging from 4% greater in N conc. up to 13% for K uptake.
- Year affected five of the six variables examined although not consistently (Table 1). Nitrogen conc., N uptake, and K uptake were up to 50% greater in 2010, while P and Ca uptake were up to 25% greater in 2011.
- Nitrogen rate did not affect TDM production (Table 1), but N conc. and N uptake were maximized at 168 kg ha^{-1} with ranges across all N rates of 5.3 – 9.9 g kg^{-1} (N conc.) and 82 – 160 kg ha^{-1} (N uptake).
- The year * tillage interaction affected four of the six variables examined (Table 1) and in each case, NI tillage produced higher values for the 2010 growing season, while CT produced higher values in 2011 (Table 2). Total rainfall received in 2010 and 2011 was within 4%, but distribution was more consistent across the 2010 growing season compared to an early dry period in 2011.

Table 2. Dry matter, N concentrations (conc.), N, and Ca uptake measured during two growing seasons across conventional (CT) and non-inversion (NI) tillage systems.

Crop	Dry matter		N conc.		N uptake		Ca uptake	
Year	CT	NI	CT	NI	CT	NI	CT	NI
	--Mg ha^{-1}--		--g kg^{-1}--		----------kg ha^{-1}----------			
2010	16.0	16.7	8.6	9.7	137.7	160.0	34.4	39.2
2011	15.6	15.2	6.8	6.1	106.6	92.0	47.8	45.6

Table 3. Nitrogen by cultivar response for dry matter production and P uptake across both sorghum cultivars.

	Dry matter		P uptake	
N rate	ES 5200	SS 1515	ES 5200	SS 1515
kg ha^{-1}	--Mg ha^{-1}--		-----kg ha^{-1}-----	
0	14.4	15.8	15.7	15.8
34	16.3	15.2	17.8	16.6
67	16.8	15.3	17.0	16.4
101	16.2	14.9	19.0	15.8
134	16.7	16.3	18.7	15.9
168	16.8	15.5	19.1	15.5

Table 4. Average root-knot nematode counts measured in the high N rate treatment across tillage systems at the end of the 2011 growing season.

	Tillage system	
Cultivar	CT	NI
	No. (cm^3 soil)$^{-1}$	
ES 5200	427.5	369.5
SS 1515	56.5	15

Courtesy: Richard Davis, ARS, Tifton, GA.

- Root-knot nematode counts averaged over 10x higher across tillage systems following ES 5200 compared to SS 1515 (Table 4).
- Despite the nematode pressure, ES 5200 performed well, but growers should be cautioned about using this cultivar in areas sensitive to root-knot nematode pressure.

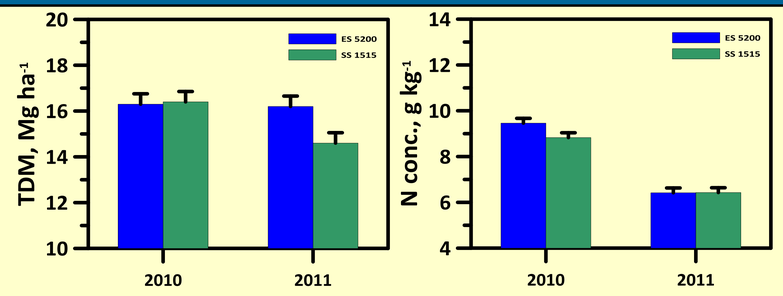

Figure 1. Total dry matter (TDM) production and N concentration (conc.) across cultivars and growing seasons.

- Total dry matter production was consistent across sorghum cultivars and growing seasons with the exception of SS 1515 in 2011, while measured N conc. were different across cultivars in 2010, but decreased on average 30% with no differences between cultivars in 2011 (Fig. 1).
- Sorghum cultivar differences were also observed across N rates for TDM and P uptake (Table 3). ES 5200 responded to 34 kg N ha^{-1}, while SS 1515 showed no response to N across TDM or P uptake.

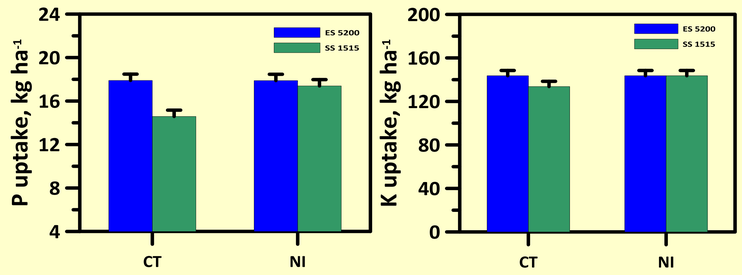

Figure 2. Phosphorus and K uptake across tillage systems and sorghum cultivars.

- Phosphorus and K uptake both decreased in CT during the 2010 growing season for SS1515 (Fig. 2), but were consistent across the NI tillage system and ES 5200.

CONCLUSIONS

- Two year preliminary results suggest the photo-period sensitive cultivar (ES 5200) produced consistently more biomass compared to the sweet sorghum cultivar (SS 1515).
- As a result, nutrient uptake and subsequent removal was generally higher with ES 5200 across N rates and tillage systems.
- The prevalence of root-knot nematodes measured in the fall, after harvest, indicates growers should be cognizant of using this cultivar in a rotation to prevent further proliferation of this nematode pest.
- Inconsistencies across results were observed between these two growing seasons, but two more years of data collection are planned to reinforce current results and provide consistent data.
- The limited N response indicates sorghum may have accessed some residual N, although not likely on this soil type or some other nutrient not accounted for may have limited production. Soil test recommendations for forage sorghums are limited in Alabama.

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