Seasonal Trends in Biomass Accumulation and Nutrient Removal of Switchgrass

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Introduction

Switchgrass (*Panicum virgatum* L.) is considered a cellulosic feedstock suitable for biofuel production because of its drought tolerance, noninvasiveness, potential for soil carbon sequestration, and high biomass yield with low input. Information is needed on seasonal trends in biomass accumulation and nutrient removal to support decision-making on timing of harvest to maximize efficiency of fertilizer nutrient use.

Objective

Our aim was to characterize seasonal trends in biomass yield, moisture content, leaf area index, light interception, gross energy density, removal rates of nitrogen (N), phosphorus (P), and potassium(K), and concentration of total ash. Results are reported for the first year of this 2-yr trial.

Methods

- Plots (1.8 m x 4 m) were established in 2008 in Fayetteville, AR with cv. Alamo in six replications, on a Captina silt loam soil, (Typic fragiudults). Different plots were sampled approx. monthly from 1 May to 1 Oct. 2009 (Days 121-274), 2009. 67 kg/ha of N was applied in April.
- We measured leaf area of live, green tissue with a leaf area meter and photosynthetically active radiation above and below the canopy with a light bar to calculate percentage light interception. Dry matter (DM) yield and moisture content were determined on plants cut from a 1.2 m x 3 m area.
- Total ash was determined by loss of DM on ignition at 475°C, and gross energy by bomb calorimetry. Total N was determined by dry combustion, and P and K by inductively coupled plasma spectrometry. Data were fitted to regressions describing the trends.

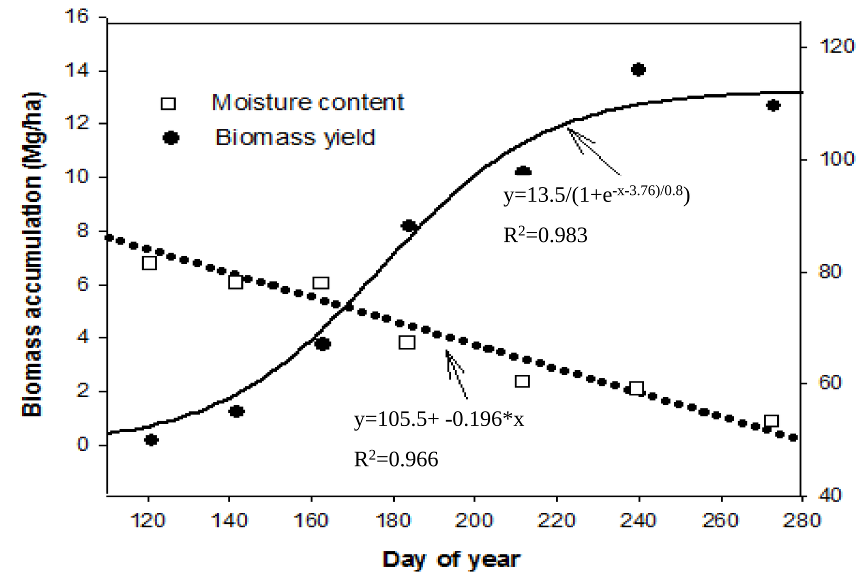

Figure1. Regressions of biomass yield (sigmoid) and moisture content (linear) of switchgrass on day of year.

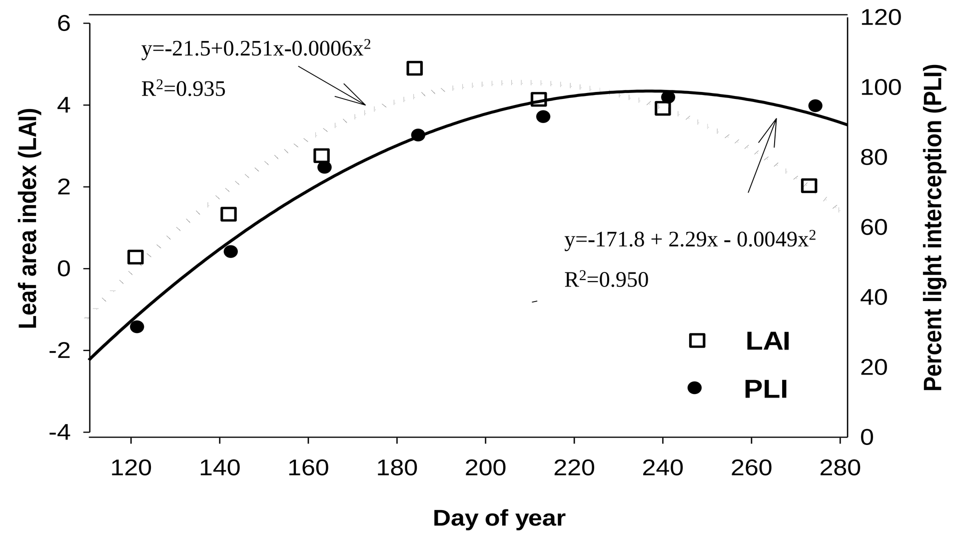

Figure 2. Fluctuation in switchgrass canopy throughout the growing season (May through October) fitted to quadratic regressions.

Results

- Switchgrass biomass yield increased in a sigmoid pattern starting at 0.18 Mg/ha on 1 May (Day 121), and leveling off at an asymptote of 13.5 Mg/ha late in the summer (Fig. 1). Moisture content declined linearly over the growing season, attaining 53% by October 1.
- Leaf area index showed a mid-season (July) peak at approx. 5, then declined in August and September to 2, reflecting loss of green leaf area low in the canopy (Fig. 2). PLI approached 98% while LAI declined late summer.
- Ash concentration decreased linearly with sampling date (7.35 to 2.57%). Gross energy density was initially high, followed by a drop, then a linear increase (Fig. 3).
- K uptake peaked in July then declined, whereas N uptake tended to level off later in the season (Fig. 4). P removal peaked at 15.7 kg/ha on day 240.

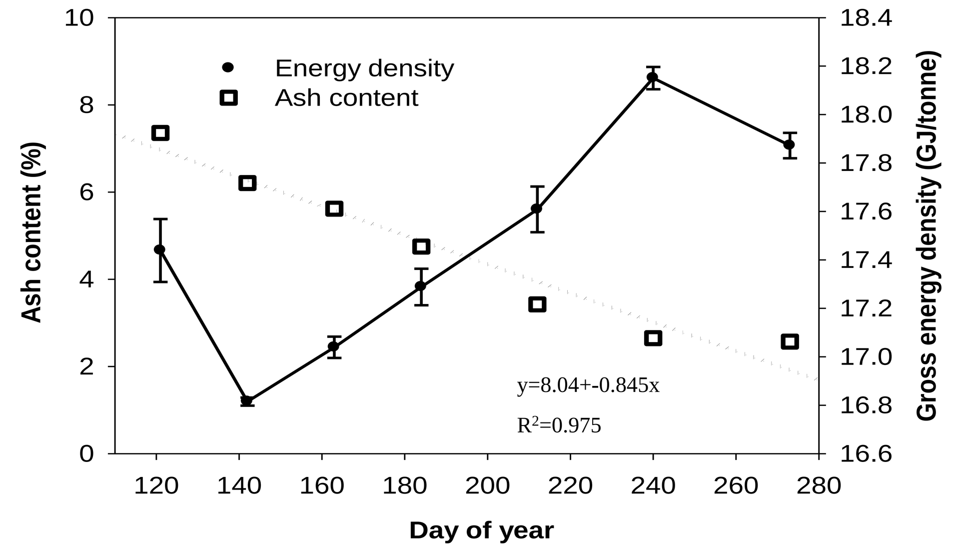

Figure 3 . Changes in energy density and ash content throughout the growing season. No regression was performed for energy density. Vertical bars are +/- SE.

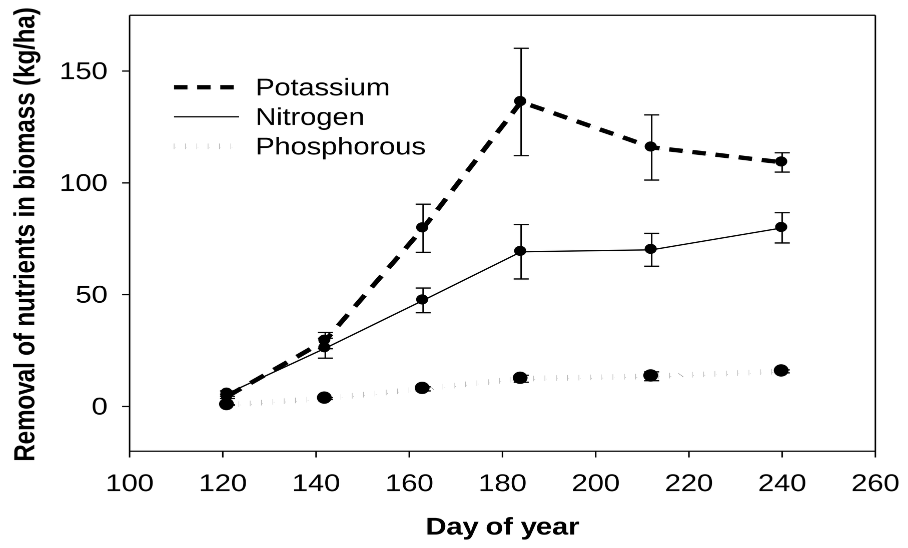

Figure 4. Nutrient uptake and removal of N, P and K in switchgrass biomass.

Interpretation

- Biomass accumulation from May through September followed a logistic function reflecting a typical growth curve, with leveling off while switchgrass growth shifted from new leaf appearance and stem elongation to seedhead production and seed maturation. The moisture content of 53% on 1 Oct. indicates field curing or artificial drying would be necessary to safely store this biomass at <20% moisture.
- Leaf area index of green (nonsenescent) plant tissue declined after early July while lower leaves started senescing. Areas of peduncle and inflorescence were included in the LAI measurement, but their effective areas were low and not enough to compensate for lower leaf loss. Light interception continued to increase owing to interception by seedheads and senescent leaves.
- Ash concentration declined linearly, reflecting high uptake of minerals early in the season followed by dilution by secondary cell wall deposition while stems elongated (Alder et al., 2006). Energy density was expected to start relatively low, then increase as cell walls lignified during the growing season. The reason for the high initial value is unclear, but could be due to relatively high content of lipids and leaf waxes on short, leafy plants that had no stems.
- Nitrogen and K uptake (removal) followed patterns somewhat similar to biomass accumulation in that uptake was relatively rapid early in the season, then leveled off in mid-season after Day 183. In contrast, biomass continued to accumulate after day 183, thereby diluting nutrients with carbonaceous biomass in stems and seedheads. Loss of K later in the season may have resulted from leaf droppage, leaf leaching, and/or translocation to roots and crown. The very low P removal rate suggests a low requirement for P by switchgrass. This trial will be repeated in 2010.

Literature Cited

Alder, P.R., M.A. Sanderson, A.A. Boateng, P.J. Weimer, and G. Hans-Joachim. 2006. Biomass yield and biofuel quality of switchgrass harvested in fall or spring. Agron. J. 98:1518-1525.

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