Above- and Below-ground Biomass Production in Corn and Prairie Bioenergy Cropping Systems

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Introduction

The Comparison of Biofuel Systems (COBS) project is a long-term, 20-acre field experiment designed to provide quantitative, side-by-side comparisons of corn- and prairie-based biofuel feedstock production systems with respect to biomass yields, liquid fuel potential, and multiple environmental impacts. The project was established in 2008 at ISU's South Reynoldson Farm in Boone County. Here, we report on above- and below-ground biomass production from selected treatments.

Materials and Methods

Four cropping system treatments contained within the COBS experiment are compared here: 1) continuous corn harvested for grain and biomass; 2) continuous corn grown following a winter cover crop (rye) and harvested for grain and biomass; 3) multispecies reconstructed prairie grown without fertilizer and harvested for biomass; and 4) N-fertilized multispecies prairie harvested for biomass. Treatments were replicated four times and arranged in a spatially balanced complete block design. The experimental site is dominated by two soil series: Nicollet clay loam (an Endoaquic Argiudoll) and Webster silty clay loam (a Typic Argiaquoll). Slopes at the site are largely ≤1 percent, with some small areas of 2–3 percent slope. Plots for the experiment were 90 ft × 200 ft, and all cropping systems were managed without tillage. During 2009-2013, mineral nitrogen fertilizer was applied to corn as a 75 lb N/acre dose at planting, supplemented with a treatment-specific side-dress dose at rates determined by soil tests conducted when corn was about 12 in. tall. Mineral nitrogen fertilizer at a rate of 75 lb N/acre also was applied in early spring to the fertilized prairie treatment. Above-ground plant materials were sampled at crop maturity and then harvested with conventional farm machinery. Soil cores were taken to 39-in. depth in all plots each year using a hydraulic probe after crops were harvested. Roots were separated from soil using a rotating washing system, then dried and weighed. Data were analyzed using linear mixed-effects models.

Results and Discussion

Averaged over the 2009-2013 cropping seasons, total above-ground biomass differed significantly among all treatments (Table 1). Corn treatments produced almost twice as much above-ground biomass as did the prairie treatments, with continuous corn without a rye cover crop producing 9 percent more than corn with rye, and N-fertilized prairie producing 39 percent more than unfertilized prairie. Grain yield of corn grown without rye was 11 percent greater than corn with rye. Reasons for lower yields of corn when rye was used as a cover crop were not determined, but other investigators in Iowa also have reported the phenomenon.

The root biomass data reported here represent accrued mass over time, which is especially important in the case of perennial prairie species whose roots can survive from year to year. As expected, total root biomass was consistently higher in the prairie treatments than the corn treatments (Table 2). Root biomass also was higher in the unfertilized

prairie than in the fertilized prairie (Table 2). In 2013, root biomass did not differ between the two corn treatments, which averaged 1.0 tons/acre. In contrast, root mass of the unfertilized and fertilized prairie treatments was 4.5 tons/acre and 2.6 tons/acre, respectively. Other investigators also have observed a lower mass of roots in fertilized as compared with unfertilized prairie and have ascribed the effect to the need for plants to scavenge nutrients in a larger soil volume under low fertility conditions.

These shoot and root biomass data are being used to determine economic returns, liquid fuel production, and soil quality effects of the various cropping systems.

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Table 1. Mean above-ground biomass and grain yields, 2009-2013.

Treatment	Above-ground biomass, dry tons/acre	Grain yield, bushels/acre @ 15.5% moisture
Continuous corn	7.5 (0.05) a	167 (1.7) a
Continuous corn + rye cover crop	6.9 (0.13) b	151 (2.5) b
N-fertilized prairie	4.6 (0.12) c	—
Prairie	3.3 (0.04) d	—

Means and their standard errors are shown. Within columns, means not followed by the same letter are significantly different (P<0.05).

Table 2. Root biomass recovered each fall, 2009-2013.

Treatment	2009	2010	2011	2012	2013
			dry tons/acre		
Continuous corn	0.4 (0.03) c	0.4 (0.08) c	0.4 (0.02) c	0.7 (0.07) c	0.9 (0.07) c
Continuous corn + rye cover crop	0.4 (0.07) c	0.6 (0.05) c	0.5 (0.06) c	0.9 (0.09) c	1.1 (0.14) c
N-fertilized prairie	1.9 (0.21) b	1.4 (0.06) b	2.0 (0.31) b	3.0 (0.19) b	2.6 (0.21) b
Prairie	2.8 (0.26) a	4.0 (0.45) a	4.2 (0.18) a	4.9 (0.34) a	4.5 (0.26) a

Sampling depth was 39 in. Means and their standard errors are shown. Within columns, means not followed by the same letter are significantly different (P<0.05).