Performance of Annual and Perennial Crops for Forage and Biomass Energy Production

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Introduction

An important aspect for economical forage production is high crop yield per unit of land. High yields allow fixed costs to be divided over more units of forage. In addition to their use for forage, the past decade has witnessed increased interest in forage crops for renewable energy sources. Thus, in addition to their use for forage, some crops could become important as dedicated energy crops. Seasonal yields of many warm-season, annual crops are reported to be greater than those of cool-season forage crops, but there have been few direct comparisons where the crops were grown under the same conditions. The purpose of this study was to determine yield and quality characteristics of several high yielding annual and perennial forage crops. The experiment was designed to evaluate the crops as potential energy crops, but the results have application to forage for livestock as well.

Materials and Methods

Reed canarygrass (harvested two times per year), switchgrass (harvested once per year), big bluestem (harvested once per year), sweet sorghum, forage sorghum (sorghum x sudangrass), and corn were grown near Ames, IA on highly productive flat soil and near Chariton, IA on marginal row-crop land with a 2-7% slope. The experiments contained four replicates at each site. These crops were fertilized with 0, 70, 140, or 280 kg N ha^{-1} (280 kg ha^{-1} is equivalent to 246 lbs N per acre). Also included in the experiments was alfalfa harvested two or three times per year. The crops were evaluated for fiber, nitrogen, and potassium concentrations.

Results and Discussion

The annual crops (sorghums and corn) produced about 50% more forage than the perennial crops at both locations (Figs. 1 and 2). The sorghums produced the highest average yields (over 16 t ha^{-1} or 7 tons per acre), especially at the lower nitrogen fertilizer rates. For most species, near maximal yields occurred at 140 kg N ha^{-1}. Corn yields at Ames were close to those of the sorghums at the maximal level of nitrogen. The less

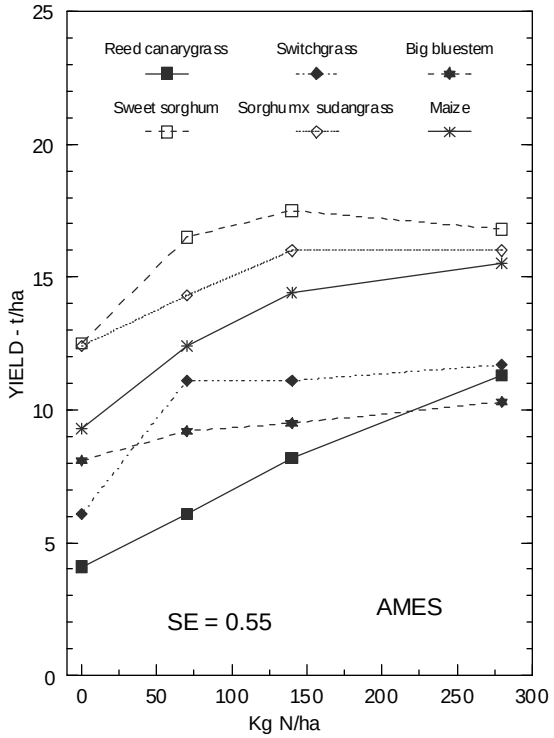

Figure 1. Yields of annual and perennial crops grown 1989 through 1992 near Ames, IA.

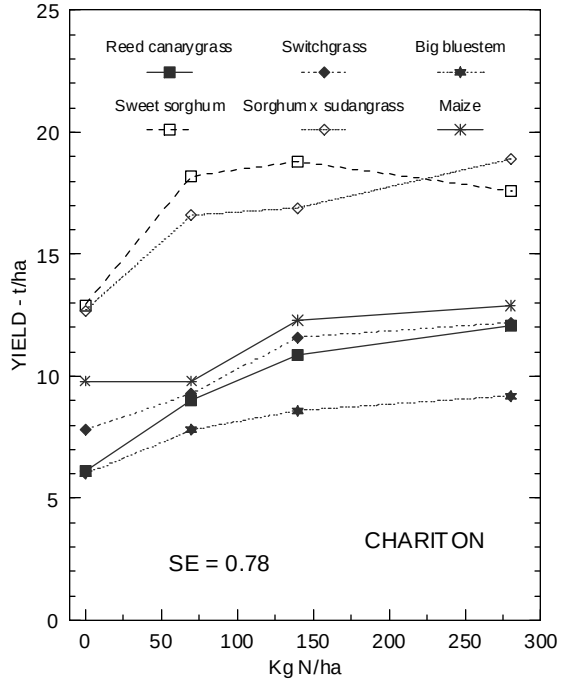

Figure 2. Yields of annual and perennial crops grown 1990 through 1992 near Chariton, IA.

productive soils at Chariton had an adverse effect on corn production. Here corn often appeared water stressed and had yields that were only about 70% of the sorghums. Switchgrass generally out-yielded big bluestem. Reed canarygrass yield was near that of switchgrass only at the highest nitrogen level at Ames (Fig. 1) and similar to switchgrass at all nitrogen levels at Chariton (Fig. 2). Alfalfa produced 5 to 8% more forage with three cuts per year than with two cuts. Its yields were as high as 12 t ha^{-1}, but declined after 4 years of production.

Estimated annual soil erosion from the Universal Soil Loss Equation was less than 1 t ha^{-1} for all perennial grasses at both locations. That of alfalfa was less than 1 t ha^{-1} at Ames and less than 2 t ha^{-1} at Chariton. Conversely, estimated annual soil erosion for the sorghums and corn was about 5 t ha^{-1} at Ames and near 35 t ha^{-1} on the sloping soils at Chariton.

The chemical composition of the forage varied by species, but location and nitrogen fertilization generally had only minor effects. The major exception was that nitrogen fertilization increased nitrogen concentration of the forage. Highest neutral detergent fiber (NDF) concentrations occurred in big bluestem (80%), switchgrass (75%), and corn stover (72%), with intermediate values in reed canarygrass (65%). Lowest NDF values occurred in sweet sorghum (54%) and forage sorghum (48%). The NDF concentration was greater in 2-cut (56%) than in 3-cut alfalfa (49%).

Conclusions

Annual, warm season crops are more productive than traditional forage crops on both prime land and marginal land in the upper midwest. Although the sorghums were the most productive at both sites, the high potential for soil erosion on sloping soils would preclude their production on these soils. Here, switchgrass was among the highest yielding crops with production that generally increased during the course of the study.