Future Opportunities in Production Agriculture-Energy from Farm Land
Evaluation of Perennial Herbaceous Biomass Energy Crops in North Dakota

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Introduction

National energy security and climate change will require large-scale substitution of fossil fuels to renewable energy, which can be produced from cellulosic biomass. Biomass is all plant and plant–derived materials. Cellulosic biomass is the nonstarch, fibrous, woody, and generally inedible portion of plant matter (Lee et. al., 2007).

A biorefinery is a processing and conversion facility that efficiently separates biomass feedstock into individual components and converts these components into marketplace products, including biofuels, biopower, and bioproducts. Biorefinery technologies, such as biochemical conversion (fermentation), thermochemical conversion (gasification and fast pyrolysis), and hybrid thermochemical and biochemical technologies, are currently being developed and will be placed in commercial production by 2009 (DOE, 2007).

The U.S. Department of Energy (DOE) and the U.S. Department of Agriculture (USDA) are both strongly committed to expanding the role of biomass as an energy source. To meet the Federal goal, 30% replacement of current U.S. petroleum-based fuels with biofuels, at least one billion dry tons of cellulosic biomass feedstock will be required annually. Biomass from agricultural lands would include 428 million dry tons of annual crop residues, 377 million dry tons of perennial crops, 87 million dry tons of grains, and 106 million dry tons of animal manure, process residues and other miscellaneous sources (DOE, 2003 and Perlack et. al., 2005).

Potential resources for cellulosic biomass feedstock include crop residues (corn stover, wheat straw, etc.), perennial grasses (switchgrass, big bluestem, intermediate wheatgrass, etc.), woody crops (hybrid poplar, willow, etc.) and other agricultural byproducts. Perennial grasses, dedicated energy crops, for biomass feedstock production have many advantages including reduced cost of fuels, pesticide, and fertilizer; high yield potential on land not suitable for annual crops; soil and water conservation; increased carbon sequestration; and wildlife habitat conservation (McLaughlin et. al., 2002). To be a promising perennial energy crop, a perennial species should be native or noninvasive, have high biomass yield potential, have high nutrient and water use efficiency, be able to be established with seed or relatively inexpensive vegetative propagules, be harvested with typical farm equipment, and exhibit positive environmental attributes.

North Dakota has over seven million acres of highly erodible and saline crop land, with some counties in the western part of the state having as much as 90% of the crop land classified as highly erodible (USDA, 1997). Perennial energy crops growing in these marginal lands would be more sustainable with soil and water conservation and have less competition in production acres with other row crops and cereal crops. CRP land, where perennial grasses are growing, could be converted to dedicated energy crop production land with minimal environmental and economic impact due to its release.

With the need for alternative fuels, the North Dakota State University Carrington Research Extension Center initiated a perennial grass evaluation trial for biomass energy feedstock production in 2006 in conjunction with other Research Extension Centers. The objective of this study was to evaluate perennial warm- and cool-season grasses and grass mixtures for biomass feedstock production in central North Dakota.

Materials and Methods

The species listed in table 1 were seeded at the Carrington Research Extension Center on May 19, 2006. The plots were seeded with a plot drill with 6-inch row spacing in a 15 x 30 foot plot. The plots were mowed three times during the summer 2006 and were harvested for the first biomass production with a forage plot harvester on September 13, 2007.

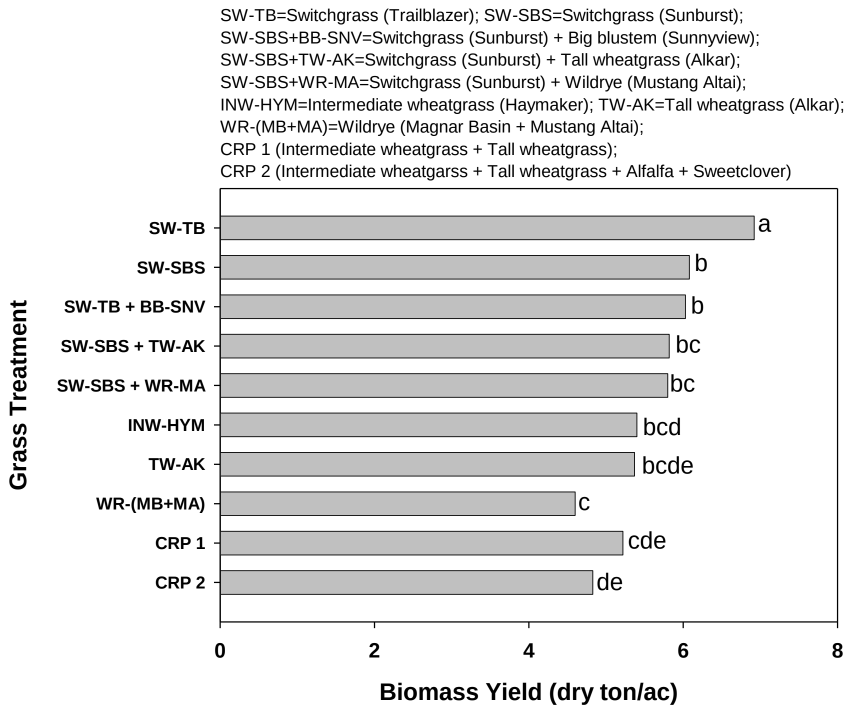
Table 1. Grass treatments and seeding rates for biomass feedstock production trial.

Grass treatment Species (Cultivar)	Seed rate (PLS/acre)
Switchgrass (Trailblazer)	10
Switchgrass (Sunburst)	10
Switchgrass (Sunburst) + Big blustem (Sunnyview)	7 + 2.5
Switchgrass (Sunburst) + Tall wheatgrass (Alkar)	5 + 5
Switchgrass (Sunburst) + Wildrye (Mustang Altai)	7 + 11
Intermediate wheatgrass (Haymaker)	10
Tall wheatgrass (Alkar)	11
Wildrye (Magnar Basin + Mustang Altai)	5 + 11
CRP mix 1 (Intermediate wheatgrass + Tall wheatgrass)	5 + 6
CRP mix 2 (Intermediate wheatgarss + Tall wheatgrass + Alfalfa + Sweetclover)	4 + 4.5 + 1 + 0.5

Biomass feedstock production evaluation plot.

Results and Summary
The preliminary biomass production data showed that our region has a very high potential for biomass feedstock production with dedicated perennial energy crops (Figure 1). Trailblazer switchgrass monoculture produced the highest yield (6.9 dry ton/acre) among grass species and mixtures followed by sunburst switchgrass. In general, warm-season grasses such as switchgrass and big bluestem produced more biomass than cool-season grasses such as intermediate wheatgrass and tall wheatgrass and CRP mixtures.

Figure 1. Biomass production yield of perennial grass monocultures and mixtures at the North Dakota State University Carrington Research Extension Center.



Bars with the same letter are not significantly different at the level of P=0.05.

Although warm-season grasses out yielded cool-season grass in 2007, which had above-average spring and summer precipitation; cool-season grasses have a great potential for biomass production in North Dakota, which usually has a more favorable climate condition for cool-season grasses than warm-season grasses. Therefore, continuous evaluation of cool-season grasses for biomass production is required.

Our trial average yield was 5.6 dry ton/acre, which is very comparable to a production yield goal of switchgrass proposed by U.S. Department of Energy and U.S. Department of Agriculture (Graham et. al., 1995). However, for sustainable biomass production, more extensive research including adopted cultivar selection, cultivar evaluation, and establishment, soil fertility, and harvest management over the long-term is required.

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