*Proceedings* 61st *Southern Pasture & Forage Crop Improvement Conference, 2007*
*Ecology/Physiology Work Group*

# Current Assessment of Dedicated Bioenergy Feedstock Crops for Southeastern United States

William F. Anderson
USDA/ARS, Tifton, GA

Renewable fuel production has become an important topic in the United States over the past few years. Increased ethanol production and use as fuel, in particular, is seen as a means of reducing the nation's dependence on petroleum. Brazil has become independent from petroleum imports by converting carbohydrates (primarily sucrose) from sugar cane to ethanol. Currently, ethanol is produces from grain starch (corn) in the United States. However, only a small percentage of the nation's ethanol needs can be supplied by starch-based ethanol (NRDC 2006). To achieve the goal of displacing 30% of the nation's current gasoline use by 2030 a study by the United States Departments of Energy and Agriculture concluded that over a billion tons of biomass would be required (Perlack et al. 2005). Most of this would be by developing more efficient means of converting biomass (as defined by cell wall lignocellulose) to bioenergy.

Besides improving industrial conversion processes, it is also important to improve plant feedstock crops through breeding and efficient production practices. High biomass yields and decreased production costs are first priorities. Biomass must be plentiful, cheap and within a short distance from the processing plant. Designing plants that maintain yields but have reduced recalcitrance to cell wall breakdown is a challenge to plant breeders. Different crop species have potential of being candidates for dedicated bioenergy feedstock crops for Southeastern Unites States.

Besides switchgrass (*Panicum virgatum*), napiergrass (*Pennisetum purpureum*), Miscanthus (*Micanthus x giganteus*), energy cane (*Saccharum* sp.), giant reed (*Arundo donax*) and even bermudagrass (*Cynodon* sp.) are being considered as potential feedstock grasses for conversion to ethanol or bio-energy. In a test at Tifton, Georgia napiergrass (var. Merkeron) (27,764 kg $ha^{-1}$) out-yielded Tifton 85 bermudagrass (17,578 kg $ha^{-1}$) and Alamo switchgrass (16,220 kg $ha^{-1}$) (Bouton, 2002). Yields of napiergrass lines tested in southern and central Florida, grown on a range of soil and cultural practices including sewage effluent and phosphate mining sites, were between 30 and 60 Mg $ha^{-1}$ $yr^{-1}$ (Prine et al. 1997). Napiergrass yields in northern areas of the South have ranged from the 20 to 30 Mg $ha^{-1}$ $yr^{-1}$ (Prine et al. 1991). Giant reed continued to increase in yield after 6 years up to 35 Mg $ha^{-1}$ $yr^{-1}$ in 2004 at Auburn, Alabama with no fertilizer inputs (Bransby personal communication).

A replicated field study was established in Tifton in the fall of 2005. Napiergrass and energy cane had the highest dry matter yields and significantly better than switchgrass after the first year (Table 1). Giant reed plants were established with plants generated from tissue culture and did not reach full height by the time of harvest.

Feedstock quality is also an important attribute for a viable industry. There are two general methods of biomass conversion to energy. The first process is saccharification and fermentation, similar to what is used in the starch to ethanol industry. Saccharification requires various pre-treatments to convert cellulose and hemi-cellulose to free sugars for fermentation. The presence and binding with lignin can often hinder efficient conversion to sugars. Leaf and stem material from bermudagrass, napiergrass and giant reed were compared for their relative efficiency of conversion to ethanol. Tifton 85 bermudagrass was superior to the other grasses when evaluated with a dilute acid pretreatment followed by simultaneous saccharification and fermentation (SSF) (Table 2). There appears to be some correlation between forage digestibility and fiber with conversion efficiency. Further studies have begun to determine this relationship with bermudagrass germplasm that has wide variation in digestibility and fiber attributes.

The second major biomass conversion process is via thermochemical breakdown of lignocellulose to fuels, chemicals, and power using gasification and pyrolyis to produce gases such as carbon monoxide, carbon dioxide and hydrogen or pyrolysis oils. Thermochemical conversion technologies convert biomass and its residues to fuels, chemicals, and power using gasification and pyrolysis technologies. For this process feedstocks are not limited by fiber variability or lignin content. For example, there is no difference between Tifton 85 and Coastal bermudagrass in the amount of non-condensable gas or bio-oils when subjected to pyrolysis at different temperatures (Boateng et al. 2005).

Genetic improvement of dedicated bioenergy crops will require breeding and selection for higher dry matter yield as well as phenotypic traits that allow for improved processing and conversion efficiency. Depending on the conversion process, plants may be bred for higher or lower lignin content as well as specific cell-wall component traits.

Table 1. Dry matter yields of potential energy crops established in October of 2005 and harvested December 5, 2006 at Tifton, GA.

| Species | Genotype | Dry matter yield (kg/ha) |
|---|---|---|
| *Pennisetum purpureum* | N 51 | 34,582 a |
| *Pennisetum purpureum* | Merkeron | 28,475 b |
| *Saccharum* sp. | L 79-1002 | 27,147 b |
| *Panicum virgatum* | GA-993 | 8,784 c |
| *Panicum virgatum* | GA-001 | 8,587 c |
| *Arundo donax* | ADF | 6,738 c |
| *Arundo donax* | ADE | 6,528 c |
| *Arundo donax* | ADS | 4,964 c |

Table 2. *In vitro* Dry Matter digestibility (IVDMD), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL) and ethanol production of leaf and stem tissues of 12 week old bermudagrass, and mature napiergrass and giant reed grown at Tifton, GA. 2004.

| Species | Genotype | Tissue | % IVDMD | NDF | ADF | ADL | Ethanol mg/g |
|---|---|---|---|---|---|---|---|
| *Cynodon* sp. | Tifton 85 | Leaf | 47.1 c | 77.6 g | 35.0 abc | 2.93 a | 139.6 a |
| *Cynodon* sp. | Tifton 85 | Stem | 49.2 c | 77.5 g | 37.2 cd | 4.04 b | 141.1 a |
| *Cynodon* sp. | Coastal | Leaf | 35.4 e | 77.0 fg | 33.7 ab | 3.85 b | 121.7 b |
| *Arundo donax* | Cicily | Leaf | 54.1 b | 67.6 ab | 36.7 bcd | 3.82 b | 109.0 bc |
| *Pennisetum purpureum* | Merkeron | Leaf | 58.5 a | 69.4 bc | 36.0 abcd | 3.04 a | 106.7 bc |
| *Pennisetum purpureum* | Merkeron | Stem | 43.5 d | 74.2 def | 48.1 ef | 6.95 c | 105.3 c |
| *Pennisetum purpureum* | N 190 | Leaf | 46.8 c | 73.0 de | 38.3 d | 3.53 ab | 96.7 cd |
| *Arundo donax* | Fitzgerald | Leaf | 52.4 b | 65.5 a | 33.7 a | 4.14 b | 84.8 d |
| *Pennisetum purpureum* | N 190 | Stem | 35.9 e | 74.1 def | 49.1 f | 7.90 d | 84.0 d |
| *Arundo donax* | Fitzgerald | Stem | 22.6 g | 75.4 efg | 49.9 f | 8.98 e | 47.2 e |
| *Arundo donax* | Cicily | Stem | 29.0 f | 71.9 cd | 45.9 e | 8.67 e | 44.2 e |

Means with the same letter are not significantly different. (p=.05)

**References**


Boateng, A.A., W.F. Anderson, and J.G. Phillips. 2007. Production of bermudagrass for bio-fuels: Effect of two genotypes on pyrolysis product yield. Energy and Fuels 21:1183-1187.

Bouton J., 2002. Final Report for 1996 to 2001; *In: Bioenergy Crop Breeding and Production Research in the Southeast*, ORNL/SUB-02-19XSV810C/01

NRDC. 2006. Ethanol: Energy well spent. A survey of studies published since 1990. Natural Resources Defense council and Climate Solutions, New York City (www.nrdc.org/air/transportation/ethanol/ethanol.pdf).

NREL. 2007. Thermochemical conversion technologies – projects. http://www.nrel.gov/biomass/proj_thermochemical_conversion.html

Perlack, R.D., Wright, L.L., Turhollow, A.F., Graham, R.L., Stokes, B.J., and Erbach, D.C. 2005. Biomass as feedstock for a bioenergy and bioproducts industry: The technical feasibility of a billion-ton annual supply. DOE/GO-10200502135, Oak Ridge Nnational Laboratory, Oak Ridge, TN. (http://feedstockreview.ornl.gov/pdf/billion_ton_vision.pdf).

Prine, G.M., P. Mislevy, R.L. Stanley, Jr., L.S. Dunavin and D.I. Bransby. 1991. Field production of energycane elephantgrass and sorghum in southeastern United States. In D.L. Klass (ed.) Proc. Final Program of Conference on Energy from Biomass and Wastes XV. Paper No. 24, 8p.

Prine, G.M., J.A. Stricker and W.V. McConnell. 1997. Opportunities for bioenergy development in lower south USA. Proc. 3rd Biomass Conference of the America: Making a Business from Biomass in Energy, Environment, Chemicals, Fibers and Materials. Vol. 1:227-235.