Biofuels and Feedstock Crops Research

Biofuels and Feedstock Crops

Energy supply in the U.S. includes petroleum (39%), natural gas (24%), coal (23%), nuclear (8%), and renewable resources (6%). Of the 6% due to renewable resources, 47% comes from biomass, 45% from hydroelectric, 5% from geothermal, 2% from wind, and 1% from solar [1]. Although bioethanol constitutes 99% of all biofuels in the U.S. [2], there are other types of biofuels. These include biodiesel, hydrogen, methanol, dimethyl ether or DME, Fischer-Tropsch- or FT-Diesel, substitute natural gas or SNG, and bio oil.

Recently, the interest in biofuels and bioenergy has been increasing and more agricultural land has been used for ethanol production. Larger amounts of ethanol are expected to be used as a motor fuel because of the Energy Policy Act of 2005, which stipulates that the amount of biofuel (usually ethanol) that must be mixed with gasoline sold in the United States be increased to 7.5 billion gallons by 2012.

Most of the ethanol in the U.S. is produced from the conversion of corn grain starch into glucose by enzymatic hydrolysis and subsequent fermentation. Greenhouse gas emissions from ethanol made from conventionally grown corn can be slightly more or slightly less (depending on the production practices applied to produce the corn crop) than from gasoline per unit of energy, but the production of ethanol requires much less petroleum inputs than the production of gasoline [2]. Relative to fossil fuels, corn grain ethanol provides a 25% net energy gain and a 12% reduction in greenhouse gas emissions [3]. However, the problem with the increase in the production of corn ethanol is that this results in a higher demand and higher price of corn and corn-dependant products [4]. Ethanol is also produced from

Relative to Cocodrie, a potentially high biomass rice line selected from the Pedigree Nursery of the Rice Breeding Program at Texas AgriLife Research at Beaumont, Texas, in 2007.

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Welcome to the April issue of *Texas Rice*. The lead article provides an interesting overview of the economics of cellulosic bioenergy feedstock production, and bioenergy feedstock research being conducted by scientists at the Beaumont Center. To say the least, the 2008 season represents a major expansion of the Center’s research base. While rice remains the primary focus, the past three years have seen a number of our scientists working to generate funding for bioenergy research. These efforts are beginning to pay off.

So far, five funded bioenergy research projects are underway (Table 1), with a sixth project expected to start later this year and a seventh project under negotiation. This represents a significant accomplishment, given that our field research in this area only started last spring with the planting of an unfunded energy cane project by Dr. Way working with USDA-ARS scientists from Houma, Louisiana, and the planting of an unfunded high biomass sorghum project by Drs. Tarpley, Way, and Wilson working with Jürg Blumenthal from College Station.

Table 1. Bioenergy feedstock research projects funded at the Texas AgriLife Research and Extension Center at Beaumont in 2008.

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<th>Source of Funds</th>
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Although we have a long way to go before we can truly provide useful research results to growers in Southeast Texas, preliminary results are encouraging. Yields from field trials suggest growers in this region of Texas have the potential to achieve 15 ton (dry weight)/acre for high biomass sorghum and 20 ton/acre for energy cane. These numbers are significant in that they are fairly high, and because we are only just starting to study their production and management, yields will very likely increase. With appropriate pricing, where the welfare of our producers is part of...
Rice Breeding and New Cultivars

Contribution of Breeding to Productivity

The cultivar is a very important component in rice production. Cultivars and their appropriate production technologies have increased rice production in Texas over the years. Most of the cultivars that are grown in Texas are either developed at the Texas AgriLife Research and Extension Center (formerly the Texas Agricultural Experiment Station) at Beaumont, Texas, or at one of the rice research centers or stations located at Arkansas, Louisiana, Mississippi, and Missouri. At the Texas AgriLife Research and Extension Center at Beaumont, the U.S. Department of Agriculture - Agricultural Research Service (USDA-ARS) rice breeders have been Dr. Hank Beachell (1931 to 1963), Dr. Charlie Bollich (1963 to 1991), and Dr. Anna McClung (1991 to present), while the state breeder has been Dr. Rodante Tabien (2002 to present).

Improvements in rice crop production over the years have been due to contributory factors from various disciplines such as agronomy, soil science, weed science, entomology, pathology, physiology, breeding, genetics, statistics, and others. Recently, Drs. Tabien, McClung, and Omar Samonte, conducted a study limited to analyzing the effects of two of these, cultivar (CV) and nitrogen (N) fertilizer, on a number of agronomic traits (number of days to heading, plant height, percentages of whole and total milled rice, and grain yield). Twenty-three rice cultivars (released during the first 50 years of rice breeding in Texas, 1942 to 1992) grown under two N fertilization levels at three environments (E) were analyzed in their study. Their results indicated that 44.9% of the improvement in grain yield in this study was due to the effect of breeding and releasing cultivars (CV), while 8.9% was due to the effect of increasing the amount of N fertilized from 85 to 170 lb/acre N. Environment (4.2%), CV x E interaction (12.8%), N x CV interaction (2.6%), E x N interaction (1.5%), and E x N x CV interaction (5.7%) also had significant effects on grain yield. The remainder was due to unaccounted reasons or experimental error. Improvements in insect, weed, and disease management obviously also contributed to increasing Texas rice yields. These factors need to be included in a study to obtain a more complete picture of the contribution of each variable to improvements in rice yield.

A number of plant traits of rice cultivars released and grown in Texas since 1942 have changed dramatically. It is amazing to note that ‘Bluebonnet’, which was released in 1944, took 105 days to reach the heading stage, was 5 inches tall, yielded 4,500 lb/acre, and had a 52% whole milled rice percentage (Fig. 1). At the time Bluebonnet was released, its important attributes included a relatively earlier maturity and shorter plant height. ‘Texas Patna’, the first cultivar released from the Beaumont Center in 1942, reached the heading stage at 13 days after planting and grew to 57 inches tall. It was estimated that the rate of grain yield increase due to cultivars released from 1944 to 1992 was about 42 lb/acre/yr when fertilized with 170 lb/acre N. In contrast, data from the 2004 to

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**Fig. 1. Milled rice percentages of Bluebonnet (released in 1944) and Presidio (released in 2005).**

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2006 Uniform Regional Rice Nursery (URRN) at Beaumont shows that ‘Presidio’, the latest cultivar released by USDA-ARS and Texas AgriLife Research needs only 84 days to reach heading, is 35 inches tall, yields 8,516 lb/acre, and has a 63% whole milled rice percentage. New cultivars will be released as part of a continuous cycle of improvement of rice populations (involving crossing, development of variation, and selection) and interactive involvement among researchers of various disciplines.

Newly Released Cultivars

Recently, the Louisiana State University (LSU) AgCenter Rice Research Station released rice cultivars ‘Catahoula’ and ‘Neptune’ for production in 2008. Drs. Steve Linscombe and Xueyan Sha reported that Catahoula is a high-yielding, good-milling, long-grain, semidwarf, which yielded an average of 7,357 lb/acre in 75 yield trials across the southern growing states from 2002 to 2007. In comparison, ‘Cocodrie’ and ‘Cheniere’ yielded 7,237 and 7,119 lb/acre, respectively. Catahoula is similar to Cocodrie in milling yield, plant type, height, and number of days to heading, but it reaches maturity earlier by 2 to 3 days. Furthermore, Catahoula is described to be moderately susceptible to sheath blight (similar to Cheniere) and straighthead, has very good ratoon crop potential, good seedling vigor, and has the typical long-grain cereal chemistry and cooking quality.

Another new long-grain cultivar is ‘Bowman’, released last March 2007 by the Delta Research and Extension Center in Stoneville, Mississippi. Dr. Kanter and his colleagues reported that Bowman is a high-yielding, early-maturing, semidwarf, which when compared to Wells has an equal yield and a higher whole-grain milling yield. Bowman is susceptible to blast, but has some tolerance to sheath blight and straight head.

Information about the yield and milling performance of Catahoula and Bowman in Texas

![Bowman](image1)

![Catahoula](image2)

Fig 2. Average number of days to heading, plant height, grain yield, and whole milled rice percentage of the main crop of Bowman, Catahoula, Cocodrie, and Presidio grown at the URRN at Beaumont, TX, in 2004 to 2006.

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Rice Breeding continued ...

is available, since they have been evaluated in the URRN at Texas AgriLife Research. A comparison of performance of Catahoula, Bowman, and Presidio (latest cultivar released by Texas AgriLife Research), relative to Cocodrie (currently, the most widely grown cultivar in Texas) based on the 2004 to 2006 URRN conducted at Beaumont for days to heading, plant height, yield, and whole milled rice percentage is shown in Fig. 2.

LSU breeders indicated that Neptune is a high-yielding, good-milling, short-statured cultivar with medium grain size similar to ‘Bengal’. Neptune yielded an average main crop of 8,300 lb/acre in 41 yield trials conducted across the southern rice growing region from 2003 to 2007. In comparison, ‘Jupiter’ yielded 8,498 lb/acre, while Bengal yielded 7,790 lb/acre. It was also reported that relative to Jupiter and Bengal, Neptune is 1 to 2 inches shorter, it heads one day later, but matures 2 to 3 days earlier. Neptune is also more resistant to blast and narrow brown leaf spot than Jupiter and Bengal, and is more tolerant to bacterial panicle blight and similar in being moderately susceptible to straighthead. A comparison of mean performance of Neptune, Bengal, and Jupiter at the URRN conducted at Beaumont from 2004 to 2006 for days to heading, plant height, yield, and whole milled rice percentage is shown in Fig. 3.

Pictures of Bowman, Catahoula, and Neptune at the grain filling stage photographed during their evaluation at the URRN show the plant type of these new cultivars.

For more information, you can consult the following references:


Article by Dr. Stanley Omar PB. Samonte and Dr. Rodante E. Tabien, Texas AgriLife Research and Extension Center, Texas A&M System, Beaumont, TX.

Fig 3. Average number of days to heading, plant height, grain yield, and whole milled rice percentage of the main crop of Neptune, Bengal, and Jupiter grown at the URRN at Beaumont, TX, in 2004 to 2006.
other crops, such as sugar beet, wheat, and sugarcane, and the ethanol produced directly from fermentation of sugarcane sugar is less expensive than the ethanol produced from starch [5]. To be a viable alternative, a biofuel should provide a net energy gain, have environmental benefits, be economically competitive, and be producible in large quantities without reducing food supplies [3]. Lignocellulosic ethanol, which is produced from fibrous lignocellulosic biomass matter, has this potential. Compared to corn ethanol, lignocellulosic biomass is not used for human consumption and is much more available in the U.S., as it is estimated that there is potentially 428 million dry tons of annual crop residues produced each year [1]. As an example, switchgrass is not a food crop and the ethanol produced from its cellulosic material reduces both greenhouse gases and petroleum inputs substantially [2].

Globally, about half of the wasted crop and lignocellulosic biomass that is potentially available for bioethanol comes from rice. The wasted rice grain and rice straw (which is routinely burned) could produce 58.5 billion gallons of bioethanol, replacing 42.0 billion gallons of gasoline (which is about 14.3% of global gasoline consumption) [6].

Biomass appears to be an attractive feedstock or energy source for several reasons. It is a renewable resource that could be sustainably developed in the future, and it appears to have positive environmental properties that result in zero releases of carbon dioxide and very low sulfur content [7]. Unlike the burning of fossil fuels, which releases stored carbon and increases greenhouse gases, the burning of biofuels releases carbon that was assimilated by the crop biomass from the atmosphere while it was still growing. In addition, biomass is the only current renewable source of liquid transportation fuel, making it important in reducing U.S. oil imports [1].

Lignocellulosic biomass is basically composed of the plant cell wall materials, which are mostly crystalline cellulose embedded in a hemicellulose and pectin matrix, and surrounded by lignin [4]. A summary of the procedure for ethanol production from lignocellulosic biomass using biochemical processes is as follows: 1) pretreatment of the biomass mechanically and physically (steam explosion) to clean and size the biomass, and destroy its cell structure to increase its accessibility to further chemical or biological treatment; 2) delignification, in which the lignin part of the biomass is removed; 3) hydrolysis or saccharification of the hemicellulose to monomeric and oligomeric sugars; 4) hydrolysis of cellulose to glucose; and 5) fermentation of sugars to produce ethanol, which is purified and dehydrated [8]. Biomass types that can easily be converted to sugars for fermentation have higher value as biofuel feedstocks [9]. The large-scale use of ethanol for fuel will almost certainly require cellulosic technology [2].

Biofuels Research at Texas AgriLife

The Texas AgriLife Research and Extension Center at Beaumont, TX, has several ongoing projects that, in general, aim to optimize biofuel production and quality from feedstock crops in the Gulf Coast region. Some research projects involve the evaluation of more than one biofuel feedstock crop.

Biomass and Economic Risk Analyzer

Drs. Yubin Yang and Lloyd Wilson are developing the Biomass and Economic Risk Analyzer (BERA) to conduct simulation analysis to optimize bioenergy productivity in diverse climatic and edaphic environments. Some of the capabilities that BERA is structured to perform include:

- Estimating the site-specific and across-year biomass and economic performance of selected candidate bioenergy crops for anywhere in the U.S. Gulf Coast
- Providing for economic risk analysis and ranking of biorefinery site selection, and providing season biomass production and delivery plans for the U.S. Gulf Coast
- Dynamically integrating climatic and soil databases
- Predicting yield variability due to temporal and spatial differences in soil and climate
- Providing estimates of optimal crop mix and harvesting schedule for year-round biomass supply

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• Optimizing road network routing and scheduling for biofeedstock transportation and delivery
• Providing GIS integration that allows for biomass and risk analysis at a wide range of temporal and spatial scale
• Identifying plant breeding selection strategies that will result in optimal yield performance for different candidate bioenergy crops for different regions of the U.S. Gulf Coast.

**Energy Cane and Biomass Sorghum**

Dr. Mo Way is cooperating with the U.S. Department of Agriculture - Agricultural Research Service (USDA-ARS) at Houma (Louisiana) and Texas AgriLife Research and Extension Center at Weslaco in evaluating 30 energy cane lines, which were selected for their potentially high fiber content and their adaptability to Southeast Texas. A multi-year, multi-location Department of Energy funded project on energy cane coordinated by Brian Baldwin at Mississippi State University involves researchers from Beaumont (Ted Wilson, Lee Tarpley, and Mo Way), Weslaco (Mike Gould, John Jifon, and Jorge da Silva), Auburn University in Alabama (Dave Bransby), Louisiana State University (Ken Gravois), and University of Georgia (Wayne Hanna) is also being initiated this year. This research will provide baseline data on the performance of a range of energy canes across the entire U.S. Gulf Coast.

Research on production practices for energy cane and biomass sorghum for the Gulf Coast, funded by Texas AgriLife Research Bioenergy Initiatives Program, is being conducted by Drs. Lee Tarpley, Garry McCauley and Mo Way (at Beaumont), and John Jifon, Jorge Da Silva and Luis Ribera (at Weslaco). The goal of their project is to develop a set of profitable and sustainable production practices for energy cane and biomass sorghum as lignocellulosic (biomass) feedstock crops for the growing regions along the Texas Gulf Coast.

**Oilseed**

Research on oilseed as a biofuel feedstock, with Dr. Tarpley directing the Chevron-sponsored study at Beaumont, is composed of winter and summer...
Biofuels continued ...

oilseed trials. This year, a state-wide variety trial was conducted to identify various oilseed species and varieties with potential as biodiesel feedstock crops for the various growing regions in the state. A statewide variety trial will be conducted this summer to evaluate selected species and characterize their growth and development patterns for the various growing regions in the state.

**Sorghum**

It is estimated that potentially 499.3 million gallons of ethanol can be produced from wasted sorghum straw in North America, and this amount is equivalent to 356.6 million gallons of gasoline [6]. At Texas AgriLife Research at Beaumont, research being conducted by Drs. Tarpley, Way, and Wilson aims to develop economical production practices for bioenergy sweet and forage sorghum types in Southeast Texas as part of a system of crops to enable year-round delivery of biomass feedstock to a large cellulose-to-ethanol facility.

**Soybean**

Soybean is a potential feedstock crop for biodiesel. In fact, soybean biodiesel yields 93% more energy than the energy invested in its production, whereas corn ethanol yields only 25% more. Furthermore, soybean biodiesel releases just 1.0%, 8.3%, and 13% of the agricultural nitrogen, phosphorus, and pesticide pollutants (by weight), respectively, per net energy gain when compared to corn ethanol. And, relative to the fossil fuels they displace, greenhouse gas emissions are reduced 41% by the production and combustion of soybean biodiesel, compared to 12% by corn ethanol [3].

This year, Dr. Way is conducting the following studies on soybeans:

- Evaluation of germplasm for resistance to stink bugs, in cooperation with Texas AgriLife Research and Extension Center at Dallas
- Identification of the cause of flat pod syndrome and delayed maturity, this study will eventually cooperate with Louisiana State University, Virginia Tech, and University of Georgia
- Evaluation of planting date effects on a promising cultivar ‘NC Roy’
- Evaluation of novel insecticides for insect control in soybeans, in cooperation with various agrichemical companies
- Evaluation of gibberellic acid as a foliar treatment to increase pod height of NC Roy, in cooperation with Dr. Tarpley.

**Switchgrass and Rice**

Dr. Rodante Tabien and colleagues’ (Drs. Bill Park and Donald Vietor of Texas A&M University at College Station, Dr. Georgia Eizenga of USDA-ARS at Stuttgart, and Drs. Tarpley and Omar Samonte of Texas AgriLife Research at Beaumont) initiated research this season on the development of high biomass switchgrass and rice for biofuel feedstock, funded by Texas AgriLife Research Bioenergy.

Fig. 1. Aboveground plant mass of high biomass rice genotypes, relative to Cocodrie, at Beaumont, TX, in 2007.
Initiatives Program. Switchgrass cultivars will be evaluated for their performance in two locations (Beaumont and Eagle Lake), while rice genotypes (selected for their high biomass potential) will be evaluated in two rice culture systems based on water supply (irrigated vs. rainfed) and in two harvest-cutting systems (one-cut vs. two-cut) at Beaumont. These studies will determine plant type and cultivars or lines of high biomass switchgrass and rice that are adaptable to Southeast Texas.

Preliminary data obtained in 2007 by harvesting aboveground plant structures of selected high biomass lines in the pedigree and observational nurseries at heading were used in identifying the genotypes that will be evaluated in the rice biomass trial. Aboveground masses of all selected high biomass rice lines were higher than that of Cocodrie. Compared to Cocodrie, which produced 7,606 lb/acre biomass at heading, the top two high biomass lines produced 19,01 lb/acre biomass at heading. A comparison of the top 5 high biomass lines are shown in Figure 1.

For more information, please consult the following references:


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From the Editor continued...

a sustainable profit-sharing arrangement, our growers could profitably produce cellulosic bioenergy crops. Wouldn’t it be great to see 100,000 to a half a million acres of low revenue generating pastureland being used to produce bioenergy feedstock. The value of a second profitable crop would have a very positive impact on the agriculture infrastructure in Southeast Texas.

Which plant species and/or varieties do we plant to insure year-round feedstock production? This is one of those 64 thousand dollar questions. A single conventional food, feed, or fiber crop in a single geographical area is rarely harvested for more than one or two months out of a year. Providing a year-round feedstock supply will require creative scheduling of planting and harvesting. What is the most efficient way to convert cellulose biomass into fuel? Bacterial fermentation of cellulose currently costs about five to six times per gallon of fuel produced compared to the cost of starch-based fermentation of corn grain. Although possibly optimistic, a 2007 World Watch Institute report funded by the German government...
From the Editor continued...

predicted that cellulose-based fermentation would become cost competitive with starch-based fermentation by 2010. This would further increase the profitability of cellulosic ethanol production. Other processing methods, such as those that involve superheating the plant material to convert the cellulose into a gas that can be easily converted into a synthetic gasoline may also have potential.

We are in an exciting time with tremendous potential for the future of cellulosic ethanol production. As results from our bioenergy research are produced, I am hopeful we will have good news to share with our producers and with companies that are interested in placing biorefineries in the Texas Upper Gulf Coast.

Please keep sending us your suggestions.

Sincerely,

L.T. Wilson
Professor and Center Director
Jack B. Wendt Endowed Chair in Rice Research

Rice Crop Update

As of April 25, 2008, about 96% of the estimated rice acreage in Texas had already been planted, and seedlings have already emerged at 83%. So far, about 3% of the rice crop has reached the permanent flood stage.