Institute of Agriculture and Natural Resources —

At Work For Nebraska

IANR

REPORT to our PARTNERS: ENERGY

Algal biofuels are new frontier

Algae may be the next frontier for biofuels, and the University of Nebraska–Lincoln is poised to be among the nation's leaders in this research.

Part of the greenhouse complex at UNL's Beadle Center will be revamped into an algal biofuels research facility early this year. Scientists will begin growing algae in small containers, then move on to five-foot long bags and, finally, a "raceway" – a small, oblong pool — as they seek answers to two key questions:

Algae will be grown in bags like these at UNL.

• What algae cultivars are best suited for biofuel development? There are at least 200,000 different algae, and ultimately genetic modification may play a role in engineering algae to produce the most lipids – specifically, triglycerides – possible for conversion to fuel.

• How can the triglycerides be most cost-effectively extracted from the algae to produce biofuel?

Algae have the potential to produce much more biomass per unit than other crops. The oil content in algae can comprise 30 to perhaps 50 percent of its weight, said George Oyler, a research associate professor in biochemistry.

Potentially, algae could yield up to 6,000 gallons of oil per acre annually. That compares to 43 gallons for soybeans, 86 for sunflowers and 171 for canola.

Algae also do not compete with food crops; do not require premium farmland; can grow on waste, salty and brackish water; and are not as nutrient-intensive as other biofuels crops.

However, the challenges of turning algae into economically viable biofuels are significant.

One key to making algal biofuels economically viable will be to develop co-products from the manufacturing process, said Ed Cahoon, a lipid biochemist. For example, it may be possible to develop livestock feed, just as distillers grains have resulted from corn ethanol production.

IANR engaged in effort to find new energy sources on numerous levels

Several years ago, a guest speaker at the University of Nebraska–Lincoln said Nebraska and other Plains states were well-positioned to become "the Saudi Arabia of biorenewables." His comments came as the United States, driven by unstable oil prices and energy-security and environmental concerns, began seeking and trying to develop new sources of energy.

The Institute of Agriculture and Natural Resources at UNL is at the forefront of these efforts, as scientists explore options on several promising fronts and educators help Nebraskans learn how to tap into this brave new world.

This special **Report to Our Partners: *Energy Issues*** offers a sampling of how IANR is *At Work for Nebraska* on these initiatives.

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Study: Corn ethanol emits 51 percent less greenhouse gas than gasoline

Corn ethanol directly emits an average of 51 percent less greenhouse gas than gasoline, as much as three times the reduction reported in earlier research, thanks to recent improvements in efficiency throughout the production process, University of Nebraska-Lincoln research shows.

The research, unveiled in 2009, evaluated dry- mill ethanol plants that use natural gas. Such plants account for nearly 90 percent of current production capacity.

This research was the first to quantify the impact of recent improvements throughout the corn-ethanol production process, including crop production, biorefinery operations and co-product use, said Ken Cassman, UNL agronomist who was part of the research team. Previous studies, which found ethanol to have a much smaller edge over gasoline in GHG emissions, relied on estimates based on corn production, ethanol plant performance and co-product use as they were seven years ago.

"Critics claim that corn ethanol has only a small net energy yield and little potential for direct reductions in GHG emissions compared to use of gasoline," Cassman said. "This is the first peer-reviewed study to document that these claims are not correct."

The newest biorefineries have increased energy efficiency and reduced GHG emissions through the use of improved technologies. Also, many are located near cattle feeding or dairy operations, which allows efficient use of the co-product distillers grains as cattle feed. For example, the distillers grains don't have to be dried to facilitate long-distance travel; drying comprises up to 30 percent of total energy use in the ethanol plant.

Also contributing to corn ethanol's GHG performance are improvements in how the crop is grown.

The result of these improvements: The ethanol industry now produces a fuel that is 48 to 59 percent lower in direct-effect lifecycle greenhouse gas emissions than gasoline. That's two to three times the reduction reported in earlier studies..

The net energy ratio, which averaged 1.2 to 1 in earlier studies, is 1.5-1.8 to 1 in the recent research. That means that for every unit of energy it takes to make ethanol, 1.5 to 1.8 units of energy are produced as ethanol.

Beef, ethanol synergy gives Nebraska competitive edge

The synergy between Nebraska's beef and ethanol industries gives the Cornhusker state a competitive edge in the new biofuels economy, and Institute of Agriculture and Natural Resources research continues to hone that advantage.

Other states have ethanol and grain production and some have cattle, but Nebraska is the only state that has all three key elements in significant size, said UNL animal scientist Galen Erickson.

Erickson and others have focused their research on improving the use of feed byproducts produced from ethanol production, increasing their use and evaluating the economics for Nebraska agricultural producers. These efforts are key in helping make the ethanol industry profitable.

Key elements of their multifaceted efforts:

• Pioneering studies in the 1990s proved the benefits of feeding wet byproducts to cattle instead of drying the material. Eliminating drying reduces ethanol production costs about 5 percent and provides an economical, high-performance feed. This work transformed wet byproducts into a feedlot staple and aided development of Nebraska's ethanol industry.

• Development of Cattle CODE, an online computer program that feedlot operators can use to predict cattle performance and economic returns from feeding byproducts, based on individualized information such as grain, byproduct and transportation costs.

• Scientists are looking into feeding a higher percentage of ethanol byproducts to cattle. Historically, wet byproducts have comprised 15-20 percent of feedlot rations. Researchers hope to boost that to as much as 50 percent, perhaps even more, and are gauging the upper limits of sulfur B which is more prevalent in distillers grains than other feed B and fat that livestock can safely consume..

• Research has resulted in formulas for mixing forages with wet distillers grains to allow for safer storage of the feed. That way, producers can buy the wet distillers grains in summer . when their plentiful supply can mean lower prices and safely store them for use later in the season, or for winter feeding.

UNL research to identify high oil, low water use crops for biodiesel

Expanded oilseed production in Nebraska not only would provide oil for human consumption, but also could be used for producing biofuels and byproducts for livestock.

To help expand this potentially new economic opportunity for agricultural producers and suppliers in Nebraska, Loren Isom, technical assistance coordinator for UNL's Industrial Agricultural Products Center, and Bill Booker, UNL Extension educator in Box Butte County, are researching oilseeds and educating producers about the benefits of planting these crops.

In the Panhandle, the oil-producing seeds of crops like sunflower, canola and camelina provide an alternative broadleaf crop for dryland wheat rotations, helping diversify production. Under irrigation, these crops use less water than corn and readily adapt to limited irrigation scenarios.

Sunflowers already are a common alternative crop in Nebraska. Canola and camelina are not as common but are being researched at the Panhandle Research and Extension Center at Scottsbluff for adoption to Nebraska's climate.

"Sunflowers have been grown for a long time across Kansas and South Dakota, so there is no reason why we shouldn't be able to grow these crops in Nebraska," Booker said.

Sunflower and canola produce two to two and a half times more oil per acre than soybeans. Regular soybean oil is 85 percent of the vegetable oil market.

However, to make soybean oil a stable cooking oil, it typically goes through a process called partial hydrogenation. This creates transfats which raise bad cholesterol (LDL) and lower the good (HDL).

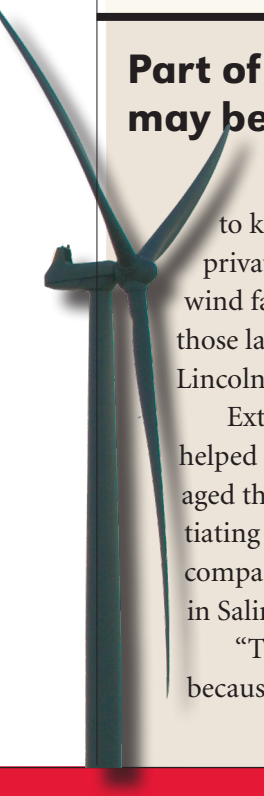
A few years ago Frito Lay eliminated its transfats and drastically lowered saturated fats by switching to NuSun sunflower oil. The human consumption and biofuel markets has resulted in increased demand for sunflower oil stabilizing the market, making it an even more viable alternative crop option.

Booker and Isom agreed that the state does face some limiting factors.

Recent developments to expand Nebraska's oilseed crushing capacities have experienced setbacks. While booming in 2007, high commodity feedstock prices, subsided fuel prices and limited political support made profitable biodiesel processing challenging in 2008 and 2009.

Plants that were in operation have shut down and new ones never came to realization. However, some individuals are growing and processing oilseeds into biodiesel in small batches for use on their own farms.

Part of energy solution may be blowing in the wind



Landowners in Saline County needed to know more when they were approached by private companies seeking their land to build wind farms. To get the information they needed, those landowners turned to University of Nebraska–Lincoln Extension.

Extension conducted educational meetings, helped the landowners form a group and encouraged them to work with an attorney before negotiating any of their land away to these private companies, said Randy Pryor, extension educator in Saline County.

"The landowners started asking questions because no one had ever offered to pay them for their wind rights," Pryor said. "Wind energy is a new frontier for landowners in Nebraska."

Wind farms use tall, three-bladed turbines that are constructed on land to create electricity from the wind. Currently, Nebraska has 73 turbines operated by several power suppliers.

Pryor worked with landowners to form the Saline County Wind Association. The 263 group members pooled their money to hire an attorney before agreeing to any wind rights contracts.

For the first targeted area the group agreed to work with one developer, RES Americas, which owns 14 percent of the wind energy projects in the United States. Eighty-five landowners in the county so far have signed wind rights contracts allowing studies to be conducted on the suitability of a combined 22,000 acres for a potential wind farm project.

Scientists study carbon storage

Institute of Agriculture and Natural Resources scientists' research into carbon sequestration is examining the potential of storing carbon in the soil in corn-soybean cropping systems.

An interdisciplinary team of 12 UNL scientists from five departments began their carbon sequestration research at the Agricultural Research and Development Center near Mead about eight years ago. Their research was designed to answer practical as well as scientific questions about carbon sequestration in the different farming systems of Nebraska and the north-central United States.

Steadily increasing atmospheric concentrations of carbon dioxide, a major greenhouse gas associated with global warming, are driving interest in storing more carbon in cropland. Utilities or other companies might pay farmers to store carbon in their soil in exchange for credit toward their carbon dioxide emissions.

AT ARDC, researchers have studied carbon exchange in three no-till cropping systems -- irrigated continuous corn, irrigated corn-soybean rotation and rainfed corn-soybean rotation.

Sensors on a tower at each study site as well as in the soil provide measurements aimed at tracking carbon dioxide and water vapor exchanges in the ecosystems, said Shashi Verma, UNL micrometeorologist. .

The ARDC research has so far shown:

• Currently, the rainfed corn-soybean rotation is approximately carbon neutral, but the rate of carbon sequestration may increase over time as changes in soil structure help protect organic matter and create a carbon "sink."

• The irrigated corn-soybean rotation is a moderate source of carbon, as a high proportion of productivity is lost as ecosystem respiration, with a more favorable soil moisture regime and higher rates of soybean residue decomposition compared to corn.

• The irrigated continuous corn field was nearly carbon neutral or a slight to moderate source of carbon.

Producers and UNL representatives observe a carbon storage site.

The field showed a high ecosystem respiration rate because of a more favorable soil moisture regime. Also, there were difficulties in achieving uniform and adequate plant population due to heavy litter layer and severity of insect and disease damage when corn is grown without rotation with soybean.

In the fall of 2005, researchers changed the residue management strategy under continuous corn. They began using a conservation plow that doesn't completely invert the top soil layer as occurs with some conventional plowing techniques. Measurements the last couple of years seem to indicate that this approach may help improve carbon sequestration in the soil by pushing crop residues deeper into the soil profile.

BESS tool

UNL researchers have developed a tool to assess greenhouse gas mitigation and energy efficiency of corn-based ethanol plants.

The Biofuel Energy Systems Simulator (BESS), available free at *http://www.bess.unl.edu/,* analyzes energy yield and efficiency, greenhouse gas emissions and resource requirements for individual biofuel production systems. This "seed-to-fuel" tool quantifies lifecycle carbon savings and environmental impact of individual biofuel systems. It factors in energy use and greenhouse gases from crop production, ethanol conversion, byproduct use, waste disposal and transportation.

Determining how well individual plants measure up will be critical to the ethanol industry's long-term success and sustainability, scientists say.

Switchgrass potential

Switchgrass grown for biofuel production produced 5.4 times more energy than needed to grow, harvest and process it into cellulosic ethanol, a large on-farm study by researchers at the University of Nebraska–Lincoln found. The study, released in 2008, highlights the prairie grass' potential as a biomass fuel source that yields significantly more energy than is consumed in production and conversion into cellulosic ethanol. The study examined the net energy output, greenhouse gas emissions, biomass yields, agricultural inputs and estimated cellulosic ethanol production from switchgrass grown and managed for biomass fuel.

Sweet Sorghum

Sweet sorghum used to be used mainly as a sugar source. Now it's being looked at as a fuel alternative.

Ismail Dweikat, associate professor in sorghum and millet genetics at the University of Nebraska-Lincoln, believes sweet sorghum is the perfect crop to produce ethanol. Ethanol can be produced by blending the juice from crushed sorghum stalks with yeast.

Dweikat views sweet sorghum as an economic alternative to corn in the development of ethanol. Corn needs irrigation and 150 to 200 pounds of nitrogen per acre while sweet sorghum requires no additional moisture other than natural rainfall and 60 to 80 pounds of nitrogen to produce about 12 to 15 metric tons per acre of dry biomass, he said.