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# Growing Crops for Better Biodiesel

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# GROWING CROPS FOR BETTER BIODIESEL

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ABSTRACT: Identifying high oil yield, low water use crops suitable for biodiesel production is a key component of addressing feedstock availability that will support the development of biodiesel production facilities in Nebraska. Expanded oilseed production can develop new economic opportunities for agricultural producers and suppliers in Nebraska.

## Growth in the biodiesel industry brings challenges and opportunities

Biodiesel is a bio-based renewable fuel derived from vegetable oils or animal fats that can be burned neat or blended with petroleum diesel for use in diesel engines. It is produced through a chemical reaction that removes glycerin molecules from the triglyceride molecules. This process called transesterification results in a fuel that has fuel properties very similar to petroleum based diesel fuels. The primary differences between biodiesel and petroleum diesel are the reduced emission profile when biodiesel is burned and cold flow constraints associated with biodiesel fuel.

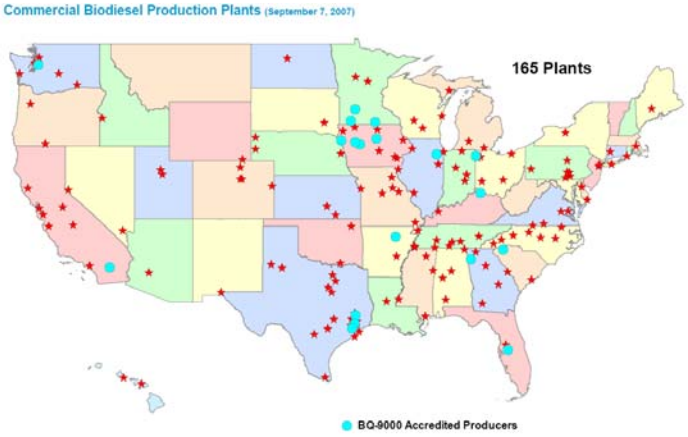


Figure 1. Commercial Biodiesel Production Plants as of Sept. 2007, National Biodiesel Board.

Biodiesel production is expanding rapidly in the United States and around the world. The U.S. biodiesel industry has grown from selling a half a million gallons in 1999 to sales over 250 million gallons in 2006. Production capacity also has expanded dramatically in anticipation of continued growth. The National Biodiesel Board estimates production capacity is 1.85 billion gallons per year from 165 operating plants as of September 2007. Approximately 100 additional production facilities are under construction with a potential production capacity of approximately an additional billion gallons per year.[1] This level of production capacity prepares the biodiesel industry for

[1] National Biodiesel Board, www.nbb.org as of November 21, 2007.

future sales growth, but it also is driving the cost of vegetable oil and animal fat to record prices that make it difficult to profitably produce biodiesel.

Animal fat is a co-product of the animal slaughter and rendering industries and is typically priced at a discount to vegetable oils. However, due to strong demand, the price of animal fat has risen from historical prices of 10 to 15 cents per pound to nearly 30 cents per pound in September 2007. Biodiesel produced from animal fat has a gel point of approximately 50 to 60°F, which limits its use as a neat fuel or even biodiesel-petroleum fuel blends to relatively warm applications. The gel point for biodiesel produced from vegetable oil is approximately 25 to 35°F and when blended with petroleum diesel fuel at levels below 20% only raises the gel point of biodiesel-petroleum fuel blends a couple of degrees.

Soybean oil is the leading vegetable oil produced in the U.S. and is a co-product of soybean processing that has been processed primarily for soybean meal, a high protein animal feed. The availability of soybean oil and soybean processing facilities has made soybean oil the primary feedstock for the U.S. biodiesel industry. Other oilseed crops, such as sunflower, canola (rape seed), brown mustard, and camelina can produce greater quantities of oil per acre. Except for sunflower other oilseed crops are not common in Nebraska. Sunflower production in Nebraska over the past 10 years has averaged 25,000 acres for confection sunflower and 43,000 acres for oil sunflower. Furthermore, processing facilities for these crops and markets for the protein meal co-products do not currently exist in Nebraska.

Figure 2. Nebraska producers are proving the potential for double-cropping sunflower after wheat.

An advantage of sunflower and canola production over other alternative oilseeds is that production practices and co-product markets are common outside of Nebraska and could be adopted from near-by regions. Due to the higher oil content, mechanical processing facilities may be feasible at the local level rather than transporting oilseeds long distances to large scale solvent extraction facilities. More importantly, sunflower and canola can produce oil that is highly desirable for human consumption. In efforts to produce healthier foods, the food industry is committed to eliminating transfats and lowering saturated fat levels. With that in mind, oilseed processors may have the opportunity to market the oil into premium food grade markets. If the premium markets are fully supplied, a strong market will likely still exist for the commodity based biodiesel feedstock market.

Oilseed production and processing are key issues for the biodiesel industry, but they are also key issues for Nebraska's agricultural producers as they adopt production practices and crop rotation systems to maximize benefits from the market demands of the biofuel industry. The University of Nebraska has and will continue to research key issues such as: biodiesel production processes, biodiesel application efficiencies, biodiesel industry economics, oilseed processing systems, alternative oilseed production, and integrated crop management systems for oilseeds throughout Nebraska.

## Suitable oilseed crops for Nebraska producers

A review of suitable oilseed varieties includes commercial and experimental varieties, although an emphasis is placed on oilseeds that are most likely to be adapted by producers in Nebraska: soybeans, sunflower, and canola. For this analysis, typical oil contents have been assumed and the oil to biodiesel conversion rate for all oilseeds has been assumed to be 1:1. A review of published literature reported soybean oil/biodiesel yields range from 48 to 63 gallons per acre, while sunflower oil/biodiesel yields range from 63 to 100 gallons per acre, and canola/rapeseed oil/biodiesel yields range from 63 to 127 gallons per acre. It appears these ranges are optimistic when compared to historical production data averaged over extended production cycles, so the lower end of the range should be used in most cases.

Soybeans are a familiar oilseed crop raised in Nebraska, but the oil content of the soybean seed is relatively low (18 - 20%) compared to other oilseeds that typically will have an oil content that exceeds 40%. Nebraska harvested 4.8 million acres of soybeans on average from 2004 to 2006, of which 47% were reported as irrigated with an average yield of 57 bushels per acre and the dry land yield averaged 41.6.[2] This level of production is equivalent to 235 million bushels of soybeans per year with approximately 330 million gallons of oil available in the seeds at an18% oil content. However, with mechanical extraction it is estimated the oil extraction yield would only be 12%, which would yield 220 million gallons of oil. Using the soybean production data averaged from 2004 to 2006, Nebraska produced the equivalent of 46 to 69 gallons per acre depending on the soybean processing method.

Sunflower production is relatively well established as an oilseed crop in the broader region of the Great Plains with a regional processing facility in Goodland, KS. For most Nebraska producers the distance to this delivery point has limited production. Current plans for additional oilseed processing facilities in Nebraska could greatly reduce transportation costs for a large production area in Nebraska. In 2006, 31,000 acres of oil type sunflower were harvested in Nebraska with an average yield of 1,200 pounds.[3] Sunflower has a standard oil content of 40%, but in good production conditions it will typically vary between 43 to 45%. Under excellent production conditions the oil percentage can reach or even exceed 50%.

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[2] USDA – National Agricultural Statistics Services, http://www.nass.usda.gov/QuickStats/ as of November 4, 2007
[3] USDA – National Agricultural Statistics Services, http://www.nass.usda.gov/QuickStats/ as of November 4, 2007

Typical dry land yields will range from 800 to 1,500 pounds per acre, while irrigated yields often exceed 3,000 pounds per acre. The national average yield for oil type sunflowers is 1,267 pounds per acre. At 40% oil content, that is approximately 507 pounds of oil per acre available in the seeds. This is reduced to 431 pounds of extractable oil per acre with mechanical extraction. Using the sunflower production data for 2006, the U.S. produced the equivalent of 57 to 67 gallons per acre depending on the oilseed processing method.

Canola production is not as widely accepted in Nebraska and Kansas as it is in other states of the Great Plains region. This is primarily attributed to the lack of development for varieties with good winter hardiness or spring frost tolerance in this area. Nebraska is located between the typical winter canola production region to the south and the spring canola production region to the north. In 2006, the United States harvested just over 1 million acres of canola. North Dakota had over 90% of the production and Minnesota and Montana were the only others states reporting canola production. The average yield for U.S. canola production from 2002 to 2006 was 1,403 pounds per acre.[4] Like sunflowers, canola has a standard oil content of 40% and it can be higher under good growing conditions. Canola oilseed yield is much like sunflower with typical dry land yields in the 1,000 to 1,500 pound per acre range while irrigated yields are in the 2,500 to 3,500 range. At 40% oil content, the national U.S. canola average of 1,403 pounds per acre is approximately 561 pounds of oil per acre available in the seeds. This is reduced to 477 pounds of extractable oil per acre with mechanical extraction. This is approximately 63 to 74 gallons per acre depending on the oilseed processing method.

Limited water availability and water management are key issues for Nebraska producers and alternative oilseed crops can expand the management options available to producers. Water management tools by Martin et al. [5] and Hergert et al. [6] integrate the water use/yield relationships with regional climatic data, costs of production, and water limitations to develop decision management tools for agricultural producers. The current version of the "Water Optimizer" includes sunflowers, while future versions are planned to include canola and camelina. This tool can be used by producers to evaluate alternative water management strategies and estimate potential returns based on the selected criteria. This tool is a field-level, single-season program which computes how many acres to irrigate, which crops to produce and how much water to apply to each crop in a normal weather year.

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[4] USDA – National Agricultural Statistics Services, http://www.nass.usda.gov/QuickStats/ as of November 4, 2007

[5] Derrel Martin, Ray Supalla and Scott Nedved, Departments of Biological Systems Engineering and Agricultural Economics, Institute of Agriculture and Natural Resources, University of Nebraska – Lincoln Lincoln, NE, March 2005. This program and instruction manual is available for download from the University of Nebraska at: http://real.unl.edu/h20/download.html as of November 6, 2007.

[6] Hergert, G., P. Burgener, D. Martin R. Supalla, D. Lyon, A. Pavlista, D. Yonts, and C. Urrea; Enhancing Irrigation Management Tools and Developing a Decision Support System for Managing Limited Irrigation Supplies for the High Plains, University of Nebraska, Aug. 15, 2007.