CANADIAN FERTILIZER INSTITUTE
INSTITUT CANADIEN DES ENGRAIS

The Importance of Fertilizer to Biofuels in Canada

DISCUSSION PAPER

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1.0 Introduction and Background

Renewable fuels, such as ethanol and biodiesel, will lower emissions, reduce greenhouse gases, provide a hedge against rising fuel prices and create sustainable jobs in rural Canada.[1] In order to meet increasing demand for biofuels, agriculture needs to ensure that crop production dedicated to biofuels is efficient and sufficient. To produce the additional crops required for biofuel production, inputs such as fertilizer may be used to attain higher yields or to provide nutrients for increased acreage. Changes in the crop mix may also affect the use of fertilizers. The Canadian Fertilizer Institute seeks a discussion paper on the role of fertilizer in biofuel markets in Canada, specifically the importance of fertilizer in the production of biofuels.

The global biofuels industry is in a developmental stage and many sources are speculative as to how the technology will develop, the impact it will have on agriculture and, consequently, the supporting input suppliers for the agricultural sector. With this in mind, this paper assesses whether fertilizer will be a critical element in the production of biofuels in Canada by examining recent developments within the biofuels sector in Canada and the United States. A key consideration with regard to fertilizer use in biofuels production is the chosen feedstock. Price and availability of the various feedstocks are likely to impact fertilizer requirements.

1.1 Purpose and Objectives

Through a literature review, this discussion paper explores the current biofuels industry and its possible development. In particular, this paper attempts to identify whether the fertilizer industry is a critical component for the production of biofuels in Canada.

The objectives of this project are to:

- Review the literature that describes the relationship between the production of crops for biofuels and fertilizers (e.g. importance of proper nutrients, desirable crop traits).
- Review the literature that examines changes in crop acreage, with specific attention paid to corn, resulting from increased demand for biofuels and implications for fertilizer and the fertilizer industry.
- Review the literature to determine whether increased crop production for biofuels will be achieved through yield increases (due to extra fertilizer) rather than changes in acreage.
    - This may be particularly relevant for canola in western Canada.

[1] Source: Canadian Renewable Fuels Association website, 2006. http://www.greenfuels.org/

2.0 Literature Review

The literature review attempts to identify whether the fertilizer industry is a critical component for the production of biofuels in Canada. There are a number of factors that must be considered in order to understand the role of fertilizer in the Canadian biofuels industry.

First, it is important to understand trends in the general expansion of the biofuels industry. Government policies, both domestic and international, influence the demand for biofuels. Furthermore, rising crude oil prices and technological change have increased the attractiveness of investment in or the production of renewable fuels. In response to rising demand ethanol and biodiesel plants enter the market, expand production capacity and hence the supply of biofuels. However, this supply also depends on the profitability of plants which relies on the spread between output prices and the combination of feedstock and plant energy costs (Mussell, 2006).

Second, in order to produce biofuels, ethanol and biodiesel plants require feedstocks as inputs. There is a variety of potential feedstocks. Price and availability of the various feedstocks are likely to determine which are selected for biofuel production. In addition, technological development may influence the selection of feedstocks in the future.

Third, in response to market price changes, acreage devoted to specific crops may change or producers may attempt to increase crop production through yield increases. Therefore, changes in fertilizer use may be required to allow changes in the amount of feedstock production.

The literature review concludes with a discussion of whether fertilizer is a critical component of the production of biofuels.

2.1 Expansion of the Biofuels Industry

2.1.1 Government Policies

Government policies, both domestically and internationally, influence the demand for biofuels due to commitments to include renewable fuels as part of fuels for transportation.

In Canada, fuel is a shared regulatory jurisdiction between the federal and provincial governments. Both levels of government have committed to renewable fuels. In December 2006, the Government of Canada announced that it would regulate 5% renewable content in gasoline by 2010 and 2% renewable content in diesel fuel and heating oil by 2012 (AAFC, 2006b; Canadian Renewable Fuels Association, 2006). In addition, several provinces have implemented legislation to ensure renewable fuel content in transportation fuels. In October 2005, Ontario legislated that all gasoline in the province have an annual average of 5% ethanol content beginning January 2007 (Ontario Ministry of Environment, 2006). Manitoba's December 2003 Biofuels Act[2]

[2] The Biofuels Act passed in December 2003. The Biofuels Act will be proclaimed when there is sufficient ethanol production capacity in the province to meet the demand of a 10% blend.

requires a 10% ethanol blend in 85% of gasoline (Manitoba Government, 2006) and Saskatchewan's Ethanol Fuel Act and its regulations require a 7.5% ethanol blend as of January 15, 2007 (Saskatchewan Government, 2007).

In the United States, a Renewable Fuels Standard has been established under the Energy Policy Act, 2005 requiring gasoline sold in the United States to be mixed with increasing amounts of renewable fuel on an annual average basis. In 2006, approximately 15 billion litres[3] of renewable fuels were to have been mixed with gasoline. The Act requires increases in renewable fuels annually to 28.4 billion litres by 2012. Beyond 2013, the renewable fuel requirement will include a minimum of 946 million litres of cellulosic ethanol[4] (US Department of Energy, 2006a).

2.1.2 Demand for Biofuels

Significant expansion in both ethanol and biodiesel production is required to meet the federal government's goal of 5% renewable fuels for transportation. According to the federal government, this commitment requires 3 billion litres of renewable fuels produced from up to 8 million tonnes of grains, oilseeds and biomass annually (AAFC, 2006a).

However, the biofuels industry within Canada remains in the early stages of development and, according to a recent study by Agra CEAS Consulting and F.O. Licht, is lagging behind other nations in this market. The report estimates that in 2004 Canada produced and consumed approximately 250 million litres of ethanol fuel. Limited industrial biodiesel production began in late 2005 (Agra CEAS Consulting and F.O. Licht, 2006). In 2005, Canadian biodiesel production was approximately 9 million litres (USDA, 2006). If the government goals are to be met, the production of renewable fuels in Canada needs to increase to 1.4 billion litres in 2007 and reach 3.1 billion litres by 2010 (Agra CEAS Consulting and F.O. Licht, 2006).

2.1.3 Current and Future Production Capacity

<u>Ethanol</u>

There are nine ethanol plants in Canada with a total production capacity of 749 million litres per year (Ethanol Producer Magazine, 2007). There are three plants under construction which will add 480 million litres to production capacity upon completion (Ethanol Producer Magazine, 2007).

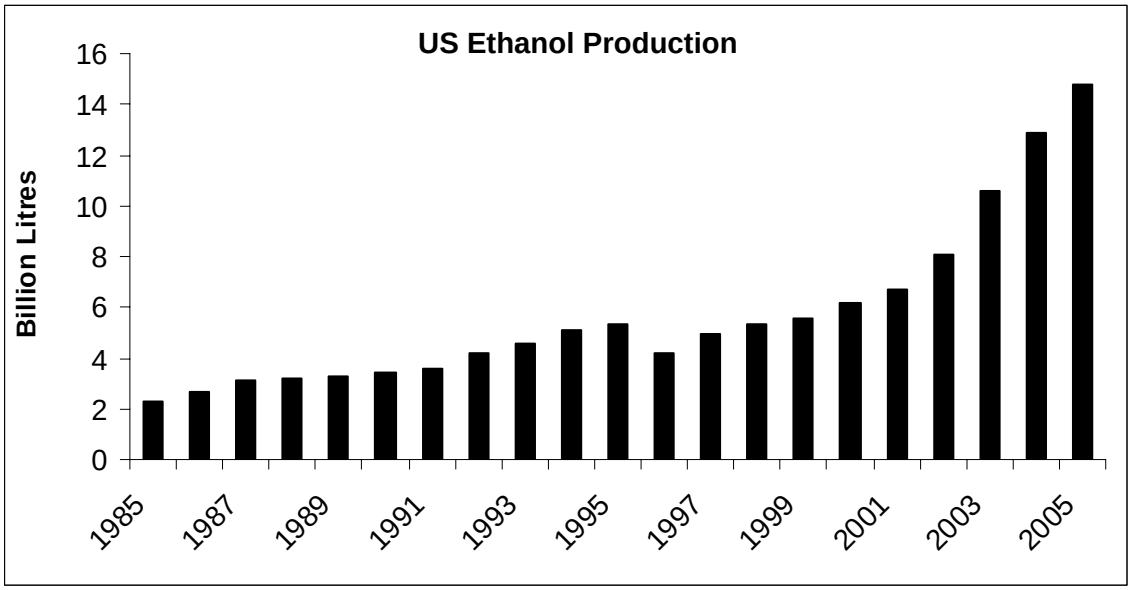
Four of the Canadian plants use corn as a feedstock while the remaining five plants use wheat (Ethanol Producer Magazine, 2007). The current capacity of Canadian ethanol plants using corn feedstock is 530 million litres per year while the current capacity of ethanol plants using wheat feedstock is 219 million litres per year (Ethanol Producer Magazine, 2007).

[3] Amounts in gallons have been converted to litres using conversion factor of 1 US gallon = 3.78533 litres.

[4] The term 'cellulosic biomass ethanol' means ethanol derived from any lignocellulosic or hemicellulosic matter that is available on a renewable or recurring basis, including: dedicated energy crops and trees; wood and wood residues; plants; grasses; agricultural residues; fibers; animal wastes and other waste materials; and municipal solid waste.

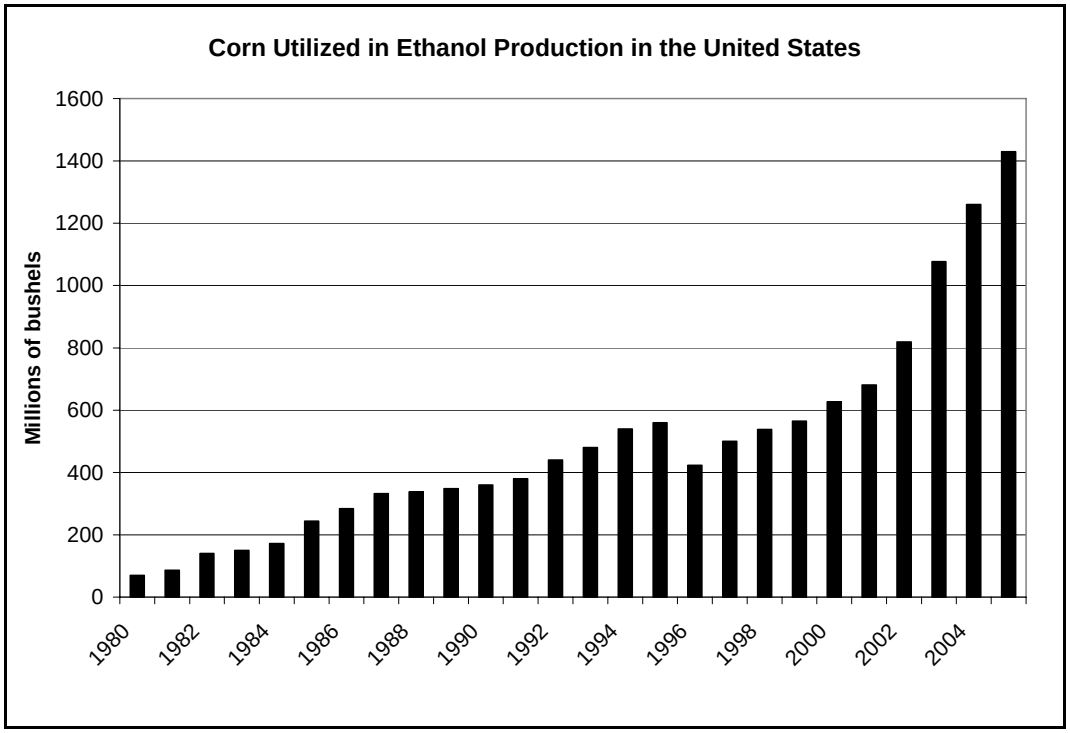
The United States has considerably more production capacity for ethanol than Canada. According to the Renewable Fuels Association, 111 ethanol plants were in operation as of January 2007 with a capacity of more than 20 billion litres (Renewable Fuels Association, 2007). There are an additional 75 plants under construction plus 8 expansions to existing plants which are expected to add an additional 23 billion litres to US production capacity upon completion (Renewable Fuels Association, 2007). These additions will give the United States a total ethanol production capacity of approximately 44 billion litres per year. Only 8 of the US plants (current and proposed) do not use corn as the primary feedstock (Renewable Fuels Association, 2007).

Trends in the production of ethanol in the United States are shown in the following graph. In 2005, the country produced 14.78 billion litres of ethanol, energetically equivalent to 1.72% of US gasoline usage (Renewable Fuels Association, 2006; US Department of Energy, 2006 as cited in Hill et al., 2006).



Source: Renewable Fuels Association as cited in OMAFRA, 2006.

In 2005, 1.43 billion bushels of corn were used for ethanol production, representing nearly 13% of the US corn crop (Renewable Fuels Association, 2006). Ethanol represents the third largest market for US corn, behind livestock feed and exports (Renewable Fuels Association, 2006). The US Department of Agriculture expected that about one-fifth of the entire 2006 US corn crop, or 2.15 billion bushels, will be used in ethanol production (Dow Jones Newswires, 2006; Dow Jones Newswires as cited in Cattle Network.com, 2007). Looking ahead to the 2007 corn crop, it is likely that the ethanol industry will require 1 billion more bushels of corn for fuel production than in 2006 (Dow Jones Newswires as cited in Cattle Network.com, 2007). The increase in the amount of corn used in ethanol production in the United States over the past two decades is shown in the following graph.



Source: National Corn Growers Association as cited in Renewable Fuels Association, 2006.

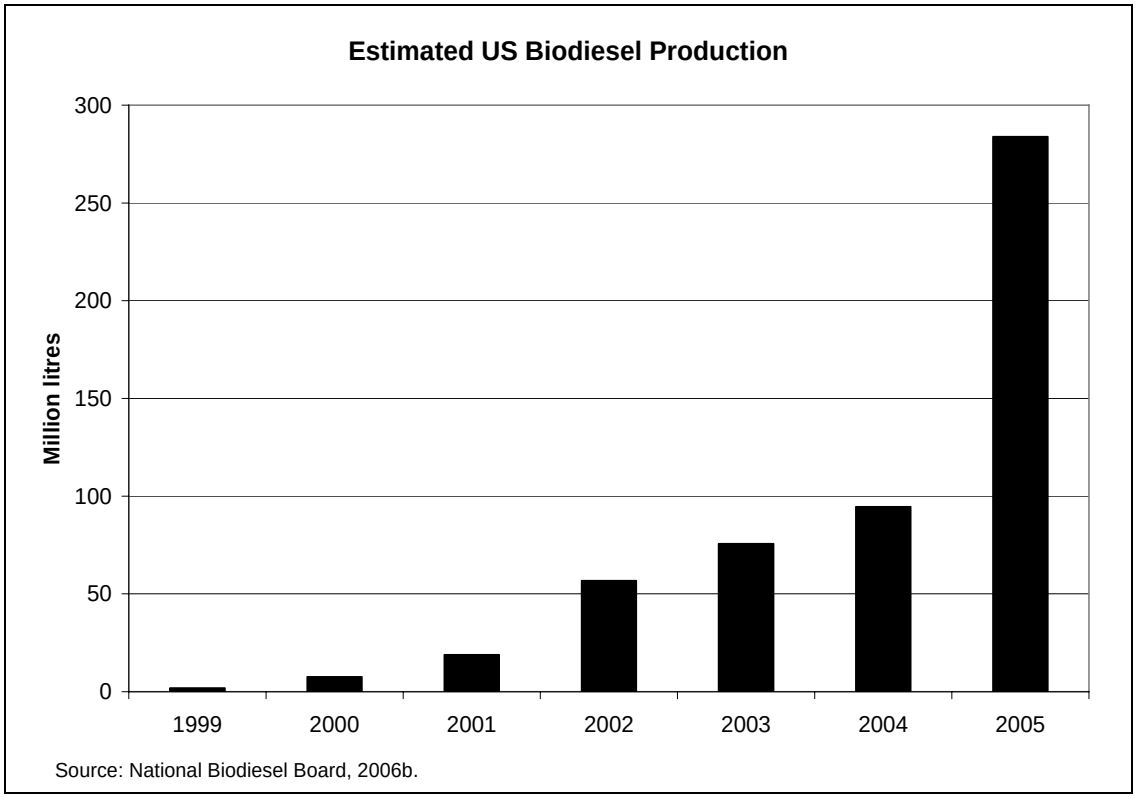
The continued development of the industry relies on the profitability of the plants, which is dependent on the cost of inputs, primarily feedstocks and energy for production. In the case of ethanol, the primary plant energy source is natural gas (Eidman, 2006). The price of fuel-grade ethanol will tend to be highly correlated with gasoline and thus crude oil prices. Natural gas prices will tend to be correlated with the same factors. Feedstock prices such as corn can fluctuate independent of these factors. However, a combination of high corn prices and weakening ethanol prices may pressure plant margins, and thus ethanol production and the demand for feedstocks (Mussell, 2006).

Biodiesel

Canada is in the early stages of biodiesel production. One biodiesel plant in Montreal, Quebec operated by Rothsay, began commercial production in November 2005 and uses yellow grease and animal fat as feedstocks. Biodiesel is now being produced on an industrial scale at Rothsay at an estimated 35 million litres per year (Biodiesel Magazine, 2007). BIOX built a plant in Hamilton, Ontario which has an annual capacity of 60 million litres.[5] Currently, BIOX is using tallow as its feedstock. Milligan Bio-Tech Inc. in Saskatchewan is in the construction phase.[6] Canadian Bioenergy Corporation is in the pre-engineering and final feasibility phase for a biodiesel plant with a proposed annual capacity of 114 million litres in Alberta (Canadian Bioenergy Corporation, 2007).

[5] Source: Personal communication on January 26, 2007 with Scott Lewis, BIOX Corp., 905-337-4970.
[6] Source: Personal communication on January 26, 2007 with Milligan Bio-Tech Inc., 306-272-6284.

As of January 2007, there were approximately 91 biodiesel plants in the US with a total capacity of 2.7 billion litres (Biodiesel Magazine, 2007). The estimated production of biodiesel was 284 million litres in 2005 (as shown in the following graph).



Source: National Biodiesel Board, 2006b.

Of the biodiesel plants in the United States, the majority are using soybean oil or multiple feedstocks in order to produce biodiesel (National BioDiesel Board, 2006a). Soybean oil extracted from 1.5% of the US soybean harvest produced 256 million litres of biodiesel, which was 0.09% of US diesel usage (Interagency Agricultural Projections, 2006 as cited in Hill et al., 2006; National Biodiesel Board, 2005 as cited in Hill et al., 2006; US Department of Energy, 2006 as cited in Hill et al., 2006).

2.1.4 Implications of Expansion for the Fertilizer Industry

Governments in Canada and the United States are focused on increasing the use of renewable fuels in transportation. Furthermore, rising crude oil prices and technological change have increased the attractiveness of investment in or production of renewable fuels. As such, biofuel markets have expanded significantly in the past several years and will continue to expand. It is important to note that the expansion of the biofuels industry may be tempered by the cost of production for plants. However, government policies and markets are encouraging continued development and production.

With the expansion of biofuel markets comes a need for feedstocks. The role of fertilizer in facilitating the expansion of biofuel markets depends on the feedstocks used as inputs in the production process, as discussed in the following section.

Currently, Canadian plants are using corn and wheat as the primary feedstocks for ethanol and tallow as the primary feedstock for biodiesel. In the United States, the majority of ethanol plants are using corn as the primary feedstock. Biodiesel plants in the United States are currently using soybean oil and multiple feedstocks as inputs.

2.2 Feedstocks

In order to produce biofuels, ethanol and biodiesel plants require feedstocks as an input. Price and availability of the various feedstocks are likely to determine which are selected for biofuel production.[7] In addition, technological development, particularly in cellulosic ethanol, may influence the selection of feedstocks in the future.

2.2.1 Feedstock Options

Ethanol

To produce ethanol, there are two primary feedstock options: corn and wheat. In Canada, the production of ethanol is split according to the growing conditions across the country. In the Prairies ethanol is produced using wheat and in Ontario and Quebec ethanol is produced using corn. Corn is the primary feedstock in Canada in terms of volume. It is important to note that using wheat to produce ethanol is less efficient than corn due to reduced amounts of starch in wheat and lower yields per acre for wheat.

In the United States, the majority of ethanol is produced from corn, as discussed above.

Biodiesel

In terms of potential feedstocks, biodiesel can be produced from almost any form of vegetable oil and animal fat. In general, there are four types of available feedstocks: virgin oil, animal fat, recycled oil, and trap and brown grease. Virgin oils are generally obtained from crushing soybeans, canola, sunflower seeds and other oil crops, while animal fats are produced by animal slaughtering and processing plants. Recycled oil, also called yellow grease, refers to used-oils recycled from restaurants, manufacturers and industrial operations. Trap and brown grease is usually collected from oil and grease traps inside sewage systems.

Price and availability are the two primary factors that determine the feedstock for biodiesel (Stiefelmeyer et al., 2006). Currently yellow and brown greases are the cheapest feedstocks available for biodiesel production with price being roughly half of that for virgin oil. Vegetable oils, on the other hand, are expensive but relatively abundant. The potential for vegetable oils will come as biodiesel plants come on line and the demand for feedstock increases faster than the growth in animal slaughter and waste grease production.

Further to the issue of price, the price for canola oil is currently higher than other widely used vegetable oils such as soybean oil. Even though canola seeds have higher oil content and cheaper market price than soybeans, their co-product value is not

[7] Other factors that influence the selection of feedstocks include quality standards and viscosity requirements.

competitive with the high protein soybean meals. The higher value co-product of soybean oil allows it to be sold at about US 50 cents per gallon lower than canola oil, making canola-derived biodiesel relatively more expensive (Stiefelmeyer et al., 2006). However, 5% of the canola seeds are frost or heat damaged, making them unsuitable for food use but perfect as a feedstock for biodiesel (Holbein et al., 2005).

Future Technology

Cellulose

Currently the production of ethanol from the starch and soluble sugars in grains (corn and wheat) is the cheapest method to produce ethanol. However new technology is developing which will allow production of ethanol from lignocellulosic biomass (leafy or woody plant material). This process produces fermentable sugars from the cellulose which is used to produce ethanol (Eidman, 2006).

Presently, the cost of producing ethanol using cellulose is higher than production from grain. However, cellulosic ethanol has the potential to become cost competitive with corn based ethanol through improvements in pretreatments, enzymes and conversion factors (Aden et al., 2002 as cited in Hill et al., 2006; Tiffany & Eidman, 2005 as cited in Hill et al., 2006).

As technology improves, the ethanol industry is likely to move toward production from lignocellulosic biomass for several reasons. First, the feedstock for cellulosic ethanol production is considerably cheaper as it consists of agricultural waste (e.g. wheat straw, corn stover), forestry waste and specified energy crops which may include fast growing trees, shrubs and switchgrass (DiPardo, 2002). In addition, switchgrass, diverse mixtures of prairie grasses and forbs, and woody plants can be produced on agriculturally marginal lands, avoiding the conversion of productive cropland to energy production (Hill et al., 2006; Murray, 2005).

Second, the current feedstocks are competing with human and livestock food supply. Hill et al. (2006) report that even if all of 2005 US corn production went into ethanol production, it would only meet 12% of gasoline demand in the country.[8] As global food and transportation fuel demands increase over the coming decades, there is evidently a need for a source of biofuels that does not inhibit food production.

Finally, the US Department of Energy is promoting the development of ethanol from cellulose technology by mandating the use of cellulosic ethanol as part of the Renewable Fuels Standard.

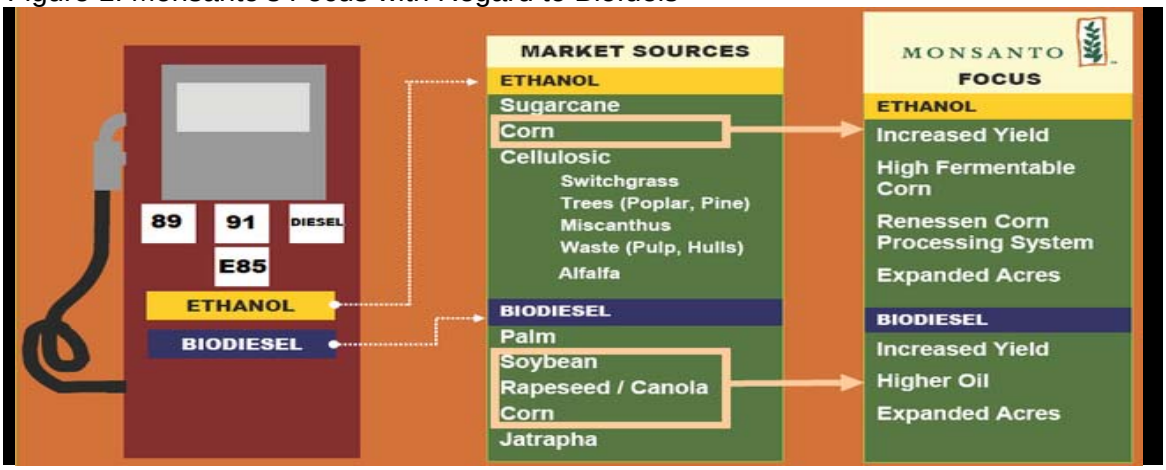
The industry is just beginning to build commercial scale lignocellulosic conversion plants in North America (Eidman, 2006). A Canadian firm began producing ethanol from wheat straw in a demonstration plant with a capacity of 3.8 million litres per year in April 2004 (Iogen Corporation, 2004 as cited in Eidman, 2006). Iogen is currently assessing potential locations for the world's first commercial prototype cellulose ethanol plant (Iogen Corporation, 2005).

[8] Similarly, if all of 2005 soybean production went into biodiesel, it would offset 6.0% of US diesel demand. Source: Hill et al., 2006.

Genetic Enhancement of Feedstocks

Many biotechnology companies and public research funds are directing their resources towards enhancing desirable traits for the production of biofuels. Syngenta is hoping to sell genetically engineered corn that contains an enzyme which is currently added during the ethanol production process (Pollack, 2006). Monsanto stated that the company is working to improve traits in corn, soybeans, and canola for both ethanol and biodiesel production as is shown in Figure 1 (Green Car Congress, 2006).

Figure 1: Monsanto's Focus with Regard to Biofuels



Source: Green Car Congress, 2006.

However, as mentioned previously, the frontier of ethanol production is using lignocellulosic biomass. The US government recently awarded US$5.7 million for research in improving the process and plant characteristics for cellulose ethanol extraction (US Department of Energy, 2006b).

2.2.2 Implications of Feedstocks for the Fertilizer Industry

At present, ethanol is largely being produced from corn. The high nitrogen requirements of corn[9] imply that increasing amounts of fertilizer will be required in order to increase corn production in response to increased demand for ethanol.

A much larger quantity of ethanol could be produced by applying new technologies that are being developed to produce ethanol from lignocellulosic biomass (leafy or woody parts of plants) (Eidman, 2006; Hill et al., 2006).

Researchers are investigating the input requirements of cellulosic biomass. As technology improves, more information on the input requirements of cellulosic feedstocks will be generated. Some researchers believe that cellulosic biomass will require fewer inputs, such as fertilizer, while other researchers suggest that inputs are an essential part of the maximization of biomass production.

[9] Average application of nitrogen to corn/maize in Canada was 156 kg/hectare in 2000. Source: FAO, 2002.

Mendal Biotechnology is investigating the use of Miscanthus (a perennial grass native to China) which according to the company's Chief Executive Officer requires no replanting, no fertilization and no irrigation (Pollack, 2006). According to Hill et al. (2006), switchgrass, diverse mixtures of prairie grasses and forbs, and woody plants, which can all be converted into cellulosic ethanol, can be produced on agriculturally marginal lands with no or low fertilizer, pesticides, and energy inputs (Tilman et al., 2001 as cited in Hill et al., 2006; Tilman et al., 2006 as cited in Hill et al., 2006).

Muir et al. (2001) investigated the production of switchgrass in response to nitrogen and phosphorus. The authors indicated that the management practices that maximize biomass production for biofuel feedstock may differ from that for herbage production for forage and grazing. The authors found that sustainable production of switchgrass biomass in the United States (south central states) was not feasible without nitrogen fertilization. The authors stated that as a single spring application, approximately 168 kg per hectare of nitrogen maximized switchgrass biomass production in most years in the region. Biomass production was not influenced by the addition of phosphorus.

In addition to biomass feedstocks such as switchgrass, cellulosic ethanol may be produced from agricultural waste (e.g. wheat straw, corn stover). In this case, the organic matter from the field might be partially or completely removed, raising concerns about nutrient replacement. The US Department of Energy released a factsheet on the use of corn stover as a feedstock for biofuels (US Department of Energy, 2001). According to the factsheet, key considerations for how much stover should be left in the field rather than harvested include erosion control, moisture retention, winter forage practices, and soil carbon and fertilizer impacts (US Department of Energy, 2001). Soil scientists suggested that, on average, leaving half of the stover in the field would be sufficient to maintain a high level of protection from soil erosion (US Department of Energy, 2001). Murray (2005) suggests that leaving two-thirds of stalk/straw in the field would allow for enough organic matter to maintain soil health and prevent erosion.

Overall, while the fertilizer requirements of cellulose feedstocks may be less than those of food based feedstocks, fertilizer will be required to sustain biomass production.

In terms of biodiesel, cheaper feedstocks such as tallow will likely be used until supply is exhausted, at which point vegetable oils will be used as inputs for biodiesel production. Fertilizer is irrelevant to animal fat, recycled oil, and trap and brown grease production. However, fertilizer may be used to expand the production of soybeans to meet increasing biodiesel demand and canola to fill the void in the food markets that will be left when other oils are used in biodiesel production (Informa Economics Inc., 2006).

2.3 Changes in Crop Production

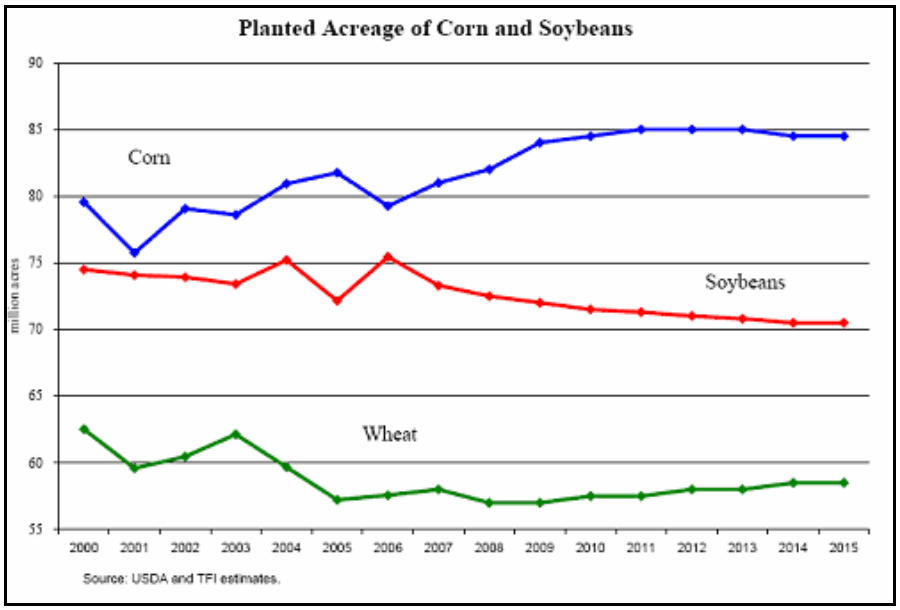
Ethanol

Given current technologies, corn is the primary feedstock in Canada (in terms of volume) and the United States for ethanol production. It is likely that as the demand for corn increases because of increased demand for ethanol, the price of corn will be driven up. These market forces have begun to appear with high corn prices during the end of 2006 and beginning of 2007. This will likely induce acreage out of other crops; the extent of the acreage shift will be determined by the extent of strengthening in the corn basis.

Thus, it is likely that there will be a new equilibrium at a higher price for corn (Brethour et al., 2005). The following paragraphs review research related to potential changes in corn acreage and prices in the United States.

Roe (2006) calculated that the United States requires an increase of 3.38 million acres (4.5%) of corn and predicts that an increase of corn acreage may come from substituting away from soybeans.

According to The Fertilizer Institute and United States Department of Agriculture's (USDA) Agricultural Baseline Projections to 2015, corn acreage rises significantly in the initial years of the projections reaching 85 million acres by 2011 (refer to graph below), as large domestic ethanol production from corn increases demand, raising corn prices and net returns. In the long run, increasing exports also underlie higher corn acreage. The USDA predicts that high energy-related production costs for corn, like fertilizer, are forecast to keep soybean plantings near 73.5 million acres in 2007. However, the long run forecast is for soybean area to decline to the 70-71 million acre ranges in the latter part of the forecast period as more favorable returns to corn production draw land from soybeans.



Source: The Fertilizer Institute, 2006.

The use of wheat to produce ethanol is expanding in western Canada. For example, in September 2006, Husky Energy official opened one of the largest wheat feedstock ethanol plants in Canada with a capacity of 130 million litres per year in Lloydminster, Saskatchewan. The company is also expanding at a previously existing site, Minnedosa, Manitoba. The Minnedosa plant will also have production capacity of 130 million litres per year. Each of these facilities will require 350,000 tonnes of grain (Husky Energy, 2006).

Increased wheat production to meet the requirements of ethanol plants using wheat as a primary input may come from increased yields or acreage in the Prairies or decreased exports. An opportunity to increase wheat yields exists through high yielding varieties

and/or increased fertilization. Currently, the Canadian Wheat Board restricts the use of new varieties of wheat in western Canada. The Canadian Grain Commission has conducted consultations and continues to work with farmers about implementing a new wheat class. Effective August 2008, a new wheat class, known as Canada Western General Purpose (CWGP) will be created and will "provide producers, marketers and customers with access to a wider range of wheat varieties than the current system permits" (Canadian Grains Commission, 2006). New varieties will allow farmers to produce wheat for industrial markets, which could have the potential to increase the use of fertilizer depending on variety requirements.

Biodiesel

Global demand for biodiesel has had a significant impact on Canadian canola markets in the past year. There has been a tremendous demand for Canadian canola. Non-traditional buyers like Bangladesh, Pakistan, Turkey, and the United Arab Emirates purchased a significant volume of Canadian canola (Informa Economics Inc., 2006). The buyers in Turkey and the United Arab Emirates (among others) are processing canola in order to 'cash in' on the vegetable oil demand in Europe, largely created by biodiesel (Informa Economics Inc., 2006).

Globally, there will be a great deal of canola/rapeseed crush capacity available in 2007 and 2008, requiring more seed (Informa Economics Inc., 2006). Looking at announced plant construction and expansion, North American crush demand should increase by at least one million tonnes during the 2007/2008 crop year (Informa Economics Inc., 2006). Even if some of the biodiesel plants (domestic and global) use other fats and oils as their main feedstock, demand for canola oil should continue to rise over time. This is due to the fact that canola oil is expected to fill the void in the food markets that would be left when other oils are used in biodiesel production (Informa Economics Inc., 2006). As such, an increase in fertilizer may be required to increase the production of canola in western Canada.

3.0 Summary and Conclusions

Through a literature review, this discussion paper explores the current biofuels industry and its possible development. In particular, this paper attempts to identify whether the fertilizer industry is a critical component for the production of biofuels in Canada.

In order to accomplish this goal, the literature review examines the expansion of the biofuels industry, the use of fertilizer in the production of feedstocks for biofuels, and the changes in acreage and yield of feedstocks resulting from market price changes due to increased demand for biofuels.

Ethanol

Over the next few years, fertilizer will be required in order to meet increasing demand for biofuels in Canada and the United States. This is due to the fact that in the short term, corn will remain the primary feedstock for ethanol. Increasing demand for ethanol, particularly in the US, will drive up the price of corn, inducing shifts in acreage towards corn and out of other crops. The larger quantity of corn acreage will require additional fertilizer, particularly nitrogen.

In western Canada, ethanol plants are expanding production using wheat as a feedstock. To meet plant requirements, increasing amounts of fertilizer may be used to enhance wheat yields while new high yielding varieties of wheat are gradually introduced. It is worth noting that wheat is less efficient than corn in producing ethanol.

However, as technology develops, lignocellulosic biomass (leafy or woody plant material) will likely represent a cheaper alternative to corn as a feedstock. While the fertilizer requirements of cellulose feedstocks may be less than those of food based feedstocks, fertilizer will still be required to sustain biomass production.

Biodiesel

Cheaper feedstocks such as tallow will likely be used until supply is exhausted at which point vegetable oils will be used as inputs for biodiesel production.

Global demand for Canadian canola has increased and will likely continue to rise. Due to its relatively high price, canola oil will likely fill the void in the food markets that will be left when other oils are used in biodiesel production (Informa Economics Inc., 2006).

Fertilizer is irrelevant to animal fat, recycled oil, and trap and brown grease production. However, fertilizer may be used to expand the production of soybeans to meet increasing biodiesel demand and canola to fill the void in the food markets.

Implications for Fertilizer

Overall, fertilizer will be a primary input into the production of corn for ethanol in the short term. However as technology improves, lignocellulosic biomass will likely replace corn as the primary feedstock in ethanol production. As a result, fertilizer will remain

necessary for sustainable biomass production but the quantities of fertilizer required may diminish due to differences in crop requirements.

For biodiesel, fertilizer may be used to enhance the production of soybeans and canola for use in biofuel and food markets.

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