Homegrown Feed, Food & Fuel

The Market Potential of Farm-Scale Oilseed Crop Products in Vermont

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Prepared for

Vermont Sustainable Jobs Fund
Vermont Biofuels Association

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PREFACE

This report is a work in progress. Growing sufficient quantities of oilseed crops for biodiesel production and/or livestock meal in Vermont is very new, although some farmers have grown soybeans for the feed value for quite some time. But as the price of diesel, No. 2 heating oil and livestock feed continues to rise due to global forces outside of our control, more and more farmers, communities, policy makers and entrepreneurs are beginning to explore opportunities for the local production of oilseed products for local use.

Up until now, much focus has centered around how best to grow, harvest, dry and store oilseed crops. Less has been known about the market demand for organic and non-organic livestock meal, food-grade oil and/or locally produced biodiesel. **This report provides important market data and analysis that will be of use to farmers, policy makers and entrepreneurs who are interested in further exploring the opportunities for various oilseed products.**

As part of this research project, we have created an *Enterprise Budget* to assist farmers in making important economic decisions about whether or not to go into the oilseed crop business, based upon current market prices and known variables. An example of the budget is included in the Appendix and an Excel file of the Enterprise Budget document is available for download on various websites (e.g. www.uvm.edu/~uvmext, www.vsjf.org, www.vermontbiofuels.org).

Additional research is already underway to improve harvesting, drying and storing techniques, to explore the economic feasibility of a mobile seed crushing and biodiesel production unit, and to continually improve on-farm biodiesel production processes to meet ASTM standards. Our intention is to continue adding to this document as more information becomes available, through additional field and demonstration trials and as the State Line Farm, Borderview Farm, and other facilities come online.

We encourage feedback and comments on this report so that we can continue to improve its usefulness and continue to add to the body of knowledge that is developing in Vermont about oilseed crop products.

Thank you for your on-going interest and support for exploring the potential of home-grown feed, food and fuel in Vermont.

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I. EXECUTIVE SUMMARY

The Vermont Sustainable Jobs Fund and Vermont Biofuels Association commissioned this oilseed crop market potential and economic feasibility study in order to explore whether Vermont farmers could sustainably, economically, and competitively produce some portion of Vermont's liquid fuel and livestock feed demand. We were also interested in the requirements for and characteristics of small-scale, Vermont-made biofuels for local use, as an alternative to industrial-scale biofuel production.

Project partners hired Emily J. Stebbins, a graduate student, and Dr. Robert Parsons, an Agronomist and professor, from the University of Vermont's Department of Community & Applied Economics, to analyze the market demand and co-production potential for livestock feed, food-grade oil, and biodiesel fuel derived from oilseed crops grown in Vermont. This report also borrows heavily from the data and analysis collected by Dr. Vern Grubinger and Dr. Heather Darby at UVM Extension over the past two growing seasons.[1]

Although farmers and biodiesel enthusiasts have been excited about the potential for these products, the full extent of the equipment, capital, and acreage needed to successfully grow, harvest and process these crops has been unknown. Determining the economic feasibility for farmers of such activities is vitally important at this early stage. Discussions with over a dozen farmers who are at various stages of growing and processing oilseed crops have indicated that market and economic viability data and decision-making tools would be of great value.

► *Finding 1: Vermont is a net importer of oilseed products and co-products*

Vermont meets most of its demand for oilseed co-products and substitutes through importation. In addition to food-grade vegetable oil, Vermont farms and businesses import over 100,000 tons of livestock meal[2], 78.6 million gallons of diesel fuel, and 147 million gallons of No. 2 heating oil per year.[3] Demand for fuel is expected to remain strong, and to continue to increase in the short term. Furthermore, volatility and increases in the price of crude oil are expected to continue to raise the prices that farmers and consumers pay for liquid fuels, fertilizers, and livestock feed.

The 2002 USDA census indicates that only about 51,000 bushels of soybeans were harvested from 1,562 acres in Vermont, and most were roasted whole and fed to dairy cows. The production of oilseeds in Vermont for fuel or food-grade oil is now taking place at a small-scale and on an experimental basis on several farms.

1 Grubinger, Vern. May 17, 2007. "On-Farm Oil Seed Production and Processing." UVM Extension, Final Report to the Vermont Sustainable Jobs Fund. Funded, in part, by the U.S. Department of Energy.
2 Report researcher's estimate: Table 4, Page 25.
3 U.S. Department of Energy, Energy Information Administration, Sales of Distillate Fuel Oil by End Use, Vermont.

Demand for oilseed meal in Vermont is driven by the dairy industry, with dairy cows estimated to account for approximately 97% of the market potential. Demand is particularly strong for organic livestock meals and vegetable oils, which are in short supply and command substantial price premiums. In general, the more "value added" to the end product, the higher the return per bushel or acre. The absence of genetically modified organisms (GMOs) is also an important criterion for organic feed mills and farmers, and could present additional opportunities for Vermont farmers interested in growing crops to meet this demand. Area purchasers of food and feed products expressed a willingness to buy and sometimes pay more for local co-products, provided they met quality and consistency standards and could be supplied reliably. For livestock meal, the key determinants of value are quality and consistency.

► *Finding 2: Farm-scale production of oilseed products is technically feasible; good yields are achievable*

Production of oilseed crops and co-products is technically feasible in Vermont. Oilseed crops can grow well, and good yields are achievable given improved harvesting equipment and techniques. Crop trials from Vermont, Maine, and New Hampshire indicate that yields for oilseed crops at, or exceeding, the national average are achievable in Vermont's climate and better agricultural soils. The primary factors necessary for consistent yields are appropriate harvesting equipment, additional experience to perfect oilseed harvesting techniques, and adequate drying and storage facilities. Custom combining could represent a new business opportunity if more farms add oilseeds to their crop rotations.

Farm-scale processing techniques can produce high-value, good-quality oilseed co-products, but further refinement and testing are needed. Thus far, the quality of the oil and oilseed meal produced at the farm scale appears promising. As much as 3 lbs per day of this meal, depending on the type of oilseed, could be included in a ration for a high-producing dairy cow. To be able to sell this meal to other farmers or a feed dealer at a competitive price however, the meal producer must be able to ensure that the meal is of a consistent quality. Further refinement and standardization of batch-processing techniques are needed, and additional, regular testing of the nutritional profile of farm-pressed meal is recommended.

In addition to proper harvesting equipment and technique, new infrastructure is needed to complete the value adding chain. Farm-scale pressing operations, including seed cleaner, storage bins, one or two expellers, and oil settling tanks, come in all sizes and price ranges. One Vermont farm spent an estimated $30,000 (Table 14) for this set up (using a single press) with an additional $35,000 (Table 21) to establish an on-farm biodiesel production facility with a 60,000 gallon annual capacity. From a technical perspective, these operations are relatively easy to establish, but do require careful space and site planning to ensure adequate safety measures and maximum efficiency (see note on page 77).[4]

4 These figures are highly variable, depending on whether paid labor is involved, whether new, used, or fabricated equipment is used, and how much equipment is already owned by a farmer.

► *Finding 3: 50,000 to 90,000 acres in Vermont could be shifted to oilseed crops per year*

Given Vermont's current dairy-centered agricultural system, FFP researchers estimate that approximately 50,000 acres could be rotated to oilseed crops in any given year. However, consistent with trends over the past 40 years, Vermont's dairy herd is anticipated to decline another 18% by 2017, and by that time an estimated 180,000 acres per year (90,000 on a rotational basis) could be shifted to oilseed crops. 90,000 acres is capable of producing enough oil for over 6 million gallons of biodiesel and 78,000 tons of oilseed meal, more than sufficient to meet the total on-farm demand for distillate fuels, and as much as 50 percent of the anticipated meal demand in 2017. Of course, much will depend on the future profitability of these operations and on the cost of imported feed and fuel at that time. These are some of the key factors that will likely determine just how much of Vermont's cropland will be placed into oilseed production.

Recommendations

Further action and research related to the development and study of farm-scale oilseed crop and co-product production in Vermont is recommended.

1. **Continue to build a network of farmers, processors, and other business owners involved in oilseed crop production, processing, distribution, and sales.** Developing and sharing local experience and expertise in oilseed production, processing, and marketing will be key factors in the success of new growers and processors.

2. **Establish systematic processes for testing, refining, and recording results of on-farm meal production to establish consistent quality standards.** The key determinants of a livestock meal's value to feed dealers and farmers are nutritional quality and consistency. Unless quality control can be established, the price of farm-processed meal will be discounted significantly. Farm-scale processors seeking to sell their meal must establish a standard process that consistently creates a product of a certain quality. Regular testing of meal batch samples is recommended until a process is established, as well as an in situ amino acid test to establish the protein characteristics of the meal.

3. **Investigate small cooperative enterprise models for oilseed processing and biodiesel production.** Several farmers have expressed interest in sharing investment in larger-scale oilseed-processing or biodiesel-making facilities. Dividing capital and operating costs among five to ten neighboring farms could lower barriers to entry of these markets, but the economic feasibility of such a model has not been studied in-depth.

4. Investigate the economic feasibility of a mobile oilseed press and/or biodiesel production unit that could travel site to site.[5]

5. Further investigate the range of equipment, capital and operating costs to set up and run an on-farm oilseed crop production facility. Because Vermont currently has one on-farm demonstration facility which is nearing completion and one other in the works, we cannot yet say with confidence how much equipment and capital are needed to run such a facility – either for on-farm only use and/or for revenue generation through sales off the farm. Additional data will be available in 2008 and 2009 once these two facilities are fully operational.

6. Conduct further research on the net energy savings to farmers from biodiesel production. Crop production, seed processing, and biodiesel production all require energy. Further study is required to understand the extent to which on-farm oilseed and biodiesel production processes can use renewable, farm-produced energy, to yield an even greater net energy savings to the farm.

7. **Conduct further research on additional potential markets for oilseed co-products.** The following potential markets for oilseed co-products were beyond the scope of this study, but should be investigated further:

- Food-grade oil sales, including analysis of Vermont's vegetable oil consumption, future price projections, and estimation of the extent to which Vermont farmers or entrepreneurs could penetrate local markets.
- Lease of filtered, unrefined vegetable oil to restaurants, with subsequent collection by fuel processors for biodiesel production. The opportunity to use the oil for both food and fuel production is being explored in Canadian and New England markets, but has not been studied extensively in Vermont.
- Use of oilseed meal as a crop fertilizer, and comparison of the value of this end-use to the value of the meal for livestock feed.
- Use of oilseed meal as a fuel (in pellet stoves, for example) may be a viable alternative use for meal that is not of sufficient quality to use as livestock feed.
- Potential uses and markets for the glycerin byproduct of biodiesel production.
- Potential market and revenue from selling organic, non-GMO oilseeds.

5 VSJF, the Vermont Biofuels Association and the Sustainable Agriculture Council plan to explore the economic feasibility of such a mobile processing unit in 2008.

II. ABOUT THE FEED & FUEL PROJECT

The Vermont Sustainable Jobs Fund (VSJF) and the Vermont Biofuels Association (VBA) created the *Feed & Fuel Project* in 2006 to focus a portion of its biofuels market development work on exploring the feasibility of a farm-based liquid biofuels, livestock feed, and food-grade oil co-production systems in strategic locations around the state.

Locally owned, community- and/or farm-based biofuels and feed/food projects could generate revenue and alternative sources of livestock feed and liquid fuel for farmers, while helping to create job opportunities, localize energy production, and protect and improve Vermont's natural and social environments.

The *Feed & Fuel Project*, in collaboration with University of Vermont (UVM) Extension and Center for Sustainable Agriculture's on-going research and technical assistance to oil-seed crop farmers, could lead to improvements in Vermont's feed and fuel security over the next 10 years.

> The year 2006 brought major breakthroughs in public awareness of the problems posed by climate change and global oil depletion. Liquid biofuels—ethanol and biodiesel—are seen widely as part of the solution for reducing greenhouse gas emissions and buffering future oil shortages. The image of biofuels has been tarnished significantly, however, as industrial ethanol production in the Midwest has impacted commodity feed prices while sugar plantations for ethanol in Brazil and palm plantations for biodiesel in Southeast Asia slice through tropical rainforests. Reckless biofuel production could replace depleted petroleum reserves with depleted topsoil and exhausted forestlands, but sustainable production methods hold the promise of yielding lower emissions, renewable fuel and quality, local food.

The Feed & Fuel Project in Context: The History of the Vermont Biofuels Initiative

In 2003, VSJF began to focus on developing a viable biofuels industry in the state. The type of biofuel that showed greatest promise for immediate introduction into the marketplace was **biodiesel**. With the formation of the VBA that same year, a growing interest among fuel dealers to begin supplying biodiesel, and growing concern about the impacts of climate change and peak-oil on the environment and our fuel security, the time seemed ripe to encourage the deployment of this product.

Building Consumer Demand

To begin building consumer use of biodiesel in the state, the Vermont Biodiesel Project (VBP) was created through a partnership between the VSJF, the VBA, the Vermont Fuel Dealers Association, and the Vermont Department of Public Service. Between 2003 and 2006, the VBP focused on building the demand for and supply of commodity-scale biodiesel and building a network of biodiesel producers, suppliers, and users. Over 30 fuel dealers now carry biodiesel in the State and in 2006 nearly 1.5 million gallons of biodiesel were consumed in Vermont (two-thirds by transportation fleets and one-third for home heating). After evaluating the impact of these activities over a three year-period, the Vermont Biodiesel Project partners believe that the market for commodity biodiesel has been firmly established.

Building Local Supply

Beginning in 2003, Stateline Farm in Shaftsbury began experimenting with growing canola and other oilseed crops for producing biodiesel and in 2005 UVM Extension Agronomist Dr. Heather Darby began the first canola field trials at the Borderview Farm in Alburgh. That same year several other farms planted oilseed crops and/or began producing biodiesel for on-farm use. A $98,000 grant to the UVM Center for Sustainable Agriculture from the VSJF in the summer of 2006 helped pay for more field trials and the initial set up of a farm-scale biodiesel production facility at Stateline Farm.[6]

With interest in oilseed crops mounting in the farm community, it became clear that a comprehensive market assessment was needed for these products, as well as an evaluation of opportunities associated with the local production of oilseed crop products for local use. In the Fall of 2006, after receiving funding from the High Meadows Fund at the Vermont Community Foundation, the VSJF and VBA created the Feed & Fuel Project to focus specifically on exploring this potential.

A. Project Objectives

In order to further develop in-state production capacity of oil-seed crops and their co-products, the VSJF and the VBA created the *Feed and Fuel Project* (FFP). The goals of the FFP are as follows:

1. Increase the amount of liquid fuel (biodiesel) and livestock feed (from oilseed crops) that is produced and consumed locally, thereby increasing the multiplier effect captured by circulating dollars in the local economy.

2. Create new revenue streams and decrease expenses for family farms, thereby encouring additional farmland cultivation.

3. Capture the environmental benefits of biodiesel use (i.e. greenhouse gas–emission reductions) and reduced transport costs of imported animal feed and biodiesel.

4. Enhance Vermont's liquid fuel security by locally producing a portion of the State's biodiesel demand.

5. Create new or retain existing jobs in the emerging renewable energy sector, based on farms and/or in rural communities via small commercial enterprises. Although the number of jobs created may be small in the short-term (<5 years), there is a significant opportunity over the longer term. Economic modeling completed in conjunction with this project by Dr. Kenneth Mulder (Green Mountain College), Emily Stebbins (UVM), and Galen Wilkerson (UVM), estimates that biodiesel production alone can produce 25 to 100 new jobs, while high levels of oilseed production in the state have the potential of tripling the employment impact (based on 500,000 gallons/year and 2.5 million gallons/year production facilities).

6 VSJF Funding came from a DOE earmark secured by U.S. Senator Patrick Leahy

6. Support the local production of sustainable biofuels, thereby decreasing the environmental impacts of commodity-based biofuels production.

Because there are various co-products from oilseed crop production (i.e. food-grade oil, oil for biodiesel production, livestock feed, and glycerin), the FFP set out to explore the market and economic opportunities, infrastructure, capital and equipment needs, and production issues associated with three scales of operation:

► **Individual Farmers** – Where individual farmers are interested and have the means, there is potential to produce liquid fuel to meet on-farm needs as well as animal feed. Farmers need to understand which crop varieties are best-suited for oil for biodiesel and/or feed for livestock, as well as effective harvesting techniques. Farmers will also need capital for equipment, production facilities, and operations and to have access to an expeller (press), a seed cleaner, a dryer/aeration system, and adequate storage. There is an opportunity to assist learning by creating a network of farmers who are growing oilseed crops for on-farm use.

► **Groups of Farmers** – Some farmers may wish to share the capital cost of producing oilseed crops for biodiesel production and livestock feed. Here, an opportunity exists for growing oilseed crops on a larger scale with a regional or mobile expeller (press), roaster, and seed cleaner. Areas of exploration include recommended business and governance models, capital and shared expense requirements, and facility/operations issues.

► **Small Commercial Producers** – Some farmers may want to grow oilseed crops to use the livestock meal but not produce biodiesel, and some entrepreneurs may want to produce biodiesel but not grow oilseed crops. The FFP will attempt to facilitate connections between these two groups and provide the tools necessary for them to work together for mutual benefit. See also: Mulder, Kenneth et al. 2007, *Homegrown Fuel: Economic Feasibility of Commercial-Scale Biodiesel Production in Vermont: A Dynamic Ecological-Economic Assessment*.

B. Project Partners and Roles

The FFP is a partnership between VSJF and VBA. Several other academic and private organizations and individuals contributed research, findings, resources, and information to the project. UVM Extension and the UVM Center for Sustainable Agriculture led research on crop trials and farm-scale biodiesel production during the 2006 and 2007 growing season, while researchers at the UVM Department of Community Development and Applied Economics compiled this report and explored the current and potential markets for oilseed co-products. In addition, the Gund Institute for Ecological Economics at UVM performed simulation modeling for two commercial scale facilities (500,000 and 2.5 million gallons per year). A report of this work was released separately in October 2007.

Please see the Acknowledgments for a complete list of the many farmers, business owners, scholars, and consultants who lent their expertise to this study.

INTRODUCTION TO OILSEED CROPS AND PRODUCTS

Soybeans, Foster Farm

Sunflowers, State Line Farm

Canola, State Line Farm

III. INTRODUCTION TO OILSEED CROPS AND PRODUCTS

Oilseed crops are those grown primarily for the oil contained in their seeds, and include soybeans, canola or rapeseed, sunflowers, flax, mustard, cottonseed, peanuts, and castor beans. The research conducted for this report focuses on soybeans, canola, and sunflowers because these crops can be grown in Vermont's climate, have a high-value livestock feed as a potential co-product, and have a sufficiently high oil content to be an efficient feedstock for biodiesel production. Table 1 summarizes the basic characteristics of these three oilseed crops.

Table 1. Basic Characteristics of Soybeans, Canola, and Sunflowers

Attribute	Soybean[7]	Canola[8]	Sunflower[9]
Sold by:			
Seed:	Bushel	Ton	Hundredweight
Meal:	Ton	Ton	Ton
Oil:	Pound	Pound	Pound
Pounds per bushel (avg)	60	50	28–32
Bushels per ton (avg)	33	40	62.5-71
Yield/acre	1–1.1 tons 35–40 bushels	0.85 tons 32–35 bushels	1–1.1 tons 66–73 bushels
Oil content	13–18% oil	40% oil	39–49% oil
Oil yield/acre[10]	48 gallons	127 gallons	102 gallons
Oil yield/bushel	1.5 gallons	2.8 gallons	1.7 gallons
Biodiesel/acre[11]	56 gallons	70 gallons	70 gallons

7 National Soybean Research Laboratory: http://www.nsrl.uiuc.edu, United Soybean Board: http://www.unitedsoybean.org, North Dakota State University: http://www.ag.ndsu.edu/procrop/syb/index.htm.
8 Canola Council of Canada: http://www.canola-council.org/portal.html, Purdue University Extension: http://www.ces.purdue.edu/extmedia/AY/AY-272.html, North Dakota State University: http://www.ag.ndsu.nodak.edu/carringt/99data/canola_economics.htm.
9 National Sunflower Association: http://www.sunflowernsa.com, Purdue University: http://www.hort.purdue.edu/newcrop/afcm/sunflower.html, Thomas Jefferson Agricultural Institute: http://www.jeffersoninstitute.org/pubs/sunflower.shtml, North Dakota State University: http://www.ag.ndsu.nodak.edu/carringt/livestock/Beef%20Report%2002/sunflower%20meal.htm.
10 Journey to Forever. Oil Yields and Characteristics. Accessed at http://www.journeytoforever.org/biodiesel_yield.html on May 25, 2007. Significant variations can occur as a result of variety, seeding regimen, and moisture content.
11 Tyson K.S. et al. 2004. *Biomass Oil Analysis: Research Needs & Recommendations*. Prepared under Task No.BBA35210 and BBA35410. National Renewable Energy Laboratory. U.S. Department of Energy.

Soybeans

Approximately 90% of the oilseeds produced in the Unites States are soybeans. Soybeans are one of the most important commodity crops grown in the United States, second only to corn in farm production value and acres planted. The production value of soybeans was $16.9 billion in 2005, with 72.1 million acres under production.[12]

Demand for soybeans is driven by demand for soybean meal, the most important high-protein feed for livestock worldwide, and the main byproduct of crushed soybeans. Soybean meal is a highly desirable protein source because of its complete amino acid profile, which is high in lysine, lower in methionine, and especially well-suited for poultry and swine feeding. Growth in the poultry industry has fueled high demand for soybean meal, which has increased soybean crop production steadily in the last 10 years. Soybeans' other byproduct, soybean oil, is typically used in salad and cooking oils, other edible uses, and industrial applications. A relatively small amount of whole soybeans are grown for food use in tofu, edamame, soymilk, or other edible soy products.

Canola

Canola is a genetic variation of rapeseed developed by Canadian plant breeders specifically for its nutritional qualities, particularly its low level of saturated fat and low eicosenoic and erucic acid contents. Canola seeds grow in small pods that are similar in shape to pea pods, but are about one-fifth the size. The tiny, round seeds are crushed to obtain canola oil. The remainder of the seed is processed into canola meal, which is used as a high-protein livestock feed.

Canola is Canada's first or second-most valuable agricultural commodity (depending on the year), and the U.S. is its largest canola customer, importing approximately 500,000 tons of canola oil, 255,000 tons of seed, and 1.1 million tons of meal from Canada each year.[13] The price of canola is driven primarily by vegetable oil markets, and is also affected by the price of soybeans.

Sunflowers

Sunflower varieties fall into two major categories: oilseed and confectionery. Confectionery seeds are only 10–20% of the U.S. crop each year, and are a premium product used for snack food, processed foods, and baking. Oilseed sunflowers are grown for birdseed or crushed primarily for their vegetable oil, with the meal as a secondary product for livestock feed.[14] In 2005-2006 the U.S. produced 382,000 tons of confectionery sunflower seed and 1,442,000 tons of oilseed sunflower seeds.[15]

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12 Ash, M., et al. April 2006. Soybean backgrounder. Electronic outlook report from the Economic Research Service. USDA.
13 Canola Council of Canada. Canola Quick Facts. Canola Facts: A Major Canadian Export. Nov 1, 2005. Accessed at http://www.canola-council.org/facts_export.html on June 6, 2007.
14 Thomas Jefferson Agricultural Institute, Sunflower: A Native Oilseed with Growing Markets: Overview. Accessed at http://www.jeffersoninstitute.org/pubs/sunflower.shtml on May 27, 2007.
15 National Sunflower Association. Sunflower Statistics: U.S. Supply & Disappearance. Accessed at http://www.sunflowernsa.com/stats/default.asp?contentID=100 on May 27, 2007.

Sunflower varieties range widely in their seed oil content, from 39% to 49%. Sunflower oil is considered a premium oil because of its light color, high level of unsaturated fatty acids, and lack of linolenic acid, bland flavor, and high smoke points. Non-dehulled or partly dehulled sunflower meal has been substituted successfully for soybean meal in isonitrogenous (equal protein) diets for ruminant animals, as well as for swine and poultry feeding. Sunflower meal is higher in fiber, has a lower energy value, and is lower in lysine but higher in methionine than soybean meal. Protein percentage of sunflower meal ranges from 28% for non-dehulled seeds to 42% for completely dehulled seeds.[16]

16 Thomas Jefferson Agricultural Institute.

VERMONT'S CURRENT OILSEED PRODUCTION & INFRASTRUCTURE

Storage Bins, State Line Farm

October 2006 Open House, State Line Farm

IV. VERMONT'S CURRENT OILSEED PRODUCTION & INFRASTRUCTURE

Vermont's current oilseed market includes local growers (suppliers) and purchasers of whole oilseeds, oilseed meals, and liquid oil. This section discusses the current status of oilseed production in Vermont, including production, supply, purchase, delivery, and storage systems for organic and conventional oilseeds.

A. Growers: Vermont's Local Suppliers

Vermont's Current Oilseed Acreage and Production

Soybeans, canola, sunflowers, and other oilseed crops are currently grown in Vermont in relatively small quantities. Table 2 summarizes the estimated oilseed acreage in Vermont currently.

Table 2. Estimated Current Oilseed Production in Vermont

	Soybeans		Canola		Sunflowers	
	Conventional	Organic	Conventional	Organic	Conventional	Organic
Soybeans (farms)	25*	9				
Soybeans (acres)	1,562*	400				
Soybeans (bushels)	51,289*					
Canola (farms)			2	0		
Canola (acres)			70	0		
Canola (bushels)						
Sunflower seed (farms)					2	1
Sunflower seed (acres)					20	5
Sunflower seed (pounds)					60,100	

*Data from 2002 Census of Agriculture, National Agricultural Statistics Service, USDA; includes any organic data.
**Calculated from pounds of seed reported, assuming 30 lbs/bushel and yield of 70 bushels per acre.
†Anecdotal data from Vermont oilseed farmers.
‡ Data from NOFA-VT, members by product.

The National Agricultural Statistics Service does not track annual data for oilseed crops in Vermont, but according to the 2002 Census of Agriculture, 25 Vermont farmers raised a total of 1,562 acres of soybeans in 2002. The Northeast Organic Farming Association of Vermont (NOFA-VT) lists nine member farms as producing soybeans.[17]

Three farms reported raising sunflowers in 2002. Although no acreage is available due to the small number of farms, given that 60,100 pounds of seed were produced, and assuming an average yield of 70 bushels per acre, it is estimated that approximately 25 to 30 acres of sunflowers were planted in Vermont.

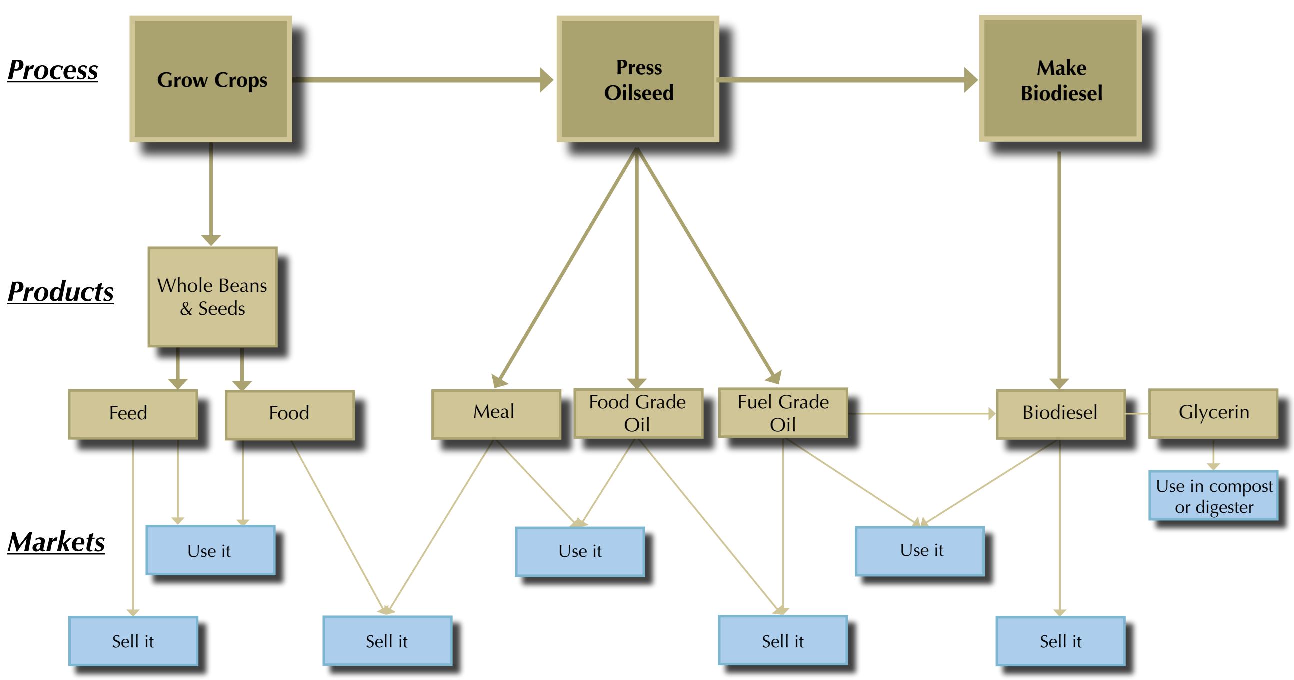
Canola is a relatively new crop to Vermont, and was not reported on in the 2002 Census of Agriculture. Anecdotal reports from Vermont farmers contacted by the FFP indicates that approximately 70 to 100 acres of canola were grown in Vermont in 2006, most as a result of UVM Extension crop trials.

Current Markets for Vermont Oilseed Crops

Each of the three major oilseeds considered in this study has six potential end-uses, depending on the amount of processing performed (Figure 1):

(1) Whole beans or seeds for livestockfeed
(2) Whole beans or seeds for human consumption
(3) Oilseed meal for livestock feed
(4) Food-grade oil
(5) Fuel-grade oil
(6) Biodiesel

Figure 1. Oilseed End-products and Their Uses



17 Northeast Organic Farming Association of Vermont. Vermont Certified Organic Farms by product. Retrieved from http://nofavt.org/farms.php on April 14, 2007.

Of the three oilseed crops examined in this study, Vermont's farmers have the most experience growing soybeans. Because the state has no large-scale crushing facility, most soybeans are sold to local feed mills, where they are roasted whole to be used as feed for dairy cows. Vermont Soy, the primary local purchaser of soybeans for human consumption, estimates that at most six farmers are growing food-grade soybeans in the state.[18]

Sunflowers, by contrast, appear to be grown primarily to produce high-quality, food-grade oil, with a few farmers just beginning to experiment with growing sunflower for fuel and feed. The small amount of canola grown in the state has been pressed to make biodiesel and livestock feed.

Prices Received by Vermont Growers

Conventional growers of soybeans for livestock feed in Vermont typically command approximately $6 to $7 per bushel, or $200 to $230 per ton, for their beans.[19] Organic farmers growing beans for the livestock market can expect to receive approximately $400 to $500 per ton. Soy food producers set high quality standards for the beans used to make soymilk, tofu, etc., and farmers growing for this market receive the highest price for their beans, ranging from $16 to $20 per bushel, or $550 to $700 per ton.[20] (Prices noted are from July 2007).

Current market data for Vermont canola is unavailable, due to the very small amount grown in the state. The situation is similar for much of the U.S., which is a net importer of canola. The USDA National Agricultural Statistics Service collects state-level canola price data only for Minnesota, Montana, and North Dakota. In 2006, prices received were $9.80, $11.70, and $11.10 per hundredweight, respectively, with all other states reported as $10.90 and the U.S. average equal to $11.10 per hundredweight.[21]

There is a similar lack of Vermont-specific data for sunflower seed and oil prices because the crop is so new to the state. Nationally, the average prices received by farmers for the 2005/2006 marketing year were $12.10/cwt for sunflower seed, $0.385/lb for oil, and $77/short ton for meal (28 % protein). In general, the more the crop is processed and the more value added, the higher the price. Several Vermont farmers are currently growing sunflowers for oil. For high-quality, organic sunflower oil for human consumption, a farmer might expect to receive $8-12 per quart, equivalent to $50–$75 per bushel of seed (assumes 40% oil content per pound of seed).

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18 Kelley, K.J. February 21, 2007. "Soy to the World." *Seven Days*. p. 6B.

19 Altemose, et al. Soybean Demonstration Trial: Assessing the Growth and Management of Feed and Food Grain Soybeans in Northern Vermont. University of Vermont Extension, 1999 and personal communications with Bourdeau Bros., Inc. of Middlebury, April 24, 2007.

20 Netaka White personal communications with Vermont soybean growers, March 2007.

21 Agricultural Statistics Database. National Agricultural Statistics Service, United States Department of Agriculture.

B. Purchasers: Aggregators of Vermont Demand

Commercial feed dealers purchase the largest volumes of oilseed products in Vermont. Feed dealers purchase soybean and canola meal from out-of-state suppliers as well as whole soybeans directly from Vermont farmers. Most meal fed in the state is in mashed grain form, not pellets. The demand for this feed is driven by Vermont dairy farmers, who purchase oilseed meals to meet the protein requirements of lactating dairy cows. Some farmers purchase roasted soybeans directly from other farmer-growers who have their own roaster.

Secondary purchasers of oilseed products include emerging local food companies such as Vermont Soy, and could include other food processors, natural food co-ops and restaurants interested in the oil. Finally, oilseed crops could be used in crop digesters to generate electricity.

Sources and Shipment

Vermont imports the vast majority of its oilseeds and meal, in part because Vermont has no commercial seed crushing facility. Due to the relatively small amount of oilseeds grown in the state, there is an inadequate supply of seeds to warrant a commercial plant.

The seed-crushing facility closest to Vermont is Ag Pro, Ltd., in Maseena, New York, which produces conventional and certified organic and kosher products. Ag Pro uses a mechanical oil extraction process, and produces both a soybean meal—"Agrasoy Natural," formulated for the dairy industry—and fully refined soy oil. Ag Pro has the capacity to process 5,500 bushels or 150 tons of beans per day, or over 50,000 tons per year. It can refine over 16,000 tons of oil per year. In 2003, the plant was operating at approximately one third of its capacity, due to the decreased demand for high-quality feed resulting from high soybean prices and low milk prices.[22]

There are two other crushing facilities in western New York, both of which also use mechanical extraction: Sheppard Grain in Phelps and Homer Oil Company in Homer. Archer Daniels Midland operates an oilseed processing plant in Windsor, Ontario, and Bunge Canada has a plant in Hamilton, Ontario.

Conventional Meal

Conventional soybean meal originates from crushing facilities in the Midwestern U.S. or Canada, whereas canola meal comes almost exclusively from Canada, especially Saskatchewan. The meals travel to Vermont by rail, and in some cases are transferred to truck for the last few miles to the mills. Vermont feed mills typically mix the meal with other components in preparing a grain ration that is delivered to the farmer. The price charged to the farmer includes the dealer's delivery cost. Alternatively, the feed dealer may sell bulk shipments of a single meal commodity to large farms that mix their own feed rations on-site.

Organic Meal

Like conventional feed mills, organic feed mills in Vermont either mix their own feed using dry meal imported from out-of-state,

22 LECG, LLC. NYSERDA Report 04-02. Statewide Feasibility Study for a Potential New York State Biodiesel Industry: Final Report. New York State Energy Research and Development Authority, June 2003. p. 14.

purchase roasted soybeans, or roast soybeans purchased from local farmers on-site. In addition, a significant quantity of organic soybeans is coming to the United States from China (at $20-$30/ton lower price).

Pricing and Key Determinants of Value

Feed mills and farmers can choose from a variety of protein sources in preparing grain rations for livestock. Soybean and canola meals are the predominant meals sold by commercial feed mills, although animal protein sources, roasted soybeans, ureas, and distillers' grains are also available. Feed mills weigh the prices of these various inputs against the nutrient requirements of the livestock in order to develop a balanced feed ration.

The key determinants of the meal's value to feed dealers and farmers are quality and consistency. Commercial suppliers guarantee that the meal will meet a minimum set of criteria for moisture, protein, fat content, and other components. One Vermont feed dealer samples loads for quality irregularly, but reports that the commodity meals' quality usually exceeds the standard. The price a farmer can expect to receive for locally crushed meal depends to a great extent on its quality (protein, fat, and other nutrient content) and on the farmer's ability to guarantee consistency in that quality from batch to batch and from load to load. Dairy farmers feed their cows a ration carefully balanced to maximize milk production. Feed of questionable quality may cause milk production to suffer, a risk few farmers will be willing to take. The buyer of the meal will not pay a competitive price if he or she cannot be sure of the meal's quality. Therefore, the price of farm-processed meal is expected to be discounted significantly unless quality control can be established.

Conventional Meal

According to Vermont feed dealers, soybean meal is the benchmark price for protein feed sources. Local feed mills pay a commodity price (established by the Chicago Board of Trade and Winnipeg Commodity Exchange for soybeans and canola, respectively), plus transportation costs to Vermont. On March 30, 2007, Poulin Grain's market prices for soybean meals delivered to the farm ranged from $278 per ton for 48% protein, solvent-extracted meal, to $329 per ton for SoyPlus (heat-processed meal high in rumen-bypass protein).[23] Whitman's Feed in North Bennington reported buying conventional, hexane-extracted canola meal for $170/ton delivered by rail car.[24] Canola seed closed at approximately US$309 per ton on April 13, 2007.[25] The price of canola meal is influenced by U.S. soy meal and oil prices, but also by world vegetable oil prices, since demand for canola is driven primarily by oil and secondarily by meal.[26]

Local conventional feed dealers stated a willingness to purchase on-farm crushed

23 Personal communication between Matthew Waldron and Poulin Grain, March 30, 2007.
24 Vernon Grubinger personal communication with Whitman's Feed, May 15, 2007.
25 Winnipeg Commodity Exchange, retrieved from http://wce.ca/index.aspx on April 16, 2007.
26 Market Analysis Division, Agriculture and Agri-Food Canada. The United States Canola Industry: Situation and Outlook, vol. 17, no. 4. February 27, 2004. Available at http://www.agr.gc.ca/mad-dam/index_e.php?s1=pubs&s2=bi&s3=php&page=bulletin_17_04_2004-02-27.

meal from Vermont farmers, provided it met quality and consistency standards (e.g., free of pods and weeds, acceptable moisture content), and could be supplied reliably.

Organic Meal

Prices for organic soybeans and other grains are substantially higher than conventional feeds due to growing demand and limited availability. Green Mountain Feeds in Bethel reported that they cannot get enough organic canola or sunflower meal to use it in their organic rations on a consistent basis; and would expect to pay $400-$450/ton for these organic meals.[27] Ag Pro, for example, sought to contract 15,000 acres of organic soybeans in 2005 at $450 per ton. The shortage is such that feed mills can be competing with buyers of food-grade beans for supply. Most organic mills stated they would pay more for domestic (U.S.) beans, seeds, or meal, with a premium (up to approximately $20 per ton) for Vermont-produced meal. Local sourcing would provide added purchasing flexibility if out-of-state shipments were off-schedule. Finally, the absence of genetically modified organisms (GMOs) is an important criterion for organic feed mills and farmers, and this could present additional opportunities for Vermont farmers interested in meeting this demand.

Volumes and Storage

The short-term volumes of soybean and canola meals purchased by feed mills depend in part on the prices of the commodities and their bases, but overall, the quantities imported by conventional feed mills are significant. The major feed mills in Vermont (Poulin Grain, Bourdeau Bros., and Blue Seal) together import over 650 tons of soybean meal and over 460 tons of canola meal each week. To meet this demand through in-state production, Vermont would have to plant approximately 39,000 acres of soybeans and approximately 48,000 acres of canola per year.

Oilseed meals are stored in grain bins, and must have a moisture content of no more than 8% to 10% to prevent rot and molding. Dry meal also moves through augers, mixers, and other processing equipment more easily, and does not stick to the sides of bins as readily. Long-term storage is not a problem for most feed mills, however, since the meal turns over quickly. Farmers with their own grain bins may store meal for a season or two at most.

27 Vernon Grubinger personal communication with Green Mountain Feeds, May 15, 2007.

MARKET POTENTIAL FOR OILSEED-DERIVED FUEL, FEED, & FOOD IN VERMONT

Biodiesel

Oilseed “cake”: canola, soy, & mustard

V. MARKET POTENTIAL FOR OILSEED-DERIVED FUEL, FEED, & FOOD IN VERMONT

Vermont imports significant quantities of oilseed protein meal, food, and diesel fuel. This section seeks to establish the size of the potential market for locally produced fuel and feed and includes a discussion of food products from oilseed crops.

A. Liquid Fuels on Vermont Farms[28]

Most liquid fuels consumed in agricultural production and space heating are the "middle distillates," including No. 2 heating oil, diesel, and kerosene. These are the grades of refined petroleum that can be easily reduced or replaced with biodiesel. In some cases, straight vegetable oil or reclaimed vegetable oil, which differ from biodiesel, can also be used as a fuel with good results by modifying the equipment.

Biodiesel is a renewable fuel derived from virgin seed oils or from reclaimed vegetable oil or animal fat. Biodiesel has a similar energy (BTU) content to that of petroleum fuels, has less negative impact on human health, and produces lower atmospheric emissions of pollutants and greenhouse gases.

Biodiesel blends easily with distillate petroleum products and can be added to or replace No. 2 heating oil or motor transport fuel ("petrodiesel"). In this report, "biodiesel" refers to the pure fuel, or "B100." Biodiesel blends are concentrations of biodiesel between 2% and 99% (B2 to B99, with the number following the "B" indicating the percentage of biodiesel in a gallon of fuel, where the remainder of the gallon is petrodiesel).

The American Society for Testing and Materials (ASTM) sets quality standards for liquid fuels to ensure that they meet the minimum accepted values for certain properties required to provide adequate customer satisfaction and protection. "ASTM-spec" biodiesel is fuel that meets ASTM standard D-6751, which covers pure biodiesel (B100) and biodiesel blends of up to 20% by volume (B1-B20).

This section uses national and local data on fuel consumption and fuel price projections from government and research sources to estimate demand and prices paid for petrodiesel and biodiesel fuel in Vermont.

Fuel Consumption

Historical Demand

According to the Energy Information Administration (EIA) of the U.S. Department of Energy (DOE), Vermont's farm sector received 6,410,000 gallons of distillate fuel oil in 2005. Historical data of the last ten years shows a high consumption figure of 6.9 million gallons in 1999 and a low

28 This section was contributed by Netaka White, Vermont Biofuels Association.

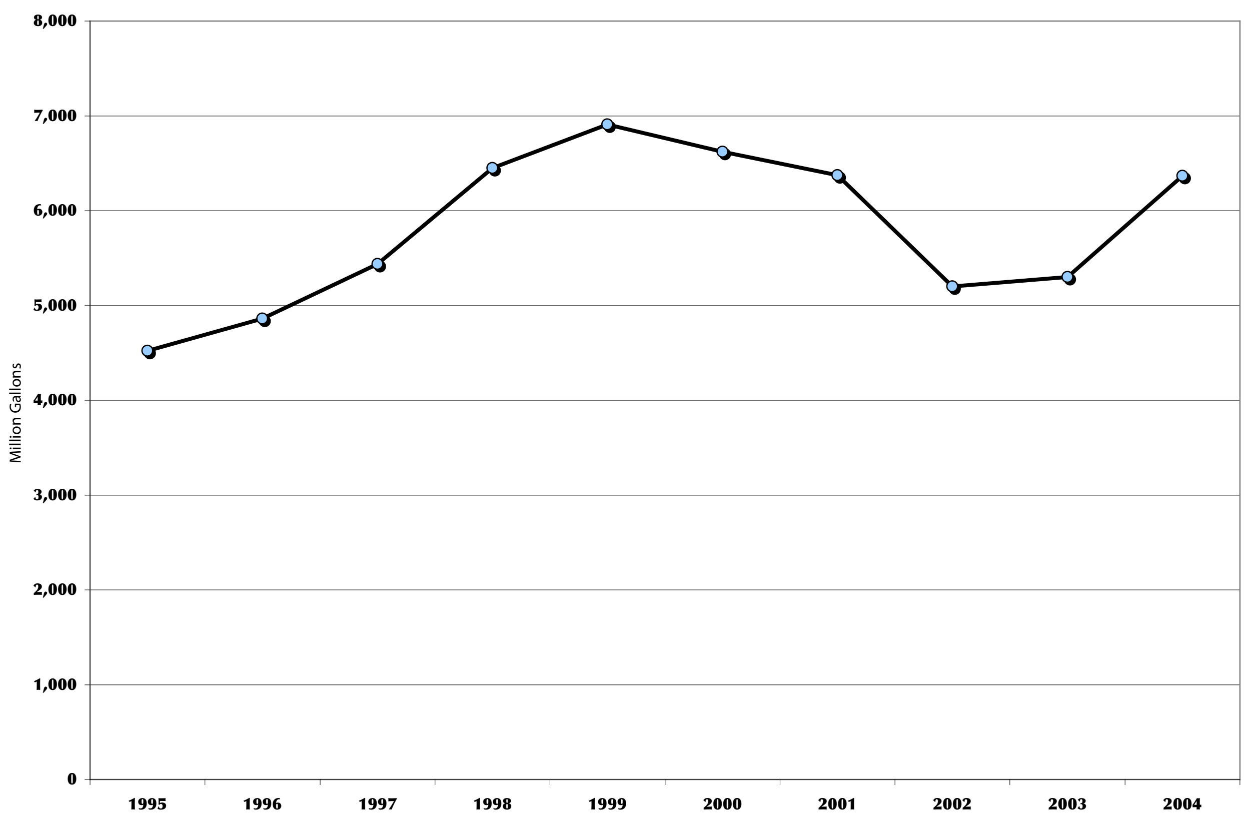
figure of 4.4 million gallons consumed in 1995 (Figure 2). The EIA relies on mandatory data submitted by every fuel supplier as part of the Annual Petroleum Report.[29]

Although the EIA identifies the sector to which the fuel was delivered (i.e., farm, residential, industrial, etc.), it does not distinguish between distillates used for farm equipment and trucking and No. 2 heating oil used to heat structures on the farm, although biodiesel can be blended with or substituted for either one.

Projected Demand

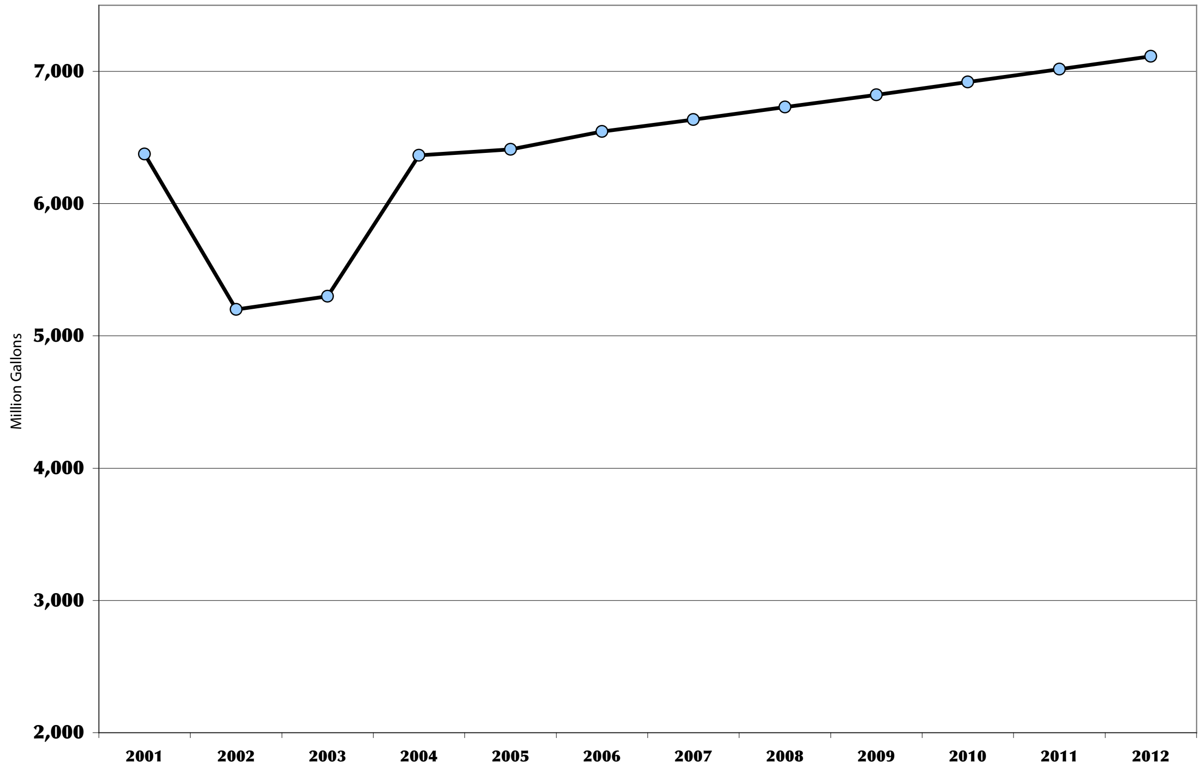
The EIA does not forecast sector demand by state. DOE's EIA 2007 Annual Energy Outlook (AEO), however, includes statistical projections that show total U.S. distillate use increasing by 1.4% per year to 2030. Using this formula for estimated growth, fuel consumption on Vermont farms will increase to just over 7 million gallons in 2012 (Figure 3).

Figure 2. Total Distillate Fuel Sales to Vermont Farms, 1995-2005



29 U.S. Dept. of Energy, Energy Information Administration. Petroleum Navigator, Definitions, Sources and Explanatory Notes for Petroleum Consumption/Sales, Adjusted Sales of Distillate Fuel by End Use. Accessed at http://tonto.eia.doe.gov/dnav/pet/TblDefs/pet_cons_821dsta_tbldef2.asp on May 27, 2007.

Figure 3. Projected Total Distillate Fuel Sales to Vermont Farms, 2006-2012



When considering future on-farm fuel demand, it is important to view it in the context of global demand and supply projections for crude oil and refined petroleum products. The on-going debate over oil depletion may have recently turned a corner with the release (in 2007) of two energy industry assessments, pointing to global petroleum demand outpacing supply from conventional sources as early as 2010-2011.[30] Though vast amounts of oil (and gas) remain underground, "complex challenges" and "global uncertainties" could destabilize the "the sufficient, reliable and economic energy supplies upon which people depend," with oil production becoming a "significant challenge as early as 2015."[31] This assessment, contained within the 420-page report from the National Petroleum Council corresponds with the latest International Energy Agency's prediction that oil supplies could become "extremely tight" in five years.

Petrodiesel Prices

Current Prices

Each month, the Vermont Department of Public Service (DPS) issues the Vermont Fuel Price Report, which averages prices for petroleum products and propane from fuel dealers around the state. According to the DPS's May 2007 report, No. 2 heating oil (and "off-road" diesel) sold for an aver-

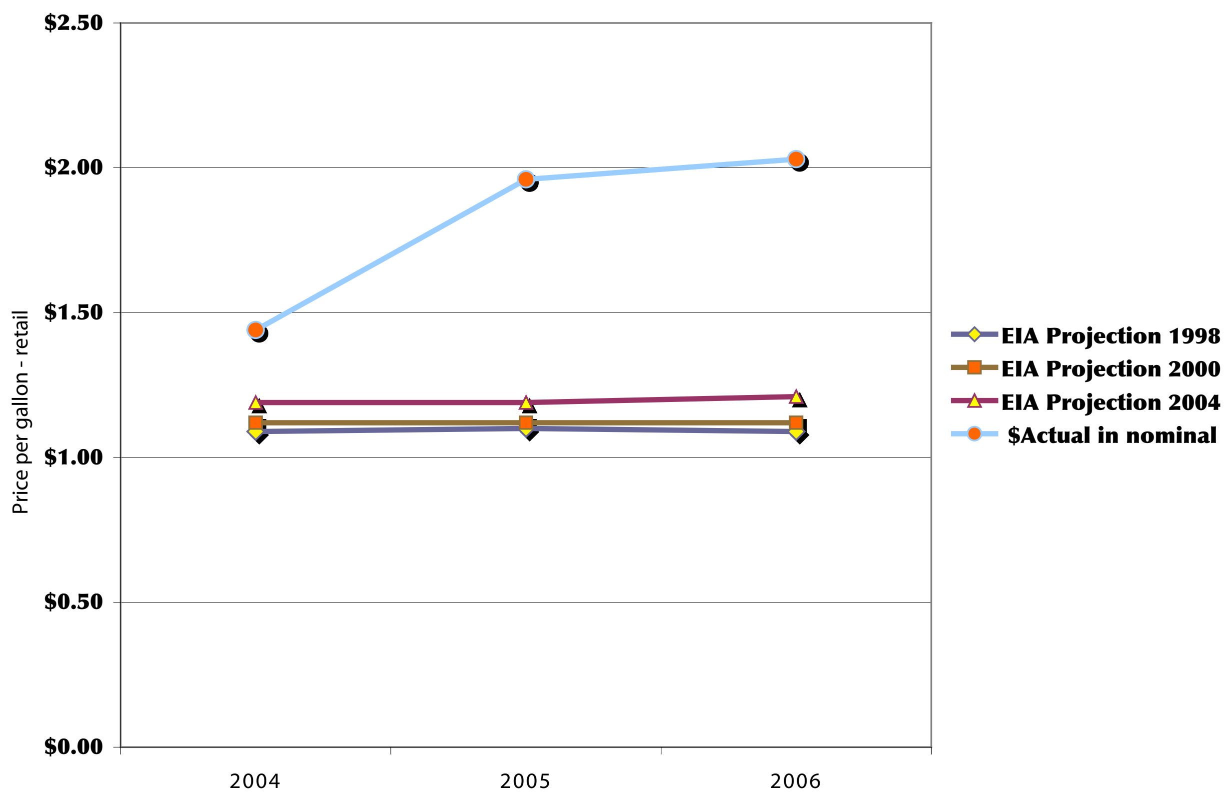
30 Oil Market Report of the International Energy Association, 2007. http://omrpublic.iea.org/.
31 http://downloads.connectlive.com/events/npc071807/pdf-downloads/Facing_Hard_Truths-Executive_Summary.pdf

age retail price of $2.55 per gallon, and "on-road" diesel was selling for $2.94 per gallon during the same period.

Future Prices

The EIA's 2006 Annual Energy Outlook forecasts trends in energy supply and consumption to 2030.[32] The 2006 AEO predicts that average U.S. retail prices for distillates will drop to $1.97 per gallon in 2007, to $1.83 per gallon in 2010 and down to $1.88 per gallon in 2015 (these figures are in 2004 dollars). Given the volatility of global energy markets in recent years and strong demand growth, the AEO has consistently underestimated the real price of refined fuels in its projections, which raises doubts as to the usefulness of the 'official' forecast. Yet these are the figures that federal and state energy and transportation planners rely on when considering future policy and infrastructure investments. For instance, as shown in Figure 4, the 1998 AEO projected the 2004 gasoline price per gallon (ppg) at $1.09 and the actual price was $1.44. The 2000 AEO projected the 2005 ppg at $1.12; the actual price was $1.96. In the 2004 AEO, the projected ppg for petrodiesel in 2006 was $1.21 and the actual price was $2.03.

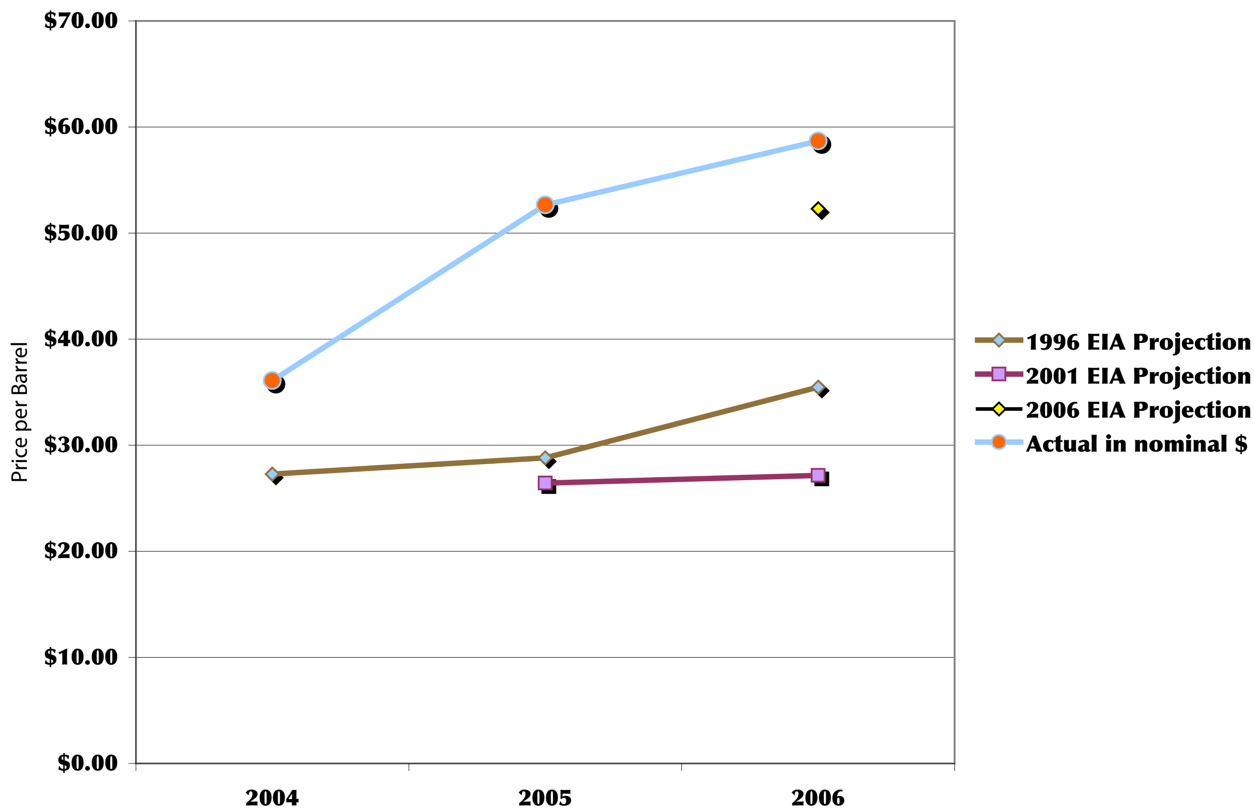
Figure 4. DOE-projected vs. Actual Gasoline Prices, 2004-2006



32 U.S. Dept of Energy, Energy Information Administration. Annual Energy Outlook 2006. Available at http://www.eia.doe.gov/oiaf/archive/aeo06/pdf/aeotab_12.pdf.

One final example shows the difficulty in relying on DOE projections. Figure 5 shows that in 1996 the AEO forecasted the 2004 price of a barrel of oil (ppb) at $27.29 (it was $36.10), in 2001 the projected ppb for 2005 was $26.43 (it was double that at $52.65), and the 2006 AEO forecasted that year's ppb at $52.29 (it was 11% higher at $58.69).

Figure 5. DOE-projected vs. Actual Prices for Barrel of Crude Oil, 2004-2006



Biodiesel Prices

Current Prices

A small survey of Vermont biodiesel suppliers in April 2007 yielded an average retail price of $3.00 per gallon for biodiesel (B100) suitable for farm or off-road equipment or space heating use, and $2.95 for a B20 blend (20% biodiesel and 80% No.2 oil). The retail price for on-road ASTM "spec" biodiesel was averaging $3.40 with state and federal excise tax included. These prices all carry a $1.00 per gallon federal credit, taken by the producer or the fuel blender and passed along to the customer (in varying degrees) by the fuel retailer. The retail price of locally produced, non–ASTM B100 for off-road use was approximately $2.40 per gallon. At the time of this report retail prices for biodiesel vary widely in Vermont, which is not unusual, given the limited distribution of the product and price volatility common in emerging markets.

Future Prices

Two recent studies that evaluated nationwide agricultural trends arrived at similar conclusions regarding the price of biodiesel over the next ten years. Both reports looked at increases in oilseed and corn acreage, as well as the impact of agricultural price supports and the rapid growth in biofuel plant capacity.

In early 2007, a research team from Michigan State University (MSU) completed a study using a simulation model that generated future crop data for corn and soybeans, future U.S. biofuel demand (ethanol and biodiesel), and price projections out to 2017.[33] To project biodiesel prices, they used several calculations relating wholesale diesel prices to crude oil prices as the base, and applied the $1.00 per gallon blender's federal tax credit now in effect. To these average wholesale prices, $0.68 per gallon was added (an estimate of transportation costs and a retail margin), in order to provide a common reference point across fuel types. Of the two reports, the MSU study projects a 'high-price' scenario, with (retail) biodiesel prices holding steady over the next ten years, from a high of $3.58 per gallon in 2008 to $3.54 gallon in 2016.

The other study that was used as a basis for forecasting biodiesel prices was published by the Food and Agricultural Policy Research Institute (FAPRI) at The University of Missouri–Columbia for the U.S. Department of Agriculture in February 2007.[34] This report factors in the impact that the rapid growth in ethanol production has had on agricultural markets. Both the MSU and FAPRI results assume that the biofuel tax provisions ($1.00 per gallon for 'virgin' oil) will be extended indefinitely. If the tax credits expire, however, the result could be sharply lower biofuel production, lower demand for oilseeds, a decline in crop prices, and higher biodiesel prices than forecasted here. Of the two reports, the FAPRI study projects a "low-price" scenario, with (retail) biodiesel prices falling from a high of $3.06 per gallon in 2006 to $2.74 per gallon in 2016.

Predicting the future price path of biodiesel is no less challenging than it is for petroleum products. The FAPRI summary concludes, "future developments in agricultural markets appear even more uncertain than in past years." Nonetheless, given the evidence available today, the assumption is that biodiesel prices will likely "track" the price of petrodiesel and carry a price premium of between $.60 and $.90 per gallon (in 2006 dollars) to 2017.

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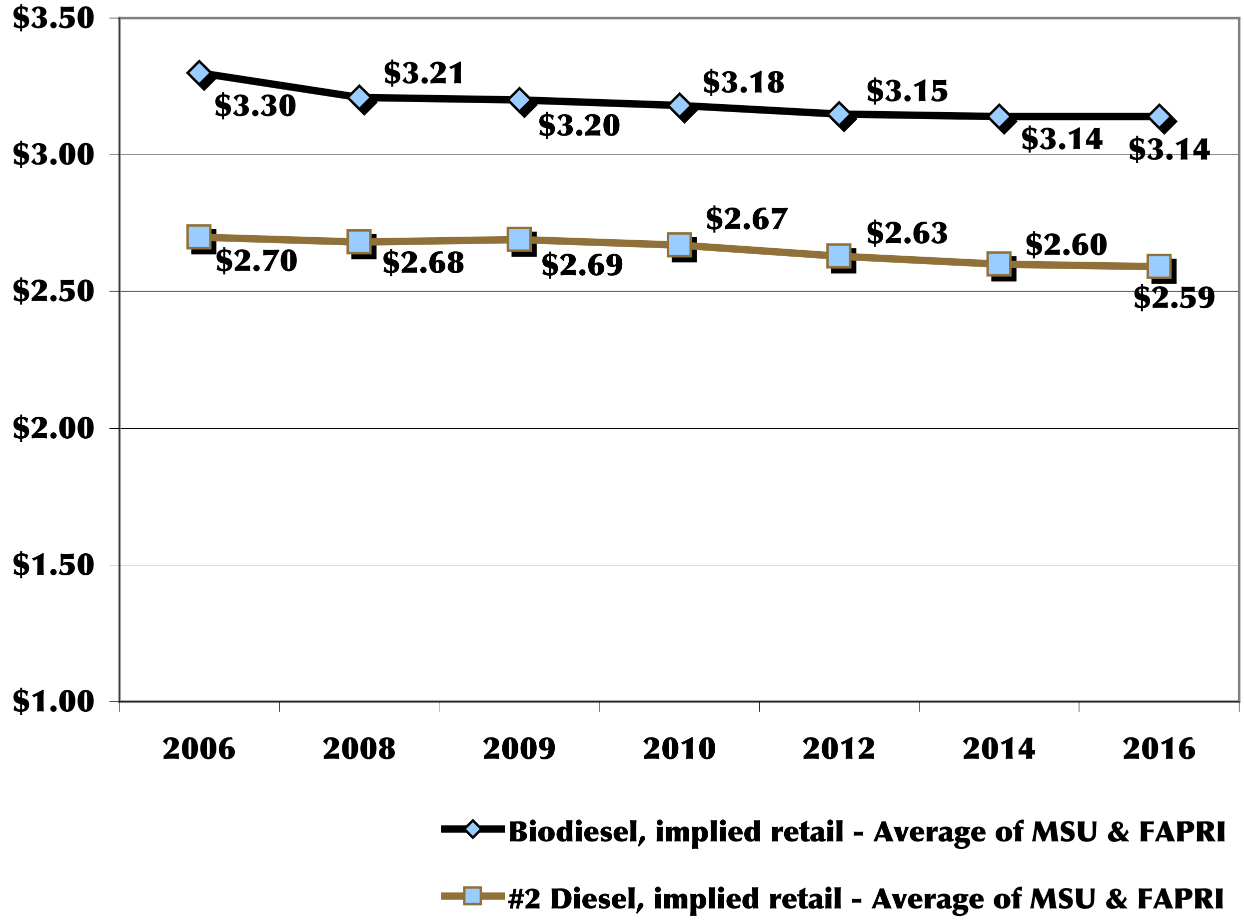
33 Ferris, J.N. and Joshi S.V. Michigan State University. *Agriculture as a Source of Fuel; Prospects and Impacts, 2007 to 2017*.

34 FAPRI-UMC Report #02-07. *2007 U.S. Baseline Briefing Book*. Food and Agricultural Policy Research Institute - College of Agriculture, Food and Natural Resources, University of Missouri-Columbia

Figure 6. Average of FAPRI and MSU Forecasted Prices For Biodiesel (B100) and Petrodiesel, 2006-2016



B. Livestock Feed

Feed for livestock drives demand for soybean meal in the United States, with soybean oil as a byproduct. For sunflowers and canola, oil is the primary product, but meal is a valuable byproduct since it also can be fed to livestock. This section estimates potential demand and projected prices for organic and conventional protein meals in Vermont.

Estimated Vermont Demand

Vermont's agriculture sector is dominated by milk production, and dairy cows are the major livestock type by number of head. Although Vermont farmers also raise sheep, emus, ostriches, alpacas, llamas, and other animals, only cows, hogs, chickens, and turkeys are raised in sufficient numbers to create meaningful demand for protein meal. Table 3 shows the estimated numbers of the major livestock types in Vermont.

Table 3. Estimated Number Of Livestock Fed Protein Meal In Vermont[35]

Livestock Type	Average # of Head Fed Protein Meal
Dairy cows – conventional	137,500
Dairy cows – organic	11,600
Beef cattle (cows, calves, yearlings)	18,000
Hogs and pigs	2,500
Laying chickens 20 weeks old and older	211,968
Pullets for laying flock replacement	30,956
Broilers and other meat-type chickens	134,529
Turkeys	55,865

Source: Conventional dairy cow, beef cattle, and swine data from National Agricultural Statistics Service, Agricultural Statistics Database. Poultry data from National Agricultural Statistics Service, 2002 Census of Agriculture. Organic dairy cow data from Economic Research Service, USDA, Data Sets: Organic Production, Table 5: Certified Organic Livestock.

Different types of oilseed meal have different characteristics. Overall, soybean meal is the most desirable for livestock feeding in terms of protein content and amino acid profile. Soybean meal contains several factors that reduce its digestibility to poultry and swine, however. The most important such anti-nutritional factors are trypsin inhibitors, which interfere with the trypsin enzyme that breaks down proteins in the animal's intestinal tract. If the trypsin enzyme is inactivated, the animal will not be able to absorb all of the protein nutrients in the meal, and the animal's pancreas may enlarge in order to produce more enzymes.[36] The presence of urease in soybeans is also a concern for ruminants. Uresase can react with urea in the cow's diet to produce ammonia. Heating the meal to at least 140–150ºF or roasting whole beans at approximately 220–245ºF both deactivates the trypsin inhibitors and urease, however.[37] Heating also decreases the amount of rumen-degradable protein in the meal, making it more attractive as a feed for dairy cows.[38]

Relative to soybean meal, canola and sunflower meal have higher amounts of rumen-degradable protein, which can limit the amount fed per day to dairy cows. Canola also cannot be fed in large amounts (maximum 3% of diet by weight) to brown egg–laying chickens.

35 Animal Feed Resources Information System, Food & Agriculture Organization of the United Nations. Soybean meal, soyabean meal, soya bean meal, sojabean meal, Manchurian meal. Accessed at http://www.fao.org/AG/aGa/agap/FRG/AFRIS/Data/736.htm on May 27, 2007.
36 Said, N.W. Soybean Processing. InstaPro International. Accessed at http://www.insta-pro.com/pdf/resources/ref_1014.pdf on May 27, 2007; Hollis, G. Swine Management & Nutrition Q&A. University of Illinois. Accessed at http://faq.aces.uiuc.edu/faq.pdl?project_id=12&faq_id=882 on May 27, 2007.
37 Randy D. Shaver, "By-Product Feedstuffs in Dairy Cattle Diets in the Upper Midwest," University of Wisconsin – Madison, (Accessed from http://www.wisc.edu/dysci/uwex/nutritn/pubs/ByProducts/Byproduct-Feedstuffs.html).
38 Randy D. Shaver, "By-Product Feedstuffs in Dairy Cattle Diets in the Upper Midwest," University of Wisconsin – Madison, (Accessed from http://www.wisc.edu/dysci/uwex/nutritn/pubs/ByProducts/Byproduct-Feedstuffs.html).

In estimating protein meal demand by Vermont livestock, it was assumed that cows on a conventional dairy farm are fed 5 to 8 pounds of protein meal per day,[39] and that organic dairy cows are fed one-third less, or 1.5 to 3 pounds of protein meal per day. Compared to dairy cows, other livestock are fed relatively small amounts of grain per day.[40] It was assumed that grain-finished beef cattle are fed 5 pounds per day for 90 days, and that beef calves and heifer replacements are fed 2 pounds per day for 180 days.[41] Hogs, turkeys, and broiler and laying chickens are fed less than a pound per day on average.[42] The lower consumption and smaller numbers of beef cattle, swine, and poultry in Vermont means that approximately 97% of the state demand for protein meal is estimated to come from dairy cows.

Conventional Meal

Table 4 gives a rounded estimate of the annual demand for conventional oilseed meals. Tables 5 through 7 detail the estimated annual demand for conventional soybean, canola, and sunflower meal in Vermont, respectively, based on typical livestock diets and rations. These estimates were derived to calculate the maximum potential in-state demand for each oilseed meal by taking each meal singly and assuming it as the only protein source. They do not, therefore, account for the blending of meals that could and does occur.

Table 4. Estimated Annual Vermont Demand For Conventional Oilseed Meals

Oilseed Meal	Estimated Annual Vermont Demand (rounded)
Soybean meal	156,200 tons
Canola meal	84,900 tons
Sunflower meal	132,200 tons

39 Personal communications with Dr. Matthew Waldron, Department of Animal Science, University of Vermont, and Jacob Bourdeau, Bourdeau Bros., Inc. Harouna A. Maiga, et al. 1997. "Alternative Feeds For Dairy Cattle In Northwest Minnesota: An Update." University of Minnesota Dairy Update, Issue 126, (http://www.ansci.umn.edu/dairy/dairyupdates/du126.htm). Randy D. Shaver, "By-Product Feedstuffs in Dairy Cattle Diets in the Upper Midwest," University of Wisconsin – Madison, (Accessed from http://www.wisc.edu/dysci/uwex/nutritn/pubs/ByProducts/ByproductFeedstuffs.html).

40 Personal communications with Willie Gibson, NOFA-VT Farm Technical Advisor; Jack Lazor, Butterworks Farm; and Brent Beidler, Beidler Family Farm; May 21, 2007.

41 Vern Grubinger personal communication with Dr. Carlton (Sam) Comstock, Beef Livestock Specialist, University of Vermont Extension, April 17, 2007.

42 Subcommittee on Poultry Nutrition, Committee on Animal Nutrition, Board on Agriculture, Nutrient Requirements of Poultry, 9th revised ed., Washington, D.C.: National Academy Press, 1994. Randy Walker, Swine: Feeding, Document RFAA084, Animal Science Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, 2003.

Table 5. Estimated Annual Vermont Conventional Soybean Meal Demand

Livestock Type	Soy Meal Demand (lbs) Min	Soy Meal Demand (lbs) Max	% Total Meal Demand
Dairy cows (conventional only)	646,900	1,035,040	97%
Beef cattle, swine, chickens, and turkeys	0	29,825	3%
Range total meal demand (lbs/day)	646,900	1,064,865	
Range total meal demand (lbs/year)	236,118,500	388,675,545	
Range total meal demand (tons/year)	118,059	194,338	
Midpoint total meal demand (lbs/day)	855,882		
Midpoint total meal demand (lbs/year)	312,397,022		
Midpoint total meal demand (tons/year)	**156,199**		

Table 6. Estimated Annual Vermont Canola Meal Demand

Livestock type	Canola Meal Demand (lbs) Min	Canola Meal Demand (lbs) Max	% Total Meal Demand
Dairy cows (conventional only)	388,140	517,520	95%
Beef cattle, swine, chickens, and turkeys	0	25,285	5%
Range total meal demand (lbs/day)	388,140	542,805	
Range total meal demand (lbs/year)	141,671,100	198,124,002	
Range total meal demand (tons/year)	70,836	99,062	
Midpoint total meal demand (lbs/day)	465,473		
Midpoint total meal demand (lbs/year)	169,897,551		
Midpoint total meal demand (tons/year)	**84,949**		

Source: Canola Council of Canada, Canola Meal Feed Industry Guide, (Accessed from http://www.canola-council.org/meal5.html on February 24, 2007.

Table 7. Estimated Annual Vermont Sunflower Meal Demand

Livestock Type	Sunflower meal demand (lbs) Min	Max	% Total Meal Demand
Dairy cows (conventional only)	388,140	1,035,040	98%
Beef cattle, swine, chickens, and turkeys	0	25,575	2%
Range total meal demand (lbs/day)	388,140	1,060,615	
Range total meal demand (lbs/year)	141,671,100	387,124,349	
Range total meal demand (tons/year)	70,836	193,562	
Midpoint total meal demand (lbs/day)	724,377		
Midpoint total meal demand (lbs/year)	264,397,725		
Midpoint total meal demand (tons/year)	**132,199**		

Source: National Sunflower Association, Meal/Wholeseed Feeding, Accessed from http://www.sunflowernsa.com/wholeseed/default.asp?contentID=253 on April 7, 2007.

Organic Meal

Of Vermont's approximately 1,180 dairy farms, about 200 are expected to be certified organic by end of 2007, with the remaining 980 using conventional methods.[43] Organic dairies typically work to increase the quality of their forage and many emphasize grazing/forage feeding practices over grain feeding practices in order to improve animal health and control (or decrease) grain purchases, which can run twice the cost per cow compared to conventional meal. As a result, organic dairies contacted for this study report protein feedings of one-third less, on average. Furthermore, organic dairy herds tend to be smaller then conventional herds. In the long run, a continued shift to organic production could decrease the *overall* need for protein meal in the state as a result of smaller herd size and feeding practices that focus on forages, not grain. In the short term, however, the shift toward organic milk production is increasing demand for *organic* protein meal in Vermont. Table 8 summarizes the estimated demand for organic oilseed meals in Vermont, estimated based on an organic dairy herd population of approximately 11,600 cows.[44]

43 Rathke, Lisa. July 30, 2006. "More Vermont dairy farmers choose the organic route." *Burlington Free Press*.

44 Estimated from NOFA data of 166 certified-organic dairy farms as of June 8, 2007 and assuming an average of 70 cows per farm.

Table 8. Estimated Vermont Organic Oilseed Meal Demand

Organic Dairy Cows	Meal Demand	
	Min	Max
Range total meal demand (lbs/day)	17,430	34,860
Range total meal demand (lbs/year)	6,361,950	12,723,900
Range total meal demand (tons/year)	3,181	6,362
Midpoint total meal demand (lbs/day)	26,145	
Midpoint total meal demand (lbs/year)	9,542,925	
Midpoint total meal demand (tons/year)	**4,771**	

For a discussion on the amount of acreage needed to meet this potential demand for livestock feed see page 75, *Land Use Implications*.

Projected Commodity Prices

The rapid expansion of biodiesel (up 490% since 1999) and especially corn-based ethanol production (up 300% between 2000 and 2006) in the United States has begun to affect U.S. corn, grain, and soybean prices and futures.

Two reports published in February 2007 forecast agricultural commodity prices over the next 10 years. Both assume that current government farm and energy policies remain in place. The first, *USDA Agricultural Projections to 2016*, published by the U.S. Department of Agriculture, finds that "long run developments for global agriculture reflect increased demand for biofuels, particularly in the United States and the European Union (EU)." The report's projections "reflect large increases in corn-based ethanol production, which affects production, use, and prices of farm commodities throughout the sector."[45] The result is generally higher market prices for corn and soybeans over the next three to four years.

The second report, the *FAPRI U.S. Baseline Briefing Book*, published by the Food and Agricultural Policy Research Institute at the University of Missouri, states that "growth in biofuel production has wide-ranging implications." FAPRI advises that one can expect to see:

- ► Projected prices for grains and oilseeds that are higher than in previous FAPRI baselines;
- ► Planted acreage increasing for corn at the expense of other crops;
- ► Higher feed costs reducing the rate of growth in meat and milk production;
- ► Taxpayer costs of the marketing loan and counter-cyclical payment programs reduced with government spending on the crop insurance program increased.

Furthermore, FAPRI finds that the long-term outlook for agricultural markets is "even more uncertain than in past years,"

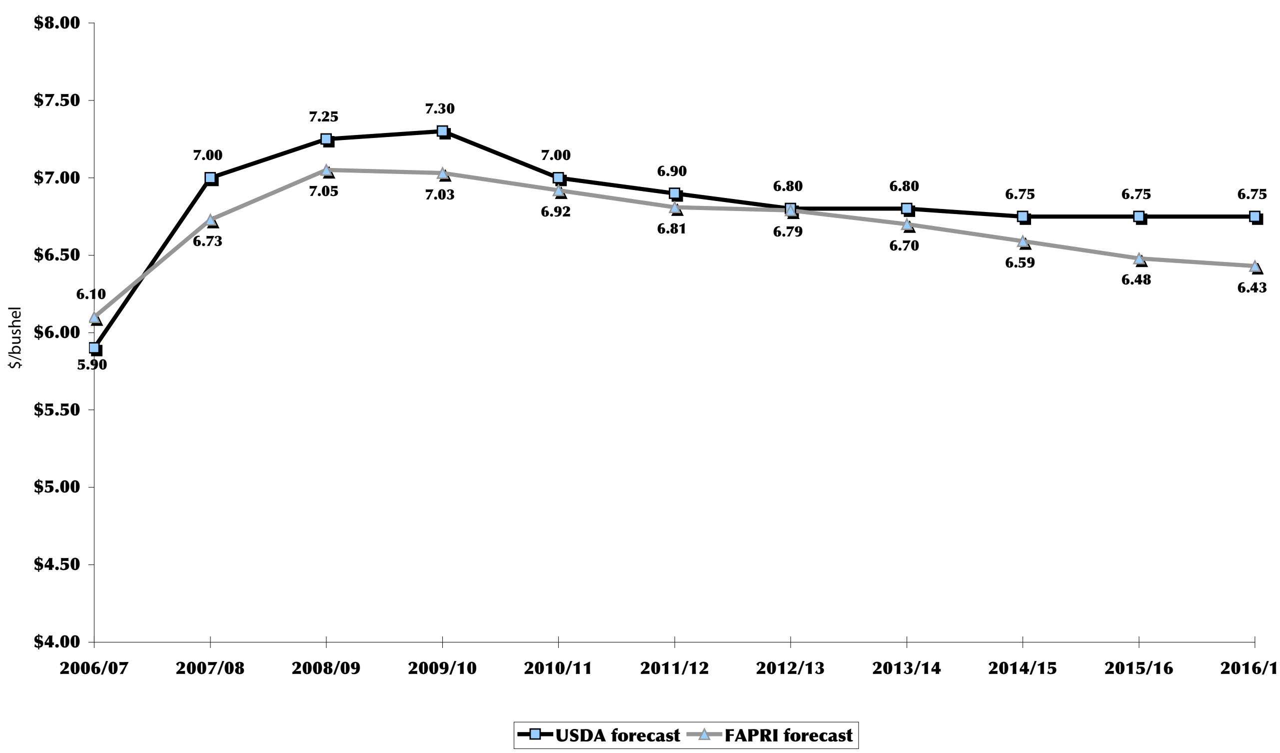
45 USDA Agricultural Projections to 2016. Office of the Chief Economist, World Agricultural Outlook Board, U.S. Department of Agriculture. Prepared by the Interagency Agricultural Projections Committee. Long-term Projections Report OCE-2007-1.

due in large part to the uncertainty of petroleum prices.[46]

Both organizations predict a short-term increase in oilseed prices over the next three to four years, followed by a gradual decline toward nominal prices near today's levels. USDA and FAPRI predict that increased biofuel production will change the relationship between oilseed meal and oil prices. On one hand, as biodiesel production increases, oil prices will rise. On the other hand, increased competition from corn co-products (e.g., dry distillers' grains) will weaken meal prices. The result is that more of the crush value of oilseeds will be derived from the oil than the meal. FAPRI goes so far to say that oil will represent a greater share of soybean value than meal by 2015.[47] USDA agrees that biodiesel production will increase soybean oil demand, but predicts that demand for soybean meal will remain the primary driver.[48]

Figures 7-11 show USDA- and FAPRI-forecasted prices for soybeans, soybean meal, and soybean oil, followed by FAPRI-forecasted prices for canola and sunflower seed.

Figure 7. USDA and FAPRI 10-year Soybean Price Forecasts (Nominal $/Bushel)



46 FAPRI U.S. Baseline Briefing Book, FAPRI-UMC Report #02-07, February 2007. Food and Agricultural Policy Research Institute, College of Agriculture, Food and Natural Resources, University of Missouri-Columbia.
47 FAPRI, p. 26.
48 USDA Agricultural Projections to 2016: Baseline Presentation, 2007-2016. Accessed at http://www.ers.usda.gov/Briefing/Baseline/present2007.htm on May 27, 2007.

Figure 8. USDA and FAPRI 10-year Soybean Meal Price Forecasts (Nominal $/ton)

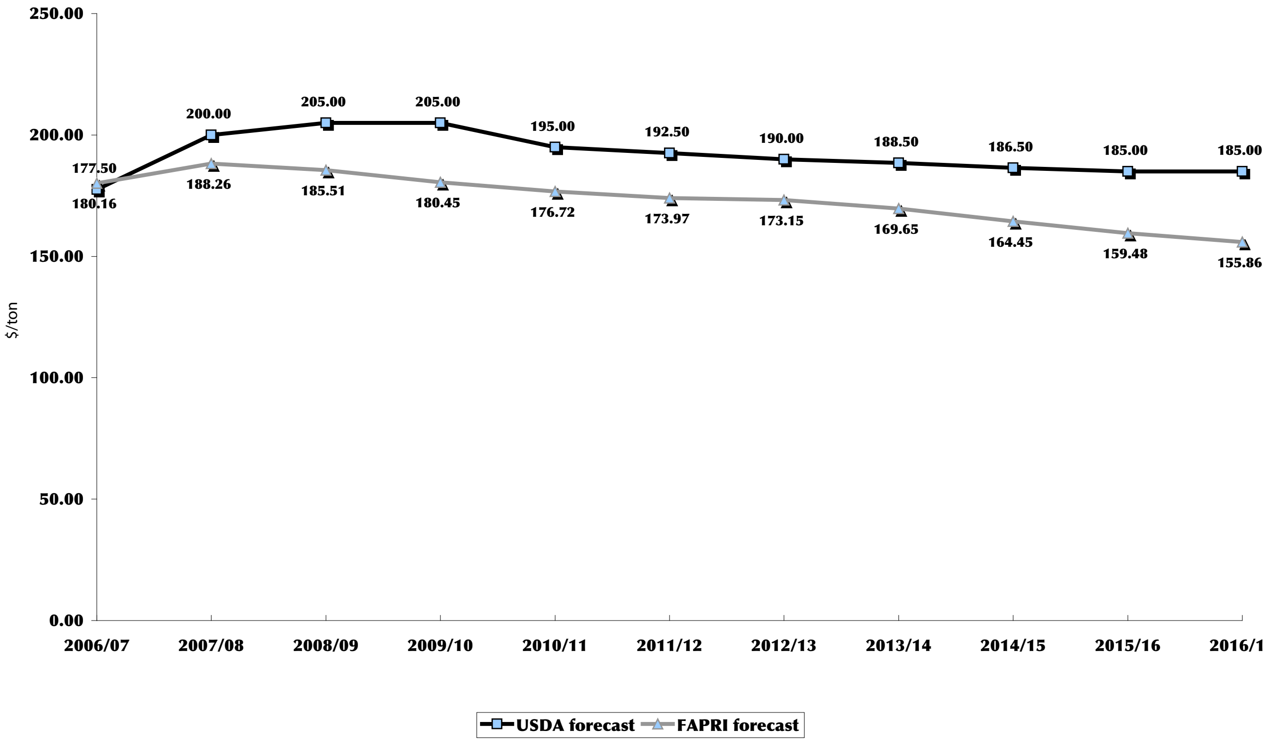


Figure 9. USDA and FAPRI 10-year Soybean Oil Price Forecasts (Nominal $/lb)

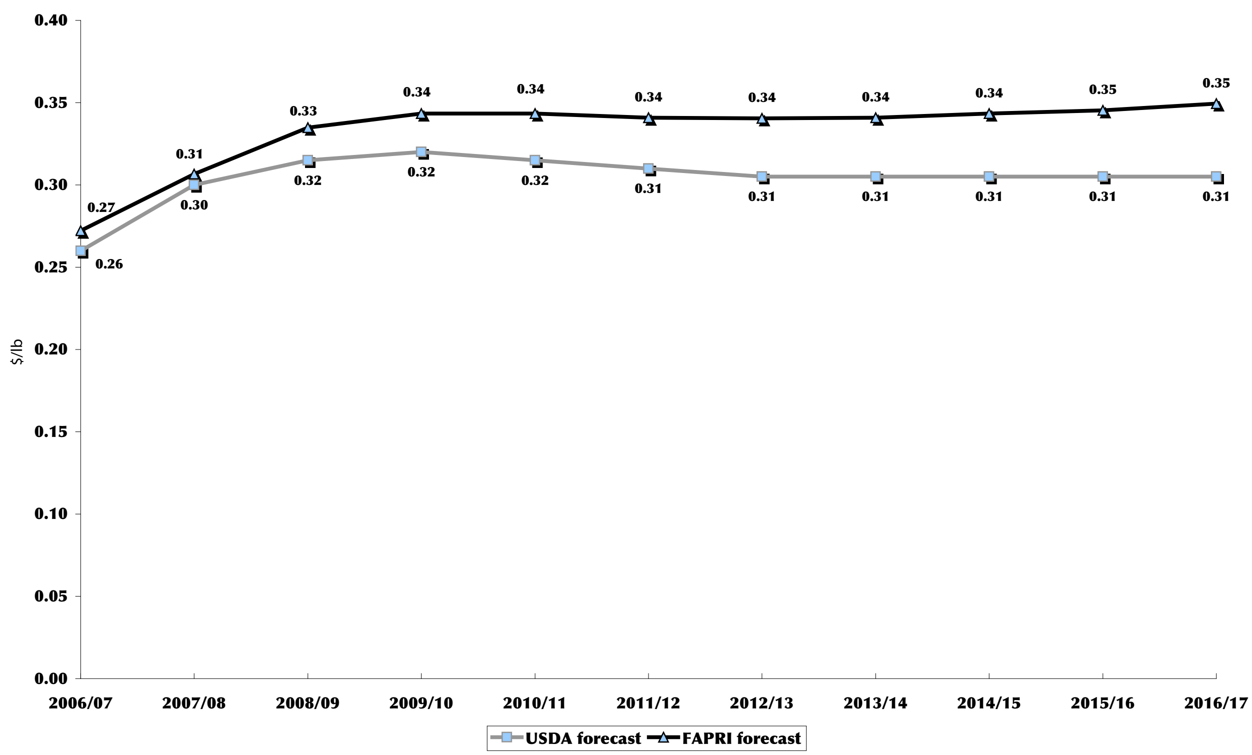


Figure 10. FAPRI 10-year Canola Seed Price Forecast (Nominal $/Bushel)

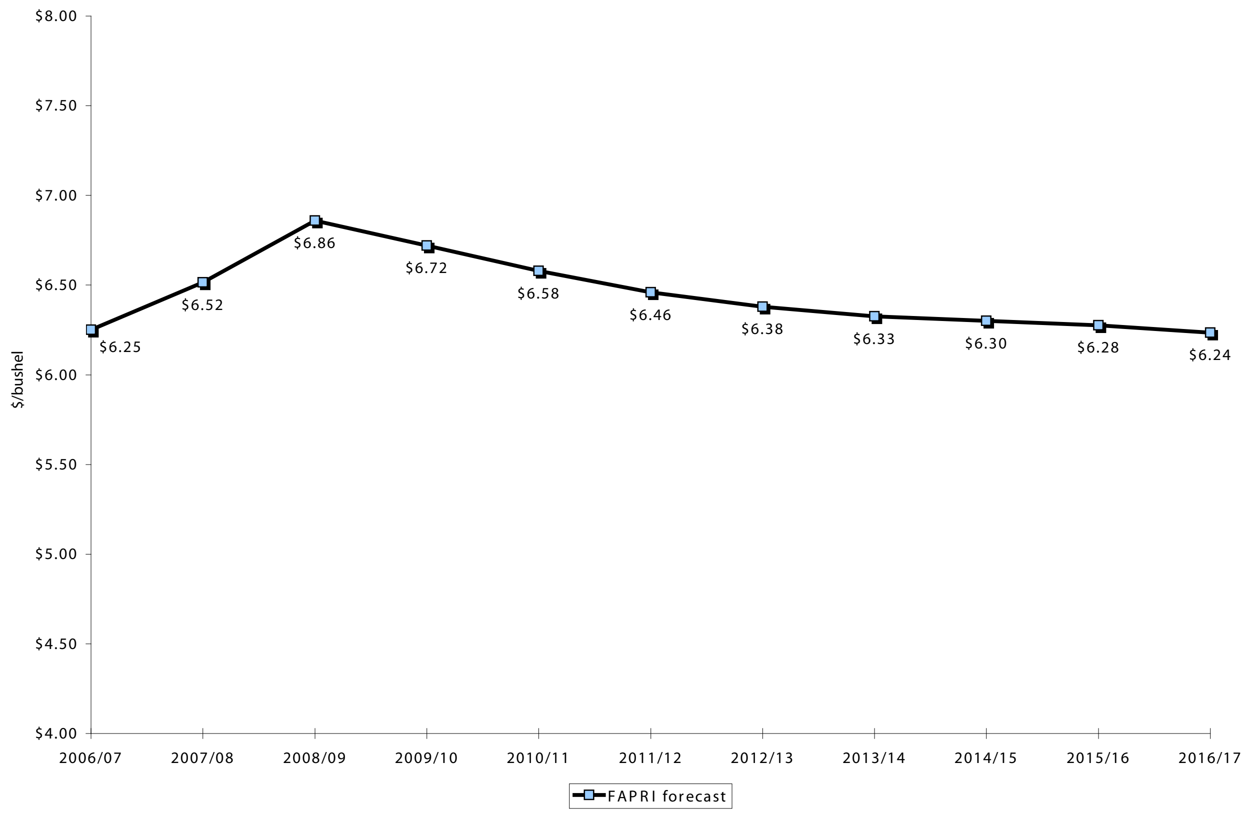
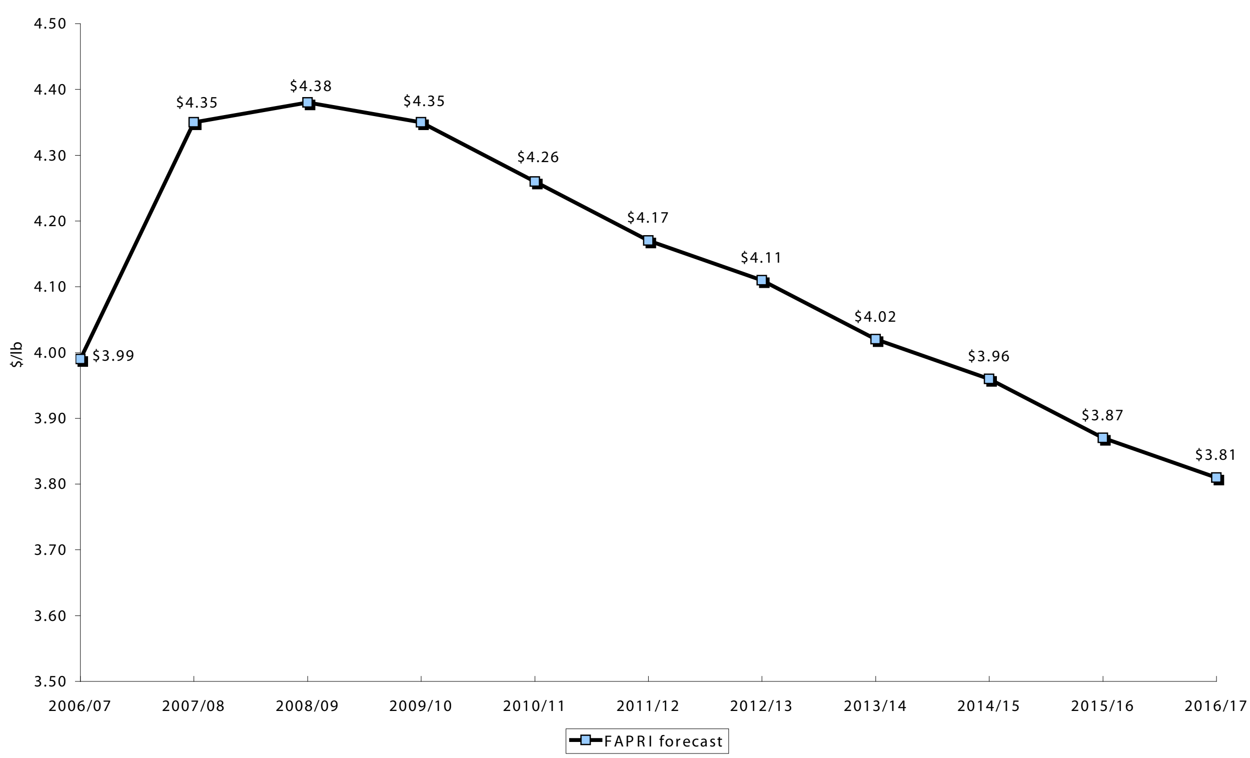


Figure 11. FAPRI 10-year Sunflower Seed Price Forecast (Nominal $/lb)



C. Food-grade Oil for Human Consumption[49]

The specialty food market can be an attractive market for oilseed growers, especially for those who have invested in a crusher/expeller and wish to maximize their investment. Specialty food products derived from oilseeds include cold-pressed bottled oil (often sold in natural food stores), or bulk sales to restaurants and producers of specialty sauces, salad dressings, baked goods, etc.

Markets for Edible Oil

In addition to olive oil, popular culinary oils include sesame, safflower, sunflower, grapeseed, canola, apricot kernel, coconut, hazelnut, hemp seed, peanut, pumpkin, and walnut oils. In addition to their culinary value, minimally processed or unrefined vegetable oils have health benefits documented by a significant body of research. Producing oilseeds to meet the demand for consumable oils in local markets presents new opportunities to expand the use and profitability of these crops.[50]

Although there are several potential markets for consumable oil sales, research tasks such as analyzing Vermont's vegetable oil consumption, projecting future pricing, and estimating the extent to which Vermont farmers or entrepreneurs could penetrate local markets were outside the scope of this project. These questions represent potential avenues for future research.

► Bulk oil sales – Sale of commodity-level oil is typically a low-margin enterprise and requires large-scale processing to take advantage of economies of scale. While a large grower (or group of growers) might be successful in this market, it will likely not be the most cost-effective option for most small-scale growers in the Northeast.

Catania Spagna, a Massachusetts-based supplier of retail, food service, bulk, organic, specialty, private label, and export food companies, reports that demand for energy crops is driving high prices for vegetable oils. Catania Spagna currently buys its oil from the Midwest (from ADM, Cargill, etc.) and expressed interest in more locally sourced oils produced in Vermont and New England. Their sales manager believes there is real market potential for Northeast oil.[51]

One alternative being explored in Canadian and New England markets is the feasibility of "leasing" filtered but unrefined bulk oil to restaurants for use in food fryers. Once the oil has been used, it is collected by the farm or fuel processor and then turned into biodiesel, rendering the oilseed crop useful as both a food and a fuel. This market requires further research.

► Direct retail oil sales – Retail sales of consumable oils offer the potential to greatly enhance the profitability of a growing and processing operation. Although start-up costs will likely be higher than with bulk sales, retail mark-up of oil products averages above 50 percent. Direct retail sales (i.e. via the Internet, farmers' markets, etc.) are well suited to organic

49 This section was contributed by Greg Strong, Spring Hill Solutions.
50 Kurki, A. and Bachmann, J. Oilseed Processing for Small-Scale Producers, ATTRA Publication #IP134, 2006.
51 Greg Strong personal communication with David M Mascioli, Industrial Sales Manager, Catania Spagna Corp, Ayer, MA, May 29, 2007

oils and could offer an opportunity to bring "designer" blended oils to specialty markets.

► Bulk seed sales – Another option is the sale of seeds directly to processors of food oil, animal feed, and other sub-products. Depending on the seed type and market condition, these buyers are often willing to pay a premium for organic and non-GMO seeds.

► Kosher oils – One largely unexplored option involves the sale of food-grade oil into kosher markets. This potentially lucrative niche market requires certification of equipment and processes consistent with kosher laws.[52]

Small-scale growers of oilseeds for food markets should also consider the possibility of adding value to their crops through contract processing, in which oilseeds are processed at a facility that serves one or more growers. Depending on the specific agreement between grower and processor, a contract processing arrangement can be a real benefit to growers interested in reaching any of the markets described above. While avoiding many of the start-up costs associated with purchasing equipment and establishing processing facilities, the grower will need to consider transportation, processing, and distribution costs when evaluating this option. A careful study of the size and needs of these markets, and development of a detailed enterprise budget, will be critical to success under a contract processing arrangement.

Edible Oil Prices

Current wholesale and retail price ranges for two organic and conventional food oils are as follows:

Bulk sales (to restaurants, specialty food manufacturers, etc.):[53]

- ► Conventional sunflower oil is selling for $1.0792 per pound, or $8.31 per gallon.
- ► Organic sunflower oil is selling for $1.4092 per pound, or $10.85 per gallon.
- ► Conventional canola oil is selling for $0.6092 per pound, or $4.69 per gallon.
- ► Organic canola oil is selling for $1.2492 per pound, or $4.69 per gallon.

Retail sales:[54]

- ► Conventional sunflower oil is commercially available for $2-4 per quart.
- ► Organic sunflower oil is available for $8-12 per quart.
- ► Non-organic canola oil is commercially available for $2-3 per quart.
- ► Organic canola oil is available for $10-12 per quart.

52 *Report On The Feasibility Of An Oilseed Processing Facility In Georgia*, Georgia Oilseed Initiative, Farmers Oilseed Cooperative, Inc.
53 Greg Strong personal communication with David M Mascioli, Industrial Sales Manager, Catania Spagna Corp, Ayer, MA, May 29, 2007.
54 Greg Strong personal communication with Jack Lazor, Butterworks Farm, March 21, 2007; retail and mail-order food companies prices from http://www.worldpantry.com.

D. Pellet Fuel[55]

Oilseed meals can also be used as a biomass fuel in furnaces or boilers designed for corn and/or biomass pellets. One such unit, manufactured by LDG, Inc of Pella, IA, (www.cornheat.com) was installed recently in a greenhouse at Walker Farm in Dummerston, VT with funding from UVM Extension. Oilseeds and seed meals will be test-burned at this facility in 2007. If successful, this type of heating system may be installed at State Line Farm's oilseed processing facility, where it could run on wood pellets, corn, or oil seeds/seed meal. Fuel may be an alternative use for oilseed meals that are not of sufficient quality to use as feed, but this area requires further study.

E. Fertilizer

Another potential area for further study is the use of oilseed meal as a fertilizer, especially if the meal is insufficient as a feed. Higher petroleum prices are increasing the cost of nitrogen fertilizer (urea) as well as diesel fuel, agricultural commodities, and livestock feed. Because oilseed meal is high in protein (containing amino acids) it is rich in nitrogen. Farmers could raise oilseed crops, extract the oil, and then return the meal to the field as fertilizer. The effectiveness of the meal as a fertilizer, and whether this approach is more economical than selling the meal for livestock feed or utilizing it as a pelletized fuel, are questions that require further investigation.

55 This section contributed by Vernon Grubinger, UVM Extension, "On-Farm Oil Seed Production and Processing." May 17, 2007; used with permission.

PRODUCING OILSEED CROPS, FUEL, FEED, & FOOD IN VERMONT

Massey Harris Combine, State Line Farm

Seed Press, State Line Farm

Biodiesel Processor, State Line Farm

VI. PRODUCING OILSEED CROPS, FUEL, FEED, & FOOD IN VERMONT

This section addresses the various equipment, processes, and challenges associated with growing oilseed crops and producing meal, oil, and biodiesel.

A. Crop Production[56]

Crop production information for oilseed crops such as canola, flax, mustard, soybean, and sunflowers is well established. The challenge is to learn which varieties, equipment, and agronomic practices work best in Vermont, and to design sustainable cropping systems that use resources wisely. In 2006, field-scale trials were conducted at **State Line Farm** and **Clear Brook Farm** in Shaftsbury, Vermont, and small-scale replicated trials were conducted by Dr. Heather Darby of UVM Extension and Roger Rainville of **Borderview Farm** in Alburgh, Vermont.

In 2007, on-farm trials were established at **TioGrain Farm** in Shoreham, **Boivin Farm** in West Addison, **State Line Farm** in Shaftsbury, and **Borderview Farm** in Alburgh. The 2007 season presented many challenges to the producers, but yielded much valuable information.

Collaboration is also occurring with nearby states doing similar work with oilseed crops and biodiesel production. Dr. Peter Sexton of the University of Maine has several years' experience working with farmers growing canola and Dr. Becky Grube at the University of New Hampshire worked with farmer Dorn Cox to conduct sunflower trials in 2006. There are plans to share information as these projects move forward.

All indications are that oilseed crops can be grown successfully in northern New England. Additional study and experience are needed to improve production methods, however, and thus optimize yields and economic returns. It will take several more years of research on species, varieties, seeding rates, seeding dates, fertility rates, and harvesting methods to make this system work well.

Seeds and Varieties

Vermont 2007 Field Trials

In 2007, the Shoreham site tested the Seeds2000 Defender, Interstate 6039, Interstate 6111, and Croplan803 varieties of sunflowers.

The West Addison site included four varieties of soybeans, all suitable for production on a conventional farm, and selected based on adaptability and enhanced oil content: Chemgro 4329, Pioneer 93M11, Croplan 4142393, and Croplan 11939-40. Five acres of KAB36 canola, a discontinued, open-pollinated variety, were also planted at this site.

56 This section was contributed by Vernon Grubinger, UVM Extension final report, "On-Farm Oil Seed Production and Processing," May 17, 2007 and Dr. Heather Darby and Karen Hills, Final Report, Project Title: Oilseed Research and Demonstration Trials, University of Vermont Extension, VSJF Grant #04-2007, December 2007; used with permission.

The Shaftsbury trial included six varieties of sunflower (Hysun1521, Interstate 6111, Seeds2000 Defender, Interstate 6039, IS6521 and IS4049) one variety each of mustard, canola (Croplan 601), soybean, and flax (golden). In addition to the oil-seed crops, three varieties of sorghum (Bella, Sugar Drip, and Umbrella) and three varieties of sugar beets (Beta 5310, Beta 5451, and M-64) were grown for potential use in biodiesel production.

Several replicated trials of canola and sunflowers were conducted at Borderview Farm in Alburgh. A canola variety trial with three varieties (Croplan 601, Croplan Python, and Oscar) was established to compare the yield of non-GMO varieties. A sunflower trial of early season varieties was also planted, including Seeds2000 Blazer, Croplan 803, Hysun 521, and Croplan 322NS.

Vermont 2006 Field Trials

The 2006 field trials in Vermont tested the following varieties of canola: KAB, untreated hybrid seed; 601 and Oscar, untreated and open pollinated seed (farmers could save their own seed from these crops); Hyola 401 and Hyola 420, treated hybrid seed. Also planted were open-pollinated, untreated Perdovia sunflower seed; and hybrid, untreated IS 6521 sunflower seed. Most canola seed comes treated with a systemic insecticide (e.g. Helix), but no losses with untreated seed were observed in Vermont.

New Hampshire 2006 Field Trials

Field trials in New Hampshire tested five sunflower hybrids from Interstate seeds, all downy mildew resistant: 378DMR, 343DMR, 3080DMR, 308NS, and 305DMR.

GMO Issues

The terms of this project prohibited the use of transgenic (genetically modified, or GMO) seed. This prohibition suits the production preference of many farmers in the region, especially organic farmers and those in transition to organic, such as State Line Farm.

Other farmers, however, will want to use transgenic varieties with herbicide tolerance for ease of weed control.

Use of non-GMO seed is especially important and challenging for canola. Crops such as soybeans and corn are easier to separate than canola, which is easily cross-pollinated over relatively long distances. Canola can also cross easily with wild mustard. This raises several concerns if canola becomes a popular crop in Vermont among both organic and conventional farmers. First, it is extremely difficult for producers in the United States to find commercial, non-GMO canola seed. Most seed companies carry only one or two conventional varieties that are not Roundup Ready. Three varieties are available from Croplan Genetics. It should be possible, however, to conduct breeding work in isolated areas to get a GMO-free line of canola. Second, although the organic standards generally accommodate use of seed with a low level of GMO contamination (out of necessity), additional contamination by cross-pollination from nearby GMO crops could pose problems in marketing organic products, such as organic canola seed meal. It may be advantageous to acquire non-GMO canola varieties from Canada or Europe.

If Vermont was able to develop (and protect from contamination) an organic canola seed industry, however, there appears to be significant market potential. According to a North Dakota Extension organic crops specialist, farmers there have trouble finding organic seed and the market for organic canola is strong.[57] This demand may be regional; Maine farmers working with Dr. Sexton found that they could not command a premium for their non-GMO canola crop in 2006.[58]

Field Cultivation

Crop Rotation

Rotation of oilseed crops is driven primarily by the need to control the major disease affecting these crops: white mold, or Sclerotinia. Soybeans, canola, and sunflowers are all broadleaf crops that are highly susceptible to white mold. It is therefore recommended that no single one of these crops be grown in the same or an adjacent field more than once every four years.[59] Air-borne spores may be released from old crop stubble for as long as three to four years. Non-host crops that could be used in rotation include forages, wheat, corn, or sorghum.[60]

Some herbicides used in corn and soybeans, particularly triazine and ALS (Group 2) products, can leave soil residues that may injure canola seedlings.[61]

Planting

Results of northern New England field trials recommend planting canola into a firm seedbed at a depth of 0.5 inches. Avoid deep planting, especially if the soil moisture is good. Try to plant early (similar to small grains); late planting appears to decrease yield. The 2007 results indicate that a seeding rate of 6–12 lbs/acre will provide optimum yields in canola. Seeding costs could be reduced by seeding at the 6-lb/acre rate. Heavier seeding rates of 22 and 29 lbs/acre resulted in severe lodging and would create disease and harvest issues. Row spacing does not seem to impact canola yield, but it may affect disease susceptibility. Wider rows may allow for more air circulation. Hardened seedlings are fairly frost-tolerant.

The following information on sunflower planting is adapted from the *Alternative Field Crops Manual* published by the University of Wisconsin and the University of Minnesota:

> *Major considerations for planting sunflowers are (1) firm placement of seed near moist soil, (2) absence of green vegetation during emergence, (3) maintaining an option to cultivate, and (4) reducing the risk of soil erosion. In northern regions, highest yields and oil percentages are obtained by planting early; in the northern Midwest and Canada this is often May 1–20. Resistance to frost damage decreases as seedlings develop into the 6-leaf stage, so sowing too early in the northern U.S. can be risky.*

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57 Personal communication with Heather Darby, UVM Extension, no date provided.
58 Personal communication with Heather Darby, UVM Extension, March 12, 2007.
59 Baute, Tracey, ed. Spring and Winter Canola: Planting and Crop Development, Agronomy Guide for Field Crops - Publication 811. Ontario Ministry of Agriculture, Food and Rural Affairs, 2002. Available at: http://www.omafra.gov.on.ca/english/crops/pub811/8dev.htm#crop.
60 Crop Profile for Sunflower in Kansas, April, 2001. National Information System of the Regional Integrated Pest Management Centers. Available at http://www.ipmcenters.org/cropprofiles/docs/KSsunflowr.html.
61 Baute, Tracey, Op. cit.

A planting date of early to mid-May is recommended in Minnesota and Wisconsin, which also applies to most of Vermont.

A planting depth of 1 to 3.5 in. allows sunflower seeds to reach available moisture and gives satisfactory stands. Deeper plantings have reduced stands and yields. If crusting or packing of the soil is expected, as with silt loam or clay soils, use a shallower planting depth. Sunflower row spacing is most often detemined by machinery available. In MN trials, sunflower yield, oil percentage, seed weight, test weight, height, and flowering date did not differ at narrow vs. wide rows over five plant populations. Hence, row spacings can be chosen to fit available equipment. Row spacings of 30 in. are most common.

Sunflowers can produce the same yield over a wide range of plant densities. The plants adjust head diameter, seed number per plant, seed size, to lower or higher populations, so that yield is relatively constant over a wide range of plant populations. Plant population does have a strong effect on seed size, head size, and percent oil.

A medium to high population produces higher oil percentage than do low populations, and the smaller heads dry down faster at higher plant populations. Recommendations in MN and WI are for 23,000 plants/acre (~3 lb seed/acre) for oilseed production. Some have suggested that north-south orientation of rows produce higher yields than east-west rows, but studies to examine this effect have found no differences in yield.[62]

Vermont 2007 Field Trials

The Shoreham sunflower trial was planted on May 9, 2007. The sunflowers were seeded in 30-inch rows at 22,000 seeds to the acre. The soil at the farm site was Vergennes clay. Dry conditions shortly after planting can be particularly problematic for germinating seeds in soils with high clay content, such as those at the Shoreham site.

The West Addison soybean trials were planted May 26, 2007. The soybeans were sown in 7.5 inch rows at 185,000 plants to the acre. The soil at the farm site was Vergennes clay. The Boivin Farm's 4 acres of KAB36 canola was seeded at 5 lbs to the acre in late June.

The trial at State Line Farm in Shaftsbury was planted on May 9, 2007. and included 6 varieties of sunflower and one variety each of mustard, canola, soybean, and flax (golden). In addition to the oilseed crops, three varieties of Sorghum and three varieties of sugar beets are being grown for potential use in biodiesel production.

The Alburgh canola trial was planted on May 23, 2007. Each 5 ft x 25 ft plot was seeded at 5 lbs to the acre and to a depth of 0.5 inches. The Alburgh sunflower trials were planted on May 23, 2007. Each 10-ft x 200-ft plot was planted at 27,000 plants per acre and to a depth of 1 inch.

62 Putnam, D.H. et al. Sunflower. Alternative Field Crops Manual. University of Wisconsin-Madison Extension and University of Minnesota Extension. Accessed at http://www.hort.purdue.edu/newcrop/afcm/sunflower.html on May 28, 2007.

Vermont 2006 Field Trials

The 2006 Alburgh canola crop trials were planted on a field scale. Three varieties (Croplan KAB36, Oscar, and Croplan 610) were grown and replicated three times throughout the field. Each replication was 16′ x 730′, or two passes of a drill down the length of the field.

New Hampshire 2006 Field Trials

Sunflower trials at the University of New Hampshire (UNH)'s Kingman Farm were conducted by planting six rows of five varieties over a 90′ by 400′ area.

Fertility

The recommended soil pH for canola is 6.0–6.3. Suggested fertilizer rates are as follows: N, 50 lbs per acre after clover, or 90 lbs per acre after small grains; B, 1 lb per acre; P and K, 70 lbs per acre. Fertilizer applications should be based on soil test results. Canola has responded well to manure application; in 2007 trials, it appeared that 90 lbs of nitrogen per acre provided a significant yield increase compared to lower rates. Crop rotation can also build the needed fertility.

In the 2007 Vermont field trials, fertilizer was used only in the canola trials at the Alburgh site; 100 lbs of 10-17-20 starter fertilizer was applied to the plots at planting.

The following sunflower fertility information is adapted from the Alternative Field Crops Manual published by the University of Wisconsin and the University of Minnesota:

> *Nitrogen is usually the most common limiting fertility factor for sunflower yield, but excess N fertilizer tends to reduce oil percentage of the seed, although yield increases from N fertilizer rates up to 175 lb/acre have been observed. Rates considerably lower than this are usually recommended. In the wetter regions of eastern and southern MN and WI, recommendations of approximately 18 lb N/acre after fallow or legume sod, 60 lb N/acre after small grain or soybean, and 80 to 100 lb N/acre after corn or sugarbeet are common. On higher organic matter soils, amounts should be lowered. Nitrogen can be supplied from mineral or non-mineral sources (manures, legumes, compost). Row placement of P and K may be important for maximizing efficiency of fertilizer use, as it is with many species. Sunflower is not highly sensitive to soil pH. The crop is grown commercially on soils ranging* in *pH from 5.7 to over 8, with 6.0 to 7.2 optimal for many soils.*[63]

Cultivation

In the 2007 Vermont field trials, both the canola and sunflower plots at the Alburgh site were treated with the herbicide Trifluralin prior to planting to control weeds. Based on experience at State Line Farm, weed pressure continues to be one of the main challenges to growing (and harvesting) canola and mustard. More effective organic weed control methods need to be developed for these crops. The following sunflower cultivation information is adapted from the ***Alternative Field Crops Manual*** published by the University of Wisconsin and the University of Minnesota:

63 Putnam, D.H. Op. cit.

> *Many different tillage systems can be used for sunflower production, including moldboard plowing or chisel plowing to invert residue plus several secondary field operations, or minimum till or ridge tillage.*
>
> *Sunflower is a strong competitor with weeds, especially for light, but does not cover the ground early enough to prevent weed establishment, so early season weed control is essential for good yields. Almost all North American sunflower plantings are cultivated and/or harrowed for weed control, and over two-thirds are treated with herbicides. Post-emergence cultivation with a coilspring harrow, spike-tooth harrow, or rotary hoe is possible with as little as 5 to 7% stand loss when sunflowers are at the four- to six-leaf stage (beyond cotyledon), preferably in dry afternoons when the plants are less turgid. One or two between-row cultivations are common after the plants are at least 6 in. tall.*[64]

Pests

Young canola seedlings are especially susceptible to flea beetles. Economic threshold is 25 % of leaf area loss. Most seed comes treated with a systemic insecticide, but no losses with untreated seed were observed in Vermont.

Cutworms are not frequently a problem. The economic threshold is 3 per square yard. The insects seem to prefer late-planted fields, tend to occur in late June, and can destroy a whole field in a few days. Cutworms may consume plants as they germinate and emerge, leaving the impression that the seed never germinated.

Vermont 2007 Field Trials

Birds were a major cause of sunflower seed loss in the 2007 growing season, confirming anecdotal information from a Vermont farmer who lost sunflower seeds to birds in 2005. Birds grazed the few sunflowers that germinated at the Shoreham site, leaving little for harvest. Sunflower plantings at both the Alburgh and Shaftsbury sites also experienced a level of bird damage.

Like many plantings of soybeans in Vermont in 2007, the soybean trial in West Addison had a severe infestation of soybean aphids. Fortunately, the growers had been scouting the field and were able to implement appropriate control measures.

Vermont 2006 Field Trials

The 2006 field trials in Alburgh noted the presence of European corn borer in canola stands, though likely with relatively little impact on yield. It may mean that canola will harbor this pest, however. No control methods have been developed, and probably are not needed.

Diseases

White mold, caused by the fungus *Sclerotinia sclerotiorum*, is a major destructive disease in oilseed crops. The fungus survives in the soil and attacks the roots first, causing wilting of leaves and rot. Cool nights and wet weather increase susceptibility to and growth of this disease.

According to Putnam et al, the most serious sunflower diseases are caused by fungi. In order of their effect on crop yield, these diseases include sclerotinia,

64 Putnam, D.H. Op. cit.

verticillium, rust, phoma, downy mildew. Resistance to rust, downy mildew, and verticillium wilt has been bred into some sunflower varieties.

Harvest and Storage

Harvesting and storage have thus far been the most challenging aspects of optimizing oilseed crop production in Vermont. Difficulties include scarcity of and familiarity with equipment, optimal timing, and having access to enough equipment to provide flexibility in using the best technique for a given crop and season. Veteran oilseed grower Ken Van Hazinga of Shoreham perhaps said it best: “You can’t have too many combines or methods of harvesting. You need to be able to pick the appropriate method as the year comes up.” Although it is clear that these crops grow well in Vermont, effective harvest and storage techniques are needed. The development of local expertise and information-sharing should help new growers.

Equipment

Harvesting soybeans, canola, and sunflowers requires either a **combine** or a **swather**. Access to a reliable combine that can handle the acreage planted in a timely fashion, when the crop is ready and weather is good, is a critical component of an oilseed farming enterprise. Finding harvesting equipment of the right type, scale, and price for small-scale oilseed production is challenging in Vermont.

New combines are likely to be prohibitively expensive to most Vermont farmers (new units typically cost over $100,000), and are too large for many Vermont fields and facilities. Buying used combines is much more realistic for farmers planning to grow oilseeds on a modest scale. Used combines are more readily available in western New York and the Midwest, and can be found for sale on websites such as www.tractorhouse.com. In May 2007, this site listed used combines in working condition for as little as $2,100 (1979 John Deere) and $5,500 (1981 International) with newer, larger units over $150,000. In Vermont, access to a combine, whether contracted or purchased, is generally easier in the Champlain Valley region than the rest of the state.

Owning a combine, especially an older model, requires mechanical skills or access to someone who can maintain and repair it, and a trailer large enough for transport, if desired. For these reasons, farmers may choose to hire a contractor for custom harvest rather than purchase their own equipment. Custom combining could represent new business opportunities in coming years as more farms add oilseeds to their crop rotations.

State Line Farm has a 1960s Massey Harris combine that harvested all its oilseed crops. It was purchased from a neighbor for $1,000, and John Williamson then spent many hours and $1,000 on parts refurbishing it to good operating condition. Dorn Cox in New Hampshire uses an old John Deere 12A with a 66-inch platform head that is pulled behind the tractor. He can combine one row of sunflowers at a time, at a decent speed. The combine does a good job, and has a bagger so it is easy to collect seed on a small scale. The fully adjustable fan speed and concave sieves allow it to be used on many kinds of crops, but it takes a long time to adjust it properly for different types of seed. Dorn also found it hard to get replacement parts, and in some cases he went to an industrial supply house to get parts custom-made.

For the 2006 field trials in Alburgh, Borderview Farm leased a commercial combine (John Deere 9500) and operator for harvesting. Direct harvesting of the canola with this equipment resulted in a large amount of green material in the harvested crop, which began to heat immediately in the gravity box. The combine was fine-tuned further, but enough green material was still present in the seed to pose a threat. Additional tuning to remove the green matter would have resulted in seed loss out of the back of the combine. Without a seed cleaner to immediately remove the foreign material, the crop would be lost, so harvest was stopped.

The next approach was to try swathing the canola first, then returning to pick it up with the combine. Swathing allows the plant to dry whole on the ground, avoiding the pod shattering that can occur when the plant is combined too dry. There are few swathers available to borrow or purchase in the New England area; an older swather was borrowed from Jack Lazor at Butterworks Farm in Westfield. The swather required some adjustment and workers faced a learning curve in using the swather correctly. Challenges included plugging, difficulty picking up the canola due to lodging, and poor cutting due to a dull cutter bar. After talking with a few farmers, it was recommended that a swather with “fingers” be used to prevent the canola from lodging.

When the combine returned to harvest after the swathed canola had dried, there were additional difficulties in picking up the canola. A special head for the combine would have helped. In addition, combining was difficult in areas where the canola was bunched from being plugged up in the swather.

Timing

Field moisture is important in determining when to harvest oilseed crops, especially canola and sunflowers. The plants should be as dry as possible for optimal harvesting and eventual storage. With canola, however, if plants dry too long in the fields, there is a high risk that the seed pods will shatter during harvest, resulting in seed loss to the ground. This is why swathing is a preferred technique for canola. Swathing lets the farmer cut the crop as the seeds begin to mature; the plants continue drying whole on the ground and can be picked up by a combine with the seed pod still intact.

Ideally, sunflowers should be left standing to dry in the field, but the length of the Vermont growing season sometimes makes this impractical. Moisture in the heads can harbor white mold, and cause them to get mushy.

Finally, for dairy farmers, optimal timing of forage harvesting may take precedence over oilseed harvesting. As a result, equipment may not be available when it is needed for oilseed crops.

Seed Cleaning

To make high-quality oil, enhance seed storage, and protect the seed presses, cleaning the seed to remove chaff, weeds, and other impurities is necessary. At State Line and Borderview Farms, batches of uncleaned seed stored with chaff caused the seed to heat up. This can reduce the quality of the seed meal, and potentially reduce oil quality if enough molding occurs. Sunflowers in both Vermont and New Hampshire trials were clean enough to press directly after combining.

Few in-state facilities for seed cleaning are currently available. State Line Farm purchased an Eclipse model 324 seed cleaner for $6,835. The operating speed depends on the seed type and level of "trash" in the seed—canola seems to go faster than sunflower seed, for example. If your combine does a good job, then it is a lot easier to clean the seed. The cleaner has hundreds of available screen sizes and types for different seeds that can be used in different configurations. Different screens may be required for the same crop because different fields have different weed seeds that can contaminate seed lots.

The Clipper uses three screens at a time. The first screen lets the small grain pass through and uses bouncing or shaking to remove or "scalp" anything bigger than the seed you are trying to clean. Then there is a series of two sieving screens that remove the weed seeds that are smaller than the crop seed. If there is a big variation in the crop seed size, you may want to run the batch through a second time to get the smaller crop seeds as well. In general, the bigger the seed, and the higher it is off the ground when combined, the easier it is to have clean seed after combining. Setting up a system to deliver and sort material to and from the cleaner can be complicated. The cleaner has one input stream and as many as six output streams. The farmer needs to have enough bins and adequate space to position them accordingly.

Drying & Storage

Adequate facilities for drying and storage are essential for successful oilseed crop production. Seeds that are stored too wet will mold. Canola combined green, for example, must be dried before being stored. The canola seed from the 2007 Alburgh trials heated immediately following harvest. The varieties were mixed in an attempt to dry the seed using an aerator, but unfortunately the seed still molded due to the heating. According to Vermont farmer Jack Lazor, sunflowers can be harvested at 19% moisture, but must be dried to a maximum of 13% moisture before storage. Harvest of the 2007 soybean crop at the West Addison site was delayed until after early December due to a lack of storage facilities. UNH had some problems with rotting of the seed heads in one of their plantings, and this bears further examination in trials. In the Vermont climate, air-drying is often inadequate, and farmers may require a blower dryer or propane heat, which adds expense. Farmers should also be aware of the potential fire hazards associated with grain dryers.

Yields

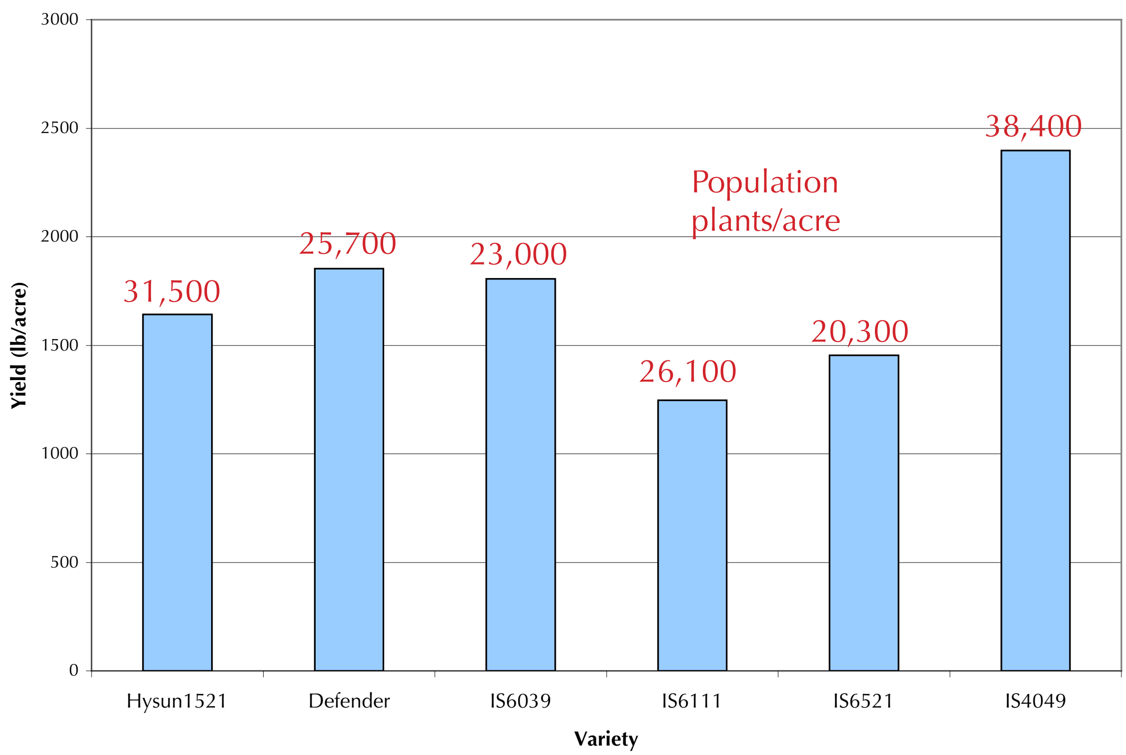
Vermont 2007 Field Trials

At the Shoreham site, the soil was extremely dry at seeding and there was no substantial rain at the site until three weeks after seeding. This resulted in a crop failure due to extremely low germination. The sunflowers that germinated and grew throughout the season were ready for harvest in early November, but unfortunately birds grazed the remaining sunflowers, leaving little for harvest. The Shoreham site was considered a complete loss.

At the West Addison site, the soil was also extremely dry at seeding and there was no substantial rain until three weeks after seeding. The soybeans experienced delayed emergence, but there was sufficient germination to continue the trial. The plants were ready for harvest in November, but were not harvested yet due to a lack of storage facilities. The canola planted at West Addison was harvested in November and yielded approximately 1.5 tons. The seed is being dried and processed for seed sale to local farmers in spring, 2008.

In Shaftsbury, the canola and mustard trials at State Line Farm were harvested on August 14. An extremely dry season led to earlier than normal harvests of the sunflower crop in September. The sunflowers were harvested with a two-row corn head modified to fit a combine. The moisture recorded at harvest was ideal for storage and for pressing. The sunflower yields were measured by harvesting the length (approximately 734 ft) of the field and measuring the weight of the harvested seeds. Yields appear to depend on variety, level of bird damage, and plant population. For example, hybrid IS6111 was the earliest maturing variety and also experienced the most bird damage; it also had the lowest yield compared to the other hybrids. It is also difficult to compare yields of the sunflower hybrids due to the high variation in plant population among harvested plots (Figure 12). The variation was most likely due to seed size differences at planting. Canola trials at Borderview Farm in Alburgh were harvested on September 5. Seed from the plots was weighed to calculate yield per acre. Non-GMO canola continues to yield well in Vermont; all yields were over 2,000 pounds per acre at this site, exceeding the national average of 1600 lbs per acre. The open-pollinated variety was the lowest yielding, whereas the hybrids performed similarly.

Figure 12. 2007 Sunflower Yields vs. Plant Population at State Line Farm



The Alburgh sunflower plots were harvested with an Almaco plot combine on October 17. The moisture content of the harvested sunflowers was 12.5% on average, higher than the 9% level recommended for storage and oil pressing. The harvest population was 21,000 plants per acre, considerably lower than the target population of 26,000 plants per acre. Yields were correlated to bird damage (Figure 13).

Figure 13. Impact of Bird Damage on 2007 Alburgh Sunflower Yields

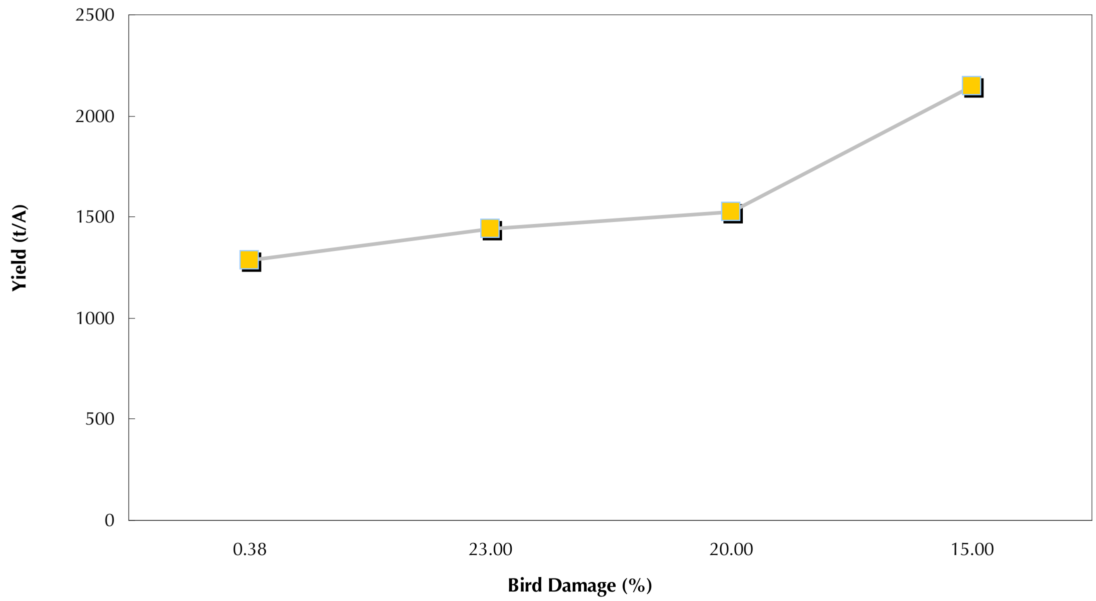


Table 9. Results Of 2007 Vermont Oilseed Field Trials

Crop	Variety	Date: Plant	Date: Harvest	Moisture	Yield (lbs/ acre)
TioGrain Farm, Shoreham, VT					
Sunflower	Seeds2000 Defender	May 9	*Crop failure due to low germination rate and bird damage*		
Sunflower	IS6039	May 9			
Sunflower	IS6111	May 9			
Sunflower	Croplan803	May 9			
Boivin Farm, West Addison, VT					
Soybean	Chemgro 4329	May 26	Not reported		
Soybean	Pioneer 93M11	May 26	Not reported		
Soybean	Croplan 4142393	May 26	Not reported		
Soybean	Croplan1193940	May 26	Not reported		
Canola	KAB 36	Late June	November	Not reported	500
State Line Farm, Shaftsbury, VT					
Canola	601	May 9	Aug 14	15.2%	792
Mustard	Golden	May 9	Aug 14	11.1%	861
Sunflower	Hysun1521	May 9	September	7.0%	1643
Sunflower	Defender	May 9	September	8.0%	1854
Sunflower	IS6039	May 9	September	10.0%	1806
Sunflower	IS6111	May 9	September	6.0%	1247
Sunflower	IS6521	May 9	September	8.0%	1454
Sunflower	IS4049	May 9	September	8.0%	2397
Borderview Farm, Alburgh, VT					
Canola	Croplan 601	May 23	Sept 5	Not reported	3160
Canola	Oscar	May 23	Sept 5	Not reported	2600
Canola	Croplan Python	May 23	Sept 5	Not reported	3360
Sunflower	Hysun1521	May 23	October 17	12.0%	1439
Sunflower	Seeds2000 Blazer	May 23	October 17	13.0%	2146
Sunflower	Croplan 803	May 23	October 17	12.0%	1247
Sunflower	Croplan 322NS	May 23	October 17	13.0%	1527

Vermont 2006 Field Trials

The Alburgh 2006 field trials yielded a respectable canola crop despite wet weather. Yields ranged from 20 to 35 bushels of canola seed per acre, or 0.5 to over 0.75 ton per acre. There were increased yields when canola was planted earlier in the season. A later planting date appeared to have an impact on yield.

As noted above, harvesting difficulties contributed to lower yield in Alburgh, where 2006 yields standing in the field appeared to be better than the previous year's, but post-harvest results were poorer. It appears that the yield potential was similar to yields in 2005, and that lack of experience in harvesting canola resulted in seed loss during harvest.

Field trial results at State Line Farm were more varied, with several crops lost to wet weather. Canola yields ranged from 15 to 28 bushels per acre. The sunflower crop, however, did well, with yields of 73 bushels, or just over 1 ton per acre.

The Clearbrook Farm fields in Shaftsbury were previously in field corn and herbicide residues appear to have caused crop injury. Canola stands were thin, probably due to low seeding rates and insufficient nutrition provided by 330 lb/acre of composted chicken manure fertilizer.

Table 10 gives results of all 2006 Vermont crop trials. Table 11 shows results of UNH's sunflower trials, based on harvest "samples" of the two 36-inch center rows of each variety.

Table 10. Results Of 2006 Vermont Oilseed Field Trials

Crop	Variety	Date			Moisture	Yield (lbs/acre)
		Plant	Emerge	Harvest		
State Line Farm, Shaftsbury, VT						
Canola	Hyola 401	May 9	May 16	Aug 25	7.7%	1404
Canola	601	May 9	May 16	Aug 25	7.9%	1128
Canola	Oscar	May 9	May 16	Aug 25	8.3%	996
Canola	Hyola 420	May 9	May 16	Aug 25	8.0%	984
Canola	KAB	May 9	May 16	Aug 25	9.4%	756
Sunflower	IS 6521	May 10	May 23	Oct 6	8.0%	2200
Soybean	IA 24, IF 61	May 10	May 25	*Crop failure due to wet weather*		
Clearbrook Farm, Shaftsbury, VT						
Canola	Oscar	June 13	Not reported	Sept. 15	~9%	471
Canola	Oscar	June 13	Not reported	Sept. 15	~9%	620
Sunflower	Perdovia	June 13	Not reported	*Crop failure due to herbicide carryover*		
Borderview Farm, Alburgh, VT						
Canola	601	May 19	Not reported	Not reported	13.6%	1750
Canola	KAB	May 19	Not reported	Not reported	12.0%	1608
Canola	Oscar	May 19	Not reported	Not reported	11.5%	1363
Canola	601	May 29	Not reported	Not reported	13.0%	1200
Canola	KAB	May 29	Not reported	Not reported	14.0%	1337
Canola	Oscar	May 29	Not reported	Not reported	12.4%	1000

Table 11. Results of 2006 University of New Hampshire sunflower field trials

	Yield per acre (lbs)		
Variety	Plot 1	Plot 1	Average
378DMR	1615.35	762.3	1188.5
343DMR	1687.95	562.65	1125.5
3080DMR	1343.1	689.7	1016.5
308NS	744.15	453.75	599
305DMR	780.45	326.7	553.5

Variable Costs of Production Per Acre

Enterprise budgets and production costs for growing soybeans in the Northeast are better established than those for canola and sunflower. Enterprise budgets are available for oilseed crops in traditional growing regions, but will vary across farms and regions, depending on the value of farm labor, the cost of using equipment, and the market price.

Soybeans

Former University of Vermont Extension agronomist Craig Altemose conducted field trials of soybeans in Vermont for several years in the late 1990s. Altemose estimated production costs for growing soybeans (Table 11) of $160 to $190 per acre, depending on the type of production (conventional vs. organic) and whether soybeans were planted following corn or a previous soybean crop. Table 12 shows non-adjusted cost data provided by Altemose for organic and conventional soybeans grown in 1999; both crops followed corn in the rotation.[65]

Canola and Sunflower

Canola enterprise budgets for conventional spring production suggest variable production costs between $100 and $200 per acre. Specific estimates include $107/acre (north-central North Dakota, 2007); $121/acre (Oklahoma, 2005), $136/acre (High Plains, 2006), $142/acre (Maine, 2003), and $206/acre (Ontario, 2007). Given that many Vermont farms will be less specialized and have small fields, costs can be assumed to be somewhat higher. Organic production may add cost, depending on whether organic fertilizers or insecticides are required, but costs may also be lower if manure is available for fertility and good crop rotations reduce the need for weed cultivation.

Sunflower enterprise budgets for conventional production range from $92/acre (north central North Dakota, 2007) to $107/acre (Nebraska, 2006) to $234/acre (Kansas, 2006).

For both canola and sunflower, a range of $150 to $250 per acre for Vermont production costs appears reasonable, including modest fixed costs. Results from 2005 and 2006 field trials in northern New England, shown in Tables 12 and 13, fall in the middle of this range.

65 Provided by Craig Altemose, Centre County Director, Agronomy, Pennsylvania State Cooperative Extension.

Table 12. Variable Costs of Soybean Crop Production

	Conventional Crop Management			No-herbicide Crop Management		
Item	Quantity	Cost/unit	Cost/acre	Quantity	Cost/unit	Cost/acre
Disc harrow (2x)	1 acre	$7.00	$14.00	1 acre	$7.00	$14.00
Chisel plow	1 acre	$11.00	$11.00	1 acre	$11.00	$11.00
Seed	1 bu	$22.00	$22.00	2 bu	$25.00	$25.00
Planting – 1 acre	30″ rows, 180,000	$7.00	$7.00	7″ rows, 220-260,000	$9.00	$9.00
Innoculant	1.25-2lb/a	$3.00	$3.00	1.25-2lb/a	$3.00	$3.00
Nitrogen	20 lbs	$0.30	$6.00	20 lbs	$0.30	$6.00
	Conventional crop management			**No-herbicide crop management**		
Item	Quantity	Cost/unit	Cost/acre	Quantity	Cost/unit	Cost/acre
Phosphorous	40 lbs	$0.30	$12.00	40 lbs	$0.30	$12.00
Potassium	80 lbs	$0.15	$12.00	80 lbs	$0.15	$12.00
Lime (pH 6.5-7.0)	1 ton	$20.00	$20.00	1 ton	$20.00	$20.00
Manure spreading/ trucking	1 acre	$15.00	$15.00	1 acre	$15.00	$15.00
Manure/compost applied to fill need			($30.00)			($30.00)
Herbicide		$35.00	$35.00		NA	NA
Rotary hoe	2x/acre	$4.00	$0.00	2x/acre	$4.00	$8.00
Avg land charge	1 acre	$30.00	$30.00	1 acre	$30.00	$30.00
Harvest	Chopping 1 acre	$20.00	$20.00	Combine @ 13%	$18.00	$18.00
Storage	As silage	$5.00	$5.00	Haul/ cool/store	$10.00	$10.00
Roasting	NA	NA	NA	1 acre	$25.00/ton	$27.00
Total variable costs			**$182.00**			**Raw $163.00 Roasted $190.00**

Table 13. Variable Costs of Canola Production, Maine 2005[66]

Item	Units per acre	Cost/acre
Land rent		$35.00
Soil test	0.08	$1.00
Harrow	Two passes	$16.00
Nitrogen*	70 lbs	$32.20
Boron*	1 lb	$2.20
Fertilizer application*	Custom application	$9.00
Trifluralin*	1.5 pint	$4.66
Herbicide application*	Custom application	$9.00
Seed	6 lb	$22.20
Seed drill	4 acres/hour	$10.00
Harvest	Custom combine	$25.00
Trucking	0.8 tons	$14.40
Storage	0.8 tons	$6.40
Management fee	5% of above costs	$9.35
Interest	10% for 6 months	$8.07
Total variable costs	***Conventional management**	**$204.48**
	Low-input management	**$147.42**

Table 14. Variable Costs of Canola and Sunflower Production, Vermont 2006

Item	Notes	Cost/acre	
		Canola	Sunflower
Soil test	$10 plus postage, 1 hour labor for 10 acres	$4.00	$4.00
15 tons farm manure	Assume $5/ton value	--	$75.00
0.5 ton 4-3-3 organic fertilizer		$100.00	--
Seed	6 lb @ $4; 4 lb @ $4	$24.00	$16.00
Manure or fertilizer spreading	1 hr for manure, 0.5 hr for fertilizer	$15.00	$30.00
Plow, disk harrow	0.5 hr	$15.00	$15.00
Weed cultivation	2 times	--	$30.00
Harvest	Includes emptying combine into bins	$30.00	$45.00
Plant winter rye	Cover crop—disk, seed, etc.	$40.00	--
	Total variable costs	**$228.00**	**$215.00**

66 Sexton, P. and Darby, H. 2005. University of Maine and University of Vermont canola trials.

Challenges and Opportunities for Oilseed Crop Production in Vermont

With good soil fertility and management, oilseed crops can be grown successfully in Vermont, with yields on par with standard levels. The greatest challenges to successful oilseed production in Vermont are lack of harvesting experience and lack of harvesting equipment suited for Vermont-scale production. Crops have been grown in the field with great success, but farmers lack the necessary equipment and experience to consistently bring the crop in at the moisture and quality level required for storage and processing.

Suitable oilseed harvesting equipment is scarce, potentially expensive, and unfamiliar to many Vermont farmers. Ideally, farmers could choose from a range of equipment and techniques to suit the particular harvest conditions of a given year. In addition, timing the harvest to obtain the optimal field moisture and getting seed to dry can be especially challenging in Vermont's cool, wet fall weather.

As more farmers experiment with oilseed crops, the development of local expertise and information-sharing among the farm and Extension community should help new growers. Farmers may also be able to share harvesting equipment, provided that participating farms are close enough together to make it practical to transport equipment between farms. Custom harvesting could represent a new business opportunity in coming years as more farms add oilseeds to their crop rotations.

B. Value adding: Small-scale Oil and Meal Production

Oilseeds have a relatively low value as a raw commodity, but require only that the farmer grow, dry, store, and/or transport the seed. Processing the seed into oil and meal adds value to the crop. The meal is a potentially valuable livestock feed, and the oil can be used for human consumption, burned directly in waste oil furnaces, or combined with alcohol and a catalyst (lye) to make biodiesel. Processing oil for human consumption adds the most value, but also adds food safety, regulatory, and marketing considerations.

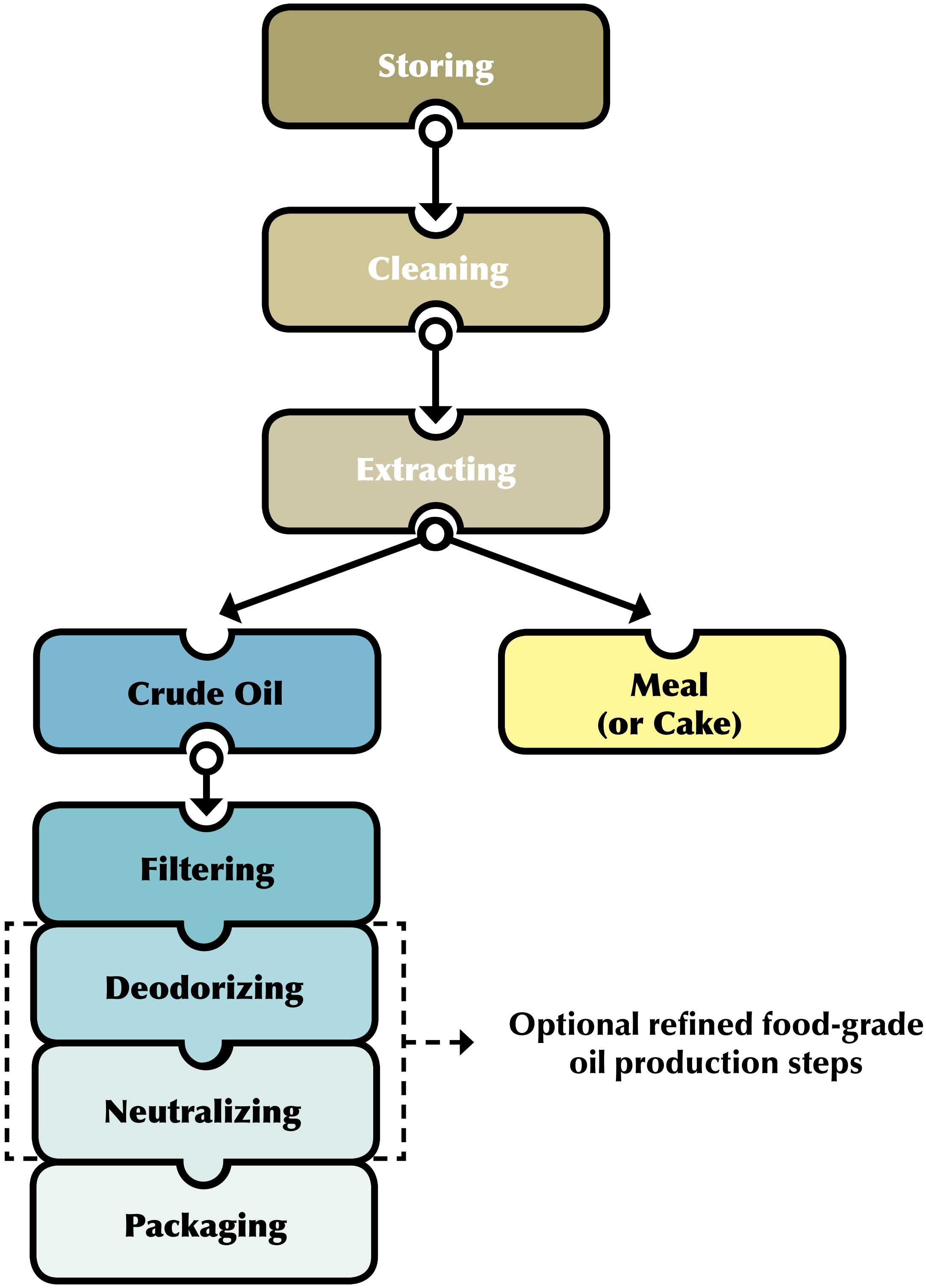
Oil Extraction and Processing[67]

After harvesting, cleaning, and drying, the oilseeds are "pressed" to extract the oil from the meal. The pressing equipment can range from a portable, bench-mounted device about the size of a large wood lathe, suitable for small-scale farm use, to much larger industrial units appropriate to a centralized processing facility. There are sizes and combinations of extruders, expellers, and presses to meet any scale of operation. Most oil processing in the U.S. is done on a large, industrial scale using proprietary processes. Small-scale oil extraction is more commonplace in other parts of the world; thus, many of the useful resource materials and appropriately scaled machinery come from other countries. More recently, however, there is growing U.S. interest in farm-scale extraction technologies, due to rising fuel and feed costs and increased interest in producing biodiesel and feed from oilseeds.

67 This section contributed by Greg Strong, Spring Hill Solutions.

Figure 14 illustrates a typical flow diagram for processing oilseeds for oil.[68]

Figure 14. Oil Production from Oilseeds



68 How to Process Oilseed on a Small Scale, http://www.howtopedia.org/en/How_to_Process_Oilseed_on_a_Small_Scale.

Extraction Methods

The method of oil extraction affects nutrient content and the meal's resulting value, both nutritionally and financially. The two methods most commonly used in the U.S and Canada are expelling and solvent extraction.[69]

► Expelling. A mechanical expeller consists of a motor-driven screw turning in a perforated cage. The screw pushes the material against a small outlet called the "choke." Significant pressure (hydraulic or manual) is exerted on the oilseed fed through the machine to extract the oil. Expelling is a continuous method and can reduce meal fat content to 6-7%, capturing 50%–85% of the available oil. Expellers cost from $5,000 to $50,000, depending on the size.

► Solvent extraction. Oil from seeds or the cake remaining after expelling can be extracted with solvents. The oil is recovered after distilling the solvent under vacuum. Hexane is the most commonly used solvent in industrial oil production processes because it is highly effective at extracting oil – capturing nearly 100% of the available oil. Hexane is a petroleum product and a known toxin, however, and can raise health concerns for the consumer. The use of hexane precludes the use of these facilities for manufacturing organic products.

Most on-farm or community-scale enterprises will find that expelling is the better extraction method, and further details on equipment are provided below. Solvent extraction, while highly efficient, involves substantial capital cost, is only economical at a large scale, and comes with health and safety risks from using inflammable and potentially toxic solvents. This study therefore assumes the use of expelling technology to produce oil.

The following four steps would take place after the oil has been separated from the meal, in order to market food-grade edible oil. Steps 2 and 3 may be optional, depending on the market. ***These steps (except for gravity filtration) are not necessary if the oil is intended for biodiesel production.***

1. Filtration

Crude, expelled oil likely contains solid particles, which can be removed by allowing the oil to stand and then filtering the clear oil by gravity through fine cloth. A more effective (and more expensive) method is to pump crude oil through a filter press

2. Deodorizing

Depending on the type of oilseeds processed, there may be trace compounds remaining in the filtered oil that give a taste and odor to the oil. These compounds are typically removed by distillation or a steam stripping process using low pressure and high-temperature steam. In most cold-press extraction systems, however, the deodorizing process is not needed, as long as the natural taste, smell, and color are acceptable to the end user.

3. Neutralizing

Neutralizing (also known as alkali-refining or caustic refining) is a process designed to neutralize free fatty acids present in the oil. This refining phase is important to remove the impurities in the oil, which have

69 See http://web.aces.uiuc.edu/intsoy/soyfood.html#Limitations for a discussion of alternatives to solvent extraction -- extrusion /expelling.

a tendency to turn dark when heated in the subsequent stages of the process. This step is not necessary if the oil is not heated above 100–120°F in any subsequent steps.

4. Packaging and Storage
Clean, dry containers should be used to package and store oils and help prevent rancidity. Sealed glass or plastic bottles are adequate. Colored containers in a dark box help to increase shelf life. The shelf life of oil is usually 6 to 12 months, if it is properly packaged and kept away from heat and sunlight.

Equipment and Facilities[70]

The specific equipment required depends on the particular crop being processed, the final oil quality required, and the scale of operation. The following discussion concentrates on one example: the extraction of sunflower and groundnut oil by cold-press expeller.

Oilseed Processing Facility
State Line Farm began its oilseed enterprise in the old dairy barn. That situation was far from ideal since old barns were not designed for this purpose, and are not suitable to optimizing efficiency, health, and safety. Pressing oil is not compatible with a barn or equipment shop because of dust entering the process, inevitable oil spills, and the need for separating processing from foot and vehicle traffic patterns.

Therefore, in 2006 State Line Farm constructed a dedicated facility for oilseed handling and processing. Before designing their building, John Williamson and Steve Plummer visited other places processing oilseeds and some that were making biodiesel on a small scale, such as Green Technologies in Winooski. Building from scratch allowed the facility to incorporate many desirable features to enhance energy efficiency, materials handling, and cleanliness.

The building at State Line Farm is 30′ x 50′ with a 16-foot interior clearance. It is built into a small hillside in order to use gravity as much as possible to feed raw seed into the building. When designing such a building, one needs to consider how the materials can flow through efficiently through all steps of the process, from input of seed to output of vegetable oil and/or biodiesel. At State Line Farm, locating the grain storage atop the hillside bank, where seed drops into a hopper in the upper level of the building, avoids the use of an auger to move seed, and reduces power consumption, potential damage to the seed, and noise of operation.

Once the seed is pressed, the oil and meal flow by gravity into separate containers. The building has large garage doors to allow easy equipment movement, and a dock for ease of deliveries. There is a pitched cement slab floor with a grated drain that can hold 1,000 gallons in the event of a spill. The floor also has radiant heat pipes that will eventually be connected to a boiler. There are windows with southern exposure to provide passive solar heat. When dealing with vegetable oil it is necessary to maintain some minimum winter temperature so the oil does not congeal.

70 This section contributed by Vern Grubinger, UVM Extension final report, “On-Farm Oil Seed Production and Processing,” May 17, 2007; used with permission.

The town of Shaftsbury was consulted before construction started, and considered the building to be an agricultural building for permitting purposes. This may not have been the case if the facility was not built on a working farm that was producing crops that would be stored and processed in the building.

Seed Presses for Fuel-grade Oil and Meal

State Line Farm purchased a Täbypressen (Tabby) model 70 seed press made in Sweden for $8,781.[71] The U.S. distributor is located in Magic Mill, New Jersey. This press is in the middle range of sizes available, capable of pressing one ton of seed per day, depending on the condition of the seed and how fast you press it. It has successfully pressed soybeans and canola, mustard, flax, and sunflower seeds. It can be adjusted to extract more or less of the total oil, affecting how much remains in the meal. Depending on feedstock and adjustment, it produces 1 to 3 gallons of oil per hour at State Line Farm (equating to 23,000-35,000 gallons of oil per year if run 24 hours per day). The press can run automatically for long periods of time. Seed must be thoroughly clean and dry before going into the press.

Electricity is used to power this mill, but it could be driven by a diesel motor. It has a 2.2-kW, 3 hp motor that runs at approximately 8 amps at 3 phase, using approximately 1500 watts. The unit has a heating collar on the nozzle which can improve meal quality by deactivating the trypsin inhibitors present in soybeans (see Section 5 below). There are electronic controls for variable speed of operation and counting of hours of operation, a voltmeter, and an automatic shutoff.

The automatic shutoff is an important feature for unattended operation. In addition to preventing damage if the screw press gets jammed, the unit also shuts off if there is an interruption in the flow of grain, or if the nozzle becomes too hot. State Line Farm learned that having a magnet is important to catch any metal that may be in the seeds. John Williamson installed a magnet over the stream of seed flowing into the mill after a bolt and a nut end got jammed in the press.

To press well, the seed has to have a moisture content of approximately 6% to 9%. If the seed is wet it does not flow through the nozzle well and if it is too dry the press grinds the seed to dust. When the Tabby press was first set up it was rigged to expel seed meal into a large wooden box. In some cases, tightly compacted seed meal (canola primarily) did not flow from the box into a gravity bin, from where it was to go into an outdoor bulk bin. The grain handling was redesigned to put small batches into polytarp totes, which facilitates handling and also will make delivery easier in the future.

Dorn Cox in Lee, NH, purchased a Chinese seed press from AGICO (Anyang General International Company Ltd. (www.ayimpex.com). The model is #GC80, rated for 200 lbs/hr, with a 7.5 hp, 3-phase motor, that Dorn runs off a 3-phase generator. He bought the unit directly from China for $1,100, including broker fees for customs; the total was about $2,000 after buying a frame and the motor.

With this unit, one has to manually adjust the tension on the concentric rings around

71 Täbypressen. http://www.oilpress.com/type70.htm.

the screw press in order to accommodate seeds of different oil content, and thus how much oil is extracted. If the setting is too tight, it backs up the oil into the screw, and the seed meal can pack into the grooves of the screw. If this happens, the unit needs to be disassembled. The operator therefore needs to watch carefully and make adjustments, taking into account that it requires about 40 minutes of operation for the unit to warm up fully. If the feedstock varies in oil content then readjustments may be needed, so a uniform seed supply is needed to run the unit without constant monitoring.

Dorn had challenges pressing batches of sunflower seed from a mix of different varieties. He is considering buying a larger, 10-ton unit, complete with frame and motor, and using direct diesel power. Then he could use the waste heat from the diesel engine to pre-heat the seed.

Roger Rainville of Borderview Farm researched oilseed presses that could handle 6 tons per day of canola and other oilseed crops. He found two companies in the U.S. that sell Chinese presses, and then visited Dorn Cox to see the Chinese press he had purchased. Roger also decided to order a press from AGICO because the price was low given the capacity and options. He ordered a model #GC-120A with a capacity of 6 tons per day, heated or cold press, with oil filters to filter the oil for $2,295. He also ordered a vibrating sieve seed cleaner with a rated capacity of 8-15 tons/hr for $2,065. In addition, he purchased spare parts (essentially all moving parts) for $320 for the seed press and $220 for the seed cleaner. Shipping cost was $920 to Montreal (close to his farm in Alburgh) plus $30 tax. There is no duty if the equipment is used for agriculture.

It is possible to get a broker to help with importing.

Roger's equipment will be single-phase, 220 volt. Three-phase models are available, but according to Roger, if the electric motor is less then 10 hp, the cost of the converter does not pay back. The press is also available with a diesel motor for additional cost. AGICO presses are available through some U.S. distributors, such as waldermfg.com, but the price is much higher. AGICO will ship individual presses, seed cleaners, and other equipment direct to a U.S. or Canadian port-of-entry.

Based on the experience of State Line Farm, farm-scale equipment for processing oilseeds into meal and oil is estimated to cost approximately $30,000 (Table 15).

Table 15 On-farm Oilseed Processing Equipment

Component	Cost
Oilseed press & accessories	$10,000
Oil tanks, seed meal totes	$ 2,000
Seed storage bin & drying bin	$10,000
Seed cleaner & accessories	$ 7,000
Miscellaneous	$ 1,000
Total	**$30,000**

Seed Presses for Food-grade Oil and Meal
A typical, small-scale, food-grade, oilseed production system can be assembled for approximately $6,000 and consists of the following components:

- Dehuller with blower to remove shell, capacity of 330 lb/hr
- Boiler, capacity of 110 lb steam/hr at 30 p.s.i.
- Cooker
- Expeller, capacity of 165–220 lb/hr
- Filter pump and press

The capacity of the small system described above is shown in Table 16:

Table 16. Food-grade Oil Press Production Capacity

	Lbs. processed/day	Lbs. oil produced/day	Lbs. cake produced
Sunflower Seed	1,585	350 (44 gallons)	1,150
Groundnut Seed	1,905	573 (72 gallons)	1,248

Health Regulations and Permitting[72]

It is important to remember that adding value by processing food products increases safety risks. Therefore, rules and regulations are established to protect the public health. Each state has its own regulations for processing kitchens, and some local governments have building codes that also apply. If there is any possibility that the producer will be selling food oil out of state, he or she must also comply with the federal regulations as stated in the Federal Food, Drug, and Cosmetic Act and enforced by the Food and Drug Administration (FDA).[73]

The FDA sets out Good Manufacturing Practices (GMP) upon which state regulations are based. GMPs include the following requirements:

- Walls, floors, and ceilings are washable, and the kitchen must be ventilated so that drip or condensation from ceiling or fixtures won't fall into food.
- Food contact surfaces, tools, and equipment must be resistant to corro sion and made of nontoxic materials.
- Seams on surfaces must be smoothly bonded to prevent accumulation of food particles, dirt, etc.
- The room must be screened to keep out birds, insects, and other pests.
- You must have a bathroom, if you have employees.
- You must have a hand-washing sink separate from sinks for washing, rinsing, and sanitizing equipment and utensils.
- Water must be from an approved source.

There may be additional state and local requirements.

72 This section contributed by Greg Strong, VSJF/Spring Hill Solutions
73 Born, H. and J. Bachmann. 2006. *Adding Value to Farm Products: An Overview*. NCAT Agriculture Specialists, ATTRA Publication #IP141.

Oil and Meal Yields[74]

Vermont 2007 Field Trials

Table 17 shows oil yields from 2007 Vermont field trials.

At State Line Farm, sunflowers were pressed for oil on October 24, 2007. For each of the six varieties, a 50-lb subsample was pressed and oil yield was measured. Oil yield for most varieties did not reach the 84-gal/acre yield of the variety grown in the 2006 trial. Three of the six varieties grown in 2007, however, exceeded the national average yield of 70 gal/acre. The variety seeded at the highest rate (IS4049) produced both the highest yield and the highest percent oil content, yielding 119 gal oil/acre. The IS6521 variety has an extremely high oil content and should be investigated further. These results suggest that plant population may have an effect on yield and oil content in Vermont's climate. More research is needed to determine ideal plant population.

Borderview Farm's sunflower and canola seeds were pressed for oil in November and December. For each of the four sunflower varieties, a 50-lb subsample was pressed and oil yield was measured. The Seeds2000 Blazer had the highest seed and oil yield compared to the other varieties. The higher moisture content may also have impacted oil content.

These were the first seeds to be processed through the seed press at Borderview Farm. As Borderview Farm became more familiar with the press and its operation, it was able to reliably extract 32% oil from sunflower seeds. Borderview Farm also showed a consistent 10% increase in oil extraction when sunflower and canola seed were double-pressed through the oil extractor. Moldy seeds had a lower amount of extractable oil on the first press than seed in good condition. However, 15% additional oil was collected when the moldy seed was double-pressed. Overall, there is potential to increase the percent of oil extracted from approximately 32% to approximately 42% by double-pressing. In other preliminary investigations, seed was processed through the press up to seven times. Additional oil (6-8%) was extracted from the meal up to the sixth pressing; on the seventh press there was no additional oil. An economic and energy analysis needs to be conducted to look at the feasibility of additional presses.

Borderview Farm also found that the meal can be processed into an extremely stable pellet when pressed at least twice. Pelleting after pressing may result in a pellet that has a longer shelf life than unpelleted meals.

74 This section contributed by Vern Grubinger, UVM Extension final report, "On-Farm Oil Seed Production and Processing," May 17, 2007 and Dr. Heather Darby and Karen Hills, Final Report, Project Title: Oilseed Research and Demonstration Trials, University of Vermont Extension, VSJF Grant #04-2007, December 2007; used with permission.

Table 17. Oil Yields from 2007 Vermont Field Trials

Crop	Variety	Moisture	Oil Content	Yield per acre Seed (lbs)	Oil (gall)
State Line Farm, Shaftsbury, VT					
Sunflower	Hysun1521	7.0%	29%	1643	64
Sunflower	Defender	8.0%	27%	1854	66
Sunflower	IS6039	10.0%	33%	1806	79
Sunflower	IS6111	6.0%	29%	1247	48
Sunflower	IS6521	8.0%	36%	1454	71
Sunflower	IS4049	8.0%	37%	2397	119
Borderview Farm, Alburgh, VT					
Canola	Blended - no mold	10%	32%	n/a	Not reported
Canola	Blended - moldy	11%	20%	n/a	Not reported
Sunflower	Hysun1521	12.0%	24%	1439	46
Sunflower	Seeds2000 Blazer	13.0%	29%	2146	83
Sunflower	Croplan 803	12.0%	24%	1247	40
Sunflower	Croplan 322NS	13.0%	24%	1527	48

Vermont 2006 Field Trials

At State Line Farm, there were challenges adjusting the seed press to properly extract the canola oil, and the canola seed had apparently absorbed moisture in storage. Running the seed meal through the press a second time tended to jam the press. A 100-lb sample of mixed canola varieties was subsequently dried by placing it near a woodstove for several days before pressing. That sample yielded almost exactly twice as much oil, 3.75 gallons or the equivalent of 52.5 gallons per acre given a 1,400-lb yield. This indicates the need to develop a seed drying system to effectively process stored canola seed.

The final oil yields from the 2006 canola seed grown in Alburgh were not as high as expected, based on results reported in many other locations, including Maine. As with canola seed from State Line Farm, this appears to be a problem with excess seed moisture which limits the ability of the Tabby press to fully extract the oil (Table 18).

Although oil yields are lower than expected, canola seed yields of 1 ton per acre should be achievable with optimum growing and harvesting practices; therefore 75 gallons of canola oil/acre is a reasonable expected "high yield" for Vermont.

Table 18. Oil and Meal Yields from 2006 Vermont Field Trials

Crop	Variety	Moisture	Yield per acre Seed (lbs)	Oil (gall)	Meal (lbs)
State Line Farm, Shaftsbury, VT					
Canola	Hyola 401	7.7%	1404	26	1205
Canola	601	7.9%	1128	19	985
Canola	Oscar	8.3%	996	11	910
Canola	Hyola 420	8.0%	984	18	846
Canola	KAB	9.4%	756	Press malfunction	
Sunflower	IS 6521	8.0%	2200	84	1563
Borderview Farm, Alburgh, VT					
Canola	601	13.6%	1750	24.1	Not reported
Canola	KAB	12.0%	1608	27.9	Not reported
Canola	Oscar	11.5%	1363	24.7	Not reported
Canola	601	13.0%	1200	22.1	Not reported
Canola	KAB	14.0%	1337	--	Not reported
Canola	Oscar	12.4%	1000	17.4	Not reported

New Hampshire 2006 Field Trials

Oil from the UNH Kingman Farm trial was processed by Dorn Cox at Tuckaway Farm in Lee, NH. Variety 378 was very easy to press, probably due to its low oil content, which kept it from backing up in the feed hopper. This problem can be avoided with better adjustment. Plot 2 was on shallower, sandy soil that produced plants of similar size but with smaller heads.

Table 19 shows oil yields from the UNH sunflower trials. This trial highlights the potential effects of soil quality and fertility on oil seed production, as well as the wide range of oil content in the seeds from different sunflower varieties. Their best yield was 75 gallons per acre, very close to the sunflower oil yield at State Line Farm. This suggests that sunflower may have greater potential as an oilseed crop for New England than originally expected. Additional varieties will be field tested during the 2007 growing season.

Table 19. Oil Yields from 2006 UNH Sunflower Trials

	Yield Per Acre						
	Seed (lbs)				Oil (gallons)		
Variety	Plot 1	Plot 2	Average	% Oil	Plot 1	Plot 2	Average
378DMR	1615.35	762.3	1188.5	26	56	27	41
343DMR	1687.95	562.65	1125.5	33	74	25	49
3080DMR	1343.1	689.7	1016.5	42	75	39	57
308NS	744.15	453.75	599	35	35	21	28
305DMR	780.45	326.7	553.5	37	39	16	28

In addition to the three crops involved in this study, other oilseeds are or could be grown in Vermont. Actual oil yields vary widely, but Table 20 gives a relative comparison of 'typical' oil and meal yields from 100 lbs of these various oilseeds.

Quality and Pricing

Food-grade Oil

Current wholesale and retail prices for organic and conventional vegetable oils are given on page 33, and range from \$5 to \$11 per gallon wholesale and \$8 to \$48 per gallon retail. Oil from crops grown in the 2006 Vermont and New Hampshire field trials has been used to make biodiesel, and has not been processed to meet food-grade quality standards. Income associated with food-grade oil production will vary depend on the type of oilseeds produced, production scale and method, and the markets where the oil is sold.

Meal for Feed

Samples of meal from 2006 soybean, canola, and sunflower seed pressed at State Line Farm were sent to the UVM Agricultural Testing Lab in October 2006. Samples of 2007 sunflower, canola, and moldy canola from Borderview Farm were sent to DairyOne lab in Ithaca, New York, in January 2007 and December 2007 for a comprehensive analysis of their components. Table 20 shows the results of these analyses.

Several aspects of the nutrient analyses are particularly important to understanding the potential value of these oilseed meals. The first crucial component is protein. Oilseed meals are used in livestock diets primarily to supply protein. All but one

Table 20. Typical Oil Yields from Various Oilseeds

Oilseed	Expected yield per 100 lbs seed
Rapeseed	37 lbs. (4.6 gallons)
Mustard	35 lbs. (4.4 gallons)
Hemp seed	35 lbs. (4.4.gallons)
Camelina	34 lbs (4.5 gallons)
Sunflower	32 lbs (4.25 gallons)
Soybean	14 lbs. (1.8 gallons)

sample of the farm-pressed meals had an available protein level of 30-50%, which is comparable with commercial feeds. (The 23% protein level on the January 2007 tested sunflower is below the normal range.

As or more important than the level of protein, however, are the quality and characteristics of the protein supplied. As discussed in Section V.B, *Livestock Feed*, different oilseeds contain different amino acids, and each species of livestock requires these amino acids in differing proportions. Further analysis is needed to determine the amino acid profile and true protein content of these meals, and therefore to establish the suitability of these meals for various animal species. University of Vermont Animal Science professor Matthew Waldron recommends conducting an in situ protein degradability test on several samples of meal. These tests involve placing meal in a nylon bag, incubating the meal in a cow's rumen for a period of time, and then analyzing the meal to see which components were used by the cow. These tests cost approximately \$100 per sample and can establish the percentage of rumen bypass protein and the amino acid levels of the feeds.[75]

75 Personal communication with Matthew Waldron, February 23, 2007.

Table 21. Nutrient Analyses Of Vermont-grown Oilseed Meals (Dry Matter Basis)

Components (dry matter basis)	Soybean Oct 06, UVM	Soybean Jan 07, DairyOne	Canola Oct 06, UVM	Canola Jan 07, DairyOne	Sunflower Oct 06, UVM	Sunflower Jan 07, DairyOne	Sunflower Dec 07, DairyOne	Canola Dec 07, DairyOne	Moldy Canola Dec 07, DairyOne
% Dry Matter	87.0	93.1	90.5	89.0	90.9	95.8	Not reported	Not reported	Not reported
% Crude Protein	54.4	40.0	39.0	34.7	33.8	23.2	35	30	29
% Available Protein	54.4	38.9	37.5	33.2	33.8	22.2			
% Acid detergent fiber	10.0	11.5	25.3	26.0	36.5	30.3	22	22	20
% Neutral detergent fiber	12.0	18.1	36.3	34.9	52.3	50.9			
% Fat	13.0	12.9	23.6	28.5	17.1	24.0	18	32	37
% Ash	5.7	6.0	5.9	5.1	5.3	5.3			
% Total digestible nutrients	97.8	92.0	105.3	100.0	92.6	87.0			

The second component of interest is fat. As discussed previously, commercial feed meals contain only 1% to 6% fat. As Table 21 shows, the fat content of these samples is quite high, ranging from 13% to 29%. The high fat content is undesirable for two reasons. First, it indicates that a substantial amount of oil is not being recovered from the seed, and is being left in the meal. Second, according to Dr. Waldron, although "in some species (such as swine or poultry), the fat in the meal may be a welcome source of energy, in other species we must be more careful about how much fat we feed."[76] Too many unsaturated fatty acids, for example, can inhibit pregastric digestion in ruminants (cows, goats, and sheep) and are therefore typically limited to 2–4% of dietary fat in these diets.[77]

Heat treating of the meal is another consideration. As discussed previously, "controlled heating of the meal is beneficial because it neutralizes anti-nutritional factors such as trypsin inhibitors." Trypsin inhibitors reduce digestibility of the meal, impairing animal performance and allowing more nutrients to pass through the animal, increasing potential environmental impacts (such as higher amounts of nitrogen excreted). An analysis of one State Line Farm soybean meal sent to Midwest Laboratories showed urease activity limited to 0.05 pH unit rise, indicating that adequate heat was applied to deactivate trypsin inhibitors. This sample indicates that the State Line press is capable of adequately heating the meal, but the test did not note the temperature or length of time that heat was applied. Further testing is required to establish the optimal time and temperature settings the press in order to deactivate the trypsin inhibitors.

Finally, when comparing the October results to the January results for each meal, the data in Table 21 also show significant variability, especially for the soybean and sunflower samples. As discussed in Section IV.B, *Purchasers: Aggregators of Vermont Demand*, the primary determinants of meal value are quality and consistency. If the meal producer cannot consistently guarantee minimum component levels (quality) from batch to batch, the value of the meal will be decreased. Protein levels and nutrient content can be affected by the field, crop, and processing techniques. It is therefore essential to perform further, frequent testing of meal samples to establish a consistent product. This will in turn allow the grower/processor to be able to command a more competitive price for the meal.

Based on the nutrient values of the soybean, canola, and sunflower meals pressed at State Line Farm and analyzed by DairyOne in January 2007, UVM Animal Science Professor Matthew Waldron used CNCPS software to determine how much, if any, protein in a high-producing (24,000 lbs/year) dairy cow ration could be replaced with on-farm pressed meal. To establish a baseline ration, Dr. Waldron made several protein sources available in the ration: 48% soybean meal at $278 per ton, soybean hulls at $200 per ton, SoyPass® (Borregaard LignoTech) meal at $330 per ton, AminoPlus® (Ag Processing, Inc® soybean meal at $313 per ton, and corn gluten meal at $447 per ton.

76 Personal communication with Matthew Waldron, February 23, 2007.
77 Hutjens, M. Feeding Soybean as an Economic Alternative. University of Illinois, Illini DairyNET. Accessed at http://www.livestocktrail.uiuc.edu/dairynet/paperDisplay.cfm?ContentID=627 on June 6, 2007.

Next, the State Line meals were assigned varying per-ton values, to see how much of the meal would be incorporated into the ration at different price points. For each meal, the ration was calculated at zero cost, $200 per ton, $228 per ton ($50 less than the current price of 48% soybean meal), $278 per ton (price of 48% soybean meal), and $313 ($35 above the price of 48% soybean meal). Forage and corn gluten meal were capped at maximum levels, and 48% soybean meal was set at a minimum level of 1.5 pounds. Together, the following Figures 15 through 20 show that farm-pressed meal indeed has significant potential to replace commercial meals in the feed ration of a high-producing dairy cow.

Figure 15 shows the amount of farm-pressed soybean meal (pounds per day) that was included in the feed ration at various price points. For example, at $0 cost for the State Line meal, the software predicted that 2.8 pounds would be fed. As the price for the farm-pressed meal was increased, the amount fed decreased. When the meal was assigned a value of $278 per ton (equivalent to the price of 48% soybean meal), only 1.87 pounds was fed. When the price was set above the price of commercial soybean meal, the farm-pressed meal was not competitive, and dropped out of the ration.

Figure 15. Farm-pressed Soybean Meal in Dairy Ration at Varying Price Points

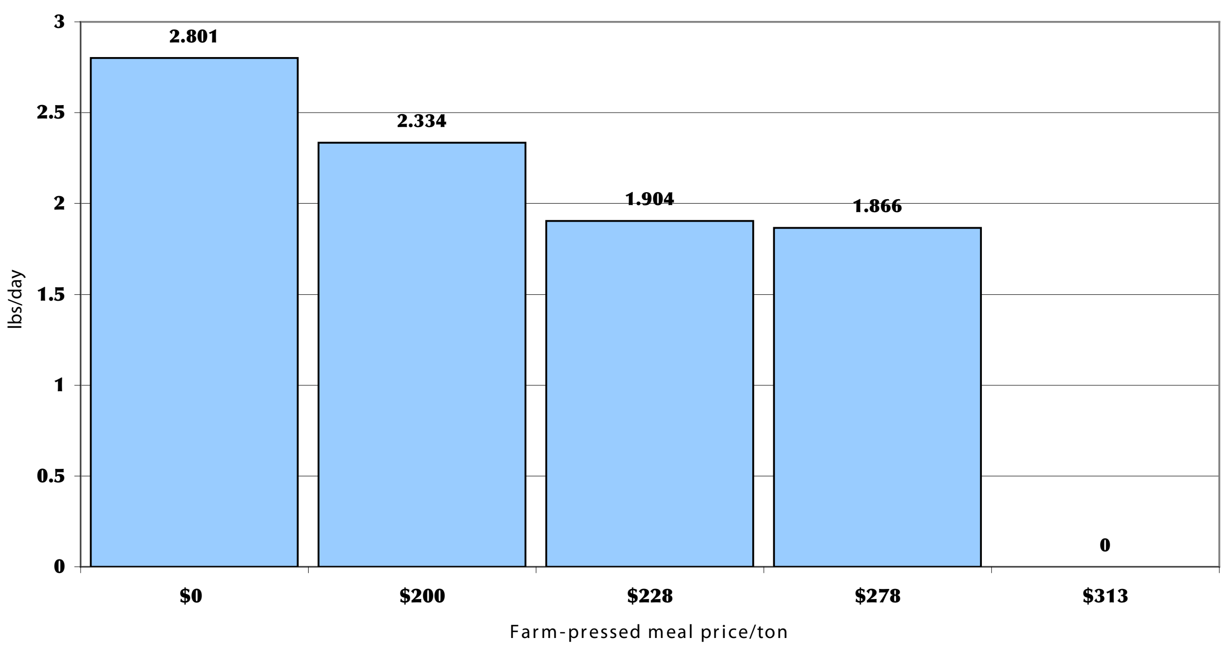


Figure 16. Protein Components of Ration for Varying Prices of Farm-pressed Soybean Meal

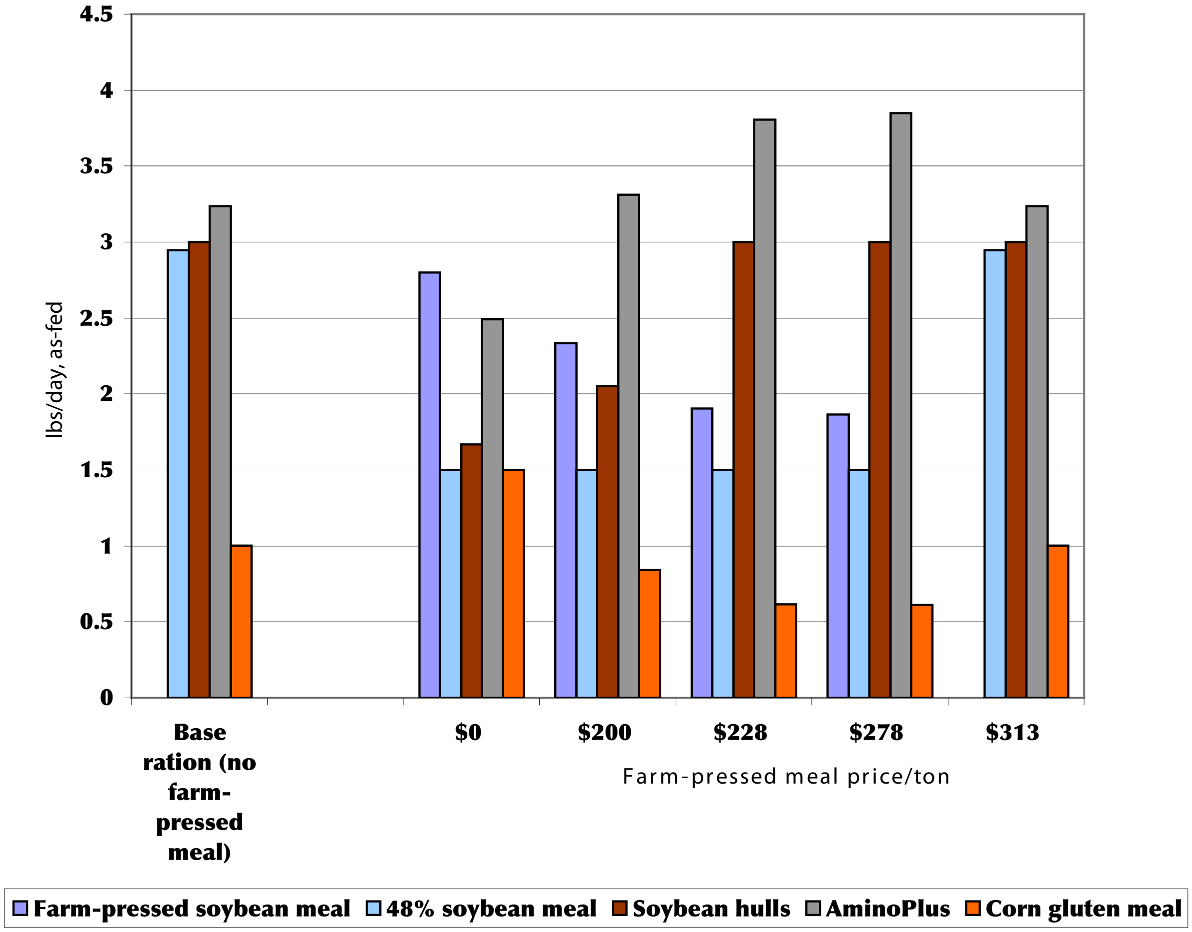


Figure 16 shows how the farm-pressed meal fits in with the other protein components of the cow's ration at various price points. The "base ration" includes no farm-pressed meal, and is the mix of protein sources the software assigns on a least-cost basis without farm-pressed meal available. When farm-pressed meal is made available, the software substitutes it for commercial meals, balancing the ration to optimize cost and nutrient intake/quality. As shown in Figure 16, the farm-pressed soybean meal replaces the maximum amount possible of the 48% soybean meal (set at 1.5 lbs minimum). As the farm-pressed meal gets more expensive, less of it is fed, but it is still a good value compared with the 48% soybean meal. To compensate for the decreasing amounts of State Line meal, more soybean hulls and AminoPlus are added to the ration.

Figure 17. Farm-pressed Canola Meal in Dairy Ration at Varying Price Points

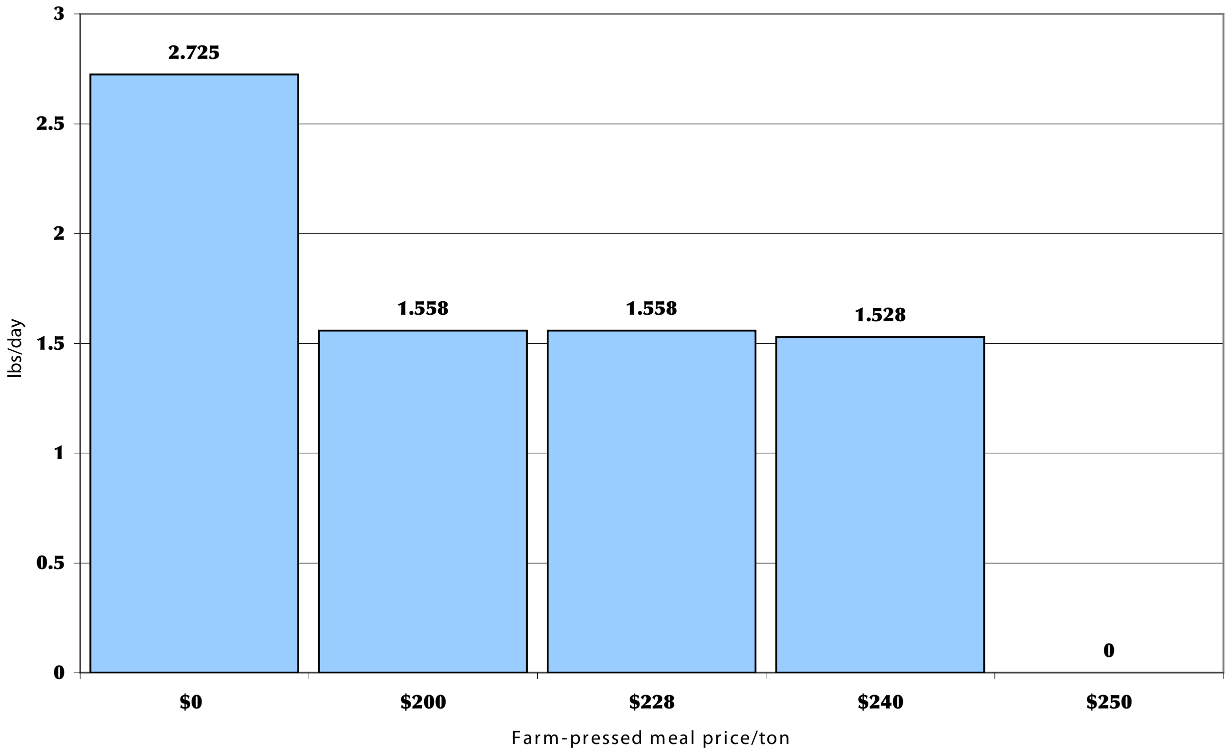
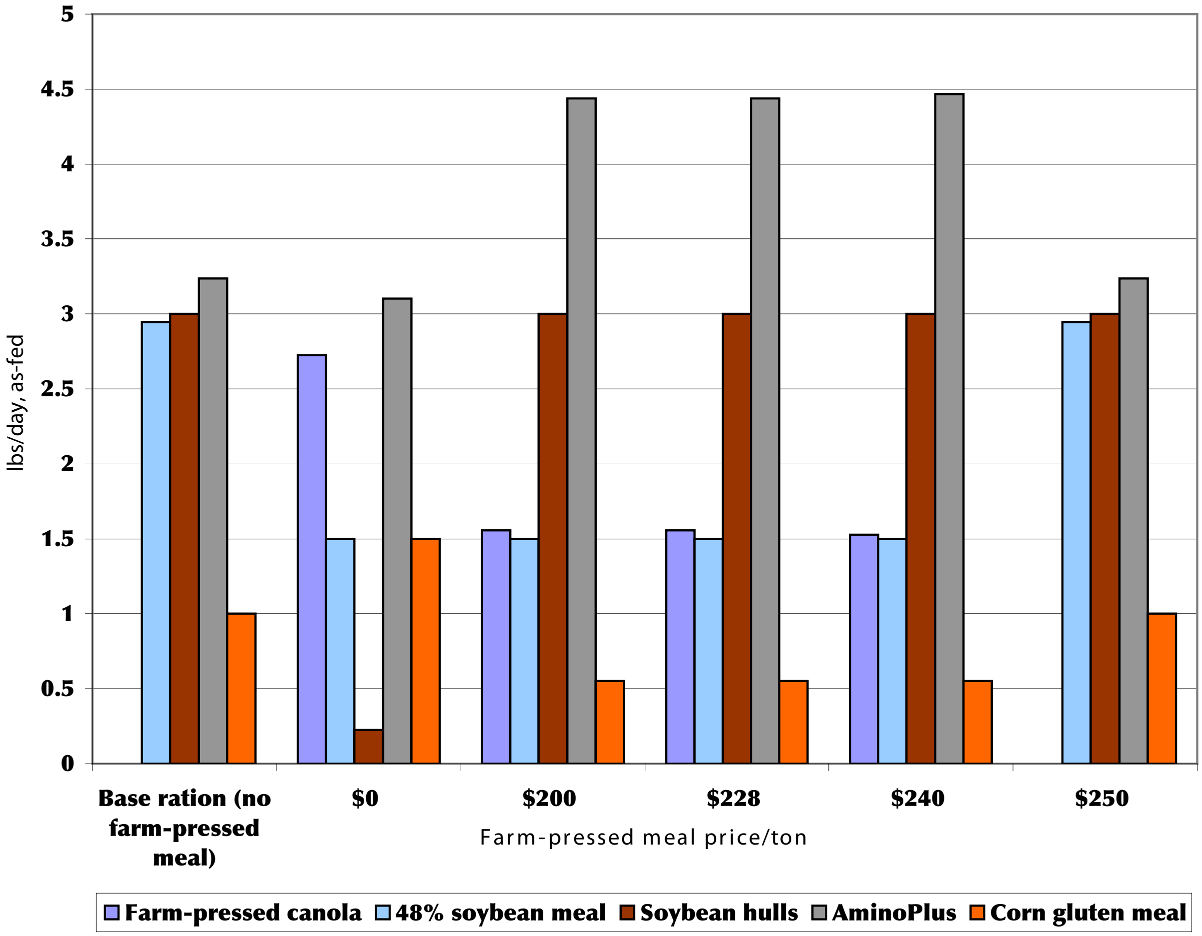


Figure 17 shows the amount of farm-pressed canola meal that was included in the feed ration at various price points. The inclusion of canola shows a different pattern than that of the farm-pressed soybean meal. At $0 cost for the farm-pressed meal, the software predicted that 2.7 pounds would be fed. Once the canola meal is assigned a cost, however, the amount included in the ration stays relatively constant, at approximately 1.5 pounds, until it drops out of the ration entirely at $250 per ton. According to the software's parameters, the farm-pressed canola meal is not as attractive a substitute as the soybean meal, and therefore will only be included in the ration if it is priced at a significant discount.

Figure 18. Protein Components of Ration for Varying Prices of Farm-pressed Canola Meal



Looking at the interactions between the farm-pressed canola meal and the other protein sources in the ration, Figure 18 shows that the farm-pressed canola meal also displaces approximately 50% of the 48% soybean meal, but its addition requires that higher levels of AminoPlus be added in order to balance the amino acids in the ration (recall that canola has a different and less attractive amino acid profile than soybean meal).

Figure 19. Farm-pressed Sunflower Meal in Dairy Ration at Varying Price Points

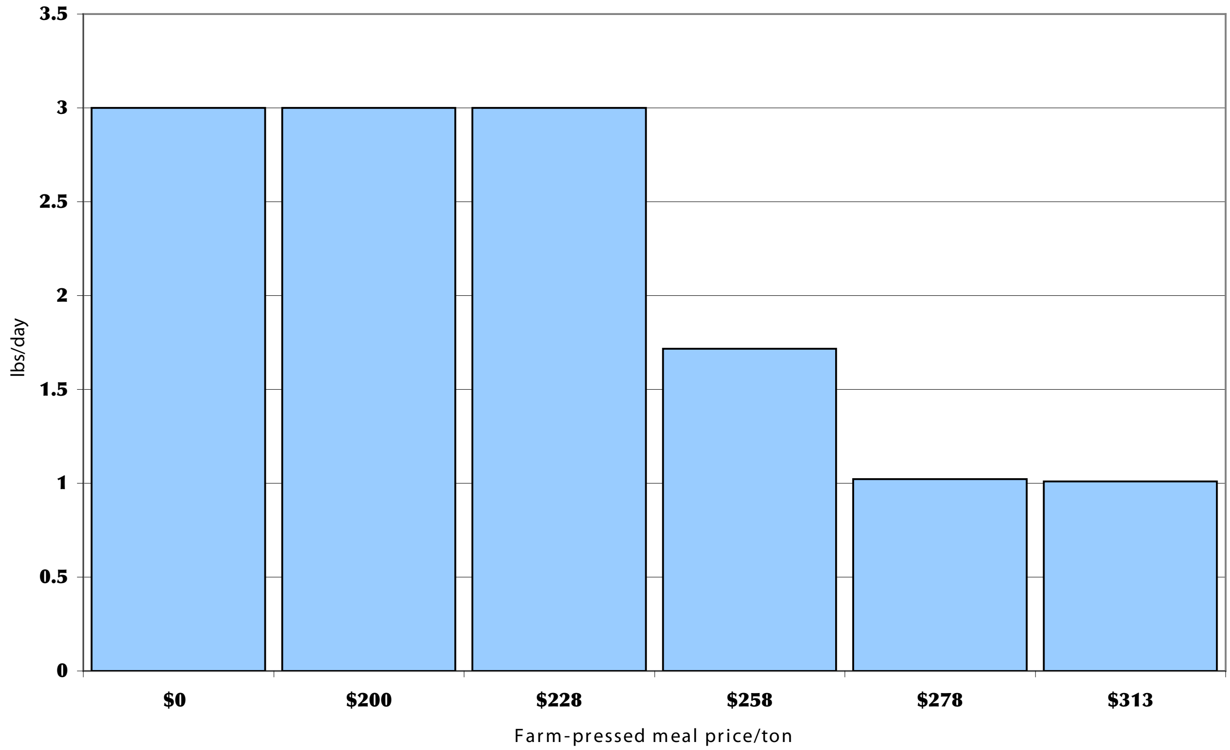


Figure 19 shows the varying amounts of State Line sunflower meal included in the feed ration at different price points. This meal sample fared the best, and was included at the highest levels by the software. In this case, Dr. Waldron set the maximum amount of sunflower meal that could be included at 3 pounds to limit the total fat in the diet. The software included the full 3 pounds of sunflower meal in the ration up to a cost of $228 per ton. When the price was set at $258 per ton, the amount fed dropped to approximately 1.5 pounds, but about 1 pound of State Line sunflower meal was included even when its price was set at or above the price of 48% soybean meal.

Figure 20. Protein Components of Ration for Varying Prices of Farm-pressed Sunflower Meal

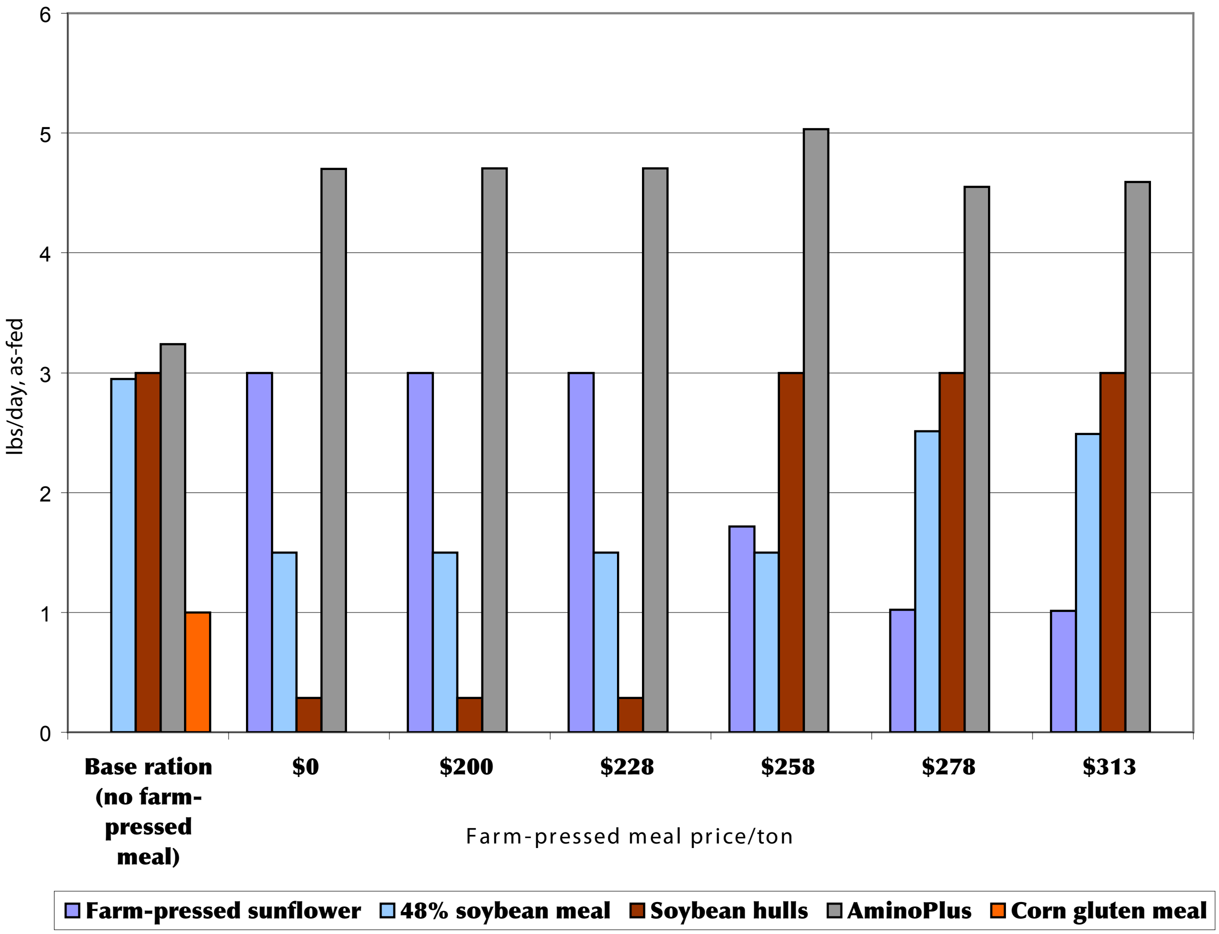
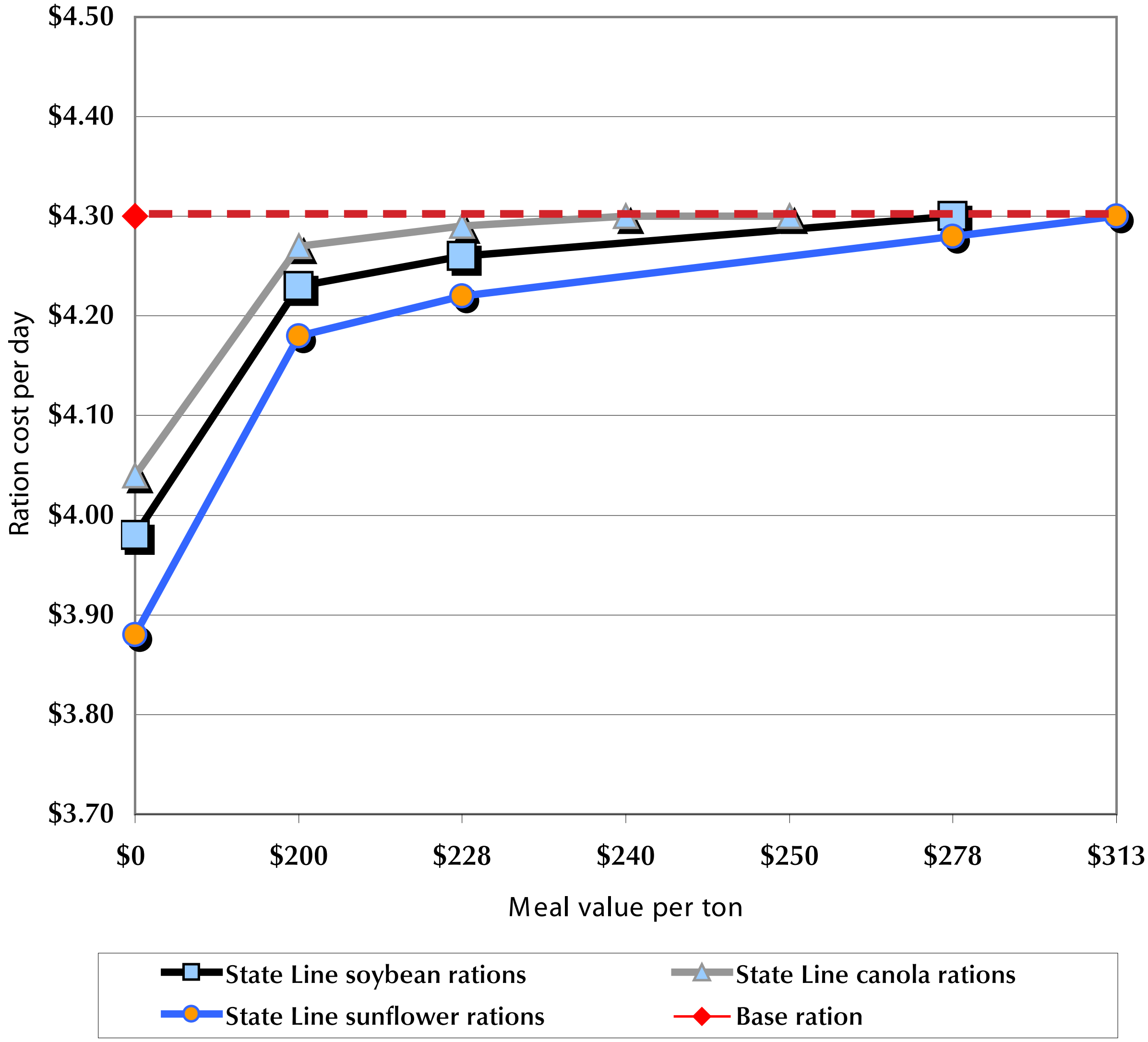


Figure 20 shows that the farm-pressed sunflower meal displaces approximately 50% of the 48% soybean meal, as well as most of the soybean hulls. (Because the sunflower meal includes the ground up sunflower hulls, it has a relatively high fiber content and can replace the fiber from the soybean hulls.) The addition of sunflower meal also requires an approximately 50% increase in the level of AminoPlus fed. As with canola, this is to balance the amino acids in the ration.

Another important consideration in this analysis is the feed cost per day. The base ration (without any farm-pressed meals) has a cost of $4.30 per day. None of the other rations that include farm-pressed meals exceed this cost, and many of them fall below this level when the price of the farm-pressed meal is discounted below that of commercial meals (Figure 19). Each pound of local soybean meal, for example, saves 11 cents per cow per day if it is free, but only 3 cents per cow per day if it costs $200 per ton, and there is no savings if it is priced at $278 per ton. Similarly, each pound of local canola meal saves 10 cents per cow per day if free, but savings diminish quickly when the meal assigned a price – at $200 per ton, for example, the per-pound savings per cow per day drop to only 2 cents. Local sunflower meal fares best, with each pound of meal saving 14 cents per cow per day when free, 4 cents per cow per day at $220 per ton, and 2 cents per day up to $278 per ton.

Figure 21. Daily Cost Per Cow of Feed Rations with Farm-pressed Meal



Figures 21 through 24 show how these small per cow per day savings would translate to annual feed savings for a 100-cow herd for each of the three farm-pressed meals. Based on the rations calculated including farm-pressed meals, estimated annual feed cost savings for a 100-cow herd range from $365 (local canola meal priced at $228 per ton) to $15,330 (local sunflower meal at no cost).

Figure 22. Estimated Annual Savings Using Farm-pressed Soybean Meal for 100-cow Herd

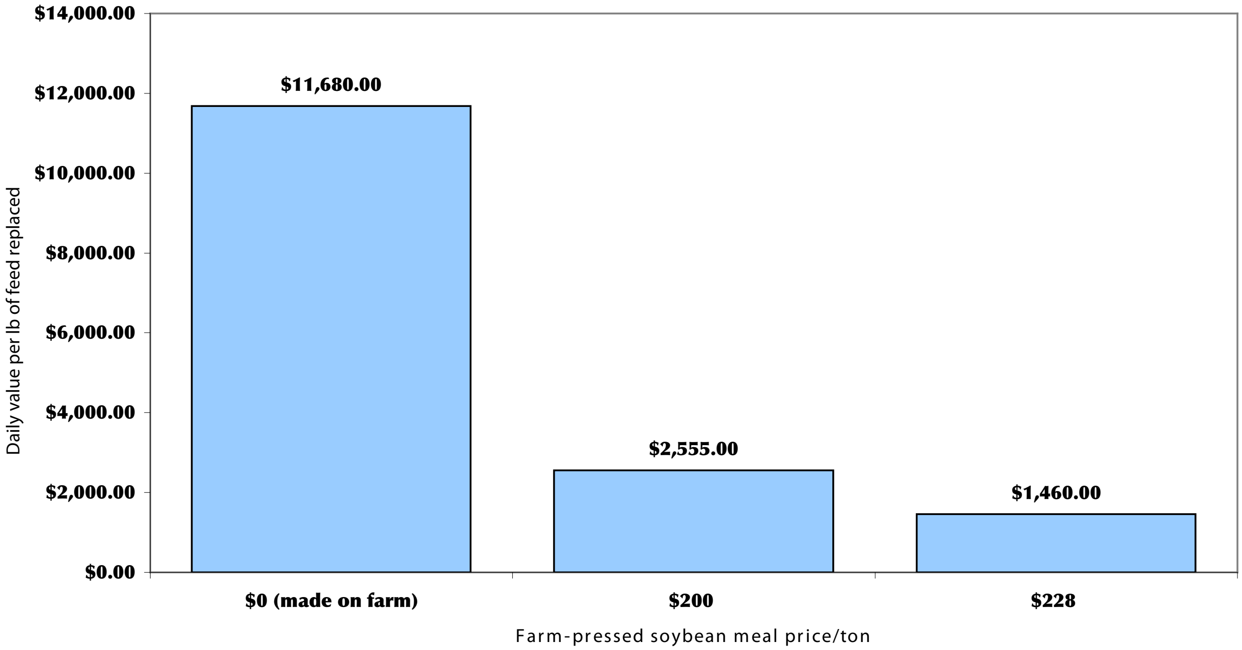


Figure 23. Estimated Annual Savings Using Farm-pressed Canola Meal for 100-cow Herd

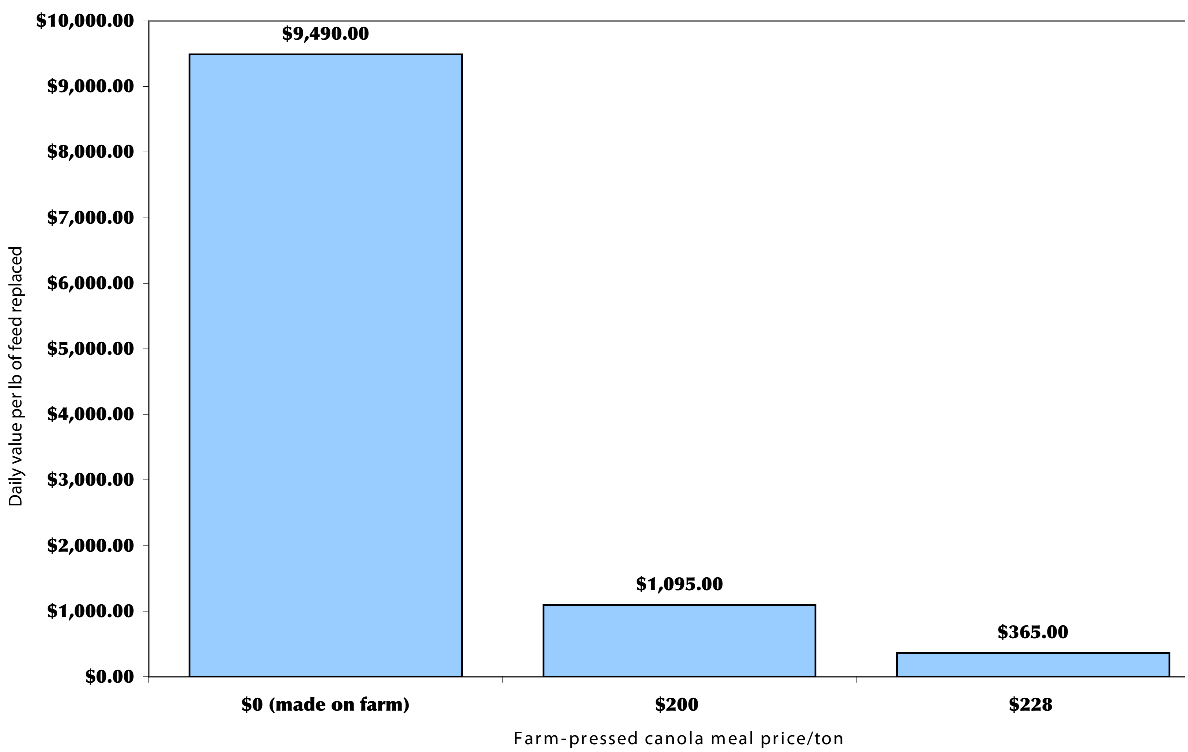
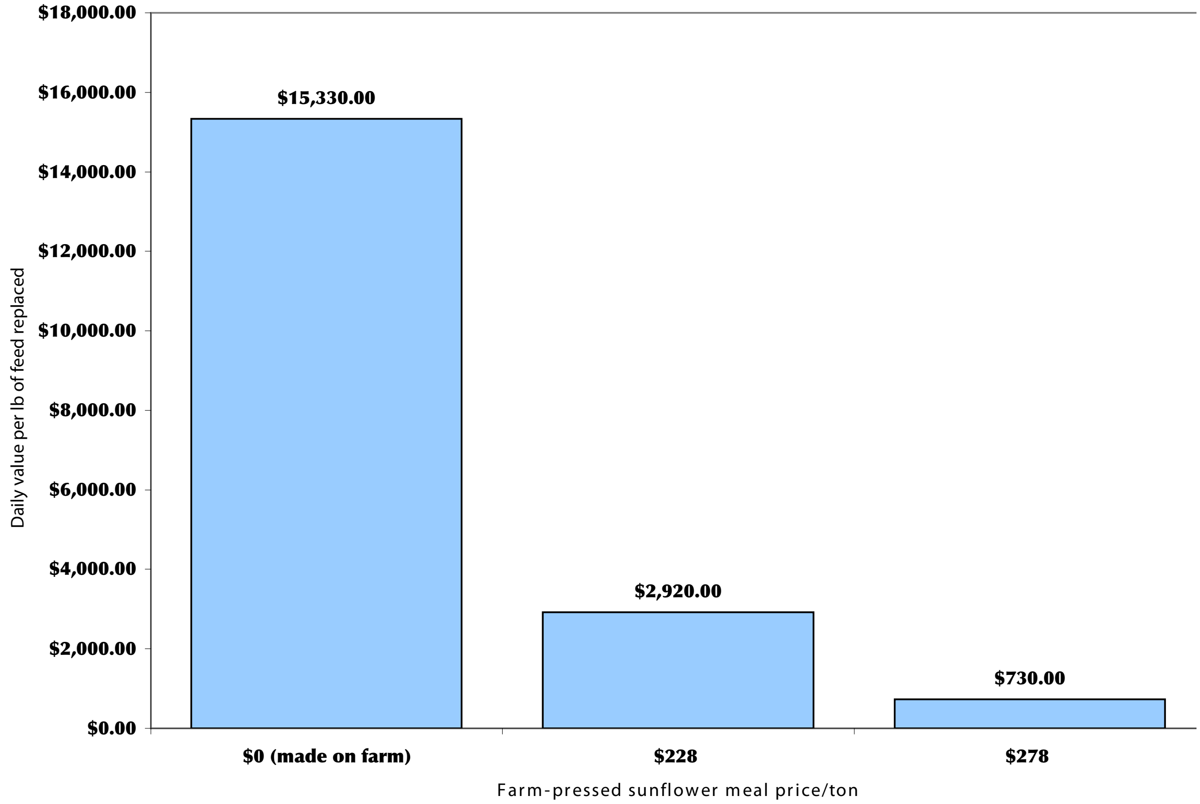


Figure 24. Estimated Annual Savings Using Farm-pressed Sunflower Meal for 100-cow Herd



In general, using farm-pressed meal reduces daily feed costs only if the local meal is priced at a discount. These savings would produce a net gain for the farm only if milk production (and therefore revenues) does not suffer as a result of the change in the cows' diet. If the switch to farm-pressed feed were to cause a drop in milk production and farm revenue, the farmer would be no better or even worse off.

For these reasons, the importance of establishing consistency and quality of farm-produced meals cannot be overstated. If the local meal is not of guaranteed quality and consistency, it represents a major risk to the farmer in terms of its potential to reduce milk production and decrease revenues. Without quality assurance, farmers' only incentive to buy locally produced meal would be if it is available at a significant discount, reducing revenue potential for the oilseed grower/meal producer. If the meal's quality can be assured and it can be priced more competitively, the CNCPS software shows that as the price of farm-pressed meal approaches that of commercial meals, the feed cost per day approaches that of the base ration, and the savings to the farmer of using local meal is reduced. In other words, when the price differential is removed, the two meals are competing solely on quality. Quality must therefore be assured to make locally produced meal competitive with commercially produced feed meals.

In sum, beyond simple cost savings, a farmer's decision to include the meal in a feed ration will also depend on several other logistical factors, such as the amount of meal processed, the consistency and reliability of supply, the need for feed analyses for each batch to ensure quality and consistency, and the effort needed to mix the meal. These factors will vary from farm to farm.

C. Value Adding: Biodiesel Production

Oilseed producers may also choose to develop small-scale biodiesel production capacity, either to reduce fuel costs by using the biodiesel on the farm, or to increase farm revenue by selling the fuel. Farm-produced biodiesel can be sold directly to end-users in the "off-road" market—for use in farm, construction, or marine equipment; heating; or running diesel generators. Production of biodiesel for use by vehicles traveling public roads requires an expensive licensure and permitting process that may be too burdensome for small producers. This report is intended to provide information regarding equipment, start-up costs, and other issues related to establishing a small-scale or on-farm biodiesel enterprise, and is not intended to be a "how to" guide on biodiesel production. More information on the mechanics of biodiesel production can be found at www.journeytoforever.org or www.biodiesel.org.

The process of refining vegetable oil into biodiesel fuel is called transesterification, in which alcohol (ethanol or methanol), and a catalyst (potassium or sodium hydroxide) are combined to separate the alkyl esters (biodiesel) from the glycerin in the seed oil. The resulting oil is a pale yellow, medium-light, non-toxic, and combustible fluid.

Table 22 shows the relative levels of inputs and outputs involved in biodiesel production. It takes just over 1 gallon of oil to produce 1 gallon of biodiesel.

Table 22. Biodiesel Production Input and Output Levels[78]

Process Input Levels		Process Output Levels	
Input	Volume percentage	Output	Volume percentage
Oil or fat	87%	Ester (biodiesel)	86%
Alcohol	12%	Alcohol	4%
Catalyst	1%	Fertilizer	1%
		Glycerin	9%

Equipment and Facilities

Producers can assemble biodiesel production systems with stock equipment or purchase turnkey units of different capacities "off the shelf." Because the process is not difficult to master and the equipment is relatively affordable, biodiesel can be produced in small batches (60–100+ gallons at a time) for on-farm use, as long as appropriate safety procedures and precautions are followed.

Every biodiesel production system contains several basic elements; in general, a processor consists of several tanks linked by piping, pumps, and valves. The "tank farm" typically includes a tank for producing and settling the biodiesel, a tank for mixing the methanol, and tanks for storing oil, glycerol, and finished biodiesel. Heating elements are sometimes included, and the system often includes electrical controls and switches. Other equipment expenses include a filtration system to remove impurities from the finished product, fireproof storage for methanol, and titration and testing equipment. If you will be storing more than 1,320 gallons of fuel or vegetable oil on your premises, the Environmental Protection Agency requires that you have a Spill Prevention, Control and Countermeasure (SPCC) plan and a facility that provides "secondary containment" (typically concrete).

Scott Gordon, owner of Green Technologies, LLC in Winooski, Vermont (a small commercial biodiesel producer), recommends that would-be processors consider their investment timeline in determining what kind of system to purchase. If getting up and running quickly is a priority, a starter kit may make sense. These kits can be added to in a modular fashion if more capacity is needed. If one's business plan is to establish a system that can support reliable, growing production over a longer term, however, greater initial capital investment in larger, higher quality equipment may make more sense. Buying the largest possible tanks up-front will save money in the long run by obviating the need to replace them. Good design is crucial to implementing an efficient system that will have a useful life long enough to create a return on investment.

The size of one's system will also be limited in part by the size and characteristics of the space or facility available for biodiesel production. Larger tanks require high ceilings. Handling vegetable oil and methanol present unique concerns—wood walls, for example, can quickly become slippery. Having dedicated tanks for each purpose, which increase efficiency (as opposed to "multi-task" tanks) requires adequate square footage. Processors must find the optimal balance among the cost factors of efficiency, safety, and throughput.

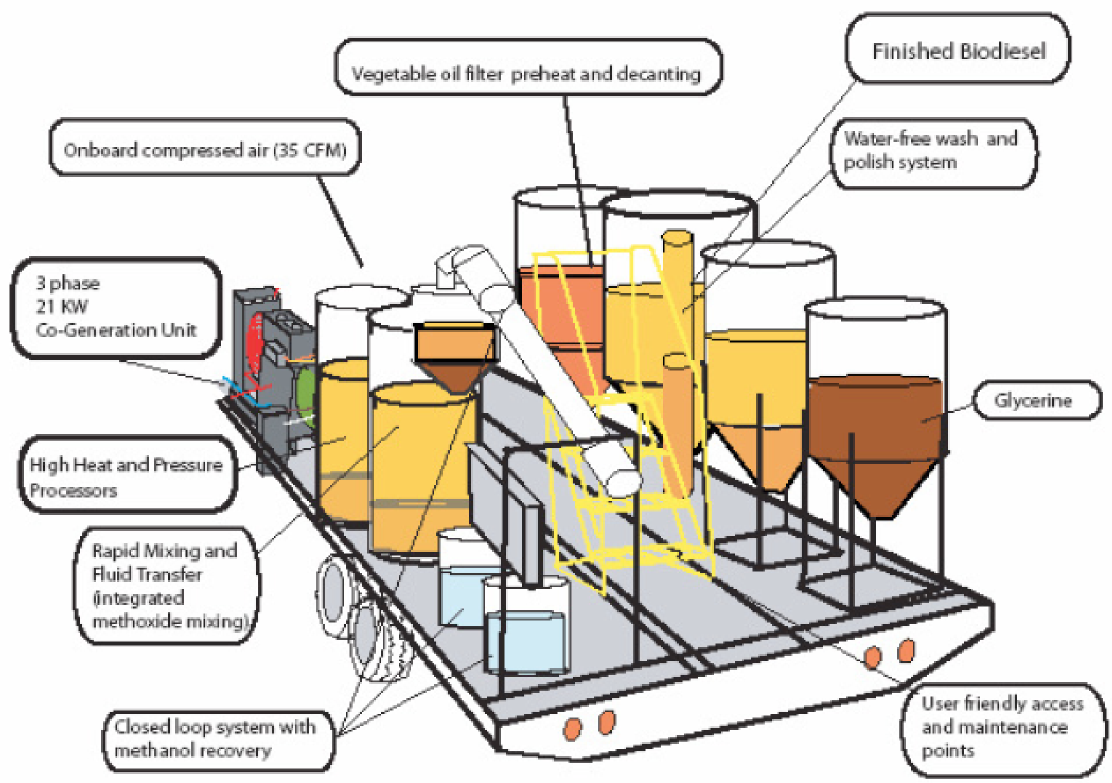
As discussed in the Oil and Meal Production section above, John Williamson and Steve Plummer at State Line Farm have constructed a facility for oilseed extraction and biodiesel production. State Line Farm has acquired a 400-gallon, water-jacketed, sealed tank for use as the biodiesel reactor, and will soon obtain an explosion-proof pump and other components necessary to minimize the safety risks associated with venting of gases and recover ethanol/methanol.

78 Methanol Institute and International Fuel Quality Center. April 2006. *A Biodiesel Primer: Market & Public Policy Developments, Quality, Standards & Handling*.

Emerging mobile seed press technologies can crush oilseeds on the farm and improve the viability of feedstock sales, but these have not been researched for this report. Dorn Cox of Tuckaway Farm in New Hampshire has built a biodiesel processor capable of producing 50 gallons per hour on an 18-foot trailer to allow portability and minimize tax liability with permanent structures.[79] He plans to build a pole structure to allow operation in inclement weather.[80] Figure 25 shows Dorn Cox's mobile processor.

Figure 25. Mobile Biodiesel Processor

Self Contained Educational Biodiesel Processor



Features:
Mobile unit -can be deployed to multiple locations
Operates inside included portable shelter
Compact design fits inside 20' or 40' container for long distance transport
Requires no outside utilities (power or water)
Provides auxiliary 3 phase power, air and heat
Uses 55 gallon drums for feed stocks and finished products
All equipment anti-vibration mounted
Easy access to all components for maintenance & cleanup
Closed system with air operated fluid transfer
Can scale from 60 gal/hr + (heat transfer limited)
Fuel consumption from 1.5 gal/hr
Single person operation

contact: Dorn AW Cox
e-mail: dornawcox@comcast.net
phone:603.781.6030

Quality

Even when making "off-road" biodiesel that does not need to meet ASTM standards for on-road use, quality testing is important. High-quality fuel will be free of excess methanol, potassium or sodium soaps, glycerin residue, and emulsifiers, indicating that the transesterification process was complete and efficient. Fuel that contains too many of these contaminants can cause engine damage. There are also several low-cost, reliable fuel quality test methods on the market, including the "pHlip Test", "the 3/27 conversion test" and the "SafeTest system".

The simplest quality test is the wash test, which involves vigorously mixing equal parts biodiesel and water and letting the solution settle. If the fuel and water separately cleanly and quickly (≤ 30 minutes), the fuel passes the test. Green Technologies in Winnoski, VT, has begun using gas chromatography testing,[81] which determines glycerin content. Once a good process is established, conducting this test two or three times per year should be adequate to assure quality control of the finished biodiesel for farm-scale production. In general, a good production process that includes a complete reaction, adequate settling times, filtration, and washing will reliably produce a high-quality fuel.

Capital and Operating Costs

Tables 23 and 24 show estimated capital (fixed) and operating (variable) costs for a farm-scale biodiesel processor, based on experience at State Line Farm. Certain variable costs, such as insurance, may be able to be shared among several pro-

Table 23. Capital Costs for Farm-scale Biodiesel Processor

Capital equipment	Cost
Biodiesel tanks	$12,000
Pumps, pipes, valves, fittings	$8,000
Boiler system	$5,000
Condensor, alcohol recovery	$2,000
Misc. supplies and equipment	$3,000
Fuel storage, fire suppression, etc	$5,000
Total	**$35,000**

79 Leech, A. April 8, 2007. "Biodiesel bill passes N.H. House." *Portsmouth Herald*.
80 Grubinger, V. May 17, 2007. *On-Farm Oil Seed Production and Processing*. VT Center for Sustainable Agriculture/UVM Extension final report, used with permission.
81 Farmers can contract with Green Technologies to analyze their biodiesel for quality. Contact Scott Gordon at www.greentechvt.com.

Table 24. Operating Costs for Farm-scale Biodiesel Processor

Item	Cost
$65,000 invested in processing equipment (annual cost over 10 years including interest and maintenance	$7,000
Half-time labor to run the system (wages, benefits, etc.)	$25,000
Permits, insurance, ASTM tests, repairs	$3,000
Total	**$35,000**

NOTE: As of this printing, the State Line Farm biodiesel production facility is not yet fully operational. There may be additional equipment and set up costs not reflected in the budgets above. An engineering and safety review is being conducted that will result in a set of engineering drawings that will make systems replication easier for farmers interested in innovating based on the State Line Farm model. Once the facility is operational, it will take some more time to optimize production processes and product quality. These figures will be updated as more information becomes available.

Tax and Regulatory Issues Pertaining to On-farm Biodiesel Production

From a technical perspective, small-scale on-farm biodiesel operations are relatively easy to establish, but they do require careful space and site planning to ensure adequate safety measures and maximum efficiency. Since methanol and the catalysts required to make biodiesel (i.e. sodium hydroxide or potassium hydroxide) are hazardous and flammable when combined, developing and following a best practices protocol is essential. In addition local health, safety, environmental and zoning ordinances may be applicable. Establishing a good working relationship with one's local zoning authority prior to beginning or modifying any projects is advised. Therefore rules, regulations, and taxes at the local, state and federal levels are an important consideration.

When directing research in 2006 for "On-farm Oilseed Production and Processing", Vern Grubinger enlisted two students at Vermont Law School, Laura Furrey and Mark Seltzer, to provide an opinion on some of these issues. Their findings, along with research conducted by the Vermont Biofuels Association, are outlined below.

Commercial Production vs. Production for Farm Use

Generally speaking, farm-produced biodiesel can be used or sold directly to end-users in the "off-road" market—for use in farm, construction, or marine equipment; heating; or running diesel generators, with a minimum of tax and environmental regulation. But as soon as farm-produced biodiesel is used or sold for use in licensed vehicles traveling public roads, then federal air quality and taxation issues, administered by the Environmental Protection Agency (EPA) and Internal Revenue Service respectively, come into play, and may be prohibitively expensive.

The following information has been arranged in three steps: before on-farm production; during on-farm production; and what to do with on-farm produced biodiesel.

When considering building biodiesel production capacity on-farm, the following factors should be taken into account:

► According to Chapter 117—Subchapter IX §4495 of the Vermont Statutes, farmers do not need to obtain a municipal permit in order to build a farm structure. However, farmers do need to "notify a municipality of the intent to build a farm structure," and "abide by setbacks approved by the Secretary of Agriculture, Food and Markets." Therefore, prior to construction a farmer would need to notify the local zoning administrator or town clerk with their plan, including a sketch of the proposed structure. Contact the Agency of Agriculture, Food, and Markets at (800) 675-9873 or (802) 828-3829.

► Producers should apply to their town's Zoning Administrator or Planning Commission to make sure they are complying with the town's local zoning by-laws.

► For State permits that may be applicable, the state permit coordinator is Nancy Manley at (802) 241-3838 and Judy Mirro, Compliance Assistance Specialist at (800) 974-9559, ext. 2 or (802) 241-3745 and judy.mirro@state.vt.us.

► The Environmental Assistance Office of the Vermont Department of Environmental Conservation also provides permitting assistance: http://www.anr.state.vt.us/dec/ead/pa/index.htm

Once producing biodiesel on-farm, the following items should be taken into consideration:

► A Spill Prevention, Control and Countermeasure (SPCC) plan written with "what if?" steps and spill control tools on site for all liquids and chemicals are required, if storing more than 1,300 gallons of oil or biodiesel on site. A secondary containment surrounding the storage (usually a concrete berm or wall) is also required by EPA SPCC rules. Review the U.S. Environmental Protection Agency's website for guidance: http://www.epa.gov/oilspill/spcc.htm. Or contact the Vermont Biofuels Association, info@vermontbiofuels.org, for a list of local engineers.

► Have an Emergency Response Guidebook on hand. Visit the Federal Department of Transportation website to download a copy: http://hazmat.dot.gov/pubs/erg/erg2004.pdf.

► Certified Hazmat handling courses are available to learn the proper handling and use of some components used in the production of biodiesel.

► The Vermont Department of Public Safety has a Hazardous Materials Response Team that is available 24 hours a day: http://www.dps.state.vt.us/vem/haz_mat.html or 1-800-641-5005.

► The Waste Management Division of the Vermont Department of Environmental Conservation also has a Spills Response Team, (800) 641-5005: http://www.anr.state.vt.us/dec/wastediv/spills/spills_program.htm.

► Review Vermont's Stormwater Pollution Prevention Plan policy here: http://www.eaovt.org/sbcap/resources.htm. For assistance in writing a Stormwater Pollution Prevention Plan, call (800) 974-9559.

► The local fire department should be notified as to what is stored on the farm (and where). To identify all on-site chemicals, oil and biodiesel use large easy-to-read signage.

Once biodiesel has been produced and a farmer is contemplating what to do with it, the following factors should be considered:

The farmer/producer needs to be aware of two areas of regulation pertaining to the use of biodiesel (B100, with no petroleum added) and these are air-quality and taxation. In addition, since the production of biodiesel involves the storage and use of hazardous and flammable materials, it should only be undertaken with adequate property and liability insurance.

Air quality issues

► Biodiesel producers are exempt from registering as a "fuel producer" with the EPA only if the pure biodiesel (B100) made or sold is for "off-road" purposes- in farm, construction, or marine equipment; heating; or running diesel generators, etc., If at any time, however, biodiesel is sold for use in licensed vehicles, the producer must be registered with EPA. If an unregistered fuel ends up in use in a licensed motor vehicle, it is the producer and/or seller who may be subject to penalty.

► Furrey reports that producers of biodiesel, selling for on-road use in licensed vehicles are subject to EPA rules regarding registration of fuel and fuel additives under the Clean Air Act (published in 40 CFR part 79). This ruling states that any commercial manufacturer of a fuel or fuel additive must submit a set of Tier I and Tier II health effects test results to the EPA (with a small business exemption from Tier II). This testing costs close to $3 million and the National Biodiesel Board (NBB) is the only organization to go through with the testing. The NBB results can be used, with their approval, only if the biodiesel being made meets ASTM D6751 specification and the producer pays the minimum $2,500 annual NBB membership, plus a few cents on every gallon sold.

► Furrey also identifies several unresolved issues, including whether an on-farm producer would have to register with the EPA as a fuel manufacturer if "the biodiesel is not ASTM certified, does not meet EPA requirements, and is not being sold, traded, or otherwise 'introduced into commerce in the United States.'" These and other questions have been submitted for review to a staff member of the National Biodiesel Board. Contact the Vermont Biofuels Association, info@vermontbiofuels.org, for additional information.

Taxation issues

► Biodiesel is subject to a federal excise tax of $0.244 per gallon when used in licensed motor vehicles. Typically this tax is paid voluntarily on the producer's or user's annual federal income tax return to avoid a penalty.

► Pure biodiesel and straight vegetable oil (SVO) are exempt from the $.25 per gallon state diesel tax, according to Doug Bissette, from the Vermont Department of Motor Vehicles fuel tax division. Any use of the word "fuel" in the Vermont statute, by definition, exempts pure biodiesel and SVO since they are neither a "clear diesel fuel" nor are they a "blend of undyed diesel and other fuel".

► A Vermont fuel dealer's license is required only if a farmer were to sell biodiesel for use in licensed vehicles that travel on public highways, according to Furrey. However, as noted above, since EPA requires that any fuel sold for use in licensed vehicles meet Tier I and Tier II health effects testing and is registered with the EPA, unless the farmer/producer meets these requirements they cannot legally sell to the on-road market and would not therefore be required to obtain a Vermont fuel dealer's license.

► Federal regulations require that petro-diesel used in off-road applications, and is not subject to excise tax, be dyed red for identification purposes (to distinguish it from on-road taxable diesel). Regarding the question of whether biofuels must be dyed for agricultural use, Seltzer found that, "unlike kerosene and diesel fuel, however, 100% biofuel 'liquid' does not need to be dyed for off-road use according to state and federal legislation. If the fuel is blended with off-road diesel or kerosene, dyeing requirement should be followed. For example: 20% biodiesel mixed with 80% off-road diesel should be appropriately dyed."

Insurance
The production of biodiesel involves the storage and use of methanol (or ethanol) and a catalyst, potassium or sodium hydroxide (i.e. lye). Methanol is flammable, and potentially lethal and the catalyst is toxic. When the biodiesel operation follows well-established production and safety protocol, the risks are greatly reduced and everything proceeds smoothly. However, most farm operations have inadequate insurance coverage in case there's an accident.

In addition to liability coverage and property loss protection, the operation also needs to be bonded if the plans include the sale of biodiesel. Insurance premiums can run $300 to $400 per month and if bonding is needed, monthly premiums can cost an additional $150 per month and sometimes considerably higher. For many small-scale farm or "home brewer" operations, these costs may seem unjustified or are simply out of reach, and the producer may decide to work "under the radar". But it is important to remember that during a few critical steps in the process, making biodiesel carries a high degree of risk to persons and property. Unfortunately as a result, a number of buildings, barns, and garages have been destroyed by fire, leaving the biodiesel producer responsible for the damages. If undertaking the production of biodiesel it is very important to understand the risks, follow established "best practices", safeguard against accidents, and carry adequate insurance.

To assure adequate coverage even small-scale biodiesel operations should obtain a policy from a "Commercial Risk Carrier". Since Vermont insurance providers, as a rule, have little experience with biodiesel production, they are usually unable to offer competitive rates. Therefore, it was important to research out-of-state companies with the necessary background and industry knowledge. The information on national and local insurance providers (listed in Appendix A) was gathered from a survey conducted in 2007, where prominent small-scale producers from the eastern U.S. were asked to submit contact information and comments on their insurance providers or industry contacts.

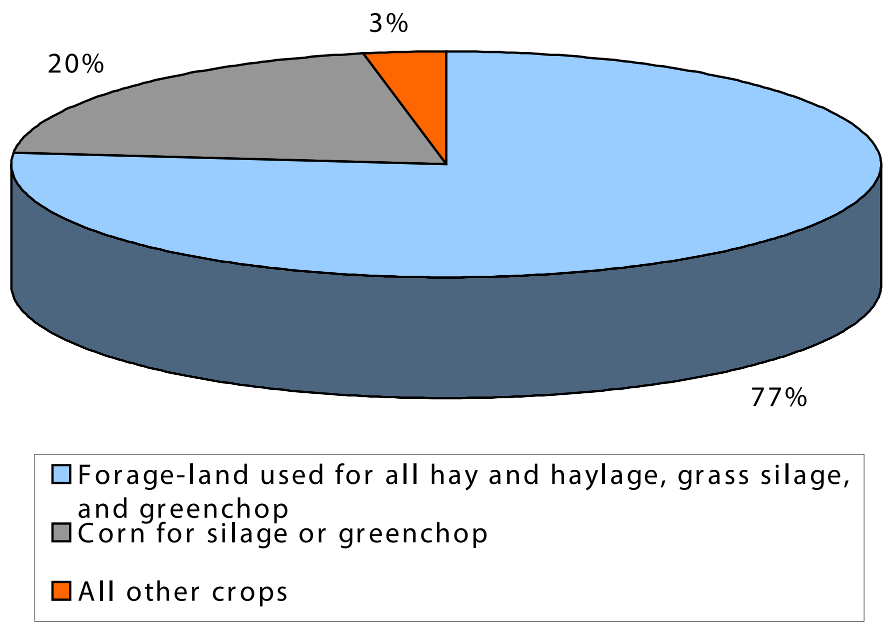
D. Land Use Implications

Vermont's Current Agricultural Land Uses

According to the 2002 Census of Agriculture, Vermont has approximately 567,509 acres of cropland (does not include pastureland), 454,699 of which are harvested. This leaves an estimated 112,810 acres of "dormant" cropland.

Of the harvested cropland, approximately 77%, or 350,261 acres, is dedicated to forage crops, such as hay, haylage, and grass silage. Approximately 20%, or 91,312 acres, is used to grow corn for silage. This corn silage acreage can be assumed to represent the best "tillable" land in Vermont for growing oilseed or other row crops.

Figure 26. Allocation of Harvested Cropland in Vermont



Land Needed to Meet Potential Demand for Livestock Feed or Biodiesel

Using estimated yields of 1500 lbs/acre for soybeans,[82] 840 lbs/acre for canola,[83] and 1200 lbs/acre sunflowers,[84] we can estimate the crop acreages that would be necessary to meet Vermont's projected demand for oilseed meals with in-state sources. As shown in Table 9, if conventional Vermont livestock were fed only soybean meal as a protein source, the state could currently meet less than 1% of the estimated demand with soybeans grown in Vermont. For organic soybean meal, we could currently meet approximately 6% of the estimated demand from organic dairy cows with Vermont-grown organic soybeans. Substantial acreage shifts from either corn or hay would have to occur in order to increase the share of Vermont's oilseed demand that is met by in-state crop production.

Table 25. Oilseed Crop Acreage Needed to Meet Estimated Vermont Meal Demand

	Crop acres needed		
Annual conventional meal demand	Soybeans	Canola	Sunflower
Midpoint	208,265	202,259	220,331
10% of midpoint	20,826	20,226	22,033
25% of midpoint	52,066	50,565	55,083
50% of midpoint	104,132	101,129	110,166
75% of midpoint	156,199	151,694	165,249
Estimated current acreage	1,562	70	20
Annual organic meal demand	Soybeans	Canola	Sunflower
Midpoint	6,362	11,361	7,952
10% of midpoint	636	1,136	795
25% of midpoint	1,590	2,840	1,988
50% of midpoint	3,181	5,680	3,976
75% of midpoint	4,771	8,520	5,964
Estimated current acreage	400	0	5

Assuming that a sustainable crop rotation plan to produce oilseed crops (canola, soy, sunflower) requires at least half the land to be in legumes for nitrogen for fertility, as well as silage corn and/or sweet sorghum to break pest cycles, then the following amount of land would be needed to produce various quantities of on-farm biodiesel per year.

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82 Maier, D.E. et al. 1998. High Value Soybean Composition. Grain Quality Task Force Fact Sheet #39, Purdue University. Accessed at http://www.ces.purdue.edu/extmedia/GQ/GQ-39.html on June 8, 2007.

83 Based on University of Maine canola crop trial data.

84 Assumes seed is 60% meal by weight and yield of 1 ton/acre.

Table 26. Oilseed Crop Acreage Needed for Various Scales of Biodiesel Production

	Annual Production of Biodiesel		
Oil yields	25,000 Gallons	50,000 Gallons	100,000 Gallons
At 50 gal oil/acre	1,000 acres	2,000 acres	4,000 acres
At 75 gal oil/acre	667 acres	1,333 acres	2,666 acres
At 100 gal oil/acre	500 acres	1,000 acres	2,000 acres

Potential Acreage Capable of Supporting Oilseed Production

Vermont's dairy herd size has been decreasing steadily for at least the past 40 years, dropping from 213,000 cows in 1966 to 141,000 cows in 2006, a 34% decline. Furthermore, the rate of decline was accelerated in the last 20 year period compared to the first. Between 1967 and 1987, Vermont lost 24,000 cows, just over 1,000 cows a year. Between 1987 and 2007, however, the herd has dropped at twice that rate, by 39,000 cows, or just under 2,000 cows per year. Based on this history, one could predict that the herd size will drop by 20,000 to 25,000 cows in the next 10 years, to approximately 115,000 to 120,000 cows by 2017. A drop of 25,000 cows equates to an approximately 18% decline from today's herd total.

Under the assumption that the corn and grass forage acreages planted in the state are consumed by Vermont's dairy herd (by and large, we do not export these crops), then a decline in the dairy herd would also mean a decrease in the number of corn and grass forage acres needed to support that herd. Therefore, if the size of the dairy herd were to decrease by 18% over the next 10 years, in 2017 an estimated 16,436 acres of corn cropland and 63,046 acres of grass forage cropland could be freed up for other uses, including oilseed production.

Together, these 79,482 acres of cropland could produce approximately 33,000 to 59,600 tons of meal and approximately 4.5 to 5.5 million gallons of biodiesel (depending on the crop; assuming 840 lbs of meal and 56 gallons of biodiesel per acre of soybeans and 1500 lbs of meal and 70 gallons of biodiesel per acre of canola and sunflowers).

In the nearer term, dormant cropland could also be used for oilseed production, but it is not likely that all 112,800 would be well suited for growing oilseeds. Some dormant cropland is hayland, and the fact that this land is dormant means that it is not likely to be prime tillable ground. These acres may be more likely to have moisture problems that would affect planting and harvest.

For purposes of estimation, however, assuming a sustainable oilseed crop rotation plan, the 79,500 acres, plus the over 112,000 acres of dormant cropland, could produce approximately 45,000 to 67,500 tons of meal and approximately 5 to 6.3 million gallons of biodiesel per year, depending on the crop. This calculation assumes 1500 lbs of meal and 56 gallons of biodiesel per acre of soybeans and 1000 lbs of meal and 70 gallons of biodiesel per acre average of canola and sunflowers and establishes a rotation plan that uses only half of the projected 180,000 acres each year for these crops.

In an effort to create new agricultural revenue, support fuel and feed cost stability, and reduce Vermont's 'carbon footprint" and its dependence on fossil fuels, farmers, entrepreneurs, and policy planners are looking to biomass to generate a greater percentage of the state's future energy output, in the form of biodiesel, biofuel pellets, biogas crops, and cellulosic ethanol. It is therefore worth considering the multiple benefits that could be derived by using half of this projected "surplus" of suitable cropland in the production of oilseeds. These 90,000 acres could meet the total on-farm demand for distillate fuels and as much as 50 percent of the anticipated meal demand in 2017, while the remaining 90,000 acres could be used to produce additional biomass crops and still not impinge on the anticipated future crop needs of Vermont's dairies.

While Vermont oilseeds could provide local, clean biofuel, increasing Vermont's oilseed acreage may have other adverse environmental impacts. If acreage is merely shifted from corn to oilseeds, impacts will be minimal. If oilseed acreage comes from hayland or dormant land that has not been tilled, however, planting oilseeds on land that was formerly sod will mean increased erosion, phosphorus loading into streams and lakes, and carbon release, especially on land with significant slope. For these reasons, plowing current grassland to plant oilseed may require farms to revise their nutrient management plans.

Market forces, geography, climate, crop rotation strategies, environmental considerations, and process technologies will each play a role in influencing a farmer's decision to focus on one energy crop (or product) over another. How these same factors might affect the conversion of even more (or less) cropland from traditional uses to energy crop production remains to be seen, and is outside the scope of this study. But for the purposes of establishing the potential, 180,000 acres, representing 31% of today's cropland, is a reasonable estimate of the land base from which a variety of dedicated energy and feed crops could be grown sustainably in the next ten years, given the historical rate of decline in Vermont's dairy herd.

ECONOMIC FEASIBILITY ANALYSIS

Photo: Wayne Fawbush

Richard Wiswall with biodiesel at Cate Farm

Open house at State Line Farm

VII. ECONOMIC FEASIBILITY ANALYSIS

A full economic analysis must consider potential costs and revenues of the crop and its value-added co-products, their markets, and all crops in the rotation. Income associated with oilseed co-products can vary widely, depending on the type of oilseeds produced, value added, production scale and method, and markets. Variable production costs must be subtracted from gross returns, and will also vary across farms and regions, depending on the value of farm labor, the cost of using equipment, and the market price. Using on-farm biodiesel, and a sustainable cropping system to provide 'free' nitrogen and weed control, could also lead to lowered costs.

Since Vermont and New England farmers have only begun to experiment with oilseed crop cultivation and value adding (beyond cultivating and roasting soybean) there is still very little regional data to work with.

In addition, there is no established market yet for locally produced oilseed co-products, adding to the difficulty of creating a complete economic analysis. Gathering this economic information from Vermont and regional small-scale processors during 2008 & 2009 is a key area of research for the *Feed & Fuel Project* partners. In the mean time, the information in this section provides a range of possibilities from which reasonable economic estimates can be developed.

Vern Grubinger has prepared Tables 27-29 to present a range of possible net returns from oilseed production. Table 25 considers four potential scenarios for canola co-product prices. The "low" price scenario assumes prices of $2/gallon for oil and $150/ton for meal; the "medium" scenario assumes $3/gallon and $200/ton; the "high" price scenario assumes $4 gallon and $300/ton; and the "future" scenario assumes $6 gallon and $500/ton for oil and meal, respectively.

Table 27. Potential Range of Gross Returns Per Acre for Canola

Canola yield (lb/acre)	Oil produced (gallons)	Meal produced (pounds)	Returns/acre*			
			Low	Medium	High	Future
1,500	69	840	$201	$291	$402	$554
2,000	92	1180	$334	$476	$668	$1052

*Low = $2/gal oil, $150/ton meal; med = $3/gal oil, $200/ton meal; high = $4 gal/oil, $300/ ton meal; future return? = $6 gal/oil, $500/ton meal.

Table 28. Potential Range of Net Returns for Oilseed Production & Processing

Expense or revenue item	Low*	High*
Variable production costs (labor, equipment, inputs/acre)	$150	$250
Fixed production costs (land, taxes, etc/acre)	$25	$50
Average oil production/acre	50 gal	100 gal
Average seed meal production/acre	1,000 lb	2,000 lb
Value of virgin oil (for fuel, soapmaking, etc. not food)	$2 gal	$4 gal
Value of seed meals for animal feed	$200/ton	$500/ton

*Estimated range of costs for canola or sunflower crops, farms, growing systems

Table 28 shows that net returns/acre range from -$100 to $700. Assuming an average of $200 total production costs and a yield of 75 gallons of oil per acre at $2.50/gallon of oil, plus 1500 lbs of seed meal at $350 per ton, average net returns are estimated to be $450/acre without making biodiesel (under good growing conditions).

If a farmer were to produce biodiesel, the following scenarios outline *potential returns*.

Biodiesel production of 25,000 gallons of fuel/year (or ~500 gal/week):

- Assume annual processing costs of $35,000
- Production cost/gallon = $1.40 before ingredients
- Add 0.2 gal methanol @ $3/gal (=$.60/gal), plus $2/gal for virgin oil
- Total cost would be $4/gallon to produce on-farm biodiesel

Biodiesel production of 50,000 gallons of fuel/year (or ~1000 gal/week):

- Requires an additional $15,000 for oil press and bins, tanks, and 0.75 FTE labor, increasing the annual processing costs to ~$50,000
- Production cost/gallon = $1.00
- Add $.60/gal for methanol plus $2/gal for virgin oil
- Total cost is $3.60/gal

Biodiesel production of 100,000 gallons of fuel/year (or ~2,000 gal/week = five 400 gallon batches):

- Requires an additional $25,000 for oil press and bins, and full-time labor, increasing annual processing costs to ~ $88,000
- Production cost/gallon = $0.88
- Add $.60/gal for methanol plus $2/gal for virgin oil
- Total cost is $3.48/gal

Table 29 considers potential returns from a four-year "community-level," sustainable crop rotation that supports traditional dairy production and includes oilseeds sufficient to produce 25,000 gallons of biodiesel per year.

Table 29. Potential Yields & Returns from a Sustainable Cropping System

Crops and Co-products	Gross Returns	Net Returns*
250 acres canola @ 1500 lb/acre		
69 gal oil/acre (Maine data) x $3/gallon= $52,000		
840 lb meal/acre x $200/ton = $21,000	$ 73,000	$22,000
250 acres soybean @ 30 bu/acre with 18% oil		
42 gal oil/acre x $3/gal = $31,500		
1500 lb meal x $200/ton = $37,500	$ 69,000	$39,000
200 acres silage corn @ 20 tons/acre x $25/ton	$100,000	$35,000
50 acres sorghum@10 ton/acre=200 gal ethanol x $3/gal	$ 30,000	$16,000
250 acres clover/alfalfa (also replaces 100 lb/acre N fertilizer)		
2 cuts legume hay = 3 ton/acre x $125 / ton	$ 94,000	$48,000
Total gross/net returns for 1,000 acre crop rotation system:	**$ 366,000**	**$160,000**

*Variable costs: canola $204/A (Maine), soybean $119/A, corn $326/A, alfalfa $182/A, sorghum $287/A (Penn State: http://agguide.agronomy.psu.edu/cm/sec12/sec12toc.cfm)

A. Enterprise Budgets

Developing a budget is a vital step in any new business endeavor, and an objective of the FFP is to support farmers and entrepreneurs in exploring new markets by providing information and tools for business planning. Accordingly, a budget template was developed for each of the three potential enterprises associated with oilseed crop and value-added production:

1. Crop Production and Use or Sale of Whole Seeds
2. Seed Pressing and Use or Sale of Meal and Oil
3. Biodiesel Production for Use or Sale

These spreadsheets, shown in Appendix B, are intended to allow a farmer or entrepreneur to assess the potential profitability of any of the three enterprises based on his or her estimated expenses; expected prices; and chosen production, products, and markets. Business owners can develop budgets for one, two, or all three of these operations, depending on their business plan; the spreadsheet will aggregate total costs and revenues to estimate total profitability of additional value-added processing.

The budgets are designed to be user-friendly. The business owner enters key information such as expected prices and estimated line-item expenses in shaded cells, and the spreadsheet automatically calculates total costs, total revenues, and profit per acre and per unit of production. Where possible, the budgets provide sample, representative, or average costs or returns as a reference, although every operation will be unique.

The budgets also include a “break-even analysis” for each enterprise, which shows the relationship among estimated costs, expected price, and expected yield, and is designed to show how a price or yield drop/rise will affect one’s ability to cover costs.

CONCLUSIONS
&
RECOMMENDATIONS

John Williamson and Steve Plummer address audience
at State Line Farm Open House, 2006

Canola growing at State Line Farm

VIII. CONCLUSIONS and RECOMMENDATIONS

Conclusions: Although many aspects of oilseed crop and co-product production remain to be tested, refined, or further studied in Vermont, several conclusions can be drawn based on existing data, research, and the experience of Vermont producers and business owners to date.

1. **Demand for oilseed co-products exists in Vermont.** Vermont currently imports significant quantities of oilseed co-products, including livestock meal (at least 58,000 tons per year), middle distillate liquid fuels (6.4 million gallons a year by Vermont farms alone), and food-grade vegetable oil. Demand is particularly strong for organic livestock meals and food products, and purchasers expressed a willingness to purchase and sometimes pay more for locally produced feed, food, or fuel products, provided they met quality and consistency minima and could be supplied reliably.

2. **Feed and fuel prices are sensitive to volatility in crude oil prices.** Any continued volatility in crude oil prices will continue to affect feed and fuel prices, raising the prices that farmers and consumers pay for liquid fuels, fertilizers, and livestock feed. The U.S. Department of Agriculture and the University of Missouri's FAPRI both predict continued uncertainty and increases in petroleum prices for the next several years, with corresponding effects on feed prices.

3. **Organic oilseed co-products have the highest potential market value.** Our evaluation of the markets for oilseed products indicates that organic feed and food markets are characterized by strong demand and limited supply, thereby enabling farmers, processors, and retailers to command higher prices.

4. **Oilseed crops are viable in Vermont, and good yields are achievable given improved harvesting equipment and techniques.** Crop trials from Vermont, Maine, and New Hampshire indicate that yields for oilseed crops at or exceeding the national average are achievable in Vermont's climate and better agricultural soils. The primary factors contributing to decreased yields are a lack of appropriate harvesting equipment, lack of experience in oilseed harvesting techniques, and a need for adequate drying and storage facilities.

5. **Farm-scale processing techniques can produce high-value, good-quality oilseed co-products, but further refinement and testing are needed.** Thus far, the quality of the oil and oilseed meal produced at the farm scale appears promising. As much as 3 lbs per day of this meal, depending on the type of oilseed, could be included in a ration for a high-producing dairy cow. To be able to sell this meal to other farmers or a feed dealer at a competitive price, however, the meal producer must be able to ensure that the meal is of a consistent quality. Further refinement and standardization of batch-processing techniques are needed, and additional, regular testing of the farm-pressed meal is recommended to establish quality and consistency.

6. Depending on Vermont's agricultural system, approximately 50,000 to 90,000 acres per year could be shifted to oilseed crops. Given Vermont's current dairy-centered agricultural system, FFP researchers estimate that at most approximately 50,000 acres would be rotated to oilseed crops in any given year. Assuming an 18% decline in Vermont's dairy herd over the next 10 years, consistent with trends over the past 40 years, an estimated 180,000 acres per year (90,000 on a rotational basis) could be shifted to oilseed crops to meet more than the total on-farm demand for distillate fuels and as much as 50 percent of the anticipated meal demand in 2017.

Recommendations:

The FFP partners make the following recommendations for further action and research related to the development and study of farm-scale oilseed crop and co-product production in Vermont.

1. Continue to build a network of farmers, processors, and other business owners involved in oilseed crop production, processing, distribution, and sales. Developing and sharing local experience and expertise in oilseed production, processing, and marketing will be key factors in the success of new growers and processors.

2. Establish systematic processes for testing, refining, and recording results of on-farm meal production to establish consistent quality standards. The key determinants of a livestock meal's value to feed dealers and farmers are quality and consistency. Unless quality control can be established, the price of farm-processed meal will be discounted significantly. Farm-scale processors seeking to sell their meal must establish a standard process that consistently creates a product of a certain quality. Regular testing of meal batch samples is recommended until a process is established, as well as an in situ amino acid test to establish the protein characteristics of the meal.

3. Investigate small cooperative enterprise models for oilseed processing and biodiesel production. Several farmers have expressed interest in sharing investment in larger-scale oilseed-processing or biodiesel-making facilities. Dividing capital and operating costs among five to ten neighboring farms could lower barriers to entry of these markets, but the economic feasibility of such a model has not been studied in-depth.

4. Investigate the economic feasibility of a mobile oilseed press and biodiesel production unit that could travel site to site.

5. Further investigate the range of equipment, capital and operating costs to set up and run an on-farm oil seed crop production facility. Because Vermont currently has one on-farm demonstration facility which is nearing completion and one other in the works, we cannot yet say with confidence how much equipment and capital are needed to run such a facility – either for on-farm only use and/or for revenue generation through sales off the farm. Additional data will be available in 2008 and 2009 once these two facilities are fully operational.

6. **Conduct further research on the net energy savings of biodiesel production to the farm.** Crop production, seed processing, and biodiesel production all require energy. Further study is required to understand the extent to which an on-farm oilseed and biodiesel production processes can use renewable, farm-produced energy, yielding a net energy savings to the farm.

7. **Conduct further research on additional potential markets for oilseed co-products.** The following potential markets for oilseed co-products were beyond the scope of this study, but should be investigated further:

- Food-grade oil sales, including analysis of Vermont's vegetable oil consumption, future price projections, and estimation of the extent to which Vermont farmers or entrepreneurs could penetrate local markets.

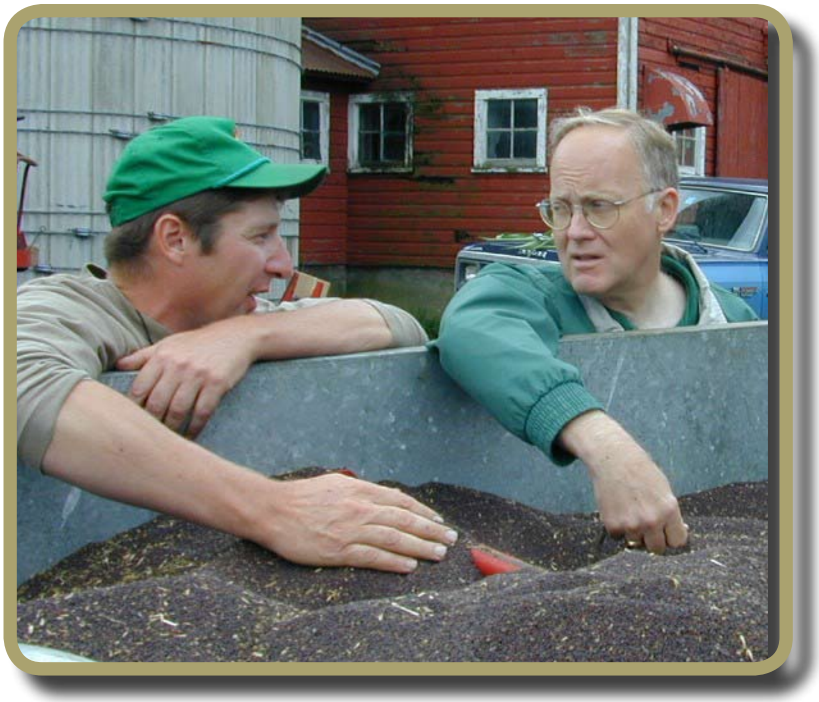
- Lease of filtered, unrefined vegetable oil to restaurants, with subsequent collection by fuel processors for biodiesel production. The opportunity to use the oil for both food and fuel production is being explored in Canadian and New England markets, but has not been studied extensively in Vermont.

- Use of oilseed meal as a crop fertilizer, and comparison of the value of this end-use to the value of the meal for livestock feed.

- Use of oilseed meal as a fuel (in pellet stoves, for example) may be a viable alternative use for meal that is not of sufficient quality to use as livestock feed.

- Potential uses and markets for the glycerin byproduct of biodiesel production.

Appendix A & B:
-Resources & Further Reading
-Enterprise Budgets



John Williamson and Governor James Douglas at State Line Farm

Appendix A: Resources and Further Reading

Oilseed Crop Information

Soybeans

National Soybean Research Laboratory: http://www.nsrl.uiuc.edu

United Soybean: http://www.unitedsoybean.org

North Dakota State University: http://www.ag.ndsu.edu/procrop/syb/index.htm

Growing Soybeans in the Champlain Valley – Cornell Coop Extension:
http://counties.cce.cornell.edu/clinton/ag/soybeans

Canola

Canola Council of Canada: http://www.canola-council.org/portal.html
http://www.canola-council.org/PDF/canolamealbkgrndmarket.pdf#zoom=100

Purdue University: http://www.ces.purdue.edu/extmedia/AY/AY-272.html

North Dakota State University: http://www.ag.ndsu.nodak.edu/carringt/99data/canola_economics.htm

Maine Extension, information for potential growers: http://www.umext.maine.edu/onlinepubs/htmpubs/2438.htm

Sunflowers

Purdue University: http://www.hort.purdue.edu/newcrop/afcm/sunflower.html

Jefferson Institute: http://www.jeffersoninstitute.org/pubs/sunflower.shtml

North Dakota State University: http://www.ag.ndsu.nodak.edu/carringt/livestock/Beef%20Report%2002/sunflower%20meal.htm

Oilseed Processing Information

Oilseed Organizations

National Sustainable Agriculture Information Service: www.attra.ncat.org

Georgia Oilseed Cooperative: www.emergingcrops.org/farmersoilseed/feasibility.asp

Articles

How to Process Oilseed on a Small Scale: www.howtopedia.org/en/How_to_Process_Oilseed_on_a_Small_Scale

Small-scale Oilseed Processing – Value-added and Processing Guide: www.green-trust.org/2000/biofuel/oilseed.pdf

Small-scale Rural Oilseed Processing in Africa: www.idrc.ca/en/ev-26984-201-1-DO_TOPIC.html#Potential

Equipment For Decentralized Cold Pressing Of Oil Seeds: http://www.folkecenter.dk/plant-oil/efdcpos_ef.pdf

Equipment Manufacturers

A.C. Horn & Co.: www.cantrellinternational.com/oilseed.html
B100 Supply, LLC: www.b100supply.com
Cropland Biodiesel: www.croplandbiodiesel.com
Plastic-Mart.com: www.plastic-mart.com
Rosedowns Presses: www.rosedowns.co.uk/products/Mini_Press.htm

Further Reading

Cox, Jeff. 1979. *The Sunflower Seed Huller and Oil Press*. Rodale Press.

In 2,500 square feet, a family of four can grow each year enough sunflower seed to produce three gallons of homemade vegetable oil suitable for salads or cooking and 20 pounds of nutritious, dehulled seed. http://journeytoforever.org/biofuel_library/oilpress.html

Head, S.W. et al. 1994. Small Scale Vegetable Oil Extraction. Natural Resources Institute.

Covers a basic understanding of the science and composition of oils and economic and marketing considerations, principles of oil extraction, basic oilseed processing methods, the major oil sources with specific small and intermediate technologies for each. Results

from actual third world situations are used. For example, the discussion of obtaining oil from sesame seed covers a hot water flotation method used in Uganda and Sudan, the bridge press (laboratory only), the ram press in Tanzania, the ghani process in Sudan, and a small-scale expeller in the Gambia. Technical details for each are summarized in a few paragraphs, including oil yields. Includes many drawings that are helpful in understanding each process, with a 14-page appendix listing suppliers of small-scale equipment. From ITDG: www.developmentbookshop.com/detail.aspx?ID=971

Jenner, Mark. April 2006. *The BioTown, USA Sourcebook of Biomass Energy*. Indiana State Department of Agriculture and Reynolds, Indiana. www.in.gov/biotownusa

The BioTown, USA concept is an effort to convert Reynolds, Indiana—a small town (population 533) in the middle of the state—from a reliance on fossil fuels to biomass-based fuels for energy.

Kemp, William H. 2006. *Biodiesel, Basics and Beyond: A Comprehensive Guide to Production and Use for the Home and Farm*. Aztext Press.

Biodiesel Basics and Beyond aims to separate fact from fiction and to educate potential home, farm and cooperative manufacturers on the economic production of quality biodiesel from both waste and virgin oil feedstock. The book includes:

- ► Detailed processes and lists of equipment required to produce biodiesel that meets North American standards
- ► How farmers can use excess oilseed as a feedstock for biodiesel production
- ► The use of the co-byproduct glycerin in making soap
- ► A guide to numerous reference materials and a list of supplier data.

Pahl, Greg. 2005. *Biodiesel: Growing a New Energy Economy*. **White River Junction, VT: Chelsea Green Publishing Company.**

Vermont's own, Greg Pahl, provides a history of biodiesel and explores the possibilities of a range of oilseed crops and technologies.

Potts, Kathryn H. and Keith Machell. 1995. *The Manual Screw Press: For Small-Scale Oil Extraction*. **ITDG Publications.**

Manual oil extraction from peanuts or other soft oilseeds can be a viable enterprise for small businesses. Describes small-scale processes of oil extraction for use in rural areas, as well as ways to market and distribute the oilcake. From IT Publishing: www.developmentbookshop.com/book.phtml?isbn=1853391980

Insurance Providers for Small-scale Biodiesel Production

► Nautilus Insurance Group (http://www.nautilusinsgroup.com) is a national underwriter with favorable rates and Vermont agents. Market Place Insurance, located in Essex Junction, is a good place to start.

► Nationwide Agribusiness appears to be one of the largest underwriters of biodiesel business and the least expensive, mostly due to their experience in the market. Contact Glenn Baker (agent) at (712) 737-3800. The Nationwide web site is www.nationwideagribusiness.com.

► Kramer-Warner Associates, Inc. of Pennsylvania is also recommended. Contact Ron Ratigan (agent) at (610) 359-1422.

► IMA of Kansas, Inc., is another underwriter with considerable experience in the biodiesel business. They can be reached by contacting David Weaver (agent) at (316) 266-6203.

Other Biodiesel Feasibility Studies

AIM-AG: Agri-Industry Modeling & Analysis Group. 2003. *Economic Feasibility of Producing Biodiesel in Tennessee*. http://beag.ag.utk.edu/pp/biodiesel.pdf.

BBI Biofuels Canada. February 2006. *Feasibility Study for a Biodiesel Refining Facility in the Regional Municipality of Durham*.
www.region.durham.on.ca/departments/edo/business/biodieselfeasibility.pdf

Fortenbery, T. Randall. March 2005. *Biodiesel Feasibility Study: An Evaluation of Biodiesel Feasibility in Wisconsin*. http://aae.wisc.edu/pubs/sps/pdf/stpap481.pdf

Mississippi Development Authority. *2003 Mississippi Biodiesel Feasibility Study*.
www.mississippi.org/content.aspx?url=/page/2756

New York State Energy Research and Development Authority. S*tatewide Feasibility Study for a Potential New York State Biodiesel Industry*. Final Report 04-02. June 2003.
www.nyserda.org/publications/biodieselreport.pdf

Shumaker, George A., et al. 2000. *A Study on the Feasibility of Biodiesel Production in Georgia*. http://www.agecon.uga.edu/~caed/biodieselrpt.pdf

Appendix B

The following enterprise budgets are for viewing only in this format. If you are interested in experimenting with and/or really using this tool, please download the Excel file from the VSJF, VBA, or UVM Extension websites. If you do not have access to the internet, call (802) 828-1260 and we will send you a copy on a CD.

Feed & Fuel Project
Enterprise Budgets for Oilseed Crop and Co-Product Production

Instructions

This spreadsheet is intended to allow a farmer or entrepreneur to develop budgets for as many as three enterprises associated with oilseed crops or their co-products: (1) crop production and sale of whole seeds, (2) seed pressing and sale of oil and meal, and (3) biodiesel production. Each tab of the spreadsheet is a separate budget for that enterprise. You can estimate expenses and revenues for one, two, or all three of these operations, depending on your business plan; the spreadsheet will aggregate total costs and revenues to estimate total profitability of additional value-added processing.

Where possible, we have provided sample, representative, or *average* costs or returns as a reference. These figures are intended only as a guide -- every operation will be unique.

To use the worksheet, choose the tab(s) or module(s) that apply to your chosen enterprises, and **enter information in the gray shaded cells.** Unshaded cells will be updated automatically based on the values you enter -- all the formulas for calculation are already in place. The worksheet has been "protected" to make it easier to use and to prevent accidental erasing of formulas. You can only type in the gray cells. If you would like to change a formula, however, go to the "Tools" menu, select "Protection," and then "Unprotect sheet."

Enterprise Option 1 - Crop Production and Use/Sale of Whole Seeds

1. **Crop Assumptions:** Select the crop you plan to grow (soybeans, canola, or sunflower) from the drop-down menu in cell B8
2. Enter the year, acres planted, projected yield, and your expected price per ton in column E. See the table below for reference case yields and prices.

	Typical yields	Typical price	
		Conventional	Organic
Soybeans	35-40 bu/acre	$6-7/bu	$12-15/bu
Canola	32-35 bu/acre	$220/ton	no data for VT
Sunflower	66-73 bu/acre	$12/cwt	no data for VT

3. **Expenses-Variable costs.** Enter your estimated variable production costs in the Expenses section (column B, rows 22-42). Enter the total amount you will spend on growing this crop. The spreadsheet will calculate the per acre cost automatically.

4. **Expenses-Fixed costs.** Enter your estimated fixed production costs in column B, rows 46-48. For fixed costs, estimate what % of your total capital cost can be allocated to production of this crop. The spreadsheet will calculate the per acre cost automatically.

5. **Break-even analysis.** The "break-even analysis" section shows the relationship among your estimated costs, expected price, and expected yield, and is designed to show you how a price or yield drop/rise will affect your ability to cover your costs. The left-hand section of the break-even analysis calculates the price needed to break-even, based on your estimated costs and yields. The right-hand section gives the yield needed to break-even, based on your estimated costs and expected selling price. All formulas will be calculated automatically based on costs, price, and yield.

6. **Revenues.** Your expected per-ton price for beans or seed is automatically carried down from cell B15. If you plan to roast beans, enter your expected price for roasted beans in cell B66, the portion of your roaster costs assigned to this production year in cell B68, and your roasting labor costs in cell B69.

7. **Profit/Loss.** The spreadsheet will calculate total profit/loss and per acre profit/loss for selling either whole or roasted seeds/beans.

Enterprise Option 2 - Press Seeds and Use/Sell Meal and Oil

1. **Expenses.** Enter your estimated variable and fixed costs associated with oil extraction (column B, rows 11-22). Total costs and cost/acre will be calculated automatically.

2. **Break-even analysis.** The "break-even analysis" section shows the relationship among your estimated costs, expected price, and expected yield, and is designed to show you how a price or yield drop/rise will affect your ability to cover your costs. The left-hand section of the break-even analysis calculates the oil and meal prices needed to break-even, based on your estimated costs and yields. The right-hand section gives the oil and meal yields needed to break-even, based on your estimated costs and expected selling price. All formulas will be calculated automatically based on costs, price, and yield.

3. **Revenues.** Enter the estimated efficiency of your seed press in cell C37. (For example, a commercial extraction plant would expect to get 1.5 gallons, or 10.5 lbs, of oil from a bushel of soybeans. If your press extracts only 1 gallon per bushel, it is 67% efficient compared to the commercial plant, and you would enter 0.67 in cell 37).

Enter your expected selling price or "replacement value" (your cost savings from not buying meal) per lb of oil in cell C41.

Enter your expected selling price or "replacement value" (your cost savings from not buying meal) per ton of meal in cell C45.

4. **Profit/Loss.** The spreadsheet will calculate total profit/loss and per acre profit/loss for the seed pressing enterprise, as well as a combined profit/loss for crop production plus seed pressing.

Enterprise 3: Make and Use/Sell Biodiesel

This worksheet will provide an estimate of the annual costs and revenue potential for an on-farm biodiesel enterprise, processing between 20,000 and 50,000 gallons of biodiesel per year. Wherever appropriate, values from the crop production and oil/meal production modules are carried forward to the biodiesel production worksheet.

All of the instructions below correspond to Line # and letters showing in the yellow shaded columns, and NOT the row # and column letter provided by Excel.

Values in blue shaded areas are averages for small-scale production, but they can be changed to reflect your true unit costs, if different. In order to update the blue shaded areas you will need to 'unprotect' the worksheet first by clicking on the program menu bar --- [Tools>Protection>Unprotect Sheet].

OIL SUPPLY ASSUMPTIONS

Oil yields from Enterprise Option 2, cell [x], are carried to Line 1.a and converted to gallons to Line 1.b.

Line 2.b - ENTER amount in GALLONS for the oil you plan to purchase in order to meet your annual biodiesel production target. Use this option if oil produced on your farm isn't sufficient to meet your annual biodiesel production target. The program will convert gals. to lbs. in Line 2.a

Line 3.b - ENTER amount in GALLONS for the oil you plan to collect from restaurants to meet your annual biodiesel production target. Use this option if oil produced on your farm (and oil you may be purchasing from other sources) isn't sufficient to meet your annual biodiesel production target. The program will convert gallons to lbs. in Line 3.a

Line 4.b - is your total ANNUAL production potential, from the sum of all your sources of oil, in lbs. and gallons

Line 5.a - is the price per lb. of oil from your crops, carried over from "Oil/Meal" worksheet. Line 5.b converts $/lb to $/gallon

Line 6.a - ENTER price you pay for oil from other sources in "cents per lb." The price is converted to $/gallon in Line 6.b

Line 7.b - is the average per gallon cost of labor and vehicle maintenance to collect and filter "free" Waste Vegetable Oil (WVO). An "average" labor rate is established in Line 10.d. [If your labor rate is different, enter the change only in Line 10.d and this will update the table]. Line 7.a calculates the $/lb price of WVO for reference.

WORK TABLE FOR BIODIESEL PRODUCTION

This table contains average known values for small-scale production, and "feeds" this information to the variable expense table. Data in blue shaded areas represents average costs for 400 to 800 gal/week production (or ~20k to ~40k gal/year) in May 2007. "Unprotect" blue shaded cells (Tools>Protection>Unprotect Sheet) in order to update data to reflect your current unit costs, if different.

EXPENSES - variable

Line 8.a - is the total cost to produce the oil from your crops. It is the product of "Line 1.a x Line 5". Line 8.b is the calculated cost per gallon of the oil from your crops

Line 9.a - is the total cost of the oil you purchased. It is the product of "Line 2.a x Line 6". Line 9.b is the calculated cost per gallon of the oil you purchased.

Line 10.e - ENTER your hourly rate of labor for oil collection. Line 10.a is the total cost of the oil you collected from restaurants and it includes vehicle maintenance. It is the product of "Line 3.b x Line 7". Line 10.b is the calculated cost per gallon of WVO. Line 10.c is now the average per gallon cost of all your oil

Line 11.a and 11.b - are the total and per gallon cost, respectively, of the methanol used. Line 11.c is the average unit cost per gal. in May 2007. [If your unit cost per lb. is different, enter the change only in Line 11.c and this will update the table]

Line 12.a and 12.b - are the total and per gallon cost, respectively, of the catalyst used, in this case Potassium Hydroxide. Line 12.c is the average unit cost per lb. in May 2007. [If your unit cost per lb. is different, enter the change only in Line 12.c and this will update the table]

Line 13.a and 13.b - are the cost to titrate the batch. [If your titration cost is different, enter the change only in Line 13.c and this will update the table]

Line 14.a and 14.b - are the total and per gallon cost, respectively, for Gas Chromatograph (GC) testing. The cost is based on a quote from a local producer in May 2007. Running at this volume this test should be conducted 2-3 times per year to assure quality control of the finished biodiesel. [If your cost for GC test or other lab tests is different, enter the change only in Line 14.c and this will update the table]

Line 15.a and 15.b - are the total and per gallon cost, respectively, for filtering the biodiesel. [If your cost for filters is different, enter the change only in Line 15.c and this will update the table]

Line 16.a and 16.b - are the total and per gallon cost, respectively, for the cost of electricity - mainly to preheat the oil. [If your KwH cost for electricity is different, enter the change only in Line 16.c and this will update the table]

The labor cost per gallon goes down, the more you make per week. ENTER your hourly rate of production labor in Line 17.c. if you are making 1 batch (~400 gallons per week). If 2 batches (800 gallons per week) LEAVE Line 17.a-d BLANK - this is very IMPORTANT! The hourly rate in Line 17.a and 17.b are the total and per gallon cost, respectively, for all labor costs associated with making 1 batch per week or ~20,000 gal. per year. Shop and equipment maintenance, clean up, etc., are included in the calculation.

ENTER your hourly rate of production labor in Line 18.c. only if you are making 2 batches (~800 gallons per week) and you left LINE 17.c BLANK. If you filled in Line 17 because you are making 1 batch per week, then LEAVE Line 18 BLANK - this is very IMPORTANT! You should either have Line 17 OR Line 18 filled in but not both! If filled in, Line 18.a and 18.b are all labor costs associated with making 2 batches per week or ~40,000 gal. per year.

ENTER any additional variable costs associated with annual production, in Line 19.a

Line 20.a - represents the total variable cost to produce biodiesel from the amount of oil shown in Line 4.b. The per gallon cost of this run is calculated in Line 20.b [Be sure you have properly entered your labor rate and your gallons per week production - these two factors have a big impact on your estimated cost per gallon of biodiesel]

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Enterprise Budgets for Oilseed Crop Co-Product Production

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EXPENSES - fixed, processor and tank farm costs

Lines 21 through 25 are the processor and tank costs for a 500 gallon reactor capable of producing 400 gallons of biodiesel per batch, or up to 40,000 gal./year

Line 22 - an average cost is provided. See also www.dultmeier.com or other "liquid handling" supply business for pricing.

Line 23 - an average cost is provided

Line 24 - an average cost is provided

Line 25 - an average cost is provided

Line 26 - an average cost is provided for glassware, titration kits, a scale, etc.

Line 27 - is the cost for a 4-drum Class 1, fireproof locker. To produce biodiesel in these quantities, you will be storing several 55-gal drums of flammable methanol. It is highly recommended, and in some locations required, that the methanol be stored in a fireproof locker. Check with your local fire marshal.

Line 28 - is an average cost of an industrial grade filter unit and is worth the expense to insure quality fuel.

Line 29 - is an average cost for all piping and valves for this system.

Line 30 - is an average cost of the pumps needed for this system. This is the cost for explosion proof pumps, which are highly recommended.

Line 31 - is an average cost of electrical switches, wiring and controls for this system.

Line 32 - is an average estimated cost for NEW POLY processing and storage tanks [Lines 21-25] and all necessary pumps, fittings and storage needed for a 55,000 gallon facility. It can be done for less or more. Purchasing new or used poly or stainless steel will impact cost.

EXPENSES - fixed, other fixed costs

ENTER the cost to build or renovate the structure where you make the biodiesel in Line 33 Or use this line for other large capital costs.

Line 34 - is the estimated cost for secondary containment, typically concrete. EPA rules require a Spill Prevention, Control and Countermeasure (SPCC) plan if you are storing more than 1,320 gallons of fuel or vegetable oil on your premises (applies to on-farm and municipal locations).

ENTER the costs of local permits in Line 35. Discussing your plan with your local zoning board before setting up your facility is highly recommended for on-farm production and required for municipal locations.

ENTER your consultant or engineer fees, if applicable, in Line 36

ENTER the annual cost of insurance, or pro-rated amount for your facility in Line 37. If you are selling biodiesel, product liability insurance may be required.

Line 38.a - is the sum of Other Fixed Costs in Lines 33-37.

TOTAL FIXED EXPENSES

Line 39.a - shows Total Fixed Expenses. ENTER the annual amount of interest you pay on your investment in the biodiesel equipment in Line 39.b. Enter the term of your loan in years in Line 39.c. The total annualized costs of the equipment will be calculated in Line 39.d. IF YOU KNOW YOUR ANNUAL COSTS ON EQUIPMENT LOANS, you can leave Line 39.b&c BLANK, and enter your annual equipment costs in Line 39.d, after you "unprotect" the worksheet.

TOTAL EXPENSES

Line 40 - is the sum of all variable and fixed costs associated with the ANNUAL production volume found in Line 4.b

PER GALLON COST

Line 41 - is your calculated cost per gallon to produce biodiesel (B100). Check that you have entered the correct information in Line 17 OR Line 18, and be sure that ONE LINE IS BLANK.

FUEL VALUE

ENTER per gallon sale price, or market price of B100 or the per gallon cost of the fuel you will be replacing in Line 42.b

TOTAL BIODIESEL REVENUE

Line 43.a - calculates total annual revenue. Line 43.b is Revenue/Acreage planted [from "Crop Production" worksheet]

ANNUAL PROFIT (loss) FROM BIODIESEL PRODUCTION

Line 44.a - calculates total annual profit (or loss) and Line 44.b calculates it on a per acre basis [from "Crop Production" worksheet]

TOTAL COMBINED ANNUAL PROFIT (or loss) from crop, seed pressing, or biodiesel production

Line 45.a - shows annual profit (or loss) from biodiesel operation, Line 45.b, brings profit (or loss) forward from "Oil/Meal Production" worksheet and the combined total is calculated in Line 45.c.

TOTAL COMBINED PER ACRE PROFIT (or loss) from meal & biodiesel production

Line 46 calculates the combined per acre profit (or loss) from the biodiesel operation and the oil/meal operation

For more information visit www.vsjf.org and www.vermontbiofuels.org

This workbook is made available to the public with funding from High Meadows Fund and the Maverick Lloyd Foundation.

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Enterprise Budgets for Oilseed Crop and Co-Product Production: Option 1

Enterprise Budgets for Oilseed Crop and Co-Product Production

Enterprise Option 1 - Crop Production and Use/Sale of Whole Seeds

shaded = ENTER YOUR DATA HERE

Crop assumptions

Crop	soybeans		**Lbs. per bushel**	60	**Yield/bu in lbs.**
Year			**Meal %**	82%	49
Acres planted			**Oil content %**	18%	11
Projected Yield		bushels/acre	**lbs oil/gallon**	7	
	0	bushels			
	0	tons			
	#DIV/0!	tons/acre			
Projected Price		per ton			
	$ -	per bushel			

Oilseed Conversion Table

Crop	**canola**	**soybeans**	**sunflower**
Lbs. per bushel	50	60	30
Meal %	60%	82%	56%
Oil content %	40%	18.3%	44%
lbs oil/gallon	7	7	7

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Enterprise Budgets for Oilseed Crop and Co-Product Production: Option 1

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Expenses			Reference table						
Variable Costs	Total	per acre	Notes for Soybeans	PSU 2006 soybean cost/acre	UVM 1999 soybean cost/acre*	Notes for Canola	UMaine & UVM 2005 canola cost/acre**	Notes for Sunflower	State Line sunflower 2006 costs/acre
fill in total cost									
Soil test		#DIV/0!		$1.00		0.08 / acre	$1.00	$10 + postage, 1 hr labor	4.00
Planting preparation (plow/harrow)		#DIV/0!	Two passes w/disc harrow		$25.00	Two passes w/harrow	$16.00	Plow, disk (1/2 hr)	15.00
Seed		#DIV/0!	170,000-225,000 plants per acre	$38.75	$22.00	5-6 lbs/acre	$22.20	4 lbs	16.00
Planting		#DIV/0!	7" rows		$7.00	seed drill, 4 acres/hr	$10.00		
Innoculant		#DIV/0!	1.25-2 lbs / acre		$3.00				
Lime		#DIV/0!	1 ton, pH 6.5-7.0	$15.00	$20.00				
Nitrogen		#DIV/0!	20 lbs		$6.00	70 lbs	$32.20		
Phosphorus		#DIV/0!	40 lbs		$12.00				
Potassium		#DIV/0!	80 lbs		$12.00				
Boron		#DIV/0!				1 lb	$2.20		
Compost/Fertilizer		#DIV/0!	Manure spreading/trucking	$30.80	$15.00	custom application	$9.00	15 tons manure + spreadin	105.00
Cultivation/Herbicides		#DIV/0!	Herbicide, rotary hoe 2x/acre	$2.34	$39.00	1.5 pint Trifluralin + custom app	$13.66	Cultivate weeds 2x	30.00
Insecticides		#DIV/0!							
Labor/management		#DIV/0!		$10.32		5% of total costs	$9.35		
Fuel		#DIV/0!		$7.32					
Drying		#DIV/0!							
Repairs & Maintenance		#DIV/0!		$5.30					
Trucking		#DIV/0!				0.8 tons	$14.40		
Storage		#DIV/0!	As silage		$5.00	0.8 tons	$6.40		
Harvest		#DIV/0!	Custom combining, chopping	$27.50	$20.00	Custom combining	$25.00	Incl empty combine into bin	45.00
Interest on operating exp		#DIV/0!		$4.09		10% for six months	$8.07		
sub-total	***$0.00***	***#DIV/0!***		***$142.42***	***$186.00***		***$169.48***		***$215.00***
Fixed Costs	**Total**	per acre							
assign portion of total costs									
Tractors		#DIV/0!		$4.12					
Equipment		#DIV/0!		$7.50					
Land		#DIV/0!			$30.00		$35.00		
sub-total	***$0.00***	***#DIV/0!***		***$11.62***	***$30.00***		***$35.00***		***$0.00***
TOTAL COSTS	**$0.00**	**#DIV/0!**		**$154.04**	**$216.00**		**$204.48**		**$215.00**

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Enterprise Budgets for Oilseed Crop and Co-Product Production: Option 1

Break-even analysis					
Price needed at proj. yield	**per bushel**	**per ton**	**Yield needed at proj. price**	**bushels/acre**	**tons/acre**
at expected yield	#DIV/0!	#DIV/0!	at projected price	#DIV/0!	#DIV/0!
at 90% of expected yield	#DIV/0!	#DIV/0!	at 90% of expected price	#DIV/0!	#DIV/0!
at 75% of expected yield	#DIV/0!	#DIV/0!	at 75% of expected price	#DIV/0!	#DIV/0!
at 50% of expected yield	#DIV/0!	#DIV/0!	at 50% of expected price	#DIV/0!	#DIV/0!
at 120% of expected yield	#DIV/0!	#DIV/0!	at 120% of expected price	#DIV/0!	#DIV/0!
at 150% of expected yield	#DIV/0!	#DIV/0!	at 150% of expected price	#DIV/0!	#DIV/0!

Revenues					
A. Sell crop (whole seeds)			**Total revenue**	**Per Acre**	
Price/ton	$ -		$ -	#DIV/0!	
B. Roast beans on site			**Total Revenue/Offset Cost**	**Per Acre**	
Roasted beans' sale price per bu	$ 7.00		$ -	#DIV/0!	
	Costs	**cost per bu**			
(less) Roaster capital expense		#DIV/0!	$ -	#DIV/0!	
(less) Roasting labor costs		#DIV/0!	$ -	#DIV/0!	
			$ -	**#DIV/0!**	

ANNUAL PROFIT (or loss) from Crop Production			
Profit (loss) from sale of whole seeds	**$0.00**	Per acre	**#DIV/0!**
Profit (loss) from sale of roasted beans	**$0.00**	Per acre	**#DIV/0!**

*Penn State Farm Management Enterprise Budget for soybeans: http://agguide.agronomy.psu.edu/cm/sec12/sec12toc.cfm
**Peter Sexton, University of Maine; Heather Darby, University of Vermont

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Enterprise Budgets for Oilseed Crop and Co-Product Production: Option 2

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Feed & Fuel Project
Enterprise Budgets for Oilseed Crop and Co-Product Production

Enterprise Option 2 - Press Seeds and Use/Sell Meal and Oil
shaded = ENTER YOUR DATA HERE

Expenses				
Variable Costs	**Total**	**per bushel**	**per acre**	**Typical costs for reference**
fill in total cost				
Seed press rental (optional)		#DIV/0!	#DIV/0!	
Energy (heat, electricity)		#DIV/0!	#DIV/0!	
Labor & management		#DIV/0!	#DIV/0!	
sub-total	*$0.00*	*#DIV/0!*	*#DIV/0!*	
Fixed Costs				
assign portion of total costs				
Seed dryer		#DIV/0!	#DIV/0!	
Seed cleaner		#DIV/0!	#DIV/0!	$2,000 - $8,000
Seed storage		#DIV/0!	#DIV/0!	$10,000
Seed press		#DIV/0!	#DIV/0!	$6,000 - $10,000
Meal storage		#DIV/0!	#DIV/0!	$1,000-$2,000
Oil storage		#DIV/0!	#DIV/0!	$1,000-$2,000
sub-total	*$0.00*	*#DIV/0!*	*#DIV/0!*	
TOTAL COSTS	**0.00**	**#DIV/0!**	**#DIV/0!**	

Oilseed Conversion Table			
Crop	**canola**	**soybeans**	**sunflower**
Lbs. per bushel	50	60	30
Meal %	60%	82%	56%
Oil content %	40%	18.3%	44%
lbs oil/gallon	7	7	7

Note: If you plan to grow your own oilseeds, you must complete the Enterprise Option 1 worksheet before proceeding to Enterprise Option 2.

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Enterprise Budgets for Oilseed Crop and Co-Product Production: Option 2

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Break-even analysis					
Price needed at proj. yield	per lb oil	per ton meal	Yield needed at proj. price	lbs oil/bu seed	lbs meal/bu seed
at expected yield	#DIV/0!	#DIV/0!	at projected price	#DIV/0!	#DIV/0!
at 90% of expected yield	#DIV/0!	#DIV/0!	at 90% of expected price	#DIV/0!	#DIV/0!
at 75% of expected yield	#DIV/0!	#DIV/0!	at 75% of expected price	#DIV/0!	#DIV/0!
at 50% of expected yield	#DIV/0!	#DIV/0!	at 50% of expected price	#DIV/0!	#DIV/0!
at 120% of expected yield	#DIV/0!	#DIV/0!	at 120% of expected price	#DIV/0!	#DIV/0!
at 150% of expected yield	#DIV/0!	#DIV/0!	at 150% of expected price	#DIV/0!	#DIV/0!

Revenues				
Efficiency of seed press (vs. commercial)	80%			
			Revenues	Per Acre
Oil value (for sale or use)				
Total oil yield in lbs	-			
Per lb sale price or replacement value		$	-	#DIV/0!
Meal value (for sale or use)				
Total meal yield in tons	-			
Per ton sale price or replacement value			$0.00	#DIV/0!
TOTAL REVENUES			**$0.00**	**#DIV/0!**

NOTE - Replacement Value is shown as income, but in reality it is a reduction in costs. One cannot assume prevailing price - meal value should be based on nutrient value; oil value depends on market.

ANNUAL PROFIT (or loss) from Seed Pressing			
Profit (loss)	**$0.00**	Per acre	**#DIV/0!**

Total combined ANNUAL PROFIT (or loss) from Crop Production & Seed Pressing			
Profit (loss)	**0.00**	Per acre	**#DIV/0!**

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Enterprise Budgets for Oilseed Crop and Co-Product Production: Option 3

Vermont Feed & Fuel Project
Enterprise Budgets for Oilseed Crop and Co-Product Production

Enterprise Option 3 - Make and Use/Sell Biodiesel

shaded = ENTER YOUR DATA HERE

	OIL SUPPLY ASSUMPTIONS				
			lbs oil		**gallons biodiesel**
1.	Oil produced on-farm (lbs)	a.	0	b	0
2.	Off-farm Purchased oil [optional]	a.	114,000	b.	15,000
3.	Collected restaurant oil -in gallons [optional]	a.	114,000	b.	15,000
4.	**Total production potential**	a.	228,000	b.	**30,000**
			($) per lb.		**($) per gallon**
5.	Unit Cost of On-Farm Produced Oil [lbs]	a.	#DIV/0!	b.	#DIV/0!
6.	Unit Cost of Purchased Oil [lbs]	a.	$0.22	b.	$1.67
7.	Unit Cost of Collected Oil [gallon]	a.	$0.08	b.	$0.64

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Enterprise Budgets for Oilseed Crop and Co-Product Production: Option 3

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EXPENSES - variable

	Variable production costs		Total cost		($) per gallon
8.	Oil produced on-farm [from "Option 2 - press oil]	a.	#DIV/0!	b.	
9.	Off-farm purchased oil (gallons)	a.	$25,080.00	b.	
10.	Collected restaurant oil (gallons)	a.	$9,534.00	c.	#DIV/0!
11.	Methanol	a.	$20,700.00	b.	$0.69
12.	Catalyst (KOH)	a.	$2,362.50	b.	$0.08
13.	Titration	a.	$0.01	b.	$0.01
14.	Other lab fees and testing services	a.	$50.00	b.	$0.002
15.	Filters	a.	$5.00	b.	$0.01
16.	Energy/electricity	a.	$540.00	b.	$0.02
17.	Labor and maintenance @ 400 gal./week	a.	$0.00	b.	$0.00
18.	**Or** Labor and maintenance @ 800 gal./week	a.	$21,000.00	b.	$0.70
19.	Miscellaneous costs	a.		b.	$0.00
20.	***Total variable production costs***	*a.*	*#DIV/0!*	*b.*	*#DIV/0!*

Work Table for Biodiesel Production

	unit		$ per unit		$ per gallon of biodiesel
Collected restaurant oil [labor & vehicle]	$/hr	d.	$14.00	e.	$0.64
Methanol (gallons)	gal	c.	$3.45	d.	$0.69
Catalyst (KOH) (gallons)	lb	c.	$1.25	d.	$0.08
Titration	ea	c.	$0.01	d.	$0.01
Other lab fees and testing services	ea	c.	$50.00		
Filters	ea	c.	$5.00	d.	$0.01
Electricity	KWh	c.	$0.09	d.	$0.02
Labor and maintenance for 1 batch per week (400 gal/wk or ~ 20,000 gal/year)	Hr	c.	$0.00	d.	$0.00
OR Labor and maintenance for 2 batches per week (800 gal/wk or ~ 40,000 gal/year)	Hr	c.	$14.00	d.	$0.70

	EXPENSES - fixed	
	Processor and tank farm - fixed costs	**Total**
21.	Biodiesel processor & settling	$10,000
22.	Methanol mixing	$500
23.	Glycerol storage	$300
24.	Biodiesel storage	$700
25.	Heating and drying	$500
26.	Lab equipment	$150
27.	Storage/fire locker	$5,000
28.	Filter housing	$600
29.	Piping/valves	$7,000
30.	Pumps	$10,000
31.	Controls/electrical	$3,000
32.	*Total processor and tank farm*	**$37,750**
	Other fixed costs	
33.	Building/other capital	
34.	Secondary containment [SPCC compliant]	$4,000
35.	Permitting fees	
36.	Consultants	
37.	Insurance	
38.	*Total other fixed costs*	**$4,000.00**

					Interest rate		Term of loan (yrs)		Annualized Fixed Costs
39.	**Total fixed expenses**	a.	$41,750.00	b.	6.0%	c.	10	d.	$3,687.92

40.	**TOTAL EXPENSE (variable + annual fixed costs)**	#DIV/0!
41.	**PER GALLON COST BIODIESEL**	#DIV/0!

			Fuel Yield (gal)		Price per gal.
42.	**Fuel value (for sale or use)**	a.	30,000	b.	$3.00

			Revenues		Per acre
43.	**TOTAL BIODIESEL REVENUES (or fuel replacement value)**	a.	**$90,000.00**	b.	**#DIV/0!**

			Profit (loss)		Per acre
44.	**ANNUAL PROFIT (or loss) from Biodiesel Production**	a.	#DIV/0!	b.	#DIV/0!

TOTAL COMBINED ANNUAL PROFIT (or loss) from crop, seed pressing, and biodiesel production

45.	**Annual combined profit (loss)**	a.	$90,000.00

		Per acre total
46.	**TOTAL COMBINED PER ACRE PROFIT (or loss) from meal & biodiesel production**	#DIV/0!