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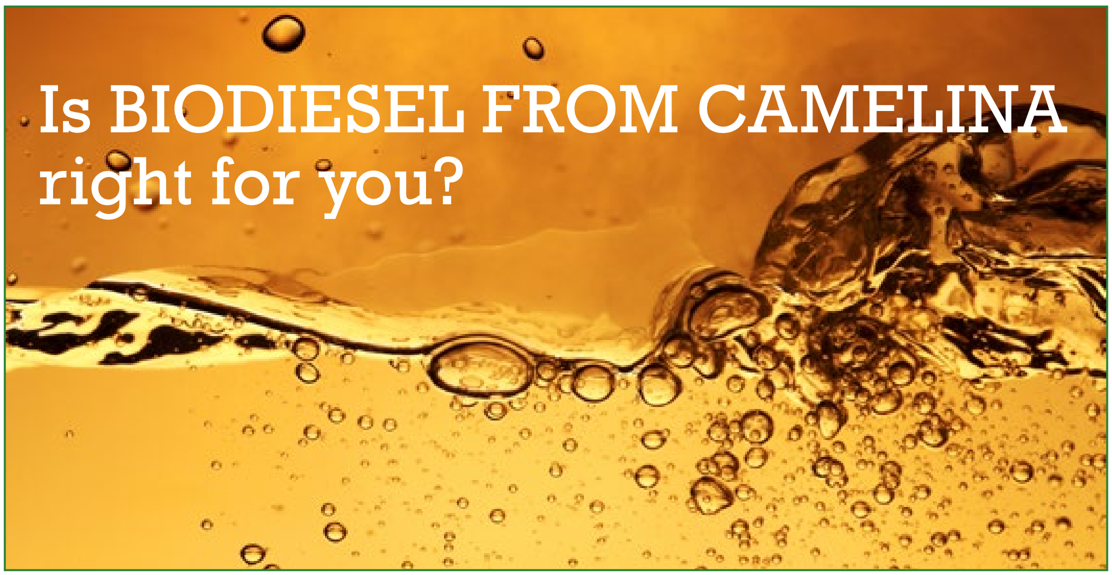

Is BIODIESEL FROM CAMELINA right for you?

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EXTENSION

Is BIODIESEL FROM CAMELINA right for you?

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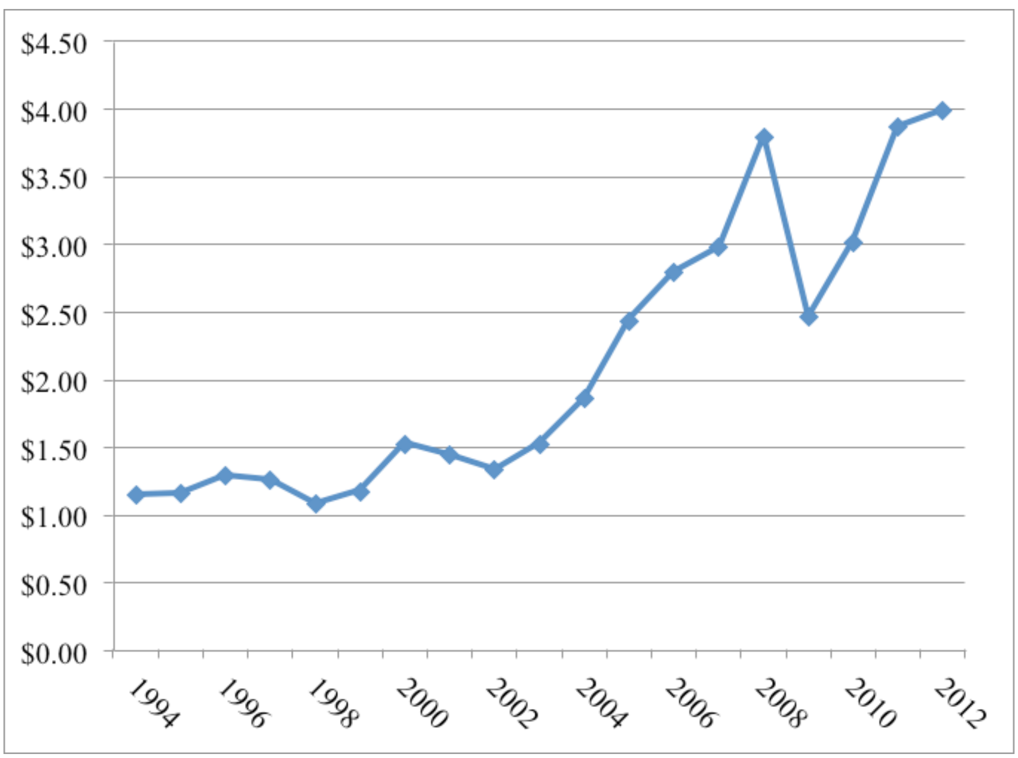
Let's get started

Have you been thinking about adding on-farm biodiesel production to your operation? Are you concerned about rising and volatile energy prices? Do you have the desire for personal energy independence? Do you want to promote cleaner energy? Figure 1 shows the average annual retail fuel price (including taxes) for the Rocky Mountain region from 1994 through 2012. Prices were fairly stable until 2002 before starting their ascent. The cause of the price rise has been attributed to demand for fuel in developing countries—particularly China. The Great Recession caused a decrease in demand, and prices fell in 2008-2009. Since then, however, prices have strengthened and moved above their 2008 peak.

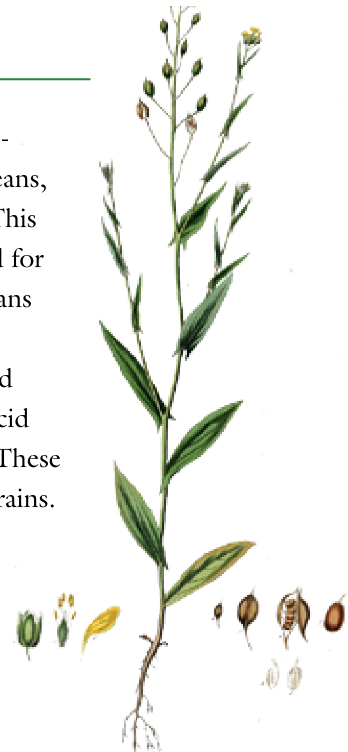
There are many factors farmers should take into account before making a significant investment in not only equipment but also in land and labor. Thinking about on-farm biodiesel production from an enterprise perspective is more appropriate. The investment parameters are similar to any other enterprise; but instead of profit, cost savings, is the principle measure of success (i.e., the amount of money not spent on feed and fuel). In this bulletin, we investigate the tradeoffs for a potential on-farm biodiesel production enterprise from dryland camelina to understand when and if it can be economically viable.

Figure 1. Rocky Mountain Region Retail No. 2 Diesel Fuel Price, 1994-2012*.



**Average annual price, PADD 4. Source EIA, 2013.*

Why Camelina?



What is camelina and why are we interested in it for biodiesel production? Much of the current biodiesel production comes from soybeans, but biodiesel competes for grain with livestock and other food uses. This can have adverse effects on prices and contributes to the ethical "food for fuel" dilemma. More importantly for farmers in the arid West, soybeans do not grow well in the West without irrigation, which makes them expensive and unattractive for biodiesel production in this region. And finally, camelina has two anti-nutritional factors. It is high in euricic acid and glucosinolates, which limits the amount of meal that can be fed. These factors limit camelina's feed potential and its competition with feed grains. This means camelina has more potential for production in the West with less competition with other feed and food crops. Still, worth noting is that land used to grow camelina, even fallow land, may impact that land's productivity for later food production.

Camelina (Camelina sativa) is a brassica and in the same family as mustard, cabbage, and broccoli. It is a drought-tolerant crop researchers at the University of Wyoming and Montana State University have been investigating for use as a substitute for fallowing in a wheat-fallow rotation scheme. Evidence of camelina cultivation in Europe has been found from 5,000 years ago (Putnam et al., 1993). However, it is a new crop for the western United States, where cultivation began in the 1980s (Robinson, 1987 and McVay and Lamb, 2008). Acreage planted had been growing for a number of years, but recently has slipped as higher wheat prices have dampened farmer enthusiasm for newer crop varieties with more risky, less-developed markets.

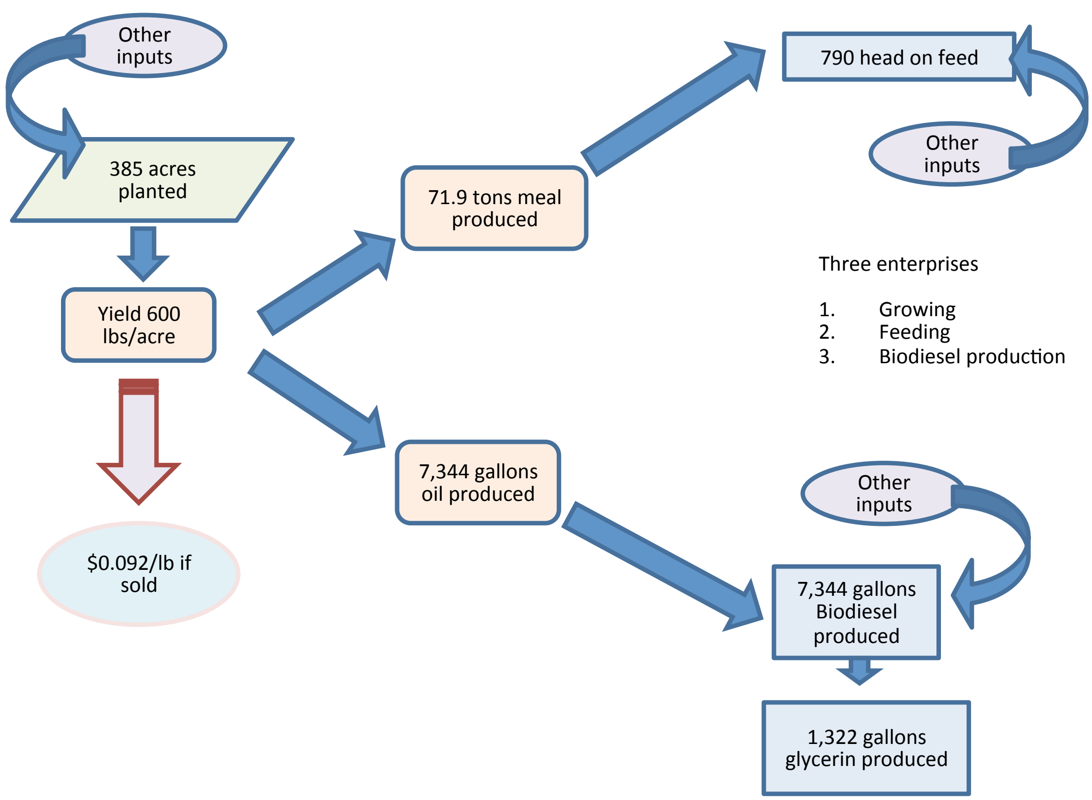
Our Approach

To understand the biodiesel production process, the best approach would be to build a system and track the costs and returns (cost savings) and document problems encountered. That was not possible for us due to lack of resources. Instead, our approach is to estimate the costs for a system based on a chosen production process. For this we selected the process outlined in Biodiesel Basics and Beyond by Kemp (2006). Kemp uses a series of electric water heaters to process vegetable oil into fuel. Note that this process has not been evaluated for safety by the University of Wyoming and as such this bulletin does not constitute an endorsement of this process. We also developed a spreadsheet-based "calculator" that has been refined for a detailed comparison between different parts of the process.

Economic analyses of agricultural enterprises often consist of enterprise budgets to analyze the costs and returns from specific activities. The biodiesel system starts with planting camelina, followed by harvesting and crushing the seed (Figure 2). This results in two major products—camelina meal and oil. The meal is fed to livestock, and the oil is processed into biodiesel. Since the majority of the output of the process is meal (in terms of weight and volume), meal becomes the primary constituent and should be consumed as close to the point of production as possible to avoid transportation costs. Therefore, having enough animals locally to consume all the meal produced is essential and should be an investor's first concern.

Glycerin is a minor product that has an energy value comparable to cornstarch. Kemp classifies it as a waste product, but treated as described later, can be fed to livestock (Moriel et al, 2011).

Figure 2. Camelina systems approach diagram.



It should also be noted that until November 2009, FDA regulations restricted camelina meal supplemental feeding to 2 percent of a dry matter ration for cattle. Camelina contains a level of erucic acid (4 to 5 percent, greater than the FDA's 2-percent limit for food consumption) and glucosinolates, which in tests on swine showed an increase in fat around the heart (Pilgeram et al., 2007). That restriction has now been raised to 10 percent for ruminants based on further research (FDA, 2009). Support for this level is also provided by Moriel et al. (2011).

We estimate the costs and returns of growing camelina on a model 4,400-acre dryland farm hypothetically located in Montana. The Montana location was used for two reasons: one, results from farmers and research at the Moccasin station supported this scale, and two, the spreadsheet crop budget used crop and input data from Montana locations. Research at the University of Wyoming has shown obtaining the same yields on dryland farms in southern Wyoming would be difficult. The model farm consists mainly of wheat/fallow dryland crop land. Cropping costs and returns are evaluated using a spreadsheet program developed by Montana State University Extension (Griffith, 2010), which analyzes tillage types and cropping mix. The price of diesel fuel reflects the five-year average (2008-2012) Rocky Mountain region pre-tax diesel price of $3.29 /gal (EIA, 2013). The camelina yield is set at 600 pounds per acre (lbs/ac), which is slightly above the 2008 Montana average yield of 546 lbs/ac (USDA, 2008). Long-term yield information does not exist. The price of camelina is set at the latest reported average Montana camelina price (2007) of $9.18 per hundred weight (cwt) (USDA, 2008). Fertilizer and glyphosate prices have been updated to their 2012 prices (Note: There is no Roundup-Ready variety of camelina, but it is used to prepare the field). Other resource parameters have not been altered from the original.

These estimates are inputs to the spreadsheet calculator. This calculator uses economic information and assumptions from the growing and feeding enterprises and combines it with biodiesel production information. The calculator is designed to be adaptable to other types of oilseed crops as well. Production estimates for oil and meal are used in conjunction with prices for other comparable meal substitutes to generate a range of alternative feed costs to compare with the cost of camelina meal. Cost comparisons with camelina are important because the market for this oilseed is not well developed. Comparisons can be made between four different rations: substitute ration of one-half corn, one-half soybean meal, linseed meal, canola meal, and an estimate of growing and pressing costs for camelina. Due to a lack of existing price information, we use an estimated value of camelina meal based upon the average of the price of canola meal and linseed meal. Under this assumption, camelina meal is valued at $0.119 /lb. Price data for camelina oil is also not available, so we use an implied price based on the estimated price of the meal and the growing costs for camelina with oil as a residual of the meal production process. Using this method, we arrive at an estimated $3.09/gal for camelina oil.

Camelina field outside Conrad, Montana.

Our model assumes a 20-year lifespan for the system. Press usage is adjusted so that the press would be used the maximum amount each year for its lifespan to be 20 years. Given these assumptions, the press would operate 68 days (24 hours per day) and crush 143,784 lbs per year.

We modeled the biodiesel production facility after Kemp (2006) in which 66-gallon water heaters process the oil in 50 gallon batches. A batch must settle overnight, so production capacity is limited to 50 gallons per day. At this rate, oil from an entire crop (385 acres), 7,344 gallons could potentially be processed into biodiesel in 147 batch/days (additional settling tanks could increase capacity but were not factored in). This would be a significant time requirement. Table 1 lists the equipment and costs derived from Kemp (2006).

Pressing costs are estimated by using nameplate data from the press. The press used in this project is a Kern Kraft, KK40F with a nameplate throughput capacity of 88 lbs per hour and a daily capacity of 2,112 lbs. We estimate electricity costs at $0.09 kilowatt/hours (kwh). Daily electricity consumption is estimated to be 38.4 kwh (24hrs X 1.6 kwh). We assume the average oil content of camelina is 34 percent and an average meal content of 66 percent. The mechanical pressing process assumes an 80-percent extraction rate. This results in actual oil yield of 27.2 percent, which accounts for 90 percent of planted acres harvested (see 'yield' section of Table 2).

Rinse water costs where not factored into the model. Rural producers will likely rely on well water, so pumping costs (in the form of electricity) will be the only cost incurred. However, it should be noted that a significant amount of rinse water may be needed that would produce a noticeable increase in electricity costs for the farm.

Table 1. Biodiesel production facility equipment list and costs.

A. PRODUCTION EQUIPMENT			
Qty	**Item**	**Price/ea**	**Cost**
3	66 gallon electric hot water heaters (@ $467 ea)	$467.65	$1,402.95
1	30 gallon mixing tank and stand (conical base)	$149.00	$149.00
1	60 gallon wash tank and stand (conical base)	$175.00	$175.00
1	300 gallon raw oil storage tank	$249.00	$249.00
1	300 gallon biodiesel storage tank	$249.00	$249.00
1	40 gallon treated water storage tank	$70.00	$70.00
4	liquid pumps, ½ hp @600gpm	$40.00	$160.00
1	reverse osmosis water purifying system (GE Merlin)	$390.00	$390.00
1	air/liquid condenser unit (estimated)	$200.00	$200.00
1	ventilator fan (Broan 701 cfm fan)	$159.00	$159.00
1	chemical mixer (Talboys lab stirrer explosion proof)	$231.00	$231.00
1	water tank heater (1,000 watt)	$19.80	$19.80
1	small compressor (airbrush compressor like below)	$80.00	$80.00
1	air blower (airbrush compressor with variable speed)	$80.00	$80.00
1	chemical hand pump (barrel fuel type pump)	$24.99	$24.99
2	2 inline oil filters (estimate)	$30.00	$60.00
1	1 inline air filter	$7.99	$7.99
16	¾" ball valves	$12.73	$203.68
1	¾" reinforced nylon tubing (per 50 foot box)	$49.49	$49.49
20	¾" black mild steel pipe (per foot)	$2.50	$50.00
1	14 gauge electrical wire -Romex (per 250' roll)	$43.90	$43.90
1	electrical load center, 100 amp	$49.00	$49.00
1	assorted fasteners and couplings (est.)	$100.00	$100.00
1	digital probe thermometer	$42.95	$42.95
	Contingency cost (10 percent)	$424.68	$424.68
			$ 4,671.43

B. TESTING AND SAFETY EQUIPMENT			
Qty	**Item**	**Price/ea**	**Cost**
1	fire extinguisher	$47.99	$47.99
1	face shield	$13.86	$13.86
1	nitrile gloves (pkg of 12)	$19.80	$19.80
1	eyewash flush kit	$14.49	$14.49
1	first aid kit	$34.95	$34.95
1	digital laboratory scale	$89.99	$89.99
1	hydrometer set (includes hydrometer and cylinder)	$36.50	$36.50
2	250 ml beakers	$3.25	$6.50
1	titration burette	$32.00	$32.00
1	titration stand	$13.00	$13.00
1	phenolphthalein reagent (1 oz.)	$3.50	$3.50
1	glycerol test kit	$0.00	$0.00
			$312.58

C. STORAGE AND BLENDING TANKS			
Qty	Item	**Capacity/gal**	**Cost**
1	Raw oil storage tank	1,000	$780
1	Biodiesel (finished) storage tank	500	$399
1	Blended biodiesel tank	1,000	$780
1	Petroleum diesel storage tank	1,000	$0
			$1,959

Labor costs are not included in this analysis. We assume all labor in the system is supplied by the operator. No requirement for hired labor has been built-in to the calculator. The amount of labor expended in set-up and production is likely to vary significantly depending on the skills of the operators and how comfortable they are with plumbing and electrical work (A 220 volt hookup is required). We believed that trying to factor in labor would be purely speculative.

Therefore, we included labor in returns to management and capital, which is consistent with the Montana State University crop budget software (Griffith, 2010). However, we realize that set-up and operation labor would be a significant input and if valued would have significant negative impacts on the results.

What we found

The estimated start-up costs farmers face to produce biodiesel includes production equipment, the press, storage tanks, and testing and safety equipment (Table 2). The production of biodiesel involves the use of some hazardous and explosive chemicals (caustic soda and methanol). Quality control of the product is also essential for personal safety and to safeguard equipment. Therefore, the model includes costs for testing and first aid equipment.

Table 2. Start-up capital summary.

TOTAL ESTIMATED	INDIVIDUAL
Biodiesel production equipment	$4,671
Press cost	$12,500
Storage tanks	$1,959
Testing and safety equipment	$313
Total estimated start-up costs	**$19,443**

Table 3 shows the summary results for the growing, yield, and feeding portions of the model. Yield information shows how much meal and oil could be produced from the given acreage. Annual meal usage and oil yield are also shown. Camelina yields in Montana in 2008 ranged from 250 lbs/ac to more than 1,000 lbs/ac and averaged 615 lbs/ac. We chose to model 600 lbs/ac yield. Note that the actual percent of oil yielded is different from the amount of oil in the seed. This is because of the difference in the percentage of acres harvested over those planted as well as the use of a mechanical press, which leaves some oil in the meal. Also, there is moisture loss from the pressed meal. We used an average value of 5 percent moisture loss by weight in our meal calculations. In this scenario, the break-even operating yield for growing camelina is 669 lbs/acre.

Table 3. Camelina calculator annual growing, yield, and feeding results.

GROWING COSTS ($/AC)	
Gross revenue (@ $0.0918lbs/ac)	$55.08
Total operating costs	-$61.44
Total ownership costs	-$46.22
Total growing costs	-$107.66
Returns over operating costs	-$6.36
Returns over total costs	-$52.58
YIELD	
Area of camelina planted	385
Area harvested (90%)	346.5
Yield	600 lbs/ac
Total harvest	207,900 lbs
Percent oil	34
Percent meal	66
Percent of oil extracted	80
Actual percent oil yield	27.2
Total weight of oil	56,549 lbs
Total weight of meal (less 5% moisture loss)	143,784 lbs
Total volume of oil (@7.7lbs/gal)	7,344 gal
Total weight of meal	71.9 tons
Total glycerol production	1,322 gal
FEEDING	
Feeding rate	2 lbs/day
Number of days on feed	90
Number of head on feed	790
Total consumption of meal	142,200 lbs
Residual meal	1,584 lbs

Ownership versus operation costs

There is often some confusion about ownership versus operation costs and when to include each. Operation (also called "variable") costs are costs that vary with each unit of production. For example, the amount of fertilizer used per acre will vary with the number of acres planted, or similarly, the amount of fuel used will vary with acreage and the number of passes.

Ownership or "fixed" costs are costs incurred by the business that do not vary or vary only slightly with production. For example, depreciation costs associated with machinery do not vary with the number of acres farmed (of course, you will have to buy bigger or more machinery if the size of your operation grows substantially). Property taxes are based on acreage but are considered an ownership cost since they must be paid whether the land is farmed or not.

The model assumes cattle consume camelina meal as a protein supplement at the rate of 2 pounds per day for 90 days (winter feeding). For all the meal produced in a given year to be consumed, 790 cattle would need to be fed this ration. This means that it is all the more important for those interested in camelina to be sure to have a plan to handle the meal inventory before investing.

Table 4 shows the summary financial results. Avoided costs are the amount of feed and petroleum diesel that the farmer does not have to buy. Using the five-year average pre-tax diesel fuel price of $3.29/gal, farmers would not have to buy 7,344 gallons of diesel fuel ($24,162). The larger savings comes from the cost savings for feed. Farmers save an estimated $36,217 from feeding camelina meal, assuming an alternate 2-pound ration of one-half corn, one-half soybean meal at $0.25 /lb. These two values added together result

Table 4. Camelina calculator summary financial results.*

	TOTAL COSTS	OPERATING COSTS ONLY
Fuel costs avoided	$24,162	$24,162
Feed costs avoided	$36,217	$36,217
	$60,379	$60,379
Growing costs	$41,449	$23,654
Biodiesel production costs	$28,233	$9,466
	$69,682	$33,121
Total est. cost or savings	**-$9,303**	**$27,258**

**Assumes labor is included in returns to management and capital* in total estimated savings of $60,379. The higher value in the process with the current price structure is from the avoided costs of livestock feed. Camelina feed costs are estimated to be 12 cents per pound. A 2-pound ration of camelina meal is only 1 cent less than the standard corn/soybean meal ration ($0.244 for camelina versus $0.252 for corn/soy ration). Yet, with the amount of feed consumed, there is still a $569 savings from feeding camelina meal. From a production standpoint, thinking of this system as being centered on feed production with biodiesel as a by-product is more accurate.

Total annual costs are estimated by adding growing costs ($41,449) and biodiesel production costs ($28,233) for a total cost of $69,682. Subtracting the avoided costs of fuel and feed ($60,379) results in the net annual overall cost of the production system (-$9,303). This number (not including labor) shows that the biodiesel production system is not economically feasible at the five-year average price of petroleum diesel. However, when evaluated from an "operating costs only" perspective, the overall savings/cost is $27,258. This is because the ownership costs of growing and processing camelina are not accounted for in this perspective.

Table 5 illustrates unit production costs. Camelina oil feedstock is the primary constituent, followed by chemicals. Depreciation and annual maintenance are estimated at 5 percent of start-up costs (see Table 2). The 'operating costs only' columns differ from the 'total costs' columns in that camelina oil costs do not include the ownership costs associated with growing the crop nor is depreciation included. The cost of producing on-farm biodiesel from camelina is estimated to be $3.84/gal.

Table 5. Camelina biodiesel unit costs of production.

	TOTAL COSTS		OPERATING COSTS ONLY	
	Per gallon	**Per batch***	**Per gallon**	**Per batch***
Camelina oil	$3.09	$155.00	$0.65	$33.44
Chemicals	$0.45	$11.12	$0.45	$22.71
Annual operating cost	$0.03	$1.69	$0.03	$1.69
Capital depreciation (5% of startup)	$0.13	$7.00	$0.00	$0.00
Annual maintenance costs (5% of startup)	$0.13	$7.00	$0.13	$6.62
Total	**$3.84**	**$192.22**	**$1.29**	**$64.45**

**1 batch equals 50 gallons*

Camelina ready for harvest.

Camelina seed pods.

Camelina seed.

There are currently no farm-level subsidies for biodiesel. Subsidies in general came under increasing pressure from Congress in 2011. The $1 per gallon biodiesel subsidy for blenders expired at the end of 2011 but has been reinstated until the end of 2013 (DOE, 2013). The outlook for future subsidies is clouded. The only potential government support for on-farm biodiesel production is the USDA Rural Energy for America Program. This is a competitive grant program that could provide up to 25 percent of the cost of equipment (USDA Rural, 2011).

Glycerol is another by-product of the biodiesel production process. Glycerol, methanol, and catalyst are the residuals to biodiesel production. The process outlined by Kemp (2006) and used here includes a methanol recovery unit to reclaim and reuse as much methanol as possible. Kemp estimates that three pints per 50-gallon batch can be recovered using this method[1]. Yet even with a methanol recovery unit, the glycerol is not "refined" and has very little, if any, value unless the producers are close to a processing facility that can use this product. Some Internet sites promote glycerol from biodiesel production as a livestock feed. The authors caution that even with a methanol recovery unit the amount of methanol in the glycerol by-product is likely too high for livestock and is toxic. To be fed, the catalyst (either potassium or sodium hydroxide)

1 Methanol recovery is problematic. Anecdotal evidence suggests this is hard to do, and the methanol recovered is of insufficient quality to be reused. We assume that recovered methanol is not reused.

must also be neutralized with vinegar and the glycerol left to stand for several days until any residual methanol has evaporated. We assign no value to glycerol in the model; instead, to avoid disposal issues, the glycerol is treated as described and fed. This process produces an estimated 1,322 gallons per year (see Table 3).

Challenges

Perhaps the greatest challenge to biodiesel profitability is the opportunity cost of putting land into camelina when prices for other crops (especially wheat in our region) are above historic levels. Growing a marginal crop like camelina is hard to justify when profitability of more mainstream crops provides greater financial returns. Crop prices do fluctuate, and there may come a time when this difference is negligible. In general, however, camelina is probably best suited for marginal cropland where yields of camelina may be expected to be better than other competing crops.

The per gallon (operating only) cost of $1.29 could lead some to think that biodiesel production is profitable given today's diesel price. However, when ownership costs are included, the resulting $3.84/gal production cost shows the enterprise is not profitable. Producers who normally only consider cash costs in production decisions would be wise to take a closer look at the ownership costs involved. Additionally, we assigned labor costs to returns to management and capital. A significant amount of operator time would likely be required to produce the amount of fuel estimated here, and these costs would likely add a significant amount to per unit production costs if factored in.

Since the current market for camelina is thin (low trading volumes and few trading hubs), having sufficient livestock resources (or access to them) to consume the meal is important, although this could change if the market matures. Our calculations show that at current meal and diesel fuel prices, camelina meal, and the role it plays in the capital flows of the system, plays a more central role than the oil.

The capital costs of setting up even a modest biodiesel production system are relatively large. The system designed for our project requires a significant investment of financial resources ($19,443). Much of this cost is associated with the press. Informal conversations with a rural banker indicate that this type of enterprise would be difficult to finance under traditional terms. Therefore, having sufficient financial resources on hand would be required.

When should I start making biodiesel?

People interested in on-farm biodiesel production often ask, “At what price (of petroleum diesel) should I start making my own fuel?” This is a more complicated question than it appears at first glance. There is no “one price” answer because there are so many variables to consider. Part of the answer depends on your risk profile; that is the value you put on having your own fuel supply and what you are willing to pay for it. If you believe fuel prices are going to be so high you will not be able to afford fuel or if you think that fuel will not be available, then you will likely put a high value on the ability to make your own fuel and not being dependent on conventional fuel supplies.

However, since mechanization has come to agriculture, there has never been a time when fuel has not been available in this country. Even during World War II with fuel rationing, fuel was made available to grow critical food supplies. The past may not represent the future, but it is an important indicator of the value society places on food production. Hopefully, scenarios such as this are not in our future.

For farmers more concerned with profitability, but who wish to explore more options for self-sufficiency, the decision whether or not to invest the land, labor, and capital into a biodiesel enterprise can be more thoroughly evaluated, but that answer is still not straightforward. In this bulletin, we have updated previous work from several years ago and found that the price of fertilizer[2] and fuel, two of the largest inputs, has increased dramatically. This has driven up production costs and the cost of producing on-farm camelina biodiesel. This means the price of on-farm produced biodiesel rises with the rise in price of petroleum diesel (since we assume farmers are using a B-20 blend of fuel) due to the other input prices dependency on the price of petroleum. Unless farmers stop using fertilizer, lubricants, and pesticide completely, it would be difficult to separate these costs.

We support other research in this area that concludes there is no single “trigger price” for economic viability (Kingwell and Plunkett, 2006). Rather, different producers will face different scenarios based on their production practices and prices that they face. Some preliminary work with our calculator shows that, when holding all costs static except the pre-tax petroleum diesel price of $3.29/gal, on-farm biodiesel would break even at $3.84/gal. However, as we have shown, when petroleum diesel prices rise, other input prices follow suite shifting the production price structure upward. In other words, there is significant price risk to achieving a break-even price for small producers. A break-even price for on-farm biodiesel likely converges at some point, but the price level at which producers would be willing to commit to investment is also likely higher than the $3.84/gal price provided by the calculator. This is especially true given the current prices for crops, such as wheat and corn.

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2 Nitrogen fertilizer is made from natural gas. The market for fertilizer is global. The U.S. imported 50 percent of the nitrogen used in 2012. The recent increase in the amount of natural gas available in the U.S. due to advanced extraction technologies has had no impact on the price of fertilizer. Nitrogen fertilizer prices in 2012 were at all-time highs (USDA-ERS, 2012)

Camelina ready for harvest, Conrad, Montana.

Our model also supports Kingwell and Plunkett's contention that the key driver in the system is the feedstock price. The amount of meal produced makes it the primary component of the system. Lower price (cost) feedstocks increase the attractiveness of on-farm production. But opportunity costs of capital and depreciation in the production system, in most cases, would keep these costs from going low enough to support economically viable on-farm biodiesel production.

Additionally, recent high prices for grain and other oilseeds make camelina with its low returns less attractive. This is the opportunity cost paradox. Camelina is a low-cost feedstock for biodiesel, but most farmers will easily see that growing more high-value crops on their lands lead to higher returns and increased profitability.

From a purely financial perspective, on-farm biodiesel production from camelina is not economically feasible. This research serves to illustrate the premium producers would need to achieve their goals. However, we understand that economics is only one variable (albeit quite important) in the decision-making process. Those farmers concerned about access to fuel, volatile fuel prices, and the impact of petroleum diesel on the environment do have a choice. Biodiesel may have a place in a farmer's production system, but it will not come without a price.

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