DRYLAND CAMELINA, A SYSTEMS APPROACH TO ON-FARM FEED AND FUEL: PRELIMINARY RESULTS

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Abstract

Recent interest in camelina production in the western United States has been generated by interest in establishing this oilseed as a rotational crop in a dry land system. Part of the interest lies in the ability to make biodiesel from the oil and use the meal as livestock feed. This paper uses a systems approach to size a production system for a single producer on-farm feeding and fuel system. A spreadsheet "Camelina Calculator" has been developed that estimates production costs for feed and fuel and can be adjusted for different yields and herd size from which estimates of profitability can be obtained.

The results show that in the eastern part of Wyoming, yields are not high enough to make this an economically viable prospect, primarily due to climatic conditions and the high cost of an oil seed press. Higher yields reported in Montana and perhaps some type of multiple ownership scheme for the press appear to be better alternatives. An interesting observation is that the cost avoided of feeding camelina meal instead of a corn/soybean ration provides the bulk of the savings in this system. The biodiesel production system itself, though apparently capable of producing a sufficient quantity and quality of biodiesel appears capital, labor and skill intensive for the individual producer.

Key words: Camelina, oilseed, biodiesel, economics

Introduction

Camelina (*Camelina sativa*) is not a new crop. Evidence of its 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 1980's (McVay and Lamb, 2008). More recently, with the rise in diesel fuel prices, there has been increased interest in Camelina as an input for biodiesel production and supplemental feeding of the meal co-product to livestock. In this paper we take a systems approach to dryland camelina and investigate the economics of growing, feeding and on-farm biodiesel production in a western United States, high-plains setting. Emphasis in this paper is given to the biodiesel production aspects of the process. These results are preliminary.

Systems approaches are now in vogue for agricultural research. This is partly the result of the trend toward awarding competitive grants to multidisciplinary projects. In the case of camelina, this approach makes sense since as a new crop to the region, markets are thin and producers need to think about how this crop will fit into their production scheme before planting. However, planning systems approach research is more difficult because the system needs to be more fully parameterized, adding a new dimension to the research. This has the effect of increasing the complexity of the research and narrowing the focus and thus, presumably, the applicability of the results. In a practical sense for camelina, it means that the number of acres planted, the number of cattle fed, and the amount of biodiesel produced must be defined in advance due to the considerable capital investment required to enter multiple enterprises at the same time. In that sense, it is like building a machine; all the gears must be designed to fit one another to make the machine work. This involves finding the parameter with the least flexibility and working backwards through the system to size the other parameters to fit.

Methods

When this project was funded, fuel prices were rising and there was significant interest in "sustainable" fuels research. The four-year project is designed to evaluate the growing, feeding and biofuels production aspects of camelina for the high plains states of Wyoming and Montana. Trial plots were planted at agricultural experiment stations at multiple locations in both states, as well as by individual producers. The plan was to crush the seed and extract the oil, and the feed the meal to cattle. In theory, the oil was to be made into biodiesel and demonstrations of this ability would be shown to farmers and ranchers, in theory. The reality was quite different. Organizing planting and finding a press proved to be more difficult and regardless of those issues, the weather did not cooperate to generate the yields that were estimated. However, barter arrangements were made for crushing and meal and eventually, the required inputs were obtained. At present, due to the low yields of the first year, the project has been extended to obtain more data. The 2010 crop year is expected to be the last.

Results of the crop trials and feeding portions of the project will be reported separately by other project participants. This paper focuses on the economics of the system, specifically, the economic feasibility of biodiesel production.

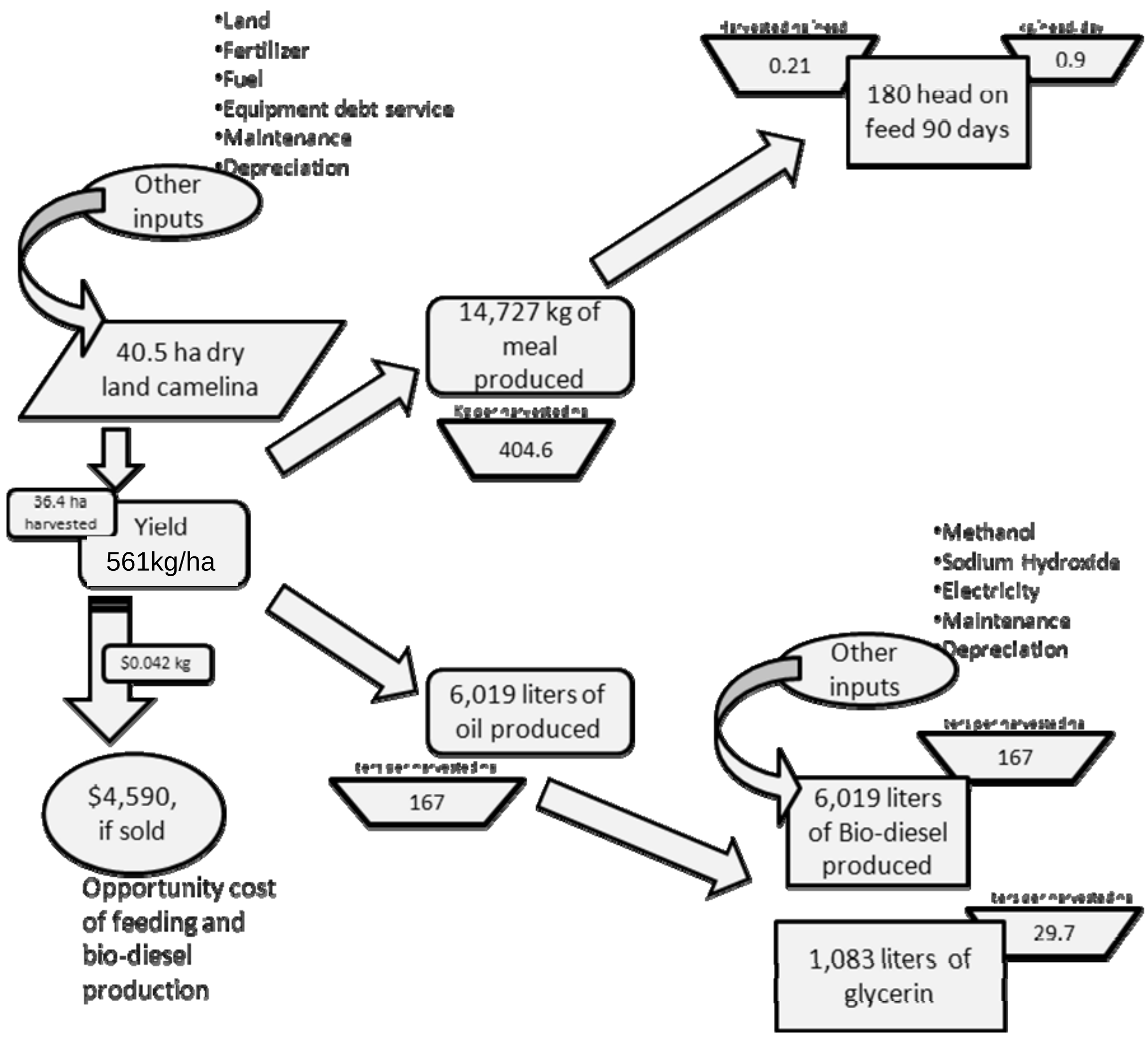
Figure 1 shows a schematic of the systems approach developed for this project. Traditional economic analyses of agricultural enterprises often consists of an enterprise budget or budgets to analyze the cost and returns from specific activities. Our approach is similar to a “whole farm” approach in that parts of this enterprise are dependent on other enterprises. The system starts with planting camelina seed. This is followed by harvesting, crushing the seed and feeding the meal. The resultant oil is made into biodiesel. This leaves a number of questions to be answered, such as:

- How many acres should be planted?
- How much meal will it produce?
- How many head will it feed and for how long?
- How much biodiesel will be produced?
- Would it be more profitable to sell the seed or feed it rather than make biodiesel?
- How much does it cost to get set up to make biodiesel?
- And at what price of petroleum diesel would it be profitable to start making biodiesel?

This is where the systems approach becomes appropriate. In the traditional view of a whole farm system, a fixed resource (land) is usually the driving constraint. However, in the production system described here, land is not constrained. It was initially thought that the number of cattle on feed would dictate the number of acres planted due the large amount of meal produced. However, further analysis shows that the system is more constrained by the size of the press used to extract the oil. Not only is the size of the press important, but the amount of oil produced will dictate the scale of the biodiesel production system. Therefore, it is also important to consider fuel needs. All these questions need to be answered prior to making investments in production equipment.

The number of answers needed brings up another important point about systems analysis. Namely, that there are more variables that need to be parameterized than in a traditional budgeting process. Also, because of this, the system is more narrowly defined and may be less applicable to other situations. This is a limitation to a systems approach as opposed to a more traditional budgeting approach.

Figure 1. Camelina systems approach diagram.



For this project, costs and returns are evaluated for three different enterprises on a model 1,780 hectare (4,400 acre) dry land farm, hypothetically located in the northern Great Plains region of the U.S., nominally in the states of either Wyoming or Montana (the project study region). The farm consists mainly of wheat/fallow dry land crop land. Cropping cost and returns are evaluated using a spreadsheet program developed by Montana State University Extension (Montana, 2010) which analyzes tillage types and cropping mix. After answering the questions outlined above, it was decided to substitute 100 acres of camelina for fallow land in the crop system.[1] The price of diesel fuel was updated to reflect the current price of $0.74/l ($2.80/gallon) (EIA, 2010). The yield for camelina was adjusted for the estimated average yield from project field trials, 561kg/ha (500lbs/ acre). And the price of camelina was set at the reported 2008 average Montana price of $0.202kg ($9.18/cwt) (USDA, 2008). All other parameters in the spreadsheet remain unaltered.

Costs and returns from this spreadsheet are used as an input in another spreadsheet we call the 'Camelina Calculator'. This spreadsheet takes in economic information from the three enterprises (growing, feeding, and biodiesel production) and is the major output of this portion of the project. The spreadsheet is designed to have the capability to be adapted to other types of oilseed crops as well.

Once the yield information is in the calculator, production estimates for oil and meal are calculated. This information, in turn is used in conjunction with prices for other types of comparable meal substitutes to generate a range of alternative feed costs to compare with the costs of growing camelina. Cost comparisons with camelina are important because the market for this oil seed meal is not well developed. Three different comparisons are used: A substitute ration of one-half corn, one-half soybean meal[2], linseed meal, and an estimate of growing and pressing costs for camelina.

Approximately 100 heifers each year were fed a camelina meal supplement as part of the project for two years. The results of this feeding trial will be reported separately. It should be noted that until November, 2009, FDA regulations restricted camelina meal supplemental feeding to 2 percent of a dry matter ration for cattle due to the high level of erucic acid (4 to 5 percent) contained in camelina (Pilgeram et al, 2007). That restriction has now been raised to 10 percent based on further research (FDA, 2009).

[1] The substitution of camelina for fallow was dictated by the project in an effort not to reduce land used for food production. Further evaluation of this aspect of the project was carried out by the project's agronomists and is not included in this paper.
[2] This is the ration that was used as the control ration in the UW feeding trials experiment with heifers.

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 40 kg (88 lbs) per hour and a daily capacity of 960 kg (2,112 lbs). Current electricity costs are estimated at $0.09/ kwh. Daily electricity consumption is estimated to be 38.4 kwh (24 hrs X 1.6 kwh).

Biodiesel production equipment costs were obtained from various internet sources. The sources are listed next to each item in the calculator so prices can easily be updated. The list of production equipment was derived from Kemp (2006) for a 189 liter (50 gal), two-tank batch system. Kemp uses an innovative system of electric water heaters to keep the oil at temperature. A ten percent contingency (of total capital costs) cost is added into the total cost of production equipment. A five percent annual maintenance fee is also included.

It is assumed that the farm will have a diesel storage tank. However, additional tanks would be needed for raw oil, blending and blended oil. The purchase of two 3,785 liter (1,000 gallon) poly tanks and a 1,893 liter (500 gallon) poly tank is therefore included. No provision for meal storage was made. It is assumed that the producer would have sufficient storage capacity for the meal produced.

Labor costs are not included in this system. The Montana State University crop budget calculator assumes labor compensation as part of a return to labor and management based on net returns to the enterprise. We continue with that convention for the biodiesel and feeding enterprises. However, we also recognize that there will be considerable time and variations in time input among operators for both start-up and production. Labor for this system in assumed to be all operator labor. No hired labor is included.

The production of biodiesel involves the use of some hazardous and explosive chemicals. These include methanol and caustic soda. Quality control of the product is also essential to safeguard equipment. Therefore testing and first aid equipment costs are built into the model.

Once the basic calculator was completed, a breakeven production cost of biodiesel was estimated. We then re-ran the costs and returns spreadsheet with petroleum diesel set to this price and re-estimated the costs and returns to produce biodiesel. Additionally, scenarios were run for petroleum diesel costs without taxes ("off-road" diesel which many farmers use) and scenarios with diesel costs of $1.58, $2.11, $2.64 and $3.17 per liter ($6.00, $8.00, $10.00 and $12.00 per gallon). This was to see how biodiesel production costs would compare at these extreme (for today) prices. It should be noted that these are statistic scenarios do not include rises in other input prices, especially fertilizer. Should petroleum diesel prices rise this much, other input prices would likely rise as well. But since it would be difficult at this level of modeling to estimate all these prices, a more simplistic approach was taken.

Results

The results of the yield portion of the calculator base model are shown in Table 1. This part of the calculator uses the yield information to show how much meal and oil would be produced from a given acreage. Additionally, the feeding rate and annual meal usage are also shown.

Table 2 shows the summary results for the base model calculator. The base model assumes a petroleum diesel cost of $0.734 per liter ($2.78 per gallon) and that the biodiesel would be blended into a B20 (20 percent biodiesel) blend for on-farm use. Growing costs are based on an average yield of 561 kilograms per hectare (500 pounds per acre), as found in the experimental trials for southeastern Wyoming. In this scenario, the breakeven operating yield for camelina would be 585 kilograms per hectare (521 pounds per acre). Therefore it would be difficult to even cover operating costs unless the price of camelina were to rise some. This means that camelina is a marginal dryland crop for eastern Wyoming. Dryland yields are reported to be somewhat higher in Montana and so this would be a more likely place to grow this crop.

Annual pressing costs include only the cost of electricity. The press itself draws 1.6 kw (kilowatts) of electricity, but would have to run for 15.5 days to crush the entire years' crop. However, it is likely that the farmer would not want to press the crop all at once, since the batch process of making biodiesel is time consuming and would require about 32 days to completely process. Additionally, more tanks would be needed to hold all the oil at once.

Table 1. Camelina calculator base model annual yield and feeding results.

	Metric	US
Area of camelina planted	40.5 ha	100 ac
Area harvested (90%)	36.4 ha	90 ac
Yield	561kg/ha	500 lb/ac
Total harvest	20,454 kg	45,000 lbs
Percent oil	0.34	0.34
Percent meal	0.66	0.66
percent of oil extracted	0.80	0.80
Total weight of oil	5,564 kg	12,240 lbs
Total weight of meal	14,891 kg	32,760 lbs
Total volume of oil	6,019 liters	1,590 gallons
Total weight of meal	14.89 tonnes	16.38 tons
Feeding		
Feeding rate	0.91kg/day	2 lbs/day
number of days on feed	90	90
number of head on feed	180	180
total consumption of meal	14,727 kg	32,400 lbs
residual meal	164 kg	360 lbs

Total equipment costs for an operation of this scale are estimated to be $19,443. $12,500 of this is for the press alone. The cost of the press is another reason why the press is the determining factor in sizing the operation. This project evaluates an on-farm system for a single producer, but the high cost of an oil seed press makes some sort of multiple ownership method appear to be a more viable alternative.

When evaluating the biodiesel production system, the authors found it useful to present the costs in two different ways: Total costs, including both ownership costs and operating costs of growing camelina and biodiesel production. And operating cost of growing only, though to be conservative, ownership costs for the biodiesel equipment are still included, Table 3. Capital equipment is depreciated using 20-year straight-line depreciation. The cost of oil, chemicals, depreciation and annual maintenance are added together to obtain the cost of production (Table 3). Oil is by far the most expensive input.

Table 2. Camelina calculator base model summary results

Camelina growing costs					
Total operating costs	-$118.21				
Total ownership costs	-$114.83				
Total costs	-$233.04	per hectare			
Value of seed if sold	$11,337	Per hectare@$0.202/kg and 561 kg/ha			
Pressing cost	$53.61	electricity			
Biodiesel production costs					
Total equipment costs	$19,443				
Biodiesel production costs					
Including ownership costs	**$1.28**	per liter	Total cost	$7,778	
	difference between buying and making biodiesel			-$3,359	
Operating costs only	**$0.52**	per liter	Total cost	$3,129	
	difference between buying and making biodiesel			$1,290	
Costs avoided if biodiesel produced		per year			
6,019	liters of diesel fuel at	$0.734	per liter	$4,419	
14,891	kg of feed at	$0.5236	per kg	$7,796	
				$12,215	

Total costs/savings	With ownership	Operating costs only	
Fuel costs saved	-$3,359	$1,290	
Feed costs saved	$7,796	$7,796	
	$4,437	**$9,086**	Estimated savings
Growing costs	$9,435	$4,786	
Biodiesel production costs	$7,778	$3,129	
	$17,213	**$7,915**	Total estimated annual costs
	-$12,776	**$1,171**	Total estimated cost/savings

Avoided costs are those of the amount of feed and petroleum diesel that the farmer does not have to buy. These values are shown in the middle of Table 2. At current diesel fuel prices, the producer would *not* have to buy 6,019 liters (1,590 gallons) of diesel fuel. However, since the price of petroleum diesel is less than the cost to produce biodiesel, the savings is a negative (a cost) -$3,359. The real savings would come from the avoided cost of feed. The producer would not have to purchase $7,796 by feeding camelina meal, assuming a 0.91 kilogram ration of one-half corn, one-half soybean meal at $0.52 per kilogram. These two values added together result in total estimated savings of $4,437. Thus the higher value in the process with the current price structure is from the avoided costs of livestock feed. In other words, from a production standpoint it is more accurate think of this system as being centered on feed production with biodiesel as a by- or "co-product".

Total annual costs are estimated by adding growing costs ($9,435) and biodiesel production costs ($7,778) for a total cost of $17,213 (bottom of Table 2). Subtracting the avoided costs of fuel and feed ($4,437) results in the net overall savings/cost of the production system (-$12,776). Add to this the assumption that labor compensation is in the form of returns to management and labor as a part of net revenue and the picture looks even bleaker. This number shows that the biodiesel production system, as outlined here, is not economically feasible at the current price petroleum diesel.

Table 3. Camelina production costs, base model.

	Total costs		Operating costs only	
	Per liter	Per batch	Per liter	Per batch
Camelina oil, gallons	$0.919	$173.94	$0.1479	$27.58
Chemicals	$0.0396	$7.50	$0.0396	$7.50
Annual operating cost	$0.0079	$1.69	$0.0079	$1.69
Capital depreciation (5% of startup)	$0.161	$30.58	$0.161	$30.58
Annual maintenance costs (5% of startup)	$0.161	$30.58	$0.161	$30.58
Total	**$1.28**	**$244.65**	**$0.517**	**$98.45**

However, when evaluated from an "operating costs only" perspective (last two columns of Table 3 and bottom right hand corner of Table 2), the total is $1,171. This is because the ownership costs of growing camelina are not accounted for from this perspective. Some farmers choose to not account for these costs in their calculations. The authors do not endorse this view, but we present these numbers here for those who would like to see them.

Discussion and conclusions

This paper has investigated the costs and returns of a biodiesel production system from camelina in a western United States, dryland crop setting. The results of our study found that yields for dryland camelina in southeastern Wyoming are marginal for profitability (operating costs only) and not economically feasible for biodiesel production at the current petroleum diesel price of $0.734 per liter ($2.78 per gallon). Higher yields reported for parts of Montana appear to be more viable. Future work with the spreadsheet calculator will explore this avenue of research. Our results are preliminary, but given the results obtained so far, it appears that from an operating cost only (and no labor) perspective, biodiesel production could break even in the range of $0.859-$0.925 per liter ($3.25-$3.50 per gallon) of petroleum diesel. A breakeven price from a total cost perspective was not calculated since the current cost of production is beyond a reasonable price, $1.28 per liter ($4.89/gallon). Additionally, should the price of petroleum diesel increase significantly, it is reasonable to expect that the cost of other inputs, especially fertilizer would increase as well, making profitability for this system a moving target.

Important insight has also been gained in several areas. The per liter (operating only) cost of $0.52 ($1.97 per gallon) could lead some to think that biodiesel production is profitable given today's diesel price. However, when ownership costs are included, this price is shown not to be profitable from an economic perspective.

The key scale component of this system is the size of the press. Given the low yields obtained, it could be argued that higher yields might increase profitability in the enterprise. However, higher yields would also require a larger herd (or a market) and more importantly a larger processing facility and more storage (meal and oil and biodiesel) capacity. Given that the press currently needs to run for 15 days to crush the crop at current yields, and that batch size limitations mean that it takes 32 days to convert the oil to biodiesel, there are some time and labor considerations that could also come into play to limit the enterprise viability. Additionally, the higher yields needed to justify the cost of the press, could push the total amount of oil and thus biodiesel (at a

20 percent blend) beyond what a single producer might be able to use. Further research would be needed to substantiate this.

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

The system designed for our project requires a significant investment of financial resources ($19,443), particularly the press. Informal conversations with a rural banker indicate that this type of enterprise would be difficult to finance under traditional means. Therefore having sufficient financial resources, on hand, would be required.

Given this situation, individual on-farm biodiesel production looks problematic from an economic perspective. Further research is needed, but the authors suspect that some sort of group ownership arrangement of at least pressing capacity seems more reasonable with respect to economies of size. This would reduce individuals' capital costs and, should the market for camelina develop further, provide additional marketing opportunities for both meal and oil.

The production of biodiesel would require considerable manual skills by the operator. Our investigations have shown that it is possible to make high quality biodiesel for on-farm use, but it is more time consuming then one can be led to believe. Those wishing to pursue this option need to have sufficient skills to be comfortable with plumbing and electrical work as well as mixing chemicals (some caustic or flammable).

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