# Feasibility of *Camelina sativa* Seed Production for Eastern Wyoming

**A Research Project Submitted to Van Hall Larenstein University of Applied Sciences**
**In Partial Fulfillment of the Requirements of Degree of Master of Agricultural Production Chain Management, Specialization: Horticulture Production Chains**

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## Dedication

To my friends and family who support me in every endeavor I undertake.

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# List of Abbreviations

| | |
|---|---|
| Camelina | *Camelina sativa* |
| EIA | Energy Information Administration |
| EPA | Environmental Protection Agency |
| EU | European Union |
| FAO | Food and Agriculture Organization of the United Nations |
| FDA | Food and Drug Administration |
| FEFANA | EU Association of Feed Additives and Pre-mixtures Operators |
| F.O.B. | Freight on Board |
| GRAS | Generally regarded as safe |
| IENICA | Interactive European Network for Industrial Crops and their Applications |
| SVO | Straight Vegetable Oil |
| U.S. | United States of America |
| USDA | United States Department of Agriculture |

## Abstract

A feasibility study was conducted for production of *Camelina sativa* for producers in Eastern Wyoming. Data collection was based on survey conducted by means of a questionnaire, interviews, as well as secondary sources.

The objective of this study consisted of examining the feasibility of producing Camelina in Eastern Wyoming. This was examined from both a technical and economical stand point, developing a potential chain for a Camelina sector, an examination of linkages in information about the crop, as well as missing links in information. Data collection was based on a survey of local producers and a case study of potential stakeholder in the chain. Data was collected throughout Eastern Wyoming, where Camelina has been proposed as an alternative crop.

The study revealed, information about the Camelina production in the dry land cropping system of Eastern Wyoming as well as its potential and limitations. It also uncovered the information that producers need in order to make a decision about whether to grow Camelina as well as the delivery method that should be used to disseminate this information. The survey explored the economic feasibility of Camelina as both a commodity crop and as part of an integrated farming system.

The study proposes a potential chain map for the sector in two phases of development. The first phase consists of on-farm utilization of the Camelina, as part of an integrated farming system. The second phase outlines channels for Camelina as a commodity crop.

From the study conducted, it is concluded that *Camelina sativa* is not a feasible alternative crop for producers in Eastern Wyoming due to economic and agronomic factors. Based on this conclusion recommendations are made to the potential producers, University of Wyoming Cooperative Extension, chain supporters, and research and educational institutes.

# Chapter 1 Introduction

## 1.1 Background of Study

In Eastern Wyoming as in many rural areas in the United States, dependency on diesel fuel is much greater than in urban areas due to its use in farming equipment. This dependency coupled with the threat of increasing fuel prices and of decreasing supplies has caused many people to look for an alternative source for fuel or a means to extend the current supply. One of the many options that have been developed is the use of bio-fuels to extend the current supply. There are a variety of crops that are being used for this purpose and many others are in their development stages.

One of the many crops being marketed as an alternative crop within the United States is *Camelina sativa*. This crop is being highlighted due to its high oil content and minimal input requirements. Camelina has been produced in Europe since the Bronze Age with the earliest production occurring in 600 BC in the Rhine River Valley. The crop is well adapted to the northern climates especial one with high summer temperatures. Camelina is also a short season crop maturing in 85-100 days making it a potential crop for producers to use in a wheat rotation. Camelina seeds rapid growth also causes it to be very competitive with weeds, thus resulting in minimal to no application of herbicides (Putnam, Budin, Field & Breene, 1993).

One of the other potentials of Camelina seed production is the use of the meal left over after processing as a livestock feed. For Eastern Wyoming, this has the potential to replace expensive livestock meal that is currently brought in from outside Wyoming. Camelina meal has currently been approved for use as a chicken feed by the USDA. This approval has opened a niche market for the production and marketing of Camelina seed. It has also led to further investigation by the USDA as to the suitability of Camelina meal as a cattle feed, resulting in trials scheduled for the summer of 2009 (Schill, 2009). This strong interest in Camelina meal is driven by both its economic as well as its positive food-verses-fuel aspects (Heacox, 2008). Traditional bio-fuels such as soy beans produce approximately 20 percent oil and 80 percent meal. Camelina on the other hand produces approximately 40 percent oil and 60 percent meal (Schill, 2009). This crop also does not displace farm land that would otherwise be used to produce crops for human consumption, but rather can be produced in areas with poor soil conditions.

Due to the positive aspects of this crop, in 2006 the Camelina Company and Wyoming Bio-Diesel Company came to northeast Wyoming to hold seminars about the potential of Camelina seed production for local cattle ranchers. Unsure of the information given by these companies' local ranchers went to the University of Wyoming Cooperative Extension requesting information about the reliability of this information and feasibility of growing Camelina. While research has been performed throughout the region by the University of Wyoming Cooperative Extension and their research stations on the production aspects and potential on-farm uses of the crop, an answer has not been formalized as to the crops feasibility for local producers. For this reason the following research has been undertaken.

## 1.2 Problem Statement

Due to the positive aspects of *Camelina sativa*, several bio-fuel companies came to Eastern Wyoming to hold seminars about the potential of Camelina seed production for local ranchers. Looking for an unbiased source of information, local ranchers went to the University of Wyoming Cooperative Extension requesting information about the reliability of the information and feasibility of growing Camelina. While research has been performed throughout the region by the University of Wyoming Cooperative Extension and their research stations on the production aspects and potential on farm uses of the crop; insufficient linkages between existing information, formal production, and marketing chains for *Camelina sativa* seed use as a bio-fuel has slowed the decision making process of local farmers to opt for *Camelina sativa* seed production as part of an integrated farming system.

## 1.3 Objective

The objective for this research is to examine the feasibility for *Camelina sativa* seed as an alternative crop for local farmers.

## 1.4 Research Questions

1. What would local farmers need to have a chain for the production of *Camelina sativa* seed?

i. How would Camelina seed be acquired?
ii. How is Camelina seed produced?
iii. What inputs (fertilizer, herbicide, and pesticides) are needed to produce *Camelina sativa*?
iv. How is seed harvested?
v. What type of storage facilities is needed for Camelina?
vi. How is seed transported?
vii. Where are the nearest refineries?
viii. Can seed be pressed locally?
ix. Can a mobile unit be used to process seed on-farm?
x. Would straight vegetable oil be used on farm?
xi. Would producers use a co-op structure for local distribution and processing?
xii. Can Camelina meal be used as an input for cattle feed?

2. Is the production of Camelina seed feasible?

i. How much will the seed cost producers f.o.b.?
ii. How much will other inputs cost (fertilizers, labor, and herbicide)?
iii. What is the average yield per acre/hectare?
iv. How many acre/ hectares would local farmers grow?
v. How much labor is required to produce an acre/ hectare of Camelina?
vi. How much will it cost to produce an acre/hectare?
vii. Could production of Camelina seed be rotated into current cropping system?
viii. Who is currently purchasing seed for processing?
ix. How can seed be transported to refineries?
x. What is the cost to transport seed to nearest refinery?
xi. Will producers make a profit or cover costs of production?
xii. What are the current government policies on bio-fuel production?

3. What information would local farmers need to make a decision on whether Camelina seed should be incorporated into their integrated farming system?

i. What is the current information that farmers have about Camelina seed production?
ii. What is the most important deciding factor local farmers make about crop production?
iii. What linkages in existing information are missing?
iv. What method of delivery of new information is the most effective for local farmers?

### 1.5 Report Structure

The report is organized into six main chapters. Chapter one contains background information about the study, as well as the main problem and objective of the research. The chapter continues to outline the main research questions and sub-questions that guide the research. Chapter two is composed of literature reviewed on the study area, government policies for the sector, production of Camelina seed and farming system. Chapter three discusses the methodology employed for the collection of empirical data during the field research. This chapter includes information about study area, research strategy, and the tools used to gather information. Chapter four contains the results of empirical findings of the field research. The results of this research are discussed in Chapter five. The final chapter of this report contains the conclusions and recommendations of this research. This report was written for both examiners and researchers in the Netherlands, as well as Agriculture Extension Agents and ranchers in Wyoming. For this reason the report includes both metric and U.S. customary units.

# Chapter 2 Literature Review

## 2.1 United States of America

### 2.1.1 Bio-fuel in the U.S.

In recent years there has been an increase in production of biodiesel and bio-fuels in the United States, see Figure 2.1. Bio-fuels are becoming more popular due to growing environmental concerns about petroleum use and to reduce U.S. dependency on foreign oil. However, according to the EIA, the total consumption of diesel fuel in the U.S. was roughly 4.53 billion gallons in 2008 (EIA, 2009). This in comparison to the data shown in Figure 2.1 indicates that biodiesel accounts for only 6.6 percent of the total consumption of diesel fuels in the U.S.

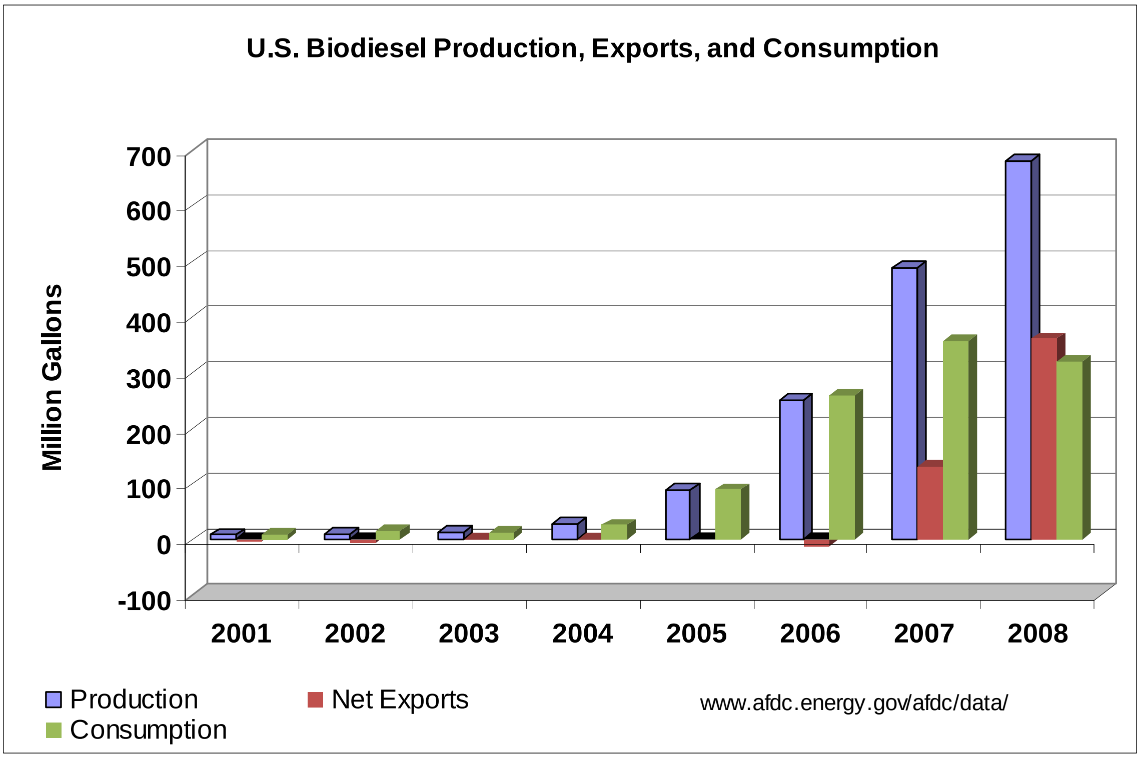


*Figure 2. 1 U.S. Biodiesel Production, Exports, and Consumption*
1 U.S. gallon= 3.785 liters
(Source: U.S. Department of Energy, 2009)

Bio-fuels are a means to extend the current supply of oil by adding a percentage of oil, which comes from a renewable source, i.e. straight vegetable oil. The most common form of bio-diesel sold in the U.S. is B20. This form of biodiesel is a mixture of 20 percent biodiesel and 80 percent diesel fuel (Hofman, 2003). Bio-fuels especially biodiesel from straight vegetable oil has many positive environmental factors. When compared to petroleum based diesel, biodiesel produces 3.2 kg less greenhouse gasses per kg of diesel than traditional diesel (Martini & Schell, 1998). This reduction of emissions consists of a reduction in promethium, hydrocarbons, and carbon oxide, see Figure 2.2. For B20 biodiesel this is a reduction of 10.1 percent PM, 21.1 percent HC, and 11 percent CO (EPA, 2002).

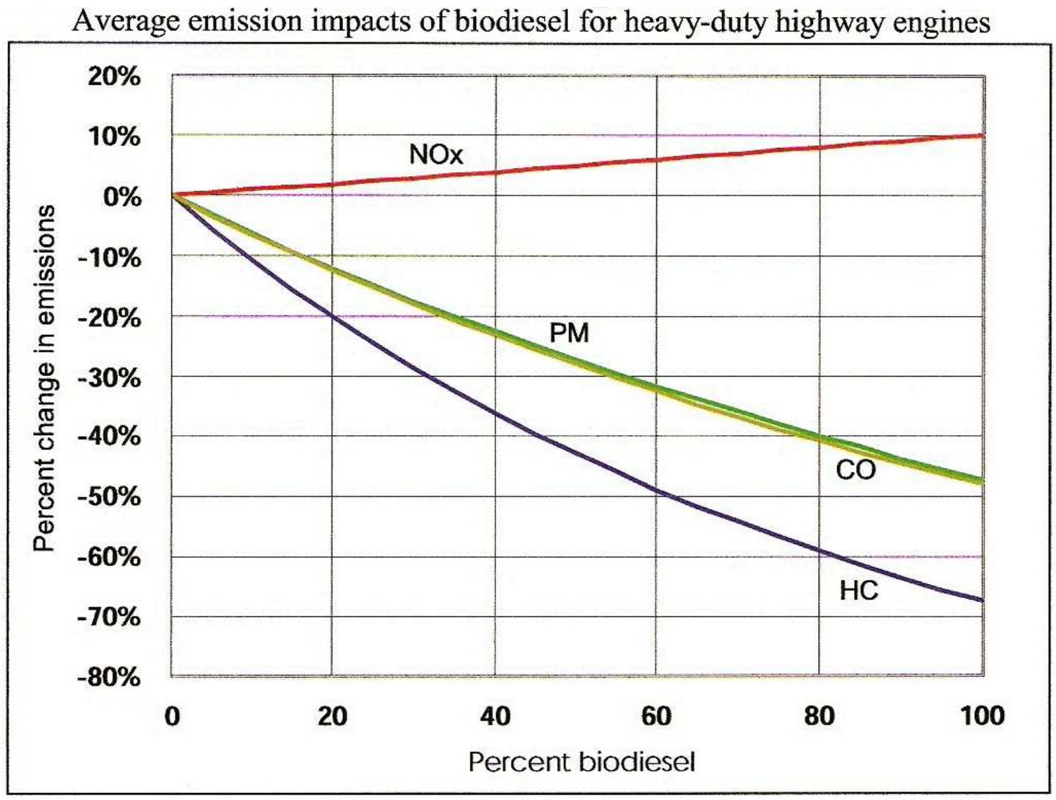


*Figure 2. 2 Average emissions impact for biodiesel*
(Source: EPA, 2002)

Biodiesel from straight vegetable oil is also highly biodegradable (90 percent biodegradable within three weeks). It also has a low flash point, low toxicity, and low evaporation (Kimber & McGregor, 1995). With biodiesel's reduction in emissions there is also a slight reduction in fuel economy of 1-2 percent (EPA, 2002). Typically diesel fuel has 140,000 BTU per gallon (38,994.86 kj/L) while B20 biodiesel has 138,000 BTU per gallon (37,602.19 kj/L). This lower energy content results in more gallons or liters of biodiesel to produce the same amount of energy (Hofman, 2003).

Within the U.S., SVO comes from a variety of crops. Commercial these crops are: canola, sunflower, safflower, peanuts, soybean, and flax. These oilseed crops are grown for both the bio-fuel industry as well as for human consumption. The planted acres for these crops are shown in Figure 2.3 (Ash, Dohlman & Wittenberger, 2009). The SVO bio-fuel sector is one of the potential areas for Camelina oil consumption (Lardy, 2008).

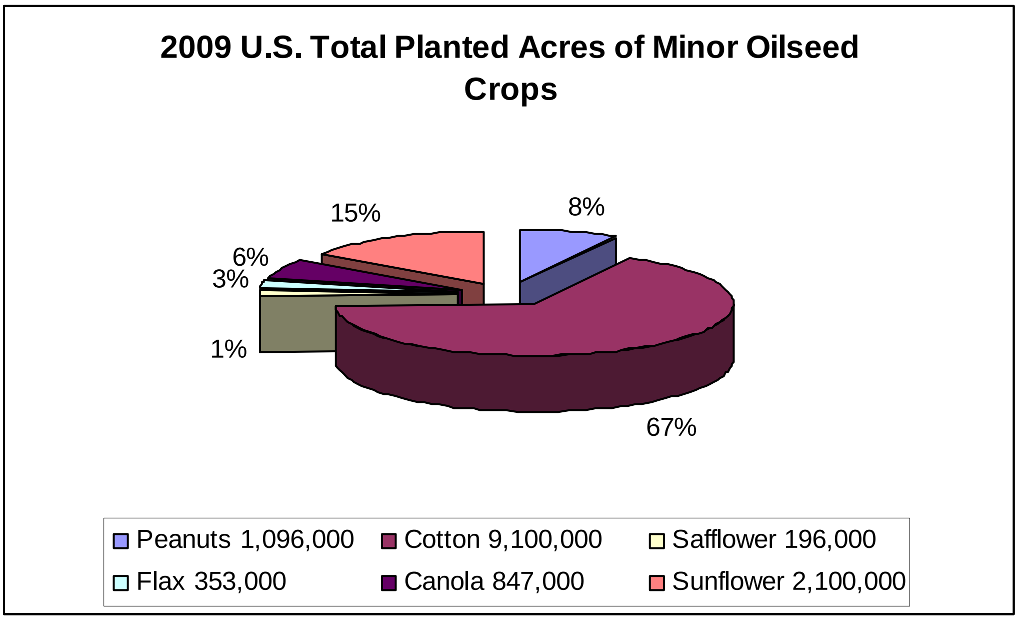


*Figure 2. 3 U.S. Total Planted Acres of Minor Oilseed Crops*
1 Acre = 0.405 Hectares
(Source: Ash & Dohlamn, 2009)

### 2.1.2 Bio-fuel Policies and Incentives

The United States government is involved in bio-fuel industry in two ways: policy and taxation. Since the early 1990's, may policies and incentives have been implemented in the United States in attempts to reduce the Nation's dependency on foreign oil from non-renewable resources. The policies concerning bio-fuels are at local, state, and federal government levels. These policies may require producers to be licensed, to register, and obtain building and operating permits. Many policies vary from state to state however; all producers must obtain certification from the U.S. Environmental Protection Agency (EPA), proving that the biodiesel they produce is in compliance with federal standards for bio-fuels. These incentives consist of tax credits, and grant programs to help stimulate the development of renewable fuels, agri-fuels, and alternative fuels within the United States.

***Biodiesel Blenders/ Mixture Excise Tax Credit***

Biodiesel Blenders/ Mixture Excise Tax Credit was established in 2004 by the American Job Creation Act. It was further extended through December of 2009 by the Emergency Economic Stabilization Act signed by President Bush (U.S. Department of Energy, 2009). This tax credit program gives producers of biodiesel a tax credit of 1 USD per gallon of biodiesel produced with straight vegetable oil. It also included a prorated tax credit for blends of straight vegetable oil with petroleum based on the percentage of straight vegetable oil used in the mix (Schumacher, 2006).

***Small Producers Tax Credit***

This tax credit was established for producers who produce lass than 60 million gallons of biodiesel per year. Producers within this category receive a tax credit of 0.10 USD per gallon for the first 15 million gallons produced (Schumacher, 2006). This credit expired in December of 2008, although it was extended by the Energy

Improvement and Extension Act of 2008 and is now set to expire in December of 2009 (U.S. Department of Energy, 2009).

### *Energy Policy Act of 1992*

This act was passed in 1992 with the goal of replacing 30 percent of petroleum based fuel with alternative fuels by 2010. In order to meet this goal, policies were implemented requiring 75 percent of federal vehicles to use alternative fuels. This goal has not been fully met due to exceptions based on fuel availability and vehicle prices (Schumacher, 2006).

### *Renewable Fuels Standard*

Renewable Fuels Standard was established by the Energy Policy Act of 2005 under section 1501, and started in January of 2006 (Schumacher, 2006). The standard was extended by the Energy Independency and Security Act of 2007 (U.S. Department of Energy, 2009). Its purpose is to increase the amount of fuel from renewable resources blended with petroleum. The minimum mixture must contain 2.78 percent fuel from renewable resources (Schumacher, 2006). Goals are set for 2009 to reach 6.1 billion gallons of blended fuel and 16 billion gallons by 2020 (U.S. Department of Energy, 2009).

### *Alternative Fuel Infrastructure Tax Credit*

The Alternative Fuel Infrastructure Tax Credit was created under the Energy Policy Act of 2005 section 1342, and extended through December of 2009 by the Emergency Economic Stabilization Act (U.S. Department of Energy, 2009). A tax credit of 30 percent is given for the cost of refueling property if the property is used for alternative fuel. The tax credit is capped at 30,000 USD for businesses and 1,000 USD for individuals (Schumacher, 2006).

### *Other Incentives*

Other incentives exist for producers of bio-fuels. Many of these are state dependent or grants. The grants are available for the development of fuel programs based in renewable fuels, and for grower organizations based in renewable fuels (Schumacher, 2006).

## 2.2 Wyoming

Wyoming is located in the western portion of the United States, see Figure 2.4. The state has a population of 522,830 living in an area of 97,814 square miles (253,338.3 square kilometers). This state is comprised of 23 counties at an average elevation of 6,700 feet above sea level (2043.5 meters). Approximately 91% of Wyoming land is classified as rural (State of Wyoming, 2009).

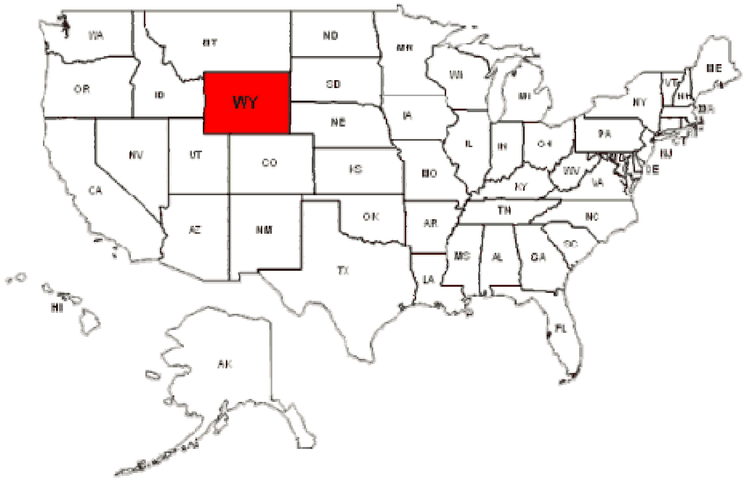


*Figure 2. 4 United States Map with Wyoming Highlighted*
*(Source: Myonlinemaps.com, accessed 10 Aug. 2009)*

The population of Wyoming consists of 87.3% whites, 2.3% Native Americans, and 7.3% Hispanics. Of the population 91% have a high school diploma and 20% have a minimum of a bachelor's degree.

Wyoming's gross state product is 57.6 billion USD and has an unemployment rate of 3.3%, which is below the national average. Wyoming's economy is driven by the mining industry, which accounts for 6.7 billion USD and produces 452.1 million short tons of coal per year (410.05 metric tons). Wyoming is the number one coal producing state in the U.S. and the second ranking producer of natural gas. The state of Wyoming also produces coal-bed methane, crude oil and uranium.

The agriculture sector has traditionally been one of the main sectors in Wyoming. In 2006 Wyoming agriculture exported 53 million dollars worth of products out of the state. The average farm size with in the state is 2,726 acres (1104.03 hectares) and there are approximately 11,069 ranches or farms within the state. The sectors main products are beef cattle, hay, sugar beets, wheat and barley.

The transportation system within the state consists of three major interstate highways and nine U.S. highways as well as an extensive rail system. There is approximately 6,800 miles (10941.2 km) of highway within the state. The state also has several airports with the largest being in Jackson Hole (State of Wyoming, 2008).

### 2.2.1 Climate

For the purpose of this research the focus will be on the eastern portion of Wyoming. The eastern portion of the state is known as the high plains, and consists of 11 counties: Albany, Campbell, Carbon, Crook, Converse, Goshen, Laramie, Niobrara, Platte, Sheridan, and Weston, see Figure 2.5. The climate of Eastern Wyoming is arid with cold dry winters and hot dry summers. In the summer temperatures can reach the 100 degrees (37.7˚C) and in the winter can dip down below freezing. Temperature varies depending on location and elevation, detailed in Table 2.1 are the average minimum and maximum temperatures by county.

*Table 2. 1 Average Maximum and Minimum Temperatures by County 2008-2009*

| County | Average Maximum ˚F | Average Minimum ˚F | Average Maximum ˚C | Average Minimum ˚C |
|---|---|---|---|---|
| Albany | 53.2 | 27.7 | 11.8 | -2.4 |
| Campbell | 56.7 | 31.8 | 13.7 | -0.1 |
| Carbon | 55.6 | 29.1 | 13.1 | -1.6 |
| Crook | 55.9 | 31.6 | 13.3 | -0.2 |
| Converse | 53.2 | 27.7 | 11.8 | -2.4 |
| Goshen | 63.5 | 31.6 | 17.5 | -0.2 |
| Laramie | 57.9 | 33.1 | 14.4 | 0.6 |
| Niobrara | 59.0 | 29.8 | 15.0 | -1.2 |
| Platte | 63.7 | 34.0 | 17.6 | 1.1 |
| Sheridan | 58.3 | 29.7 | 14.6 | -1.3 |
| Weston | 59.5 | 33.8 | 15.3 | 1.0 |

(Source: Worldclimate.com, accessed on 19 Aug. 2009)

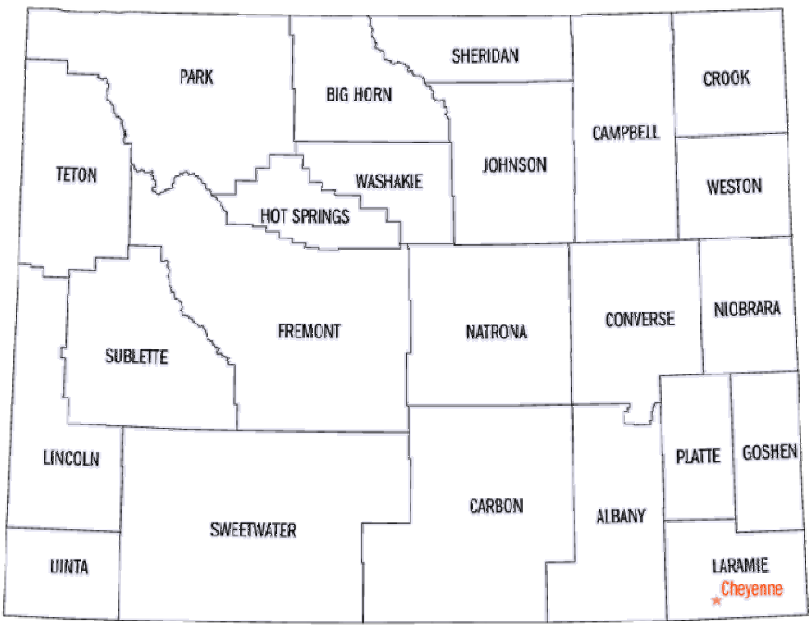


*Figure 2. 5 Map of Counties in Wyoming*

*(Source: census finder.com, accessed 10 Aug. 2009)*

The precipitation for this area varies from approximately 8-12 inches (203.2 – 304.8 mm) during the Camelina growing season, and is highest from March to July. Precipitation data is given in Table 2.2 for selected counties for the Camelina growing season. The remaining counties precipitation data is given in Appendix 1.

*Table 2. 2 Precipitation data for selected counties in Wyoming*

Goshen County

| | Feb. | Mar. | April | May | June | July | Aug. | Total |
|---|---|---|---|---|---|---|---|---|
| mm | 9.7 | 18.2 | 44.2 | 61.8 | 68.1 | 39.7 | 25.5 | 267.2 |
| inches | 0.4 | 0.7 | 1.7 | 2.4 | 2.7 | 1.6 | 1.0 | 10.5 |

Campbell County

| | Feb. | Mar. | April | May | June | July | Aug. | Total |
|---|---|---|---|---|---|---|---|---|
| mm | 16.6 | 25.4 | 49.4 | 71.1 | 78.0 | 31.5 | 34.6 | 306.6 |
| inches | 0.7 | 1.0 | 1.9 | 2.8 | 3.1 | 1.2 | 1.4 | 12.1 |

Carbon County

| | Feb. | Mar. | April | May | June | July | Aug. | Total |
|---|---|---|---|---|---|---|---|---|
| mm | 19.5 | 30.5 | 39.2 | 39.5 | 26.6 | 21.5 | 24.8 | 201.6 |
| inches | 0.8 | 1.2 | 1.5 | 1.6 | 1.0 | 0.8 | 1.0 | 7.9 |

Crook County

| | Feb. | Mar. | April | May | June | July | Aug. | Total |
|---|---|---|---|---|---|---|---|---|
| mm | 15.9 | 24.4 | 49.8 | 70.4 | 84.3 | 47.9 | 33.0 | 325.7 |
| inches | 0.6 | 1.0 | 2.0 | 2.8 | 3.3 | 1.9 | 1.3 | 12.9 |

Sheridan County

| | Feb. | Mar. | April | May | June | July | Aug. | Total |
|---|---|---|---|---|---|---|---|---|
| mm | 10.6 | 15.7 | 29.2 | 51.7 | 72.5 | 25.1 | 22.5 | 227.3 |
| inches | 0.4 | 0.6 | 1.1 | 2.0 | 2.9 | 1.0 | 0.9 | 8.9 |

(Source: Worldclimate.com, accessed on 19 Aug. 2009)

The above climate date demonstrates that Camelina can be grown in Eastern Wyoming. As detailed later in Section 2.3.1 Camelina needs approximately 9 inches (230 mm) of water during the course of the growing season. Seeds and seedlings are also well adapted to colder temperatures, withstanding temperatures of -11˚C (12˚F), and during maturity can tolerate temperatures above the 100 degrees (37.7˚C).

### 2.2.2 Agriculture Land and Land Use

As previously stated 91% of the land in the state of Wyoming is considered to be rural, and the eastern portion of the state is no exception. Farming and ranching is a major part of Wyoming's heritage and is still practiced in abundance today. According to the USDA's Agriculture Census Report there are 11,069 farms within the state covering 30.1 million acres (12.19 million hectares) of land. Within the state the average farm size is approximately 2,726 acres in size (1104.03 hectares). Of these farms approximately 5,625 produce cattle and calves, 272 produce swine, 776 produce chickens, and approximately 1,000 produce sheep. The remaining farms engage in the production of other livestock (i.e. bison, horses, and goats) as well as in arable farming (USDA, 2009). The majority of these livestock producers also engage in forage production, making them potential Camelina producers. The acres of production for the major crops within Wyoming are shown in Figure 2.6.

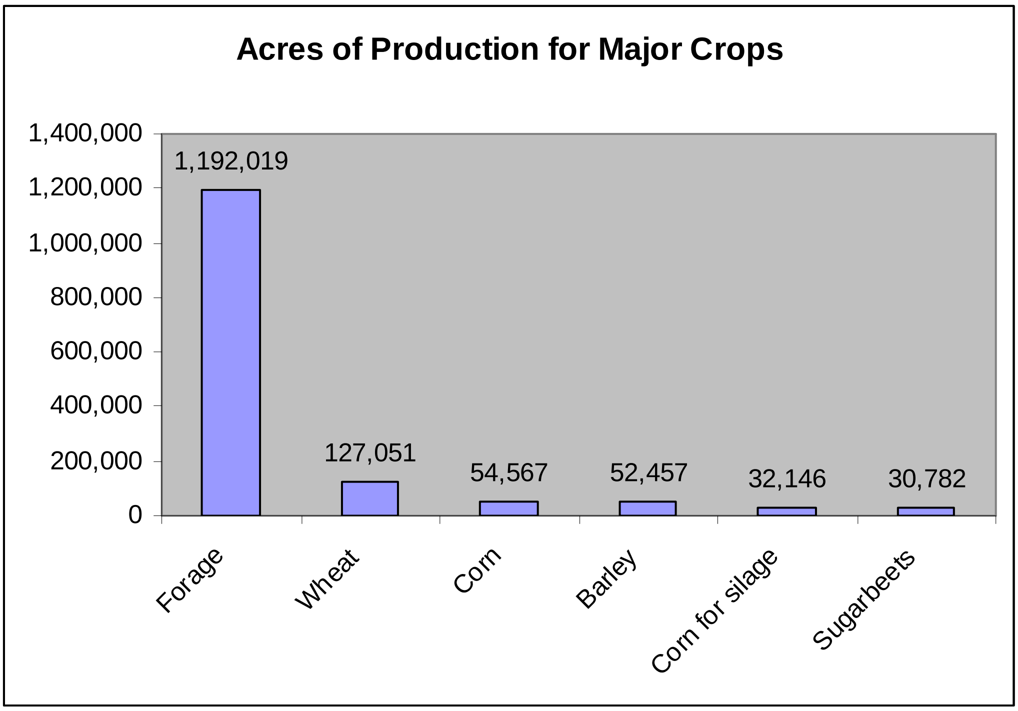


*Figure 2. 6 Acres of production for major crops in Wyoming*
(Source: USDA, 2009)

**2.2.3 Topography, Soils and Drainage**

Soils in Wyoming vary by location but are typically characterized by shallow to deep loams, silt loams, clay loams, silty clay loams, fine sandy loams, and clays. According to the University of Wyoming there are 10 soil zones within the state, five of which make up the eastern portion. These zones are Zone 5 and Zone 6 in the northeast and Zone 7, Zone 8 and Zone 9 in the southeastern portion. The details of these zones are listed in Table 2.3 (Munn & Arneson, 1998).

*Table 2. 3 Wyoming Soil Zones and Description*

| Soil Zone: Name<br>Topography | Soil Type | Soil Temperature | Soil Moisture |
|---|---|---|---|
| Zone 5: Powder River Basin<br>Northern Great Plains | Fine-loamy<br>loamy-skeletal | mesic, 8˚C (47˚F)<br>to 15˚C (59˚F) | aridic, dry more than half the time. Arid to semi-arid |
| Zone 6: Black Hills<br>Mountains | Fine-loamy<br>sandy-skeletal<br>Loamy-skeletal | frigid, 0˚C (32˚F)<br>to 8˚C (47˚F) | udic and ustic, humid soils not dry for more than 90 days in most Parts |
| Zone 7: Southeast Wyoming<br>Northern Great Plains | Fine-loamy<br>loamy-skeletal | frigid, 0˚C (32˚F)<br>to 8˚C (47˚F)<br>mesic, 8˚C (47˚F)<br>to 15˚C (59˚F) | aridic, dry more than half the time. Arid to semi-arid |

| | | | |
|---|---|---|---|
| Zone 8:Medican Bow & Laramie. Mountains | loamy-skeletal Fine-loamy | Cryic, 0˚C (32˚F) to 8˚C (47˚F) | udic, humid soils not dry for more than 90days Aquic, seasonal saturation of soil |
| Zone 9: Laramie & Wind River Basin. Intermountain Basins | fine-loamy Loamy-skeletal coarse-loamy | frigid, 0˚C (32˚F) to 8˚C (47˚F) | aridic, dry more than half the time. Arid to semi-arid |

(Source: Munn & Arneson, 1998).

The typical pH of soils throughout Wyoming ranges from 7.0-8.5, making them more alkaline than acidic. The soils also inherently have low organic matter and fertility. This makes erosion control very important, as both erosion by wind and water can be an issue. Also under intensive cropping, soils can become deficient in both nitrogen and phosphorus and should be well managed (NRCS, 2007).

## 2.3 Plant Description

*Camelina sativa* is a member of the Brassicaceae family. This family of plants includes other oilseed crops such as canola, rapeseed, and mustard. Camelina has been cultivated throughout Europe since the Bronze Age, although it's production has decreased since the 1940's as production of other oilseed crops such as canola and rapeseed have increased (Lafferty, Rife & Foster, 2009). According to the IENICA it is still produced in some countries including the United Kingdom, Belgium, the Netherlands, and Germany (IENICA, accessed on 20 Jul. 2009).

Camelina is a short season plant which reaches maturity in 85-100 days (Ehrensing & Guy, 2008). At full maturity, Camelina is approximately 30 to 90 cm (10.1-30.3 inches) tall (Putman et al, 1993). Camelina is an annual plant that produces seed pods containing several small brown to reddish seeds approximately 1.5 mm (0.585 inches) in length. These seeds are high in both omega-3 fatty acids as well as contain 36-38 percent oil (Meakin, 2007). Recently the crop has been introduced to the high plains area of North America (Montana, Wyoming, Colorado, Nebraska) due to its potential to grow in poor soils with low nutrients and irrigation.

### 2.3.1 Growing Requirements

***Climate and Soils***

Camelina is well suited to cool arid regions. It is a cool season plant which germinates at a soil temperature of 3˚C (38˚F). Seedlings are frost tolerant down to temperatures of -11˚C (12˚F), making early planting in areas that exhibit late frosts possible. Optimal growth occurs at temperatures of 15.6-18˚C (60-65˚F). Camelina also grows well in regions with low rainfall, and exhibits drought tolerance (Ehrensing & Guy, 2008).

Camelina can be cultivated in a variety of soil types including marginal soils. However, it is best suited to light to medium soils with good drainage. Soils composed of high organic matter or heavy clay soils are not conducive to the cultivation of Camelina (Zubr, 1996). Optimum pH for soils is 6.5 but can be grown in more alkaline soils up to pH 8.0. Acidic soils can have a negative effect on Camelina's root development, thus resulting in a poor stand, or uneven development

(Meakin, 2007).  In examining the soil for suitability it is also important that the site does not have residual herbicides present as they may hinder plant development (Ehrensing & Guy, 2008).  The site selected should be a field where weeds have been controlled and sanitation has been practiced (Lafferty et al, 2009).

### *Seeding and Planting*

There is some debate among researches as to when the optimum planting time is for Camelina. Some recommend planting in late March to late April, while recommendations from Montana and Wyoming agronomists, state that planting from mid-March to mid-April is better (Meakin, 2007; Lafferty, et al, 2009).  However most agree that earlier planting will result in the best weed competition.  It has also been shown that earlier planting typically results in higher yields and oil content (Ehrensing & Guy, 2008).  Late winter planting does not exhibit a significant yield increase, and thus is not preferred (Meakin, 2007). In studies delays in planting of thirty days resulted in a 25 percent decrease in yield (Ehrensing & Guy, 2008).

Seedbed preparation is critical to even emergence of Camelina from the soil and competitiveness against weeds.  Seedbed should be composed of fine well drained soil that has been firmed.  If clay soil is present, soil should be worked several times until soil is light (Meakin, 2007).

Seeds can be drilled into the seedbed or broadcasted (Ehrensing & Guy, 2008). There is some debate as to which method of seeding yields the best results. However, in a trial performed in Akron, Colorado drilling was determined to be the best method for the high plains area.  In discussions with Blue Sun Bio-diesel's agronomist, Dr. Charlie Rife, "Broadcasting may be possible for the area if performed early enough to allow for frosting and thawing to work seeds into the soil."  For planting with a drill, drills should be set to a small seed setting, e.g. rapeseed, or alfalfa settings (Meakin, 2007).  Drills should be set to plant at a shallow depth of 1-2 cm (0.4-0.8 in).  Row spacing is dependent on weed pressure.  For areas of limited weed pressure, row spacing can be 12-15 cm (5-6 in) (Meakin, 2007).  However, in areas with greater weed pressure, narrow rows of 8-10 cm (3-4 in) should be used (Lafferty et al, 2009).  After drilling, a light rolling should take place for optimum seed to soil contact.

Seeding rates for Camelina vary depending on soil type, soil moisture, and weed pressure (Zubr, 1996).  Seeding rates of approximately 7-9 kg per hectare (6-8 lbs per acre) are recommended (Meakin, 2007).  This rate will produce a stand 220-250 plants per square meter (22-25 plants per square foot).  However, in field trials performed in Montana, a seeding rate of 4-6 kg per hectare (3-5 lbs per acre) was adequate (Ehrensing & Guy, 2008).  In areas where establishment is difficult, the higher seeding rate should be used.

### *Nutrition and Water Usage*

Camelina is a low input crop requiring low amounts of both fertilizers and water for cultivation.  Although many studies have provided information on fertilization rates it is important to take into consideration that fertilization is dependent on may factors including: soil type, rainfall or irrigation, and producers yield goals.  Table 2.4 provides fertilization rates for Camelina production based on crop water and expected yield.  The typical situation, in terms of crop water, in Eastern Wyoming has been highlighted.  For dry land farmers where water is a limiting factor it is important to apply slightly less nitrogen than the recommended amount.  Several studies indicate that Camelina does not respond to increased levels of phosphorus or potassium. Never the less these elements should be available at minimum levels of 12 ppm and 30 ppm respectively (Lafferty et al, 2009). Sulfur also seems to have no effect on the yield of Camelina, although it does have an effect on the oil content of the seed (Ehrensing & Guy, 2008). Therefore, sulfur should also be applied at a rate of 25kg per hectare (23lbs per acre) for seed oil content and in order to maintain a balanced ratio between nitrogen and sulfur (Meakin, 2007).

*Table 2. 4 Expected yields and fertility requirements for Camelina at varying water use levels*

| Crop water (inches)[1] | Expected Yield (lbs/ac)[2] | Nitrogen (lbs/ac) | Phosphorus (lbs/ac) | Potassium (lbs/ac) |
|---|---|---|---|---|
| 7.5 | 796 | 32 | 19 | 25 |
| 10.0 | 1026 | 41 | 25 | 33 |
| 12.5 | 1255 | 50 | 30 | 40 |
| 15.0 | 1485 | 59 | 36 | 48 |
| 17.5 | 1714 | 69 | 41 | 55 |
| 20.0 | 1944 | 78 | 47 | 62 |

(Source: Lafferty et al, 2009)
Conversion[1]: 1 inch = 25.4 mm
Conversion[2]: 1lbs/AC = 1.123kg/hectare

Fertilizer application should take place in two stages. Half the total fertilization should take place at the time of planting either at time of seeding or incorporated into the seedbed prior to sowing. The second portion should be applied to the crop at the four-leaf stage (Meakin, 2007; Zubr, 1997).

For production of Camelina available moisture should be between 152- 381mm (6-15 inches). In most studies and field trials, the average moisture was approximately 230 mm (9 inches). Moisture should be higher during seeding and seed emergence, making Camelina conducive to the weather patterns of Wyoming (Lafferty et al, 2009). However, once plants have established they exhibit positive drought tolerance (Meakin, 2007).

***Weed Control***

Weed control may or may not be required depending on cultivation technique and location of production. In many situations, weed control is not necessary due to the crops rapid growth (Meakin, 2007). Winter sown Camelina is especially competitive against many weeds due to its low germination temperature of 3˚C (38˚F) which is lower than many weed seeds. Camelina also has allelopathic properties, which is a plants ability to inhibit the growth of other plants (Ehrensing & Guy, 2008). If weeds are known to be a problem in the cultivation area precautions should be taken to plant in a sterile seedbed (Schumacher, 2006). Weed control has been achieved in the EU by applying a pre emergent herbicide such as trifluralin (Meakin, 2007). Trifluralin is not currently registered for use on Camelina in the United States.

Crop trials in Wyoming indicate that weeds could be a potential problem in the production of Camelina. Due in part to Camelina being a newly introduced crop in the United States, there are limited chemical controls registered at this time. In 2008 BASF received a label for the use of Sethoxydim (Poast) to control weeds in Camelina. Sethoxydim is a post emergent herbicide that can be used effectively to control most grasses. However, there is no herbicide currently registered for control of broad leaf weeds in Camelina. Labels are currently being sought for this purpose with Glyphosate (Roundup) (Lafferty et al, 2009).

### ***Diseases and Pests***

Diseases and pests in any crop are dependent on the location and climate that the crop is being cultivated in. For Camelina, a few diseases and pests have been identified but their presence and impact vary from location to location.

The main diseases identified are Downy mildew (*Peronospora spp.*), *Sclerotinia*, and *Botrytis* (Meakin, 2007). Of these diseases *Sclerotinia* and *Botrytis* were seen in commercial production of Camelina in England and Ireland, but have not been reported in the United States. However, Downy mildew has been observed in the United States in late sown crops. These crops were sown after April and experienced hot dry conditions (IENICA, 2004). Camelina is highly resistant to Blackleg (*Lepotosphaeria maculans*) which is a major disease in other oilseed crops such as Canola (Salisburg, 1987 cited in Putnam et al, 1993).

Common pests associated with Camelina are Flea Beetle (*Phyllotreta cruciferae*) and Pollen Beetle. Of these pests, Flea Beetle was identified in the United States in field trials. The flea beetles threaten seedlings of Camelina; however, once Camelina is established flea beetle does not cause economic damage to crop (Meakin, 2007). In trials performed in semi-arid Wyoming and the High Plains area Camelina was tolerant to most diseases and pests (Lafferty et al, 2009). Although flea beetle was occasionally observed on the crop it did not cause any economical damage or warrant any treatment (Taylor & Waller, 2008).

### ***Yield***

Yield can vary based on location of cultivation, fertilization level, irrigation or rainfall. Due to these factors trials of Camelina have varying levels of yield. First time growers of Camelina on average have seen yields from 898.2-1684.1 kg per hectare (800-1500 lbs per acre); while experienced growers typically yield 1684.1-2020.9 kg per hectare (1500-1800 lbs per acre). The maximum yield recorded in the U.S. was recorded in Idaho at 2694.5 kg per hectare (2,400 lbs per acre) (Schill, 2008). Table 2.5 highlights the positive relationship of yield with average rainfall.

In trials performed in Northeast Wyoming yields varied substantially. The highest recorded yield was 518.7 kg per hectare (462 lbs per acre). It is important to take into consideration that this was a first time grower and that with more agronomic experience with the crop yield should be improved (Taylor & Waller, 2008). In trials performed in Southern Wyoming the yield was greatly increased to 2102.9 kg per hectare (1873 lbs per acre) (Lafferty et al, 2009). Over time with more agronomic studies and improvement in varieties available the yield of Camelina should become more consistent. Table 2.5 shows a comparison of Camelina yields by location and amount of rainfall.

*Table 2. 5 Average yield in field trials based on rainfall levels*

| **Location** | **Rainfall inches for growing season (mm)** | **Yield (lbs/ac)** (1lbs/AC = 1.123kg/ hectare) |
|---|---|---|
| Montana | 13-15 in. (330.2-381 mm) | 900-1,700 |
| Montana | 16-18 in. (406.4-457.2 mm) | 1,800-2,000 |
| Idaho | 25 in. (635 mm) | 2,100-2,400 |

(Source: Ehrensing & Guy, 2008)

### 2.3.2 Harvesting and Storage

***Harvesting***

Harvesting time for Camelina seed varies due to precipitation, temperature, seeding date and harvesting method; however, typical harvesting takes place from late June to mid September (McVay & Lamb, 2008). In studies conducted in Central and Northern Europe harvesting was also recommended to take place prior to late July (Zubr, 1997). Harvesting takes place when seeds have reached full maturity and seed moisture content is 8-16 percent (Meakin, 2007). This can be observed when hulls have changed color from green to golden-brown and seed is orange in color (Ehrensing & Guy, 2008) (Meakin, 2007). Due to their resilient seed hulls and low risk of shattering, mature Camelina can be mature for six weeks before harvest without any damage; allowing for greater flexibility in harvesting time. This flexibility also allows farmers to harvest during favorable weather conditions which can result in a lower seed moisture content post harvest (Meakin, 2007).

The harvesting process can take place in one of two ways. Camelina can be directly cut at the time of maturity with the use of standard combine, or swathed prior to combining. The preferred method of harvesting is to direct cut at time of maturity due in part to it being less labor intensive. At the same time, swathing may be required if maturity is uneven due to a variations in soil type (Meakin, 2007).

For direct cut harvesting, combines should be set to small seed size, small seed screens in place, and concaves set tight enough to break seed pods (Meakin, 2007). In trials performed in Oregon State University these settings were comparable to alfalfa and rape seed settings, which have an equally small seed size and will allow seeds to be separated from hulls (Ehrensing & Guy, 2008; Zubr, 1997). However, in trials performed in Wyoming, there were still a significant amount of hulls present in the hopper at these settings. The small seed size should also be taken into consideration when adjusting the blower and should be at a low setting. Also due to the small seed size added precautions should be taken to seal all leaks to ensure that seeds are not lost from equipment or hopper.

The second form of harvesting requires that the crop be swathed prior to being combined. Swathing is done prior to maturity and can be used to quickly dry drop for combining; however the time of swathing varies researchers. According to data from Oregon State University swathing can occur when two thirds of the pods are yellow however, according to literature published in the United Kingdom it is recommended that the entire crop be at least 50 percent mature prior to swathing (Ehrensing & Guy, 2008; Meakin, 2007). The closer the crop is to maturity the better the yield results. After swathing the crop can be harvested with the use of a combine 7-14 days later, which is dependent on favorable weather conditions (Meakin, 2007).

***Storage***

Storage of Camelina seed is very similar to the storage of other seeds and grains. Seed can deteriorate during storage due to high moisture content, high relative humidity, high temperature that can result in fungal infection (Weiss, 2000). The most important factor in storage is seed moisture. For Camelina, seed moisture should be at 8 percent or lower, although in the United Kingdom recommendations for seed moisture can be as high as 9 percent (McVay & Lamb, 2008; Meakin, 2007). Low moisture content is desired to reduce the deterioration of oil, and to avoid clumping (McVay & Lamb, 2008). If moisture content is above the desired 8 percent, seed can be dried using floor drying, continuous flow system, or small batch dryers with a maximum temperature of 40˚C (104˚F). Mechanical drying of seed is not always necessary and floor drying at shallow depths is often sufficient (Meakin, 2007). Although there is no current information on the length of storage for Camelina, information about similar crops such as Crambe, also a Cruciferae of the Brassica family is comparable. Storage experiments on Crambe in Poland showed that seeds can be stored in an uncontrolled environment with an average temperature of 21˚C (70˚F) and 71 percent relative humidity for up to two years, while seed stored in a controlled environment at 10˚C (50˚F) and 40 percent relative humidity could be stored for up to eight years. As a result uncontrolled on-farm storage should be kept at a minimum. Although there have been no recorded insect problems with Camelina during storage; insects can be a problem when storing seed for over three weeks. It is advisable to pre-treat storage containers (Weiss, 2000).

### 2.3.3 Potential Uses

Originally, Camelina oil was used in Europe for both human consumption and as a lamp oil. Today there are several new potential uses for Camelina seed products. The main uses of this crop are based on the oil contained in the seed. Camelina oil can be used as cooking oil, in cosmetics, bio-lubricants, and biodiesel. The meal that is left after oil extraction can also potentially be used as livestock meal and livestock supplements.

In Europe Camelina has seen a recent revival and is available as salad dressing oil and cooking oil in countries such as the Netherlands, Belgium, and England (Ehrensing & Guy, 2008). The interest in the oil for human consumption comes from its high content of omega 3 fatty acids. Omega 3 fatty acids have been shown to have positive effects on human health (McVay & Lamb, 2008). Camelina oil has a low level of saturated fat of 12 percent, which is comparable to vegetable oil (Putnam et al, 1993). It also has a longer shelf-life when compared to other omega 3 oils due to the level of vitamin E (Ehrensing & Guy, 2008). These positive aspects of the oil also give it the potential to be used in omega 3 rich margarine (Meakin, 2007).

Aside from the oils edible aspects, it is used within the European Union in soaps, detergents, and cosmetics (Meakin, 2007). Of these categories the cosmetic industry has been using Camelina oil for organic cosmetics (Ehrensing & Guy, 2008). The oil is used as an oil base in skin care, lotions and creams (Meakin, 2007). This industry requires high quality oil that has been filtered and deodorized, but also returns higher prices (Seedtech, 2000). In the U.S. these cosmetics are available however they are not currently manufactured in the U.S.

The third use of Camelina oil is for use as a petroleum replacement. The oil replaces petroleum based oils in bio-fuels, and blended with other oils in paint (Meakin, 2007). Camelina oil has also been effectively used as a replacement of petroleum based surfactant in pesticide applications (Robinson & Nelson 1975 in Putnam et al, 1993). The properties of Camelina biodiesel are similar to that of soy-bean bio-diesel (McVay & Lamb, 2008). One of the positive aspects of this crop is that it can be processed into bio-fuel on a small scale, making it technically feasible for on-farm application (Schmacher, 2007). On-farm use of Camelina oil as a biodiesel is prepared by mixing Camelina oil with petroleum fuel. The percentage of Camelina oil can be decided by the producer; however, most manufacture warrantees stipulate that this percent cannot be above 2 percent. By blending Camelina oil and diesel fuel the diesel can be used in standard diesel engines (Zubr, 1997).

***Livestock Feed***

Oilseed protein supplements are commonly used in cattle diets and feedlot rations. In Wyoming, feed supplements and meals are often used in winter and fall months to supplement the low quality natural forage. After extraction of oil from the seed, the residual meal has the potential to be used as a livestock meal. The meal is of particular interest due to its high amount of alpha-linolenic acid, an omega 3 fatty acid (McVay & Lamb, 2008). Recent trials performed by the USDA have shown that these omega 3 fatty acids can be transferred to animal products such as chicken eggs, which can contribute positively to a human diet (Ehrensing & Guy, 2008 & Zubr, 1997). The nutritional composition of the meal varies depending on extraction method and production techniques. Camelina meal is composed of approximately 10 percent oil, 13 percent fiber, and 5 percent minerals. The crude protein percentage is on average between 27 to 37 percent depending on extraction method. Cold press extraction yields lower crude protein levels than mechanical extraction (Schill, 2009 ). In a Belgium, trial crude protein was recorded at 45 percent, which is comparable to soybean meal (Zubr, 1997). Soybean meal is, a desirable vegetable oil meal used in the U.S. due to its high digestibility and amino acid content (Zubr, 1997). Camelina meal contains lower essential amino acids than soybean meal. In trials conducted on beef cattle there was no significant difference between Camelina meal and soybean meal. Due to the composition of Camelina meal, it is better suited for ruminants than gastric animals (Böhme & Flachowsky, 2005).

Camelina meal also contains glucosinolates, an anti-nutritive compound, that studies indicate has a negative effect on animal health and performance (Zubr, 1997 & McVay & Lamb, 2008). Glucosinolate can be unpalatable and in some studies cause thyroid problems resulting in less weight gain (Schill, 2009). Due to this compound Camelina meal has been banned for use as livestock feed in some countries within the European Union (McVay & Lamb, 2008). However, in studies performed in Montana had positive results and did not experience any decrease in animal performance (McVay & Lamb, 2008). In the United States the USDA and FDA are currently evaluating the meal and has approved it for use in rations for broiler chickens, giving it the GRAS (generally regarded as safe) rating (Great Plains Oil & Exploration, 2009). In poultry layer trials, conducted at the University of Georgia, Camelina supplement feed increased the omega 3 content of eggs. However, when Camelina meal is above 15 percent of the feed mixture it can have negative effects on egg flavor (Zubur, 1997). In other trials, Camelina supplement feed also increased the omega 3 content of milk, and in meat products (McVay & Lamb, 2008). Further trials are scheduled and currently meal can be fed to beef cattle, at a rate of less than 2 percent of their total ration (Schill, 2009). Nevertheless Camelina meal is not currently approved for use in cattle above this percentage, and 2 percent is not a large enough amount Camelina meal to be commercially applicable.

### 2.3.4 Current Marketing Options

Marketing of Camelina seed is dependent on the oil quality that it produces. Higher quality oils can be sold for higher prices to cosmetic industry and for use as specialty oils intended for human consumption. However there are currently no refineries operating in Wyoming. The closest cash delivery points are in Montana, South Dakota, Nebraska, and Colorado. Since, Camelina is a relatively new commercial crop it is advisable for producers have forward contracting or budget for long hauls to sell their product. Storage facilities, for seed, are the most critical factor in the marketing of Camelina. Access to storage facilities allows growers time to explore the most economically beneficial option for selling their product (Lardy, 2008).

### 2.3.5 Processing of Camelina for Bio-fuel

Bio-fuel produced from Camelina oil is typically used as bio-diesel. There are several mechanical choices available to extract oil from Camelina seed that can be used on a commercial or on-farm scale. No matter which method is utilized the basic process of extracting oil from the seed is very similar.

Oilseed processing or extraction has existed since 2000 B.C. when it was recorded as being used in ancient Egypt. Processing began with ox driven mills and developed further in the seventh century with the invention of the Dutch press. The Dutch press is a wedge driven press driven by steam or water. In 1795 to 1920 oilseed was processed by hydraulic press. In the U.S. the continuous high pressure screw press and expeller are used (Weiss, 2000).

Prior to processing seed moisture content is checked with the use of an analyzer that performs rapid nuclear magnetic resonance. The seed is cleaned to remove soil and plant debris (Weiss, 2000). Bio-diesel is produced by a process known as transesterification. Transesterification is a reaction between triglyceride molecules in vegetable oils, alcohol (e.g. methanol), and a catalyst. When the transesterification reaction is complete, it produces bio-diesel (e.g. three methyl ester) and glycerin (Schumacher, 2007). The glycerin is separated from oil by allowing it to settle at the bottom of a holding tank. After oil is separated, it is heated to remove access alcohol. The remaining fuel is washed with water to remove any remaining impurities (Kimber & McGregor, 1995). In small scale production these impurities are often retained producing a lower quality fuel which can still be used for personal use. Finally the fuel is dried and filtered for final use. According the European production figures 1050 kg (2310 lbs.) of oil will yield 1000kg (2200 lbs.) of biodiesel and 100 kg (220 lbs.) of glycerin (Kimber & McGregor, 1995) This process produces 10 to 15 percent glycerin which can be used to make soaps or as a dust retardant (Schumacher, 2007).

For small-scale production or on-farm production expeller extraction is commonly used. This process leaves more residual oil in the meal than commercial extraction (Schill, 2009).

## 2.4 Farming System

In order to develop the best strategies for the group of farmers and ranchers throughout Eastern Wyoming the concept of farming systems has been utilized. This concept allows individual farm systems to be grouped into larger farming systems. Examining and categorizing the similarities among these groups will allow for the development of a strategy, for the potential Camelina sector, that is applicable for a larger group of farmers and ranchers.

Most farmers in both developed and developing countries view their farms as a system in itself. This system consists of a variety of resources such as, land, water sources, climate, biodiversity, human capital, and social and financial capital. These resources in combination with farm households interact with one another at the farm level creating what is called a farm system.

Farm systems are influenced by external factors such as policies, institutions, markets and information linkages. In some cases, depending on products produced, these systems can also be linked to commodity pricing and labor markets.

In contrast a farming system contains multiple farm systems and takes into consideration the complexity of the eternal environment these systems are operating in (IFSA, 2009). According to the FAO, a farming system, "…is a population of individual farm systems that have broadly similar resource base, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate."(Dixon & Gulliver, 2001).

Within a farming system, inputs both external and internal are converted into agricultural outputs. External factors are composed of markets, policies, institutions, public goods and information. Figure 2.7 shows the interaction between internal and external factors and the influence these factors have on production and consumption decisions.

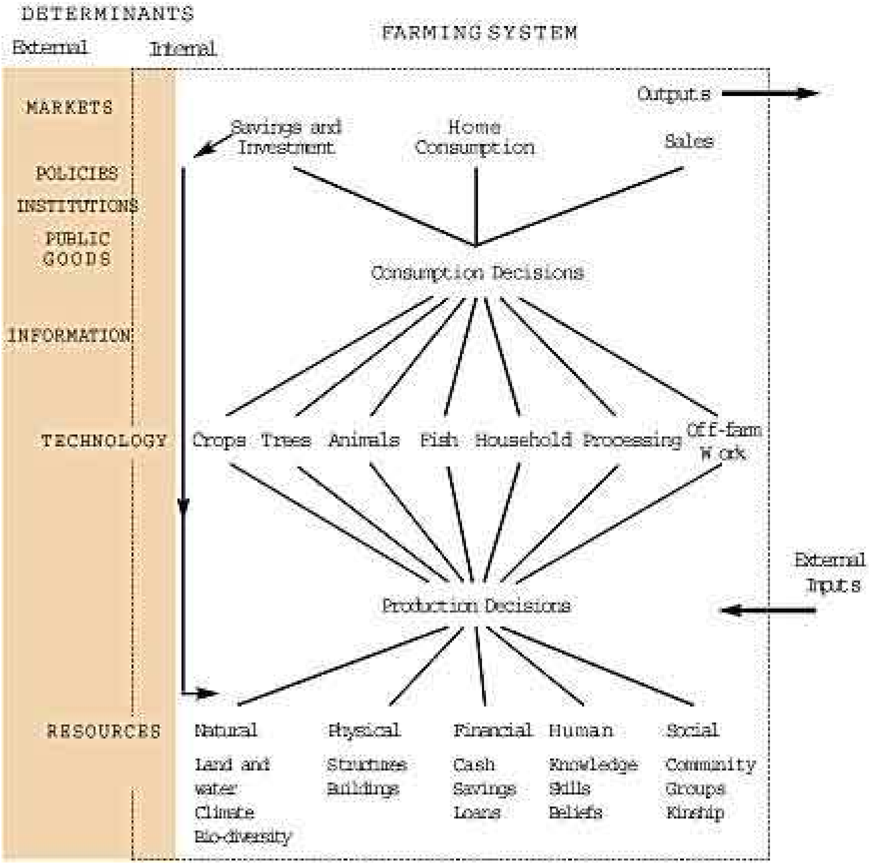


*Figure 2. 7 Systematic Representation of Farming Systems*
(Source: Dixon & Gulliver, 2001).

The concept of farming systems started in the 1970's with a top-down approach focused on technique aspects to increase productivity. In recent years the approach has shifted towards a more holistic approach of agriculture development (Cleary, 2003). With this shift there has been an adoption of a participatory approach, which focuses on farmer knowledge, participatory planning, experimentation and monitoring (Dixon & Gulliver, 2001). The International Farming System Association (IFSA) further expands participatory approach to include: understanding farmers' goals, adapting scientific results to fit farmers, looking towards farmers as experts in socio-economic factors (e.g. labor, values, and social attitudes) (IFSA, 2009).

In order to develop strategies and interventions farming systems are divided into categories based on available natural resources, farm activities, and livelihoods (Dixon & Gulliver, 2001). The FAO has established eight categories three of which are present in Wyoming.

- Rain-fed farming systems in dry or cold low potential areas, with mixed crop-livestock and pastoral systems merging into sparse and often disperse systems with very low current productivity due to cold and or dry conditions.
- Mixture of large commercial and small holder farming systems, with a variety of natural resources and diverse production.
- Urban based farming systems, focused on horticulture or livestock production.

While considering these categories strategies can be developed to improve the livelihoods of farmers with in the system. The strategies that can be employed to do this include: intensification of production, expansion, increasing income from outside farm system, leaving a farming system, or diversification (Dixon & Gulliver, 2001).

# Chapter 3 Methodology

## 3.1 Study Area

This study was conducted throughout Eastern Wyoming. The area is comprised of eleven counties including Albany, Campbell, Carbon, Crook, Converse, Goshen, Laramie, Niobrara, Platte, Sheridan, and Weston. The total area and area by county, in square miles and square kilometers, is detailed below in Table 3.1.

*Table 3. 1 Total study area and area by county*

| County | Area (sq miles) | Area (sq km) |
|---|---|---|
| Albany | 4,273 | 11,070 |
| Campbell | 4,796 | 12,424 |
| Carbon | 7,896 | 20,453 |
| Crook | 2,859 | 7,405 |
| Converse | 4,255 | 11,020 |
| Goshen | 2,225 | 5,763 |
| Laramie | 2,686 | 6,957 |
| Niobrara | 2,626 | 6,801 |
| Platte | 2,085 | 5,400 |
| Sheridan | 2,523 | 6,535 |
| Weston | 2,398 | 6,211 |
| **Total** | **38,622 sq miles** | **100,039 sq km** |

(Source: U.S. Census Bureau, accessed on 10 Aug. 2009)

Agriculture is one of the major economic activities in this area. As stated above in section 2.2, 91% of this area is considered rural. The majority of agriculture enterprises are composed of cattle production, i.e. cow-calf or yearling, and forage production. In the southeast portion of the study area there is also crop production and the presence of irrigated crop land which is minimal in the northeast section of the study area. In the northeast production of crops is mainly limited to forage and some wheat production while the southeast produces forage, sugar beets, wheat, barley, and other specialty crops. Typically the forage production is used on farm and any additional production is sold locally to other livestock producers.

## 3.2 Research Strategy

Fieldwork was conducted between July 15th and August 23rd 2009. Main fieldwork consisted of several interviews and a surveys completed by 30 farmers and ranchers from Eastern Wyoming. The original strategy for these surveys was to have ten respondents from each of three clusters based on crop/forage production area, i.e. 39 acres (15.8 hectares) and under, 40-79 acres (16.2-32 hectares), and 80 acres (32.4 hectares) and more. However, through the course of the field study this strategy was abandoned when it was determined that the sample size of individuals within the smaller acreage amount would be too small. Ultimately two clusters where obtained, i.e. 79 acres and under and 80 acres and more. Surveys of farmers began on July 20th by contacting farmers and ranchers that had been referred to me by Ms. Lindsay Taylor, a University of Wyoming Extension Educator. Surveys continued in the southern portion of the state on July 23rd at a “farmer’s field day” at the University of Wyoming Extension research station located in the town of Torrington. To continue to get a random sample of farmers and ranchers surveys were conducted at Campbell County Fair and Livestock Auction in Northeast Wyoming from July 29th to July 30th to obtain a minimum of 30 completed surveys, collection of surveys of farmers and ranchers continued until August 19th by attending various events throughout Eastern Wyoming. The surveys were used to gather data on eastern Wyoming farms and ranchers interest in growing Camelina. The questions asked of the ranchers and farmers included business types, major reasons for growing new crops, information they had previously received on Camelina, and information they were missing about the crop.

The second portion of the strategy was to conduct a case study. This case study involved interviewing potential chain actors and supporters in order to examine the feasibility of Camelina production in Eastern Wyoming. In total six interviews where conducted. These interviews covered various topics including production, agronomics, markets and market development, information exchange, as well as the potential and challenges of producing Camelina in Wyoming.

### 3.3 Surveys

Surveys were obtained from 30 farmers and ranchers in Eastern Wyoming, using a structured questionnaire. The questionnaires were self administered throughout Eastern Wyoming at various locations. These farmers and ranchers where randomly selected from the Eastern Wyoming population in regards to their crop/forage production and potential for Camelina production. The farmers/ranchers represented property sizes from one of two clusters: 79 acres and under or 80 acres and up. Table 3.2 shows the total farmers surveyed from each cluster.

*Table 3. 2 Number of interviewed Farmers and Ranchers by Crop/ Forage Acreage*

| Number of Acres | Number of surveys | Total |
|---|---|---|
| 79 Acres and under<br>(32 hectares) | 10 | 10 |
| 80 Acres and up<br>(32.4 hectares) | 20 | 20 |
| | | 30 |

The survey questionnaires provided information on the farming system (i.e. business type, acreage, and location), potential for Camelina (i.e. acreage, and uses), and about information used to make key farming decisions, information delivery method, information received, and missing information about the crop, see Appendix 2.

### 3.4 Case Study

A case study was conducted by interviewing potential stakeholders for the Camelina seed chain. Interviewees were selected based on the categories below:

- Bio-diesel company
- University researcher working with Camelina and seed improvement
- Potential grower of Camelina seed
- Grower who has grown Camelina in the past
- University of Wyoming Cooperative Extension representative
- State government chain supporter

These interviews where semi-structured with a list of questions for each interview, although additional information was strongly encouraged. The interviews were constructed to:

1. Provide information about the potential of production of Camelina.
2. Determine areas where linkages in existing information where missing in order for farmers and ranchers to make a decisions on whether they should produce this crop.
3. Obtain information about how a chain could be formulated for this sector.
4. Find potential uses, and markets for Camelina oil and meal.

### 3.5 Data Collection

Initial data collection took place through exploring all relevant documents about Camelina production and research. In some instances, this included cross-referencing between data from Europe as well as neighboring states. This included looking at documents created by the University of Wyoming Cooperative Extension and their research stations. Prior trials of Camelina seed by the University of Wyoming were paramount in uncovering the potential for this crop for Wyoming producers.

Surveys were conducted using a structured questionnaire. These questionnaires where self administered to each of the respondents. Prior to administration the questionnaire were pre-tested for question clarity and ease of use by participants from various disciplines and backgrounds. The questions in the questionnaire were composed to aid in answering several sub-questions and ultimately aid in answering main research questions.

Interviews were conducted with the use of a semi-structured questionnaire. These interviews were self-administered. Questions were tested prior to interviews in order to examine the clarity of each question. Questions were guided by the main research questions and sub-questions. The formulation and pretesting of these questions was paramount in becoming familiar with the field of research and were geared specifically for each interview.

# Chapter 4 Results

## 4.1 Farming System

The current farming system present in Eastern Wyoming primarily consists of multiple enterprises. These enterprises are primarily livestock with secondary crop forage production. Of the livestock enterprises cattle production, either cow/calf or yearling is the most prominent and according the USDA's Agricultural Census, make up 50 percent of all farms within the state (USDA, 2009). These cattle producers also engage in forage production. This forage is mainly used in their cattle enterprises with any excess sold in the local market. The forage that these ranchers produce is used to over-winter their cattle. In Wyoming the winter is extremely cold with temperatures below freezing. This climate requires producers to feed cattle in order to maintain their body condition. Currently they provide all forage for their livestock and purchase meal, such as soy-bean and corn ration or cottonseed cake, from neighboring states. These rations provide livestock with additional protein that cannot be met with the low quality forage available during winter months. In addition to livestock and forage production, some producers also grow wheat. This wheat is sold as a commodity crop through the local Farmers Cooperative.

In addition to agricultural practices many ranchers throughout Eastern Wyoming also have coal-bed methane pumps and or oil pumps on their property. This property is leased to local energy companies, and thus provides some additional income to these ranchers.

### 4.1.1 Characteristics of Farms

The characteristics of farms in Eastern Wyoming and in the survey group are composed primarily of livestock production with crop/ forage production. Seventy three percent's primary business is cattle production (i.e. cow calf, or yearling), 10 percent perform arable farming, 6.67 percent produce a mixture of livestock (i.e. cattle, horses, sheep/goats, and swine), and 6.67 percent produce horses, as seen in Figure 4.1.

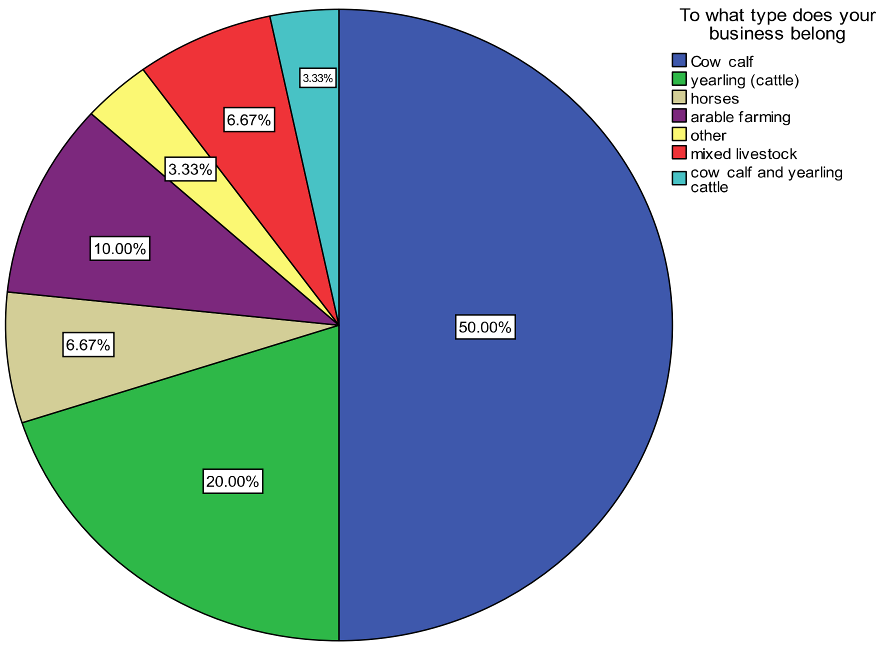


*Figure 4. 1 Primary business type of surveyed farmers in Eastern Wyoming (N=30)*

Of the surveyed producers 10 people produce their livestock on fewer than 79 acres (32 hectares) with the remaining 20 producing on more than 80 acres (32.4 hectares), see Table 3.2. One reason why there were more respondents in the larger production category could be due to the amount of acreage needed to maintain an animal in Eastern Wyoming. According to Ms. Taylor, Campbell County Cooperative Extension Livestock Systems Educator, 40 acres (16.2 hectares) of the rangeland in Eastern Wyoming are necessary to provide enough forage to maintain a single cow. In contrast, some of the smaller acreage is often seen in horse production operations where supplemental feeding is given.

Furthermore when comparing the farming systems present in Eastern Wyoming to those described in the FAO's definitions of the eight categories of farming systems there is a distinct link between three of the categories and the systems present in Eastern Wyoming, as shown in Table 4.1.

*Table 4. 1 FAO Farming system categories present in Eastern Wyoming*

| FAO Farming system categories | Farming System in Eastern Wyoming Situation |
|---|---|
| • Rain-fed farming systems in dry or cold low potential areas, with mixed crop-livestock and pastoral systems merging into sparse and often disperse systems with very low current productivity due to cold and or dry conditions. | • Dry land farming systems in low potential areas with extreme cold below freezing, with mixed crop-livestock systems, very disperse systems due to low current productivity of rangeland, caused by cold and dry land conditions |
| • Mixture of large commercial and small holder farming systems, with a variety of natural resources and diverse production. | • Mixture between large commercial and family business farming systems, ranging in production size from 40 acres to several thousand acres. Producing various types of livestock and crops |
| • Urban based farming systems, focused on horticulture or livestock production. | • Few urban based farming systems that focus on livestock production. Concentrated at the edges of major cities |

## 4.2 Potential Camelina Production in Eastern Wyoming

Interviews with potential stakeholders, indicate that there is potential for Camelina production in Eastern Wyoming. One of the main areas that the interviewees see potential for this crop is in filling a void for an alternative crop, particularly a spring annual. Camelina has the potential to fill this void while fitting into the areas rainfall pattern. This not only makes the crop applicable to the area but also allows for farmers and ranchers to produce it in a dry land situation, which will allow them to forego the added cost of an irrigation system.

Camelina also has the potential to fit into their current crop rotation. Although the major business type in this area is cattle production, some ranchers also grow wheat. For those few individuals Camelina will allow them to produce two crops on a piece of land that would otherwise only yield wheat. For the farmers who engage in arable farming, farmers and researchers agree that Camelina has the potential to aid in weed control, of mustards and grasses, as well as provide erosion control from wind and water.

Many people also stated that Camelina would have an even greater potential if given GRAS status by the FDA, allowing it to be feed to cattle. According to the Livestock Systems Educator at the University of Wyoming Cooperative Extension, Ms. Taylor, the potential for the crop if it could be fed to cattle would be significant especially since Wyoming is so far from the mid-west where the traditional soy-bean meal and cottonseed meal are produced (Appendix 3, Interview #5). For this reason Ms. Taylor sees potential for Camelina meal to cut production costs for their cattle enterprises. This area of potential is also echoed by the surveyed group. According to the survey results many of the producers are interested in Camelina production to use on as a livestock meal as well as biodiesel, or for sale as a commodity, see Figure 4.2.

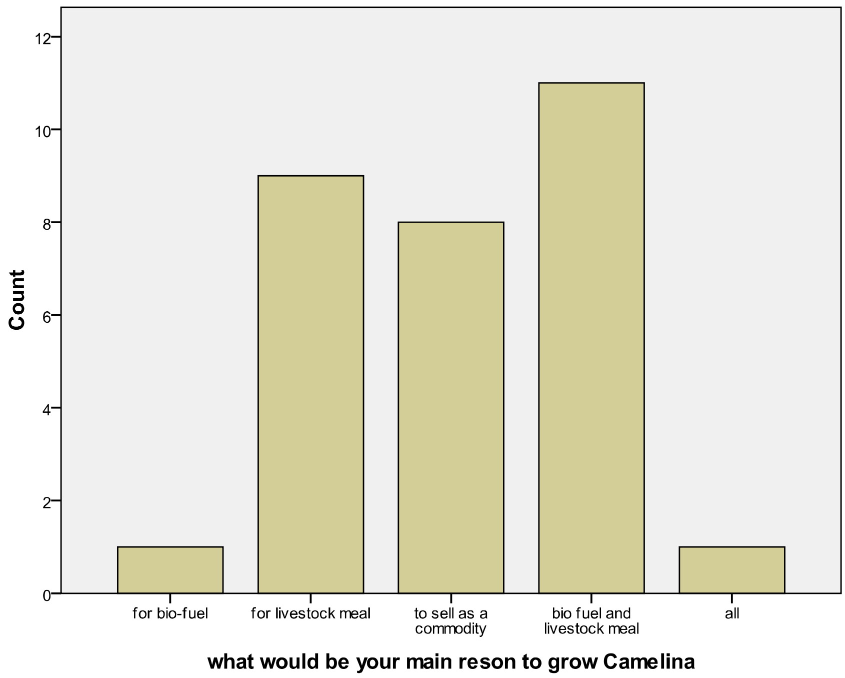


*Figure 4. 2 Frequency of Main reason for growing Camelina (N=30)*

### 4.2.1 Potential Production

One of the major factors in potential production of a new crop lies with the producers. It is important to take into consideration that if they are not interested in the crop it will not be applicable to them. Of the producers that were surveyed approximately 77 percent where interested at some level, leaving approximately 23 percent that were not interested in producing Camelina, see Figure 4.3. This level of interest was not significantly influenced by their business type or age, see Appendix 4.

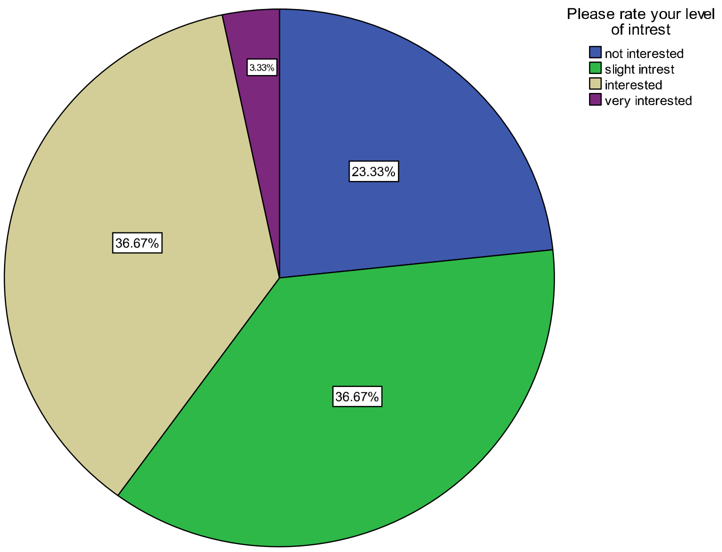


*Figure 4. 3 Interest level among surveyed producers (N=30)*

Of the survey group there was no significant difference between their current crop/forage acres and the amount of acres they would consider growing, see Appendix 4. From the frequency shown in Figure 4.4 the majority of producers would produce less than 39 acres of Camelina, given the current information they have about the crop.

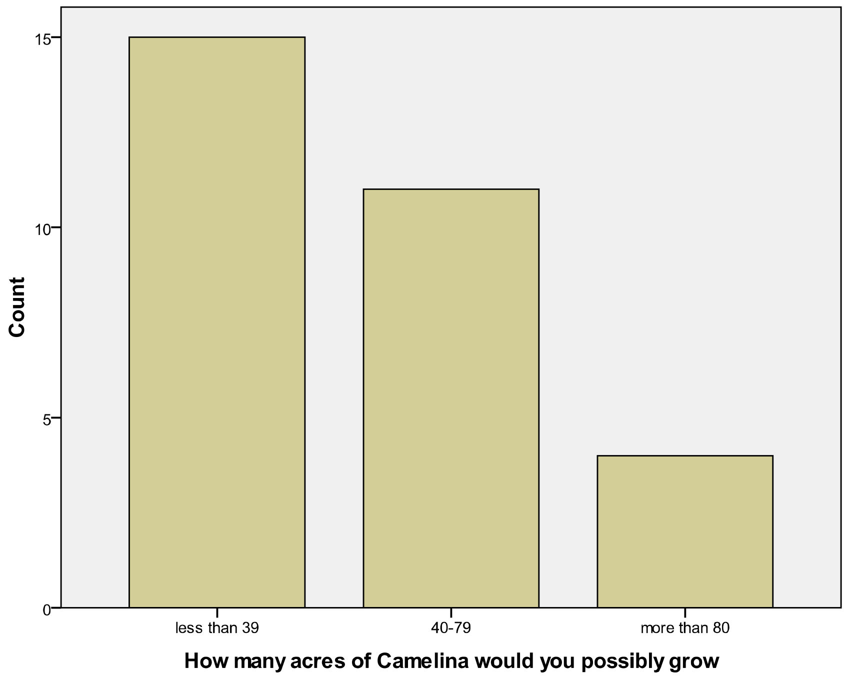


*Figure 4. 4 Frequency of amount of acres of Camelina producers would grow (N=30)*

Another important factor in potential production is the main reasons local producers decide to adopt a new crop into their farm system. According to the surveys, potential on-farm use of a crop is the number one factor with the option of selling the crop as a commodity following close behind, see Figure 4.5.

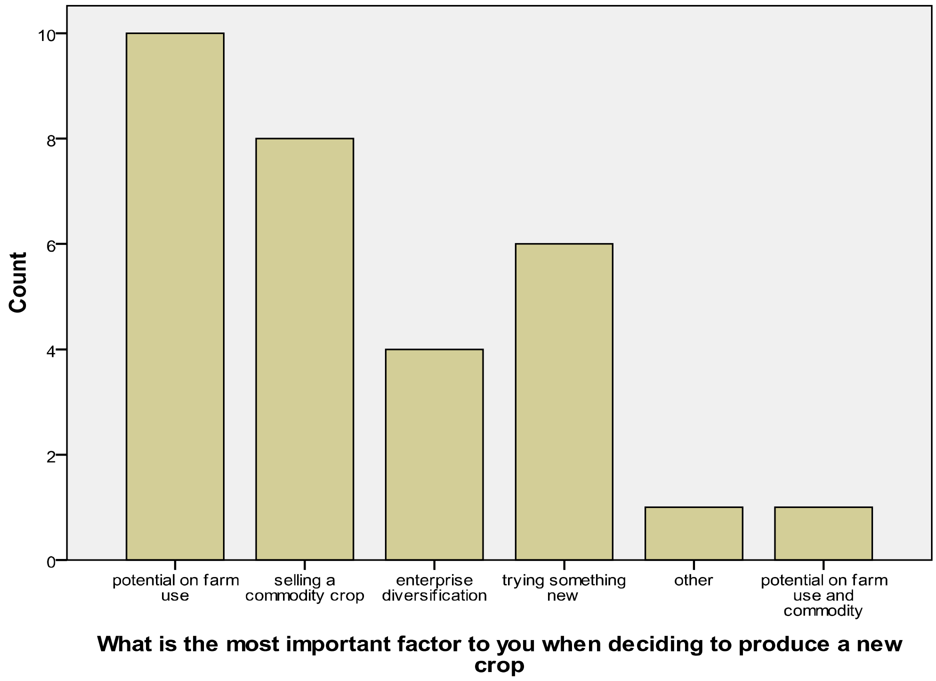


*Figure 4. 5 Frequency of most important factor in deciding to produce a new crop (N=30)*

### 4.2.2 Yield

During interviews with Ms. Lindsay Taylor from the University of Wyoming Cooperative Extension yield potential of Camelina in Eastern Wyoming was discussed. According to Ms. Taylor in field trials conducted by the University of Wyoming, yield results varied by variety and production method. These trials were conducted throughout Wyoming; the dry land trial was performed in Northeast Wyoming and the irrigated trial in Southeast Wyoming. The details of these varieties trials are given in Table 4.2. The data shows the differences in both height and yield of several varieties. When comparing the averages of the dry land cultivated varieties and the irrigated varieties, there is a 33 percent decrease in yield in the dry land situation. This decrease could also be caused in part by a lack of fertilizer used in the dry land trial.

*Table 4. 2 Camelina yield data from University of Wyoming Experimental Varieties Trials 2009*

| Variety | Dryland Height (in) | Dryland Yield (lbs/ac) | Irrigated Height (in) | Irrigated Yield (lbs/ac) |
|---|---|---|---|---|
| Celine | 28 | 392 | 38 | 1225 |
| Ligena | 30 | 378 | 36 | 1048 |
| Calena | 29 | 443 | 37 | 1022 |
| Cheyenne | 29 | 349 | 37 | 965 |
| MT5 | 26 | 261 | 37 | 938 |
| Jungle Gold | 28 | 254 | 36 | 801 |
| Average | 28 | 334 | 37 | 1000 |

Conversions: 1in = 2.54 cm
1lbs/ac = 1.23kg/hectare

## 4.3 Constraints on Camelina Production in Eastern Wyoming

### 4.3.1 Agronomic Constraints

In Table 4.3 agronomic constraints on the production of Camelina for Eastern Wyoming producers is examined. This table shows agronomic constraints in two categories: technical constraints and institutional constraints. Technical constraints are the constraints on farm such as soil fertility and weed control. The Institutional constraints are constraints on agronomics from a research and legislative standpoint.

*Table 4. 3 Agronomic constraints for the production of Camelina*

| | Constraints | Nature of Constrains |
|---|---|---|
| Technical Constraints | Weed Control | • Farmers must start with clean fields<br>• Weeds can be a problem at time of maturity |
| | Soil Fertility | • Fertilizers are needed to meet yield potential<br>• Eastern Wyoming soils are alkaline<br>• Organic matter easily lost due to soil erosion by wind and water |
| | Crop water | • Yield can be increased with additional crop water<br>• Dry-land situation only provided 8-12 inches of crop water in Eastern Wyoming |
| Institutional Constraints | Varieties | • Improved varieties are needed<br>• Varieties with improved yields in dry-land situation are needed<br>• Shatter resistant varieties are needed in Eastern Wyoming with likelihood of high winds at time of maturity |
| | Herbicides | • No broad leaf herbicides registered for use on Camelina |

### 4.3.2 Marketing Constraints

During data collection with interviews, it became apparent that there are several market constraints that exist for producers in Eastern Wyoming. As detailed in the section 2.3.3 there are several applications for both Camelina oil and meal.

However, within the context of Eastern Wyoming some limitations exist.  In interviews with potential growers of Camelina they sited a lack of a market in the state and limited markets in nearby states.  This fact was further confirmed by Dr. Charlie Rife of Blue Sun Bio-Diesel (Appendix 3, Interview #3).  He stated that his company had plans to attempt to develop a refinery within the state but due to problems with logistics it never came to fruition.  During discussions with Dr. Alice Pilgeram, a researcher at Montana State University, she stated that the nearest refinery accepting drop offs of Camelina seed was in Billings, Montana, which is approximately 179 miles from Northeast Wyoming (Appendix 3, Interview #4).  The current rate for seed transportation from Wyoming to Billings, Montana is $4.25 a loaded mile making the transportation cost an estimated $760.75.  According to both Dr. Rife and Mr. Randall another reason why markets, especially refineries, have not developed in the area is because of a lack of production to keep their operations running at full capacity (Appendix 3, Interview #1).  The farmers and ranchers perspective is that they are unwilling to grow a crop without a market.

The other market constraint is lack of a contract to grow Camelina.  Although there have been attempts by some companies to develop the production of Camelina in Eastern Wyoming they are unwilling to contract the production, guaranteeing producers an end market.  According to a potential producer Mr. Leslie Drake this was one of the main reasons why he decided to not grow Camelina (Appendix 3, Interview #2).  He stated that with limited markets and no contract it did not seem like a good option for his business.

The final constraint on the market for Camelina lies in legislation, particularly with the FDA.  One of the main markets within this region would be livestock feed.  Camelina meal could provide an alternative to the current protein meal that is imported form outside the state.  However this market can not develop due to a lack of approval by the FDA to feed Camelina meal to livestock.

## 4.4 On-Farm Usage of Camelina

One of the options that are considered in designing a chain that will work for the farming system present in Eastern Wyoming is the option of on-farm usage and processing of Camelina seed.  According to data shown in Section 4.2.1, Figure 4.5 the main reason respondents decide to produce a new crop lies in its potential for on-farm use.  This leads to an examination of how this could be performed and what producers would like to use Camelina for on-farm.

### 4.4.1 Local Pressing of Camelina

Local pressing of Camelina seed for oil extraction is one of the options that were examined through both interviews and also surveys.  Of the producers surveyed 22 producers would be interested in using SVO on their farms as a bio-fuel while the remaining 8 had no interest, see Figure 4.6.

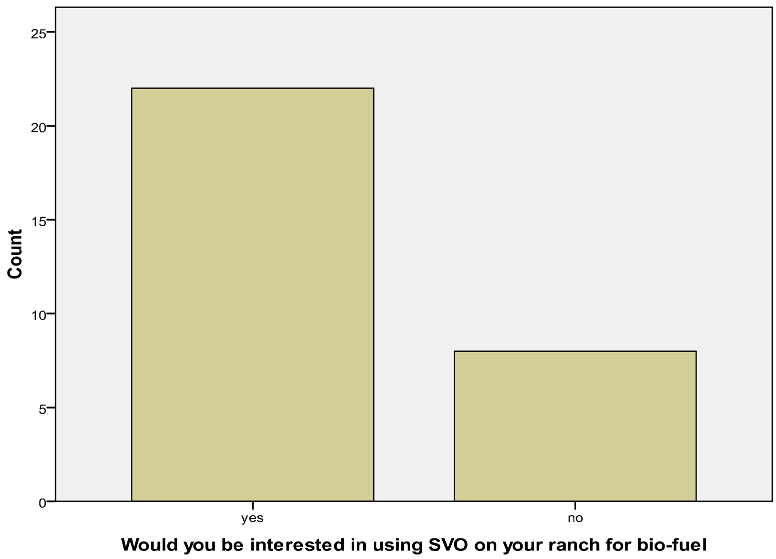


*Figure 4. 6 Frequency of interest in using SVO as a bio-fuel on producers' ranches (N=30)*

In an interview with Ms. Lindsay Taylor, a University of Wyoming Cooperative Extension Educator, local pressing and on-farm pressing of Camelina seed was discussed. In this discussion it was highlighted that currently there are two options available to local producers to crush their seed. The first option to crush seed would be for a local producer to partner with the Extension office to hold a demonstration at the producer's ranch where the Extension office could bring in their mobile unit and crush the seed for the producer. The University of Wyoming has purchased a press for this purpose. This would be an educational event that would be open to the public and other producers. This will work if there are not many producers in the area, as the Extension office cannot have these educational events constantly. The second option would be for producers to purchase their own press and press Camelina seed on-farm. The pressing of seed can be done during slower times of the year. These presses can range in size and price, but nonetheless they can be easily stored by producers. The presses themselves run off 220 volt electrical outlet and once set up require minimal labor to run (4 hours per day).

In interviews with several potential stakeholders a third option was also discussed. This option would be to form a cooperative for the purpose of pressing. The majority of interviewees were not very enthusiastic about this idea. However, in an interview with a local rancher, Mr. Chuch Rourke, he thought that this would be an area where the local Farmers Cooperative might be able to offer assistance (Appendix 3, Interview #6). The majority of farmers and ranchers already have a relationship with Farmers Cooperative and it already contains the infrastructure to handle storage and transportation of seed, should a commodity market develop. He also stated that he felt there could be potential for Camelina oil, if economically feasible, locally not only for producers but also local oil companies. He said that they have expressed some interest in SVO due to its lubricant properties and low sulfur. The diesel used now must have a lower amount of sulfur and because of that the diesel fuel has lost some of its lubricity.

### 4.4.2 Camelina as a Livestock Meal

As seen in Figure 4.2, one of the main reasons local producers would grow Camelina is for use as a livestock meal. In interviews with potential stakeholders many cited the potential benefits of using the meal produced in the pressing process for a livestock meal. According to Dr. Alice Pilgeram, a researcher at Montana State University, feeding trials have been previously performed at her university with positive results. In Montana State University trials with beef cattle positive results were seen with rations containing up to 15 percent Camelina meal. At this rate the ration is comparable to soy-bean meal in terms of feeding efficiency. She also stated that the results also showed that feeding Camelina meal to livestock had a positive effect on omega-3 fatty acids contained in the end meat products. However, recently their trials have been discontinued by the FDA. Currently under FDA regulations Camelina meal has only been approved at 2 percent for beef cattle rations. Dr. Pilgeram explained that FDA regulations are voluntary for livestock feed until adopted by individual states as compulsory. The state of Wyoming and the state of Montana currently follow FDA regulations, however other states such as Utah, Nevada and Arizona do not. Thus in many of those states feeding trials are continuing. She stated that in March of this year the FEFANA, which is in charge of feeding regulations in the EU, approved Camelina meal use as a livestock feed. This approval gives hope that the FDA will also approve the meal in the future.

## 4.5 Linkages in Information

Part of this feasibility study was to examine the existing linkages in information between chain supporters and farmers. These linkages are paramount in producers' ability to make sound decisions for their businesses. Within the context of Eastern Wyoming, the main supporter whose purpose it is to give farmers unbiased information about new crops, improved farming techniques, and aid them in analyzing new ventures is the University of Wyoming Cooperative Extension. In order to analyze the existing and missing linkages in information about Camelina, producers were surveyed about the information they have previously received and the information they still need. In addition a representative from the University of Wyoming Cooperative Extension and Wyoming Business Council were interviewed and asked what information they believe the producers still need. This helped to establish whether the missing linkages where caused by a lack of delivery by these support organizations or perhaps the unavailability of the information.

Of the surveyed producers, 40 percent have not received any information about Camelina. Of the producers who have received information on this new crop 30 percent have received information on production. In Figure 4.7 the information that producers have received the least is information on marketing and economics aspects of Camelina.

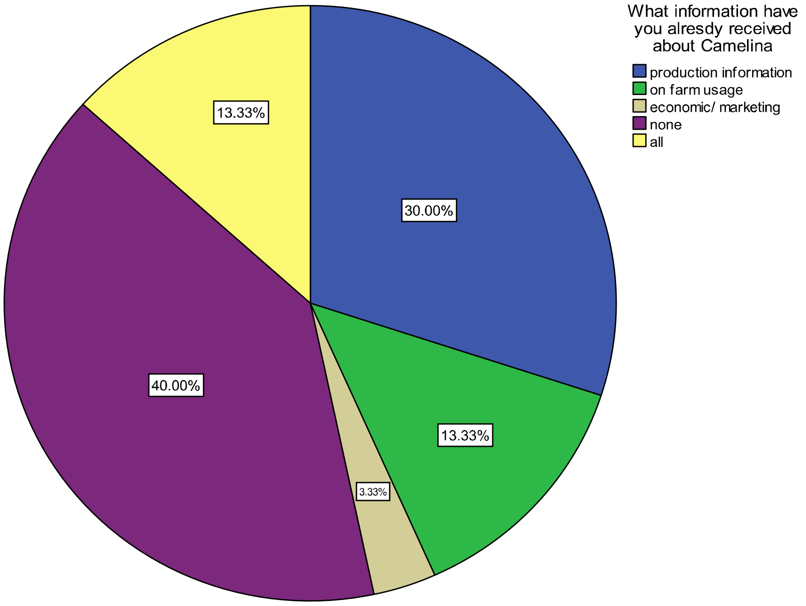


*Figure 4. 7 Information received by Eastern Wyoming producers about Camelina (N=30)*

Surveyed producers were then asked about the additional information they were interested in receiving about Camelina. From the surveys 50 percent stated that they are interested in receiving information about the marketing and economic aspects of Camelina, see Figure 4.8. This follows directly from the information they were lacking in Figure 4.7. 30 percent of producers said that they are interested in receiving additional information about on-farm usage of Camelina. This follows directly from Figure 4.5, in which producers stated that potential on-farm usage of a new crop is one of the most important factors to them when deciding to adopt a new crop.

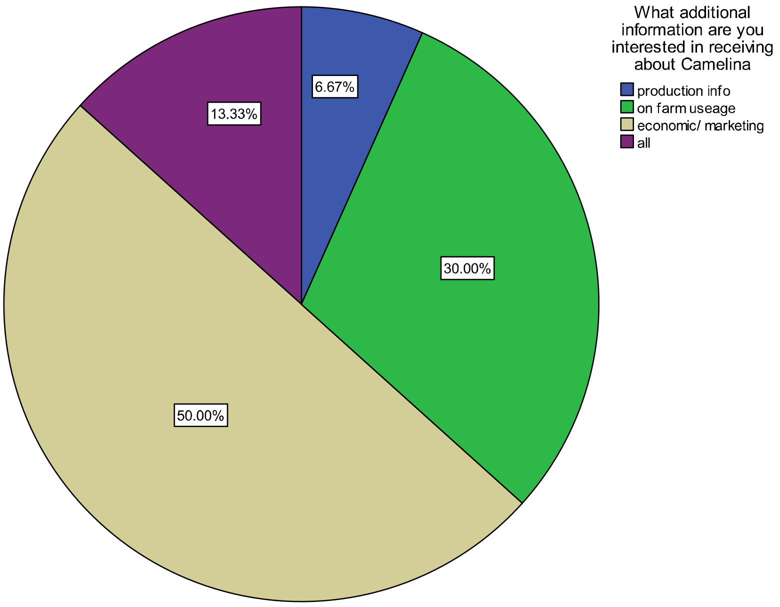


*Figure 4. 8 Additional information needed by Eastern Wyoming producers about Camelina (N=30)*

The University of Wyoming Cooperative Extension and Wyoming Business Council they also echoed producers' sentiments by acknowledging that the missing information for Camelina was in the area of marketing and economics. According to Mr. Randall producers need to know not only economic information but economic feasibility. There is a need for information about the costs and benefits of Camelina for producers. Ms. Taylor added that producers also need information about markets and market infrastructure. She stated that additional information about on-farm uses such as the potential for Camelina's application as a livestock meal and on-farm processing is needed. Mr. Randall and Ms. Taylor also stated that this information has yet to be complied and thus has not been disseminated.

The delivery method of this information is important in order to effectively communicate new information to producers. As a result, producers were asked to state the channel in which they prefer to receive information from the University of Wyoming Cooperative Extension Office. From the survey most respondents prefer to receive information via mailed pamphlet (i.e. through the postal service), see Figure 4.9. Other respondents also expressed an interest in receiving information through electronic channels. Of these preferences in delivery method (i.e. electronic channels, or traditional channels) there was no significant difference found between age groups, see Appendix 4.

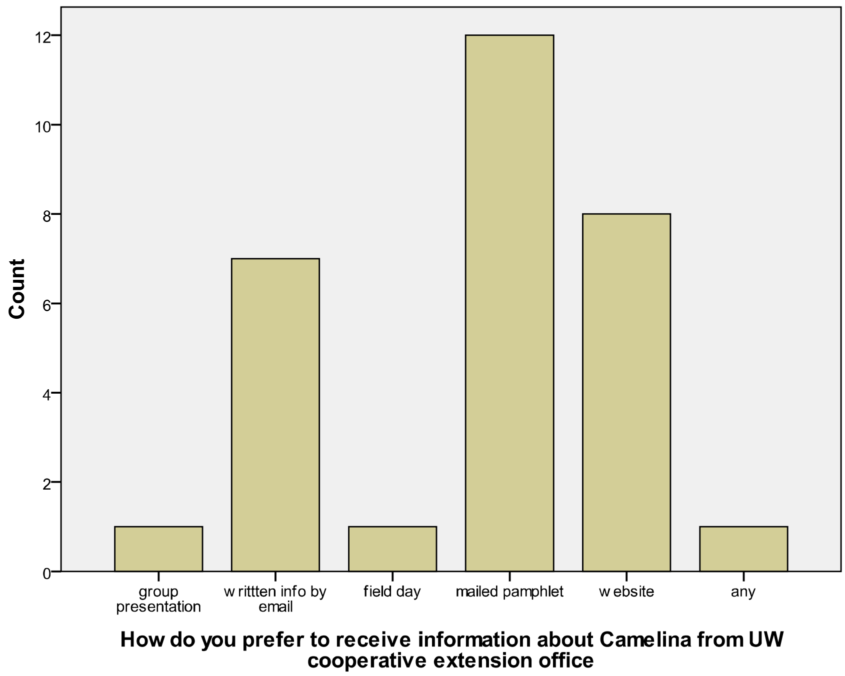


*Figure 4. 9 Frequency of preferred channel of communication for producers (N=30)*

## 4.6 Economic Feasibility of Camelina

### 4.6.1 Operational Costs Analysis

Operational costs for the production of Camelina seed are calculated in Table 4.4. This calculation considers both preharvest and harvesting costs of production. The preharvest and harvests costs have been calculated separately in order to calculate interest, since preharvest interest is calculated for six months and harvest cost are only calculated for two months. Fertilizer costs are calculated based on the fertilizer rates given in Table 2.4 for an expected yield of 1026 lbs/acre. The total operational cost for one acre (0.405 hectares) is $105.64. These costs may be decreased slightly if fertilizer and seed are bought in larger quantities.

*Table 4. 4 Operational cost per Acre (0.405 hectares) for Camelina*

## Operational Costs per Acre

**Variable factors of production**

| | Item | Cost | Units | Number of Units | Total per Acre |
|---|---|---|---|---|---|
| **A. Preharvest Costs** | | | | | |
| | Seed[1]* | $1.40 | lbs | 8 | $11.20 |
| | Fertilizer[2] | | | | $0.00 |
| | Nitrogen | $0.46 | lbs | 41 | $18.86 |
| | Phosphorus | $0.40 | lbs | 25 | $10.00 |
| | Potash | $0.40 | lbs | 33 | $13.20 |
| | Sulfur | $0.37 | lbs | 23 | $8.51 |
| | Fertilizer application[3] | $5.00 | Acre | 1 | $5.00 |
| | Herbicide[4] | $10.00 | Acre | 1 | $10.00 |
| | Labor (planting)[5] | $5.15 | hour | 0.5 | $2.58 |
| | Tractor operating costs (fuel, oil, grease, repairs)[6] | $2.68 | Acre | 1 | $2.68 |
| | Machinery operating costs (oil, grease, repairs)[7] | $1.90 | Acre | 1 | $1.90 |
| | Insurance (Fed. Crop, hail)[8] | $2.30 | Acre | 1 | $2.30 |
| **B. Subtotal Preharvest Costs** | | | | | **$86.23** |
| **C. Interest on working capital** | | 12% | months | 6 | $2.59 |
| **D. Total Preharvest Costs** | | | | | **$88.81** |
| **E. Harvest Costs** | | | | | |
| | Combine operational costs[9] | $15.00 | Acre | 1 | $15.00 |
| | Truck operational costs[10] | $1.66 | Acre | 1 | $1.66 |
| **F. Subtotal Harvest Costs** | | | | | **$16.66** |
| **G. Interest on working capital** | | 12% | months | 2 | $0.17 |
| **H. Total Harvest Costs** | | | | | **$16.83** |
| **E. Total Operational Costs** (Preharvest Costs + Harvest Costs) | | | | | **$105.64** |

*Based on yield goal of 1026 and 10" of crop water

Sources:
1. (Rife, 2009).
2. (Farmers Cooperative, 2009)
3. (Johnson, 2006)
4. (Johnson, 2006)
5. (U.S. Department of Labor, 2009)
6. (Johnson, 2006)
7. (Johnson, 2006)
8. (Johnson, 2006)
9. (Johnson, 2006)
10. (Johnson, 2006)

### 4.6.2 Gross Margin Analysis

A gross margin analysis was performed to examine the profitability of an acre of production of Camelina for Eastern Wyoming producers. This analysis takes in to consideration the variable costs of production and the possible gross output the producers could reasonably expect from one acre of Camelina production. From this analysis the gross output would be $7.11 per acre of production, see Table 4.5. Highlighted are the fertilizer costs, which account for roughly fifty percent of the total variable costs; this amount of fertilizer is the recommended dosage to acquire yields of 1026 lbs/ac.

*Table 4. 5 Gross Margin Analysis per Acre of Camelina*

| | | | | | |
|---|---|---|---|---|---|
| **Gross Output** | | | | | |
| Yield [11] | lbs/acre | 1025 | $0.11 | $112.75 | |
| **Total gross output** | | | | **$112.75** | **$112.75** |
| **Variable Costs** | | | | | |
| ***Preharvest Costs:*** | | | | | |
| Seed[1] | lbs | 8 | $1.40 | $11.20 | |
| Fertilizer[2] | Acre | 1 | $50.57 | $50.57 | |
| Fertilizer application[3] | Acre | 1 | $5.00 | $5.00 | |
| Herbicide[4] | Acre | 1 | $10.00 | $10.00 | |
| Labor (planting)[5] | hour | 0.5 | $5.15 | $2.58 | |
| Tractor operating costs (fuel, oil, grease, repairs)[6] | Acre | 1 | $2.68 | $2.68 | |
| Machinery operating costs (oil, grease, repairs)[7] | Acre | 1 | $1.90 | $1.90 | |
| Insurance (Fed. Crop, hail)[8] | Acre | 1 | $2.30 | $2.30 | |
| Subtotal | | | | $86.23 | |
| Interest | months | 6 | 12% | $2.59 | |
| ***Harvest Costs:*** | | | | | |
| Combine operational costs[9] | Acre | 1 | $15.00 | $15.00 | |
| Truck operational costs[10] | Acre | 1 | $1.66 | $1.66 | |
| Subtotal | | | | $16.66 | |
| Interest | months | 2 | 12% | $0.17 | |
| **Total variable costs** | | | | **$105.64** | **$105.64** |
| **Gross Margin** | | | | | **$7.11** |

Sources:
1. (Rife, 2009).
2. (Farmers Cooperative, 2009)
3. (Johnson, 2006)
4. (Johnson, 2006)
5. (U.S. Department of Labor, 2009)
6. (Johnson, 2006)
7. (Johnson, 2006)
8. (Johnson, 2006)
9. (Johnson, 2006)
10. (Johnson, 2006)
11. (Rife, 2009)

### 4.6.3 Partial Budget Analysis for On Farm Pressing and Livestock Meal

A partial budget was also created to examine the profitability of processing Camelina seed on-farm. This was performed by calculating the reduced cost of feeding 100 head of cattle for 80 days on traditional cottonseed meal, see Table 4.6. This situation is very typical for most producers in Eastern Wyoming in order to maintain their cattle during the winter months. In the partial budget Camelina meal is compared to a comparable protein meal, i.e. cottonseed meal. Camelina oil is considered to be added returns and in this situation would be sold to refineries directly. When calculating the negative aspects of on-farm processing and use variable costs of production and processing were calculated. Also the added costs of shipping oil to the nearest refinery in Billings, Montana was calculated and added to the total costs. Ultimately there is a savings of $1213.91 to use Camelina meal and process on-farm. For the farmer this would work out to be a positive economic outcome of $57.80 per acre, based on the 21 acres it would take to produce the needed product. It is important to state again that this is not a viable option given the FDA restrictions on feeding Camelina meal to beef cattle. However, this could be an important option for the future.

*Table 4. 6 Partial Budget for on-farm pressing and Camelina Meal Use as Cattle Feed*

**Partial Budget for On-Farm Pressing and Camelina Meal Use as Cattle Feed**

| **Positive Impacts** | $ per 100 head |
|---|---|
| **Added Returns** | |
| Camelina oil [14] | $1,723.68 |
| **Total Added Returns:** | $1,723.68 |
| | |
| **Reduced Costs** | |
| Operating Costs: | |
| Feed: cottonseed [15] | $2,800.00 |
| 2 lbs X 100 head X 80 days | |
| at $350/ton | |
| **Total Reduced Costs:** | $2,800.00 |
| **TOTAL POSITIVE IMPACT** | $4,523.68 |
| **NET IMPACT** | **$1,213.91** |

| **Negative Impacts** | $ per 100 head* |
|---|---|
| **Added Costs*** | |
| Preharvest Costs: | |
| Seed[1] | $235.20 |
| Fertilizer[2] | $1,061.97 |
| Fertilizer application[3] | $105.00 |
| Herbicide[4] | $210.00 |
| Labor (planting)[5] | $54.08 |
| Tractor operating costs[6] | $56.28 |
| Machinery operating costs[7] | $39.90 |
| Insurance (Fed. Crop, hail)[8] | $48.30 |
| Interest on above (12%) | $54.32 |
| Harvest Costs: | |
| Combine opperational costs[9] | $315.00 |
| Truck opperational costs[10] | $34.86 |
| Interest on above (12%) | $3.50 |
| Pressing Costs: | |
| Depreciation [11] | $480.00 |
| Interest on press (12%) | $216.00 |
| Repairs | $60.00 |
| Labor (pressing)[5] | $15.45 |
| Press operating costs [12] | $15.48 |
| Interest on above (12%) | $5.46 |
| Oil Shipping: | |
| Barrels [13] | $220.00 |
| Transportation to Billings (price based on shared load) | $78.98 |
| **Total Added Costs:** | |
| **Reduced Returns** | |
| None | $0.00 |
| **TOTAL NEGATIVE IMPACT** | $3,309.77 |

* 21 Acres of production to produce 16,000 lbs of feed required for 100 head with given yield of 1026lbs/AC

Sources:
1. (Rife, 2009).
2. (Farmers Cooperative, 2009)
3. (Johnson, 2006).
4. (Johnson, 2006).
5. (U.S. Department of Labor, 2009).
6. (Johnson, 2006).
7. (Johnson, 2006).
8. (Johnson, 2006).
9. (Johnson, 2006).
10. (Johnson, 2006).
11. (Circle Energy, 2009)
12. (Powder River Energy Corporation, 2009).
13. (Baytec Containers, 2009).
14. (Ash, Dohlamn, & Wittenberger, 2009).
15. (Farmers Cooperative, 2009).

# Chapter 5 Discussion

## 5.1 Agronomic Feasibility

Trials conducted throughout Eastern Wyoming; show that Camelina can be grown in the area. Camelina fits well into the climate of Eastern Wyoming. Although Eastern Wyoming experiences extreme cold, occasionally into the spring months, it has been shown that this has little effect on Camelina production, as seedlings can withstand temperatures of-11˚C (12˚F) (Ehrensing & Guy, 2008). This coupled with high temperatures in the summer months provides adequate conditions for crop ripening. The precipitation patterns of this area provide sufficient amounts of crop water to produce Camelina in a dry land cropping system. However there are many challenges for this crop within the area. At time of maturity high winds are often experienced leading to shattering and reductions in yield. Also it is not uncommon during the summer to have occasional hail storms which can also be devastating to this crop.

Examination of the soils in this area shows that there is a tendency for them to be alkaline. This is not optimum for Camelina production; but the crop has been shown to be tolerant of this condition. The soils in this area typically have low fertility due in part to the low organic matter. For optimum production fertilizer must be applied.

At this time it is difficult to gauge the expected yield for producers in Eastern Wyoming. According to several researchers, Camelina has the capacity to produce up to 1684.1-2020.9 kg per hectare (1500-1800 lbs per acre) (Schill, 2008). However, these trials are often performed at optimal conditions with the use of additional irrigation and fertilizer. From trials conducted in Eastern Wyoming there is a 33 percent decrease in production in a dry land situation, see Table 4.2. According to Dr. Pilgeram from Montana State University, it is difficult to gauge the expected yield for producers in Wyoming. She stated that some of the initial data is from first time growers of Camelina and thus should be disregarded as there are several challenges for any producer in their first year of production with any crop. There is also the added challenge of selecting the correct variety for the area. As seen in Table 4.2 there are several varieties of Camelina being trialed with varying results.

Agronomiclly there are also many advantages to Camelina production. In discussions with Mr. Chuck Rourke a local producer who grew Camelina in 2007, stated that he obtained many benefits from the crop. In his experience the crop aided in weed suppression during its initial growth. However, weeds can become a challenge at time of maturity. He also stated that the crop has the ability to improve soil structure by both breaking up soil in no-till situations and by helping to hold onto organic matter that might have been lost to wind and water erosion during the typical fallow period. He also stated that this crop would fit well into a winter wheat rotation. In Table 5.1 is a detailed chart of how Camelina could fit into this rotation.

*Table 5. 1 Camelina in Winter Wheat Rotation*

| | Months | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Jan. | Feb. | Mar. | April | May | Jun. | July | Aug. | Sept. | Oct. | Nov. | Dec. |
| 2010 | | | | | | | | | | | | |
| 2011 | | | | | | | | | | | | |
| 2012 | | | | | | | | | | | | |
| 2013 | | | | | | | | | | | | |
| 2014 | | | | | | | | | | | | |
| | Pink: Fallow | | | | Yellow: Camelina | | | | Green: Winter Wheat | | | |

According to Dr. Charlie Rife, of Blue Sun Biodiesel we are still a few years away from having complete agronomics for Camelina. Of course with continued research and development this crop could prove to be an alternative crop for the high plains area.

## 5.2 Camelina Marketing

### 5.2.1 Potential Markets

Currently in the U.S. there are a few markets for Camelina seed. The main market at this point in time would be for Camelina oil. The oil can be used by the bio-fuel industry in the manufacturing of B20 biodiesel. Although this market is not large it is continuing to grow. Bio-fuel industry could easily absorb the limited production of Camelina. However, this industry is not located within the state of Wyoming and selling to this market would require the added cost of transportation.

With improved cultivation and refining, Camelina oil can also be marketed as edible oil. This has great potential as a niche market. Due to a lack of herbicides and pesticides being registered for use on Camelina, cultivation must take place in an organic manner. This could result in a product that is organic and also has the added benefits of being high in omega-3 fatty acids. Currently Camelina edible oils are being used in a supplement for dogs called Omega Dog. This product is being manufactured by Animal Naturals, a company based in California.

The third potential market for Camelina would be the cosmetics industry. Although Camelina oil is not currently being used for this purpose it could again find a niche as organic cosmetics become more popular with U.S. consumers. Currently in Montana a soap company has developed as soap line that uses high quality Camelina oil. This company, TaDa Soapy Solutions, makes handcrafted soaps for high end markets.

For the meal which is left over after pressing there are several possible applications, although they are mainly in the research and development stage. As previously discussed Camelina meal has a great potential in the livestock feed area, especially in Wyoming. This would provide Wyoming ranchers with a protein meal that is produced in the state, possibly cutting down feed costs to maintain their livestock in winter months. However, Camelina has yet to receive GRAS status for all livestock feeds from the FDA, and thus is only applicable to broiler chickens at this time. With continued trials and the recent acceptance of Camelina meal by the FEFANA this approval may occur in the near future.

## 5.3 Proposed Chain for Camelina

### 5.3.1 Chain Map

A potential chain map for the Camelina sector in Eastern Wyoming has been developed based on potential stakeholders and markets, see Figure 5.1. This chain map is presented in two phases. The first phase is to process and use the products of Camelina on-farm. In this way local producers can integrate their Camelina enterprise into their existing livestock enterprise. This will allow for an increase in production acreage and the eventual development of a commodity market. It should be noted that this chain cannot be currently adopted as Camelina meal has not been approved as a livestock feed by the FDA.

In the first phase, the main actors are the farmers and ranchers, refineries, and biodiesel wholesalers. The initial processing of Camelina seed will take place on-farm, creating meal and oil. The oil will then be sent directly to refineries for further processing, while the meal will be utilized in producers livestock enterprises. Pending FDA approval of Camelina as a livestock meal this could be a feasible option within 5-10 years.

In the second phase, there is a development of a commodity market. In this phase the main actors are farmers and ranchers, farmers cooperative, refineries, livestock feed companies, and various wholesalers and retailers. In this phase producers could continue to use Camelina in their livestock enterprises and sell their additional product to the commodity market. Farmers Cooperative is placed in the chain map as a wholesale, as they currently have the infrastructure to handle storage and transportation from this area to destinations outside of the area. The second phase of this proposed chain could be a feasible option with in 10 or more years.

There is also improvement in the oil extraction between phase one and two. With the presses that producers would likely use full extraction is not possible, resulting in 25 percent oil and 75 percent meal. However, at the refinery level extraction is improved resulting in 36 percent oil and 64 percent meal.

In both phases the chain influencers and supporters remain the same. This chain is supported by the University of Wyoming Cooperative Extension, Wyoming Business Council, Crop Insurance Companies, and Banks. This chain is influenced by the USDA, FDA, EPA, and U.S. Government.

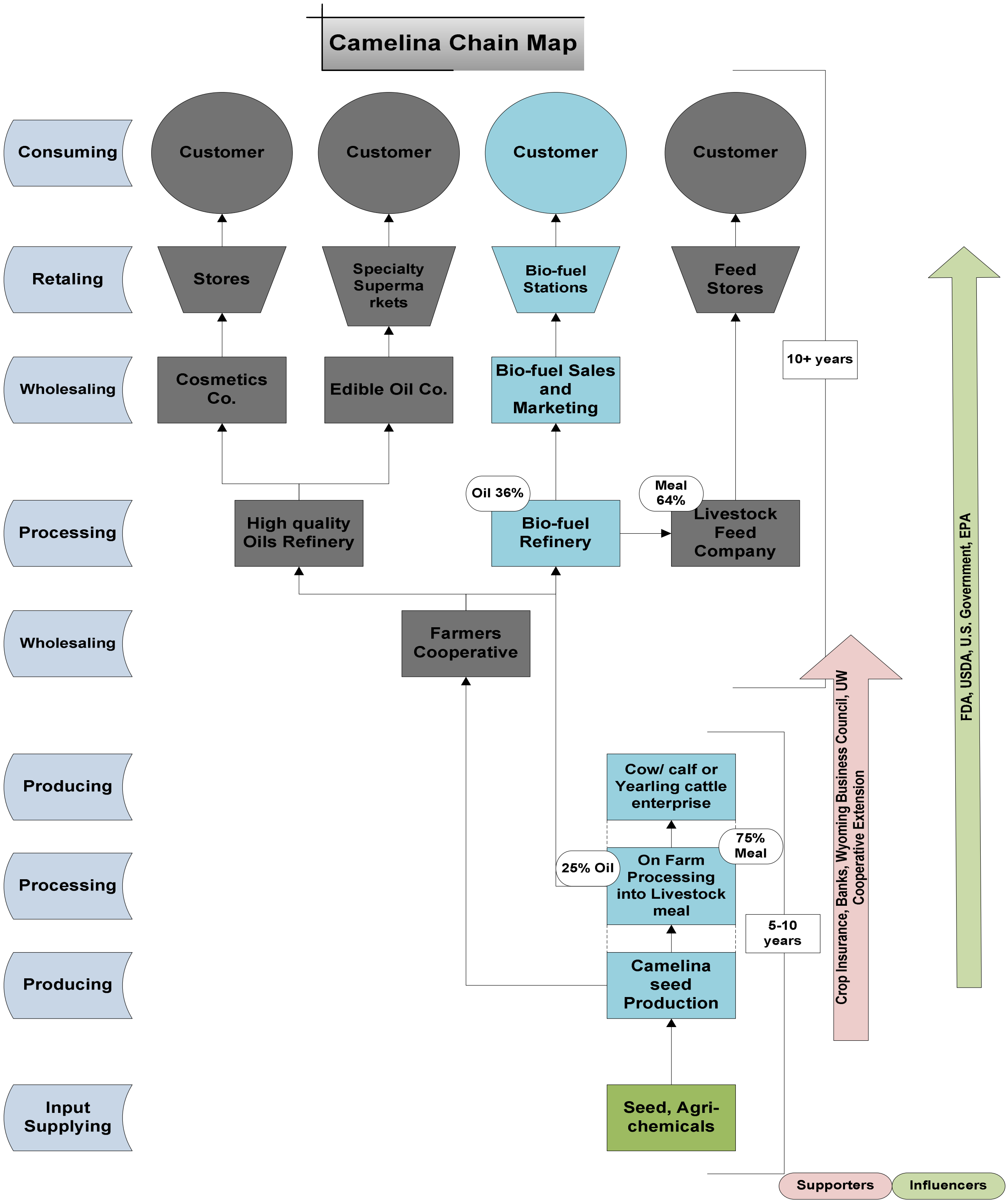


*Figure 5. 1 Proposed Chain Map for Camelina Sector in Eastern Wyoming*

### 5.3.2 Main Stakeholders

This section discusses the stakeholders that could play a role in further development of the Camelina sector. These stakeholders consist of farmers cooperative, research and education institutes, and the private sector.

***Farmers Cooperative***
The local Farmers Cooperative is made up of local farmers and ranchers who become members and receive discounts on inputs such as fertilizers and feeds. This organization also provides a wholesale marketing and distribution service. Farmers and ranchers can sell and store their commodity crops through the organization. By utilizing this function they can save money on transportation by pooling with other producers in the area.

***University of Wyoming Cooperative Extension***
The University of Wyoming Cooperative Extensions main mission is to provide "…lifelong learning opportunities for the people of Wyoming and empower them to make choices that enhance their quality of life." (University of Wyoming Cooperative Extension Services, 2002). With this mission in mind the organization has several programs dedicated to the promotion and adoption of sustainable agriculture systems. These programs provide education and information about alternative crops and livestock systems, which bridges the gap between university research and application.

***Wyoming Business Council***
The Wyoming Business Council provides services to facilitate economic growth for the state. They provide specialized programs for agribusiness and work to assist in business development. They also aid in market development of new Wyoming products. They provide promotion of Wyoming product locally and nationally (Wyoming Business Council, 2009).

***Bio-Fuel Sector***
Several private sector bio-fuel companies, such as Blue Sun Bio-diesel, work on the continued development of agronomics for crops such as Camelina. These companies provide producers with additional knowledge on ways to optimize their yields and recommendations that are crop and area specific. They also contribute to new developments in varieties of oilseed crops.

### 5.3.3 PESTE Analysis

The business environment of the proposed Camelina sector in Eastern Wyoming has been analyzed with the use of a PESTE analysis. This tool allows for an examination of the aspects that affect the sector including: political, economical, social, technological, and environmental.

<u>Political Aspects</u>

- Stable government
- Sector supported by U.S. Department of Agriculture
- Government tax incentives for renewable fuels
- EPA regulation of emissions
- FDA has not approved Camelina meal for livestock feed

Economical Aspects

- Loans available for agriculture sector
- Crop insurance available
- Ranchers may save money by producing their own livestock feed
- Added transportation cost to ship to refineries located outside of the state
- Minimal labor required
- No local market

Social Aspects

- Farmers Cooperative exists for commodity crop sales (existing infrastructure)
- Ranchers do not claim to be farmers
- Increased consumer awareness and interest in organic and renewable products
- Small communities with open communication among producers
- People are surrounded by energy companies and thus do not see oil or coal production ending

Technological Aspects

- Small scale oil press available for on-farm processing of seed
- Camelina can be used in a winter wheat rotation
- Producers already have the equipment necessary for mechanized production of Camelina
- Currently no approved broad leaf herbicides or pesticides registered for use on Camelina
- Fertilization required for sufficient yields
- Weed control prior to planting is necessary
- Production possible in no-till situations
- Camelina can be produced on marginal land that cannot be utilized by other crops
- Yield is still very variable by variety

Environmental Aspects

- Eastern Wyoming climate is suited to Camelina production
- Rainfall pattern allows for dry-land cropping of Camelina
- Camelina bio-diesel has lower emissions than standard diesel
- Camelina can aid in erosion avoidance
- Organic production is possible
- Hail and high winds can cause shattering and reduction in yield

The business environment for the proposed Camelina sector has many supporting and limiting factors. The sector is limited by several political factors in regard to approval of Camelina products by legislation and registration of chemicals. However, it is supported by government agencies that give both incentives and regulations for the sector. The economic aspect for Camelina production is well structured with loans available to producers and crop insurance. One of the main economic pitfalls is the lack of a local market thus causing added costs from transportation. However, pending FDA approval of Camelina use as a livestock feed a local market could potentially develop as well as reduce local livestock producers cost of production. Adding to the potential for this crop is the social aspect of a local Farmers Cooperative. This existing infrastructure will allow for Camelina's potential transition into a commodity crop. It will also enable local producers to work together and share costs of inputs and transportation. At the same time, these communities are often small in size and producers openly communicate with one another. This means that with any poor experience with the crop other producers may decide to not adopt it.

Technologically speaking there are several limiting factors such as the lack of registered broad leaf herbicides and pesticides, and the need for improved varieties of Camelina seed that will be able to produce higher yields in dry land conditions. At the same time, the sector is supported by having producers who are already engaging in some form of arable farming resulting in having the equipment required for mechanized farming of Camelina. Socially though it is important to point out that these producers are mainly livestock oriented and may not posses all the knowledge necessary to produce high yielding crops. Fortunately Camelina can utilize these producers marginal land and will fit into current crop rotation.

The Camelina sector has several positives in the way of the environment. As U.S. consumers become more aware of organic and renewable products Camelina will have the ability to fit into several niche markets. As a bio-fuel it has reduced emissions when compared to standard diesel fuel. It is also has beneficial to crop land by reducing erosion and fits well into the climate of Eastern Wyoming.

## 5.4 Economic Feasibility

### 5.4.1 Commodity Crop

The economic feasibility of Camelina as a commodity crop is analyzed in Section 4.5. This was completed by examining both the operational costs as well as a gross margin for one acre of production. From these analyses it is apparent that the highest costs are associated with fertilizers. If fertilizer is not applied there is a minimum of a 33 percent reduction in yield, as seen in Wyoming trials, see Section 4.2.2. If the crop is sold strictly as a commodity crop it will be sold currently for approximately $0.11 per pound. As seen in the gross margin analysis in Table 4.5 this will result in a profit of $7.11 per acre. It is important to take into consideration that this does not include the cost of transportation to the nearest delivery point located approximately 179 miles away. With the current price of freight shipping this would result in transportation costs of $760.75. Even when this is calculated for a full truck, which holds 50,000 lbs or 49 acres worth of production, it still does not cover the cost of transportation. This means that given the current market structure with delivery point outside of the area, potential producers will be unable to earn a profit selling Camelina as a commodity crop. Consequently should a refinery open locally this may become an option in the future.

### 5.4.2 On-Farm Integration

Another option would be on-farm processing of Camelina. This option is illustrated in Table 4.6 with the use of a partial budget. In this analysis Camelina is processed on-farm and the meal left over after pressing is utilized as livestock feed. The oil is shipped to the refinery located outside the area. This option results in less cost for transportation as 75 percent of the weight is left behind in meal. The partial budget also takes into consideration the reduced costs for cottonseed meal that is currently purchase for livestock feed. This will result in a savings of $1213.91 or $57.81 per acre. In some respects this savings could be looked at as a profit, since it is money that is not spent. Mr. Chuck Rourke, a local producer, stated that if Camelina could earn approximately $50 per acre he would be able to justify placing acreage into Camelina production. Although a promising option for local producers this option is still not possible due to FDA restrictions on feeding Camelina meal to livestock.

# Chapter 6 Conclusions and Recommendations

## 6.1 Conclusions

From the study conducted, it is concluded that Camelina sativa is not a feasible alternative crop for producers in Eastern Wyoming due to economic and agronomic factors. Agronomically there is not enough information to gauge the yields producers reasonably can expect. Economically, given current market constraints producers will not be able to produce Camelina as a commodity for a profit.

From information gathered during this research it was determined that Camelina can be grown in the area. It is well suited to the climate, rainfall patterns, and current farming system. The challenge for this crop lies in the amount of research available on varieties that are best suited for the area and accurate yield information.

From the research conducted, there is an interest in producing Camelina by producers in Eastern Wyoming. This research indicated that producers' main interest in Camelina lies in its potential as a commodity crop, bio-fuel, and livestock feed. Of these options producers expressed a keen interest in the use of Camelina meal as a livestock feed. The research explored this option and discovered that while this is an economically feasible option it cannot be currently adopted due to FDA restrictions.

This study also examined the linkages in information between potential supporters and producers. It determined that producers still need information about the marketing and economics of Camelina production. It was also determined that this information has not been provided due to a lack of information by a potential stakeholder and is not in the stakeholders' delivery method.

Based on this study's results, a chain map has been proposed for the Camelina sector. This chain map is provided, applicable for the sector if the FDA approves Camelina as a livestock feed and if producers can achieve the initial expected yields of 1026 pound per acre. If these steps occur Camelina is an economically feasible alternative crop. Until such time, Camelina will continue to be unfeasible for producers in Eastern Wyoming.

## 6.2 Recommendations

Based on the results of this study, it is concluded that Camelina production in Eastern Wyoming is not a feasible option at this point in time. Although, Camelina still has the potential to be an alternative crop for this area in the future. Therefore, this crop should be researched and developed further so that it can reach its potential.

For the Camelina sector to develop, the following recommendations are made:

***To producers***: Continue to follow the developments of Camelina in order to chose the appropriate time to add this enterprise to existing farming system. This includes thoroughly investigation of the crop by seeking information from unbiased sources, and carefully examining the profitability of this venture prior to adoption. Currently it is advisable for producers to seek a guaranteed contract for production of Camelina as markets are limited.

***To the University of Wyoming Cooperative Extension***: Continue to research the potential of this crop as an alternative crop for Eastern Wyoming producers. This should be done by continuing to test varieties under both optimum and dry land situations. Also as yields increase examine the economic aspects of producing this crop given realistic yields. Information about Camelina's potential and challenges should be compiled and disseminated to local producers. This information should include new developments in production, on-farm usage, and most importantly economics and marketing. It is recommended that the information be disseminated by mailed pamphlet with supplemental information posted on the extension website in order to reach the largest audience. Also it is important that given the current research and information available about this crop to exercise caution when promoting Camelina. If producers fail when producing and marketing Camelina the reputation of this crop could be destroyed resulting in few farmers and ranchers ever adopting this alternative crop.

***To chain supporters***: First and foremost work towards improved agronomics and varieties that are fitted to Eastern Wyoming and the high plains area. Secondly, to continue to work on market development by investigating Camelina development in other states as well as looking for opportunities to create a market within the state.

***To research and educational institutes***: Continue to work on trials and development of Camelina seed in order to find improved varieties that fit into the dry land cropping system of Eastern Wyoming. Also to continue to perform feeding trials and present the FDA with research study information on the benefits of Camelina meal as a livestock feed.

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# Appendices

## Appendix 1: Precipitation data for selected counties in Wyoming

Albany County

| | Feb. | Mar. | Apr. | May | Jun. | July | Aug. | Total |
|---|---|---|---|---|---|---|---|---|
| mm | 2.4 | 12.9 | 27.7 | 38.3 | 30.0 | 41.5 | 8.5 | 161.3 |
| Inches | 0.1 | 0.5 | 1.1 | 1.5 | 1.2 | 1.6 | 0.3 | 6.3 |

Converse County

| | Feb. | Mar. | Apr. | May | Jun. | July | Aug. | Total |
|---|---|---|---|---|---|---|---|---|
| mm | 7.6 | 14.6 | 26.6 | 62.3 | 49.7 | 25.5 | 31.5 | 217.8 |
| Inches | 0.3 | 0.6 | 1.0 | 2.5 | 2.0 | 1.0 | 1.2 | 8.6 |

Laramie County

| | Feb. | Mar. | Apr. | May | Jun. | July | Aug. | Total |
|---|---|---|---|---|---|---|---|---|
| mm | 11.4 | 25.5 | 34.6 | 64.3 | 55.6 | 50.5 | 41.8 | 283.7 |
| Inches | 0.4 | 1.0 | 1.4 | 2.5 | 2.2 | 2.0 | 1.6 | 11.1 |

Niobrara County

| | Feb. | Mar. | Apr. | May | Jun. | July | Aug. | Total |
|---|---|---|---|---|---|---|---|---|
| mm | 12.9 | 24.8 | 52.7 | 69.5 | 66.4 | 45.2 | 27.2 | 298.7 |
| Inches | 0.5 | 1.0 | 2.1 | 2.7 | 2.6 | 1.8 | 1.1 | 11.8 |

Platte County

| | Feb. | Mar. | Apr. | May | Jun. | July | Aug. | Total |
|---|---|---|---|---|---|---|---|---|
| mm | 7.8 | 17.5 | 40.2 | 62.3 | 55.3 | 36.0 | 25.1 | 244.2 |
| Inches | 0.3 | 0.7 | 1.6 | 2.5 | 2.2 | 1.4 | 1.0 | 9.7 |

Weston County

| | Feb. | Mar. | Apr. | May | Jun. | July | Aug. | Total |
|---|---|---|---|---|---|---|---|---|
| mm | 12.1 | 18.3 | 36.7 | 61.9 | 64.2 | 43.5 | 40.0 | 276.7 |
| Inches | 0.5 | 0.7 | 1.4 | 2.4 | 2.5 | 1.7 | 1.6 | 10.8 |

(Source: Worldclimate.com, accessed on 19 Aug. 2009)

**Appendix 2: Survey**

# Camelina Survey

****Please write in or circle one answer for each question that best applies to your situation****

1. What city/ town is your ranch located in? ______________________________

2. What is your age?
A. 39 or under
B. 40-49
C. 50-59
D. 60-69
E. 70 or over

3. How many acres do you currently have in crop/forage production?
A. less than 39 acres
B. 40-79 acres
C. more than 80 acres

4. To what type does your business belong?
A. Cow calf
B. Yearling (Cattle)
C. Sheep
D. Horses
E. Arable farming
F. Other: ____________

5. Please rate your current level of interest in producing Camelina.
0 (not interested)
1 (slightly interested)
2 (Interested)
3 (very interested)

6. If you were to grow Camelina,
how many acres of Camelina would you possibly grow?
A. less than 39 acres
B. 40-79
C. more than 80 acres

7. If you were to grow Camelina,
What percentage of your current crop/ forage acreage would you use for Camelina production?
A. 0% (would use other acreage)
B. 1-10%
C. 11-25%
D. 26-50%
E. 51-75%
F. 76-100%

8. What is the most important factor to you when deciding to produce a new crop?
A. potential on farm use
B. selling a commodity crop
C. enterprise diversification
D. trying something new
E. Other:____________

9. If you were to grow Camelina, what would be your main reason?
A. for bio-fuel
B. for livestock meal
C. to sell as a commodity
D. both A and B

10. Would you be interested in using Straight Vegetable Oil on your ranch for bio-fuel?
A. yes
B. no

11. What information have you already received about Camelina?
A. production information
B. on farm usage information
C. economic/ marketing information
D. None

12. What additional information are you interested in receiving about Camelina?
A. production information
B. on farm usage information
C. economic/ marketing information
D. None

13. How do you prefer to receive information about Camelina production from the University of Wyoming Cooperative extension office?
A. Group presentations
B. Written information by email
C. Field Day
D. Mailed pamphlet
E. Website

Thank you!

## Appendix 3: Interview Questions

Camelina Interview #1

Wyoming Business Council: Donn Randall

- What do you do with the Wyoming Business council and the Value-added program?
- On your trip with producers what where producers most interested in about Camelina?
- Can you tell me a little about the companies you visited on your trip?
- Do you know of any refineries for bio-fuel in Wyoming or neighboring states?
- What do you think the main marketing opportunities are for Camelina oil and byproducts?
- Do you think that a co-operative structure for local producers would be beneficial, why or why not?
- What do you think the potential is for Camelina production in Wyoming?
- What do you think the potential is for on-farm processing in Wyoming?
- What do you think Wyoming ranchers/farmers still need to have about Camelina?

- What do you think are the challenges for Camelina production in Wyoming?
- Any additional information?

Camelina Interview #2

Potential Camelina Producer: Leslie Drake

Location: Arvada, WY

- What is your primary business?
- Do you currently grow any crops or forage?
- What is your main reason for considering growing Camelina?
- What are your main hesitations for growing Camelina?
- If possible would you like to use the SVO and meal on farm, why or why not?
- What information would you still like to have about Camelina?
- Do you think that ranchers in the area would be willing to form a co-operative for Camelina?
- What do you think the potential for Camelina production is for Wyoming?
- What do you think the challenges are for Camelina production in Wyoming?
- How do you prefer to receive information about Camelina from the UW extension office and why?

Camelina Interview #3

Camelina Seed Company and Biodiesel Company: Charlie Rife, Blue Sun Bio-diesel

Location: Torrington, WY

- Can you tell me a little about what Blue Sun Bio-diesel does?
- What Camelina seed varieties are you selling?
- Is your company currently doing any research or development of Camelina varieties?
- What is the current price for Camelina seed f.o.b. to Wyoming?

- What extension services does your company offer to farmers growing your product?
- What are your company's recommendations for cultivation of Camelina (field selection, seeding rate, fertilizer requirements, water requirements, planting dates)?
- Do you currently have producers in Wyoming?
- Is your company currently refining Camelina seed or are their plans to produce a refinery?
- Do you know of any refineries that are processing Camelina?
- What is the most important factor in the storage of Camelina?
- How is Camelina typically transported?
- Has your company had any previous experience with the development of bio-fuel crops, explain?
- What do you think the challenges are for Camelina production in Wyoming?
- What do you think the potential for Camelina production is for Wyoming?

<u>Camelina Interview #4</u>

<u>University Researcher:  Dr. Alice Pilgeram, Montana State University, Plant Science</u>

<u>Location: Bozeman, Montana</u>

- What do you think the potential is for Camelina production in Wyoming?
- What do you think are the challenges facing Wyoming production of Camelina?
- Can you tell me about the crops development in Montana?
- Do you know of any refineries in Wyoming, or near by states?
- What do you think the potential is and challenges for Camelina as a livestock meal?
- What do you think the yield potential is for Camelina meal in Wyoming?
- What are the other applications for Camelina meal and oil that are being researched?

<u>Camelina Interview #5</u>

<u>University of Wyoming Cooperative Extension Agent: Ms. Lindsay Taylor</u>

<u>Location: Gillette, WY</u>

- In your field trials what was the yield that producers in Wyoming could expect?
- Did you have any nutrient deficiency problems of disease and pest problems?
- What is the major difference between UW mobile processing unit and seed sent to a refinery?
- What do you think the potential is for Camelina meal?
- Do you know of any Camelina seed processors?
- What information do you think Wyoming ranchers still need about Camelina?
- What do you think the potential for Camelina production is for Wyoming?
- What do you think the challenges are for Camelina production in Wyoming?
- Has UW extension had any previous experience with development of bio-fuel sector/crops?

Camelina Interview #6

Farmer who has produced Camelina: Chuck Rourke

Location: Gillette, WY Rourke Ranch

- What is your primary business?
- Do you currently grow any other crops or forage?
- What was the main reason why you decided to grow Camelina?
- How many acres of Camelina did you grow?
- What was your average yield?
- What was the amount of labor that you had to put into growing Camelina?
- From your experience what were the positive aspects of this crop?
- What were your major challenges with producing this crop?
- What did you do with the seed that you produced?
- If possible would you like to use the SVO and meal on farm?
- Do you think that ranchers in the area would be willing to form a co-operative for Camelina?
- From your experience where do you think improvements can be made in Camelina production for Wyoming?
- Would you recommend Camelina seed production to other ranchers why or why not?

## Appendix 4: Statistical Analysis

## Mann-Whitney Test

Ho: There is no significant difference in interest level in producing Camelina and producers' age.
H1: There is a significant difference in Interest level in producing Camelina and producers' age.

**Ranks**

| | age_cat | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| Please rate your level of interest | 49 and under | 16 | 13.47 | 215.50 |
| | 50-59 | 11 | 14.77 | 162.50 |
| | Total | 27 | | |

**Test Statistics[b]**

| | Please rate your level of interest |
|---|---|
| Mann-Whitney U | 79.500 |
| Wilcoxon W | 215.500 |
| Z | -.445 |
| Asymp. Sig. (2-tailed) | .657 |
| Exact Sig. [2*(1-tailed Sig.)] | .680[a] |

a. Not corrected for ties.

b. Grouping Variable: age_cat

With a p value of 0.657 there is no significant difference in interest level in producing Camelina and producers' age.

## Mann-Whitney Test

Ho: There is no significant difference in the interest level in producing Camelina among business type.

H1: There is a significant difference in the interest level in producing Camelina among business type.

**Ranks**

| | business_categorie | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| Please rate your level of intrest | Cattle | 21 | 15.05 | 316.00 |
| | other livestock and arable farming | 8 | 14.88 | 119.00 |
| | Total | 29 | | |

**Test Statistics[b]**

| | Please rate your level of intrest |
|---|---|
| Mann-Whitney U | 83.000 |
| Wilcoxon W | 119.000 |
| Z | -.052 |
| Asymp. Sig. (2-tailed) | .959 |
| Exact Sig. [2*(1-tailed Sig.)] | .981[a] |

a. Not corrected for ties.

b. Grouping Variable: business_categorie

With a p value of 0.959 there is no significant difference in interest level by business type.

## Crosstabs

Ho: There is no significant difference between the amount of current crop/ forage acres and possible Camelina acres.

H1: There is a significant difference between the amount of current crop/forage acres and possible Camelina acres.

**Case Processing Summary**

| | Cases | | | | | |
|---|---|---|---|---|---|---|
| | Valid | | Missing | | Total | |
| | N | Percent | N | Percent | N | Percent |
| acres_cam * acres | 30 | 100.0% | 0 | .0% | 30 | 100.0% |

**acres_cam * acres Crosstabulation**

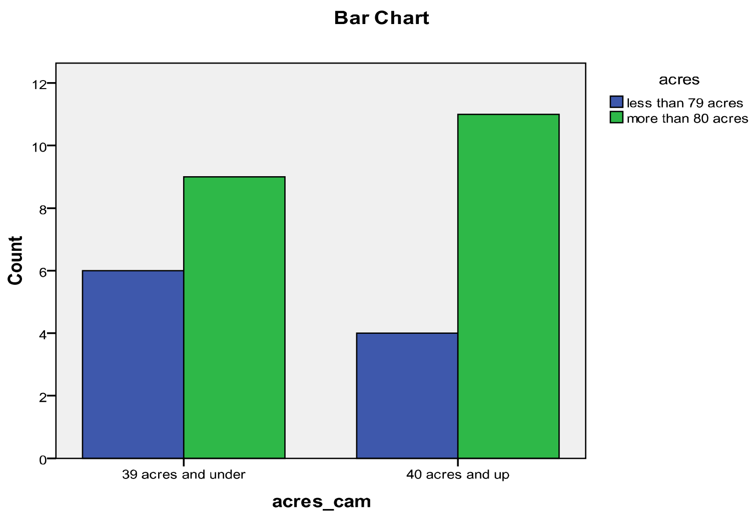
| | | | acres | | |
|---|---|---|---|---|---|
| | | | less than 79 acres | more than 80 acres | Total |
| acres_cam | 39 acres and under | Count | 6 | 9 | 15 |
| | | Expected Count | 5.0 | 10.0 | 15.0 |
| | 40 acres and up | Count | 4 | 11 | 15 |
| | | Expected Count | 5.0 | 10.0 | 15.0 |
| Total | | Count | 10 | 20 | 30 |
| | | Expected Count | 10.0 | 20.0 | 30.0 |

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) | Exact Sig. (2-sided) | Exact Sig. (1-sided) |
|---|---|---|---|---|---|
| Pearson Chi-Square | .600[a] | 1 | .439 | | |
| Continuity Correction[b] | .150 | 1 | .699 | | |
| Likelihood Ratio | .603 | 1 | .437 | | |
| Fisher's Exact Test | | | | .700 | .350 |
| Linear-by-Linear Association | .580 | 1 | .446 | | |
| N of Valid Cases | 30 | | | | |

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 5.00.

b. Computed only for a 2x2 table



Given the p value of 0.439 there is no significant difference between the amount of current crop/ forage acres and possible Camelina acres.

## Crosstabs

Ho: There is no significant difference between age groups and the way they prefer to receive information form the University of Wyoming Cooperative Extension.

H1: There is a significant difference between age groups and the way they prefer to receive information from the University of Wyoming Cooperative Extension.

**Case Processing Summary**

| | Cases | | | | | |
|---|---|---|---|---|---|---|
| | Valid | | Missing | | Total | |
| | N | Percent | N | Percent | N | Percent |
| age_group * info_cat | 30 | 100.0% | 0 | .0% | 30 | 100.0% |

**age_group * info_cat Crosstabulation**

| | | | info_cat | | Total |
|---|---|---|---|---|---|
| | | | traditional methods | electronic sources | |
| age_group | 49 and under | Count | 6 | 10 | 16 |
| | | Expected Count | 8.0 | 8.0 | 16.0 |
| | 50 and over | Count | 9 | 5 | 14 |
| | | Expected Count | 7.0 | 7.0 | 14.0 |
| Total | | Count | 15 | 15 | 30 |
| | | Expected Count | 15.0 | 15.0 | 30.0 |

**Chi-Square Tests**

| | Value | df | Asymp. Sig. (2-sided) | Exact Sig. (2-sided) | Exact Sig. (1-sided) |
|---|---|---|---|---|---|
| Pearson Chi-Square | 2.143[a] | 1 | .143 | | |
| Continuity Correction[b] | 1.205 | 1 | .272 | | |
| Likelihood Ratio | 2.170 | 1 | .141 | | |
| Fisher's Exact Test | | | | .272 | .136 |
| Linear-by-Linear Association | 2.071 | 1 | .150 | | |
| N of Valid Cases | 30 | | | | |

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 7.00.

b. Computed only for a 2x2 table

With a p value of 0.143 there is no significant difference between age groups and the way they prefer to receive information form the University of Wyoming Cooperative Extension.

**Bar Chart**